Carbon Monitoring Report
VII 2018
[GS 751] National Biodigester Programme, Cambodia

CARBON MONITORING AND USER SURVEY 2018

National Biodigester Programme, Cambodia

Monitoring period VII of the Second Crediting Period (01/01/2018 – 31/12/2018, including both days)

Version 1.3

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Acronyms

AWMS	Animal Waste Management System
BE	Baseline emission
BFT	Baseline fuel test
BUS	Biogas User Survey
CDM	Clean Development Mechanism
CH_4	Methane Gas
CMDG	Cambodian Millennium Development Goals
CMS	Carbon Monitoring Survey
CO_2	Carbon Dioxide
CO_2eq	Relative potency of non-CO_2 gases compared to CO_2
DAPH	Department of Animal Production and Health
EF	Emission factor
ER	Emission reduction
GBM	Gold Standard Biodigester Methodology
GHG	Greenhouse Gas
GS	Gold Standard
GSPP	Gold Standard Passport
GWP	Global Warming Potential
hh	household
IPCC	Intergovernmental Panel on Climate Change
KPT	Kitchen Performance Test
LPG	Liquefied Petroleum Gas
LSC	Local Stakeholder Consultation Report
MCF	Methane conversion factor
MPx	Monitoring Period x (I, II, III etc)
MRx	Monitoring Report (I, II, III etc)
MS	Manure system (equivalent to AWMS)
N_2O	Nitrous dioxide
NBP	National Biodigester Programme
NIS	National Institute for Statistics
NRB	Non-Renewable Biomass
PBPO	Provincial Biodigester Programme Office
PDD	Project Description Document
PE	Project Emission
PFT	Project fuel test
SD	Sustainable Development
SNV	Netherlands Development Organisation
TLS	Traditional Lao Stove
TPDDTEC	Technologies and practices to displace decentralized thermal energy consumption
UNDP	United Nations Development Program
UNFCCC	United Nation Framework Convention on Climate Change
US	Usage Survey
VER	Voluntary emission reduction
VGS	Voluntary Gold Standard

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1. INTRODUCTION

The National Biodigester Programme (NBP) of Cambodia is an undertaking of the Ministry of Agriculture, Forestry and Fisheries (MAFF) in close collaboration with several implementing stakeholders. The main objective of NBP is to establish a permanent domestic biodigester sector on a commercial market-oriented basis for the dissemination of biodigesters as an indigenous, sustainable energy source in selected provinces in Cambodia. This report presents the monitoring activities of NBP per the modalities and procedures set by the Gold Standard (GS) for the monitoring period VII (MPVII) of the second crediting period (CPII); 01/01/2018 to 31/12/2018, both dates inclusive.

All data in this report is referenced in ER database sheet MRVII report. References are therefore not mentioned unless they deviate from the default.

1.1 VGS PROJECT CHARACTERISTICS

The table hereunder details the characteristics of the VGS project.

Table 1: NBP VGS project characteristics

Item	Data
Host country	Cambodia
Project title	National Biodigester Programme, Cambodia
Project size	Large scale
Gold standard project animal icon	Pelican
GS project ID	GS751
Gold Standard version	2.1
GS website link	https://products.markit.com/br-reg/public/project.jsp?project_id=103000000002177
Sectoral scope	Renewably energy delivery to the user and methane avoidance
Applied methodology	Technologies and practices to displace decentralized thermal energy consumption, version 2.0 Sectoral scope 1,3,13[1] version 2.0
Crediting period	7 years (renewable)
Start date of project	13/03/2006
Start date of crediting period	24/05/2009
Registration	24/05/2011
Monitoring period I (MPI)	24/05/2009 to 31/08/2010
Monitoring period II (MPII)	01/09/2010 to 31/12/2011
Start date of CPII	01/01/2012
Monitoring period I of CPII	01/01/2012 to 31/12/2012, inclusive both dates
Monitoring period II of CPII	01/01/2013 to 31/12/2013, inclusive both dates
Monitoring period III of CPII	01/01/2014 to 31/12/2014, inclusive both dates
PDD design change	19 October 2015
Monitoring period IV of CPII	01/01/2015 to 31/12/2015, inclusive both dates
Monitoring period V of CPII	01/01/2016 to 31/12/2016, inclusive both dates
Monitoring period VI of CPII	01/01/2017 to 31/12/2017, inclusive both dates
Monitoring period VII of CPII	01/01/2018 to 31/12/2018, inclusive both dates

[1] *http://www.goldstandard.org/sites/default/files/revised-tpddtec-methodology_april-2015_final-clean.pdf*

The VGS project targets 20[2] provinces in South-east Cambodia, at this stage NBP is active in 16[2] provinces, see the next table:

Table 2: Project location by provinces in Cambodia and GPS coordinates of provincial capitals

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

1.2 VERs – CLAIMED VERSUS THE PDD ESTIMATE

Table 3: Credits claimed versus credits estimated as per PDD[3]

Monitoring period	Year or date (inclusive both dates)	Credits estimated	Estimated as per PDD	Difference
MPVII of CPII	01/01/2018 – 31/12/2018	103,000	113,826	-10,826

The emission reductions claimed in MPVII are a bit lower to those estimated in the PDD. The difference is just -10% and can be attributed to 2 main factors: there are less units than estimated 33,287 versus, 27,231, but the ERs/unit are higher, 5,07 versus 3.93 in the PDD (main reason: Baseline fuel use is higher than estimated, BE fuel is 3.11 versus 2.58 in the PDD and BE AWMS is 2.3 instead of 1.5 in PDD. That is mainly caused by the fact that the IPCC used IPCC default

[2] Originally 19, but now 20 as Kampong Cham was split into 2 new provinces: (1) Kampong Cham and (2) Tbong Kmum as per 6 January 2016, see http://db.ncdd.gov.kh/gazetteer/view/index.castle. In addition, a number of districts have moved from Kandal to Phnom Penh with biodigesters and as a result Phnom Penh has become part of the project area. The project area is not enlarged by this.

[3] As per PDD v2.3

values for pig VS excretion which turned out to be overly conservative) which combined resulted in a small decrease is forecasted in ERs.

1.3 TECHNICAL PROJECT DESCRIPTION

The National Biodigester Programme

In March 2006, the Ministry of Agriculture, Forestry and Fisheries (MAFF) and SNV agreed on the joint development of a National Biodigester Programme (NBP) to create a permanent national domestic biodigester sector for the dissemination of household biodigesters as a clean, indigenous and sustainable energy source in Cambodia and to utilise the fertilizing potential of bio-slurry.

Baseline scenario

Before the onset of the project activities most households, with the technical potential for a biodigester, relied primarily on wood to meet their thermal energy demand for cooking and kerosene for lighting. The reliance on these fuels causes substantial indoor air pollution which can lead to respiratory diseases and eye ailments; especially women and children are mostly at risk here. Furthermore, the collection of wood contributes to deforestation. A substantial part of the fuel wood is collected, which is both a drudgery and a significant time expenditure. Purchased wood on the other hand, is a burden on the limited households' revenues. In addition, unhygienic animal waste management practices and the lack of access to basic sanitation result in pollution of farmyards and surface water, foul odour, methane emissions and a relatively high prevalence of hygiene related diseases, such as diarrhoea.

The Programme

The programme aims to resolve the issues sketched above; by hygienically treating animal and human waste in a biodigester to produce a clean, convenient and renewable cooking fuel; biogas, whereas the treated waste is to be used as a potent and safe organic fertiliser.

The specific objectives of the National Biodigester Programme contributing to its overall objective are:

1. Cumulative construction of 33,287 biodigesters by 2018[4]
2. Ensuring the continued functioning of all biodigesters built under the programme;
3. Ensuring a maximum return on their investment for the biodigester owners by maximising the use of bio-slurry and biogas;
4. Expanding the programme area to all provinces in Cambodia with sufficient biodigester market potential, this is expected to be in total 16-20 provinces;
5. Working towards financial autonomy and expand the project area to all provinces where the programme is active;

[4] As per PDD v2.3

6. Working towards technical autonomy and long-term managerial sector sustainability through decentralization of programme components ownership and institutional capacity building;
7. Achieving full privatization of the marketing, construction and after-sales service activities, through a micro-franchise system, in a well-regulated market environment.

Technology and emission reductions

Deployed technology: Domestic household digesters, in this document referred to as *'biodigesters'*. In a biodigester, manure is anaerobically degraded by a consortium of microbes, whereby biogas is released by methanogenic microbes. The released biogas is subsequently captured in an integrated gasholder and stored for various thermal energy services; mostly for cooking and by some households also for lighting.

In each household, NBP will install a biodigester, an overflow pit, several biogas lamps, a number of biogas stoves and the necessary piping. A toilet connected to the biodigester is optional but recommended by the programme. The installation of a slurry compost facility for the effluent from a biodigester will further decompose the slurry under aerobic conditions, thereby removing any remaining pathogens. The composted slurry can be utilized as an excellent organic fertiliser and/or fish feed.

GHG emission reductions: The technology reduces GHG emission through three pathways:

1. The displacement of non-renewable cooking fuels by biogas;
2. The avoidance of methane emissions from the animal waste by capturing and destroying methane for thermal energy services;
3. The displacement of chemical fertilizers by bio-slurry. The production of chemical fertilizers is fossil fuel intensive and the soil application of chemical fertilizers results in the emissions of potent GHGs, such as N_2O.

The emission reductions are realised by installing biodigesters in 16 provinces at the moment. The biodigesters have a digester size, of either 2,3, 4, 6, 8, 10 or 15 m^3 depending on the amount of collectable manure available on a daily basis. Other eligible sizes are not constructed so far.

1.4 CONTRIBUTION TO SUSTAINABLE DEVELOPMENT

Social benefits

- Avoided health hazards associated with unmanaged waste in farmyards;
- Reduced drudgery and time expenditure on wood collection especially for women;
- Avoided health hazards associated with indoor air pollution and open fires from wood fired stoves, especially for women and children;
- Hygiene: hygienic anaerobic treatment of waste and less foul odour;
- Sanitation: access to basic sanitation by attaching a toilet, energy for sterilising drinking water;
- Energy security: continuous provision of a renewable energy resource;

- Increase in rate of enrolment of girls in school because of the liberty from fuel collection.

Environmental benefits

- Reduced local environmental pollution through a better waste management system, and soil improvement by the use of bio-slurry;
- Reduced deforestation;
- Nutrient recovery from waste;
- Increase in soil productivity due to added NPK and micro nutrients from bio-slurry;
- Reduction in GHG emissions to the atmosphere;
- Prevention in land-fertility degradation due the reduction of the use of chemical fertilizers.

Economic benefits

- Savings to national economy by providing renewable cooking instead of imported fossil fuels;
- Revenue saving: Reduced expenditure on cooking fuels;
- Savings to national economy by providing organic fertiliser instead of imported chemical fertilisers while achieving better crop yields;
- Employment opportunities, both skilled and unskilled, resulting from the project activities (i.e. masons, supervisors and technicians);
- Private sector development through the establishment of small and medium sized biodigester construction companies;
- Capacity building of rural based engineers, artisans and supervisors;
- Introduction of affordable micro-credit for biodigester farmers through micro finance institutions;
- Reduced pressure on the forests; the forest in Cambodia have a considerable potential for other uses than firewood and timber, i.e. non-timer forest products and tourism.

Technological benefits

- South to south transfer of a sustainable technology. The biodigester design is based on the Deenbandhu model, a well proven and widely disseminated digester in India;
- Creation of a skilled labour force, skills created resulting from the NBP activities have overspill to other sectors;
- The Indian Deenbandhu digester is modified and indigenized to fit the socio-technical situation in Cambodia, the modified digester is named the ‘farmers friend digester’ in Khmer;
- R&D activities of NBP aim to indigenise the biodigester system further, by for example, producing biogas stoves, taps and water drains locally and continued R&D efforts are in place to improve on these appliances. The locally developed stove is now also widely copied in African biodigester programmes.

1.5 UNITS DISSEMINATED

The next table shows the units built in the period from 13-03-2006 to 31-12-2018 in the VGS project:

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

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

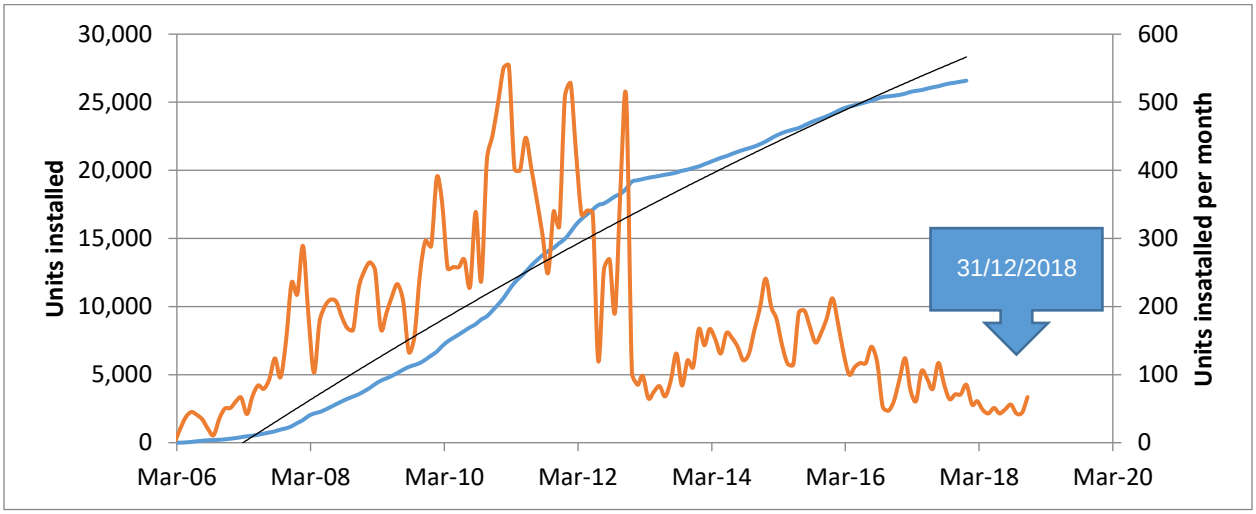

Figure 1: Cumulative and installations per month until 31/12/2018

Figure 1 shows that the number of units installed is steadily increasing. The figure also shows that there are seasonal effects affecting the monthly number of units installed.

- Baseline households are switching to LPG and take up loans for this, consequently they don't have money available or interest in biogas.
- Farmer cannot take up loan for biogas because of indebtedness – farmers can only take up 2 loans at the same time and therefore cannot invest in biogas.
- Competition with other biogas companies and other renewable energy companies such as solar home systems

NBP has installed 7 different digester sizes; the next figure shows the popularity of each digester size expressed in fraction of total number of digesters built:

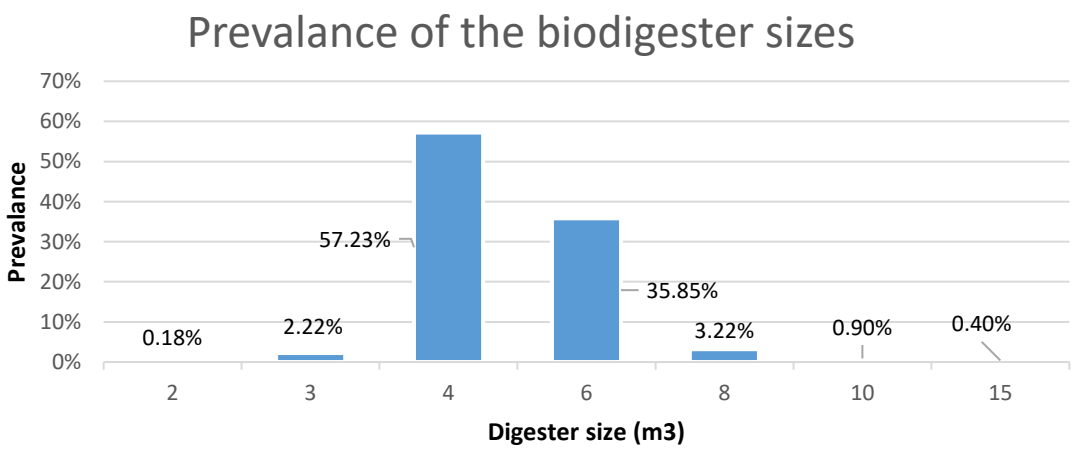

Figure 2: Share of digester volume (m^3) in total digester population (as per 31/12/2018)

The most proliferated digester has a volume of 4 m^3, followed by the 6 m^3; according to the VGS database. Other digester sizes are built to a much smaller extent. The average digester size built has a volume of 4.92 m^3, the smallest average of all the years so far. This indicates that the technology is becoming more popular with smaller farmers and at the same time indicates that NBP is increasingly reaching poorer farmers.

1.6 SUMMARY OF VERS CLAIMED IN CPII MPVII

The next table summarizes the total number of VERs claimed for this MP (sheet ER database):

Table 5: Estimated emission reductions of MPVII CPII

Crediting month, including end and beginning dates		Units installed at the end of the month	Estimated emission reductions in tCO_2e	Estimated cumulative emission reductions in tCO_2e
01/01/2018	31/01/2018	26,670	8,484	8,484
01/02/2018	28/02/2018	26,726	8,511	16,995
01/03/2018	31/03/2018	26,787	8,529	25,523
01/04/2018	30/04/2018	26,835	8,548	34,072
01/05/2018	31/05/2018	26,878	8,564	42,635
01/06/2018	30/06/2018	26,929	8,577	51,212
01/07/2018	31/07/2018	26,972	8,594	59,806
01/08/2018	31/08/2018	27,021	8,607	68,413
01/09/2018	30/09/2018	27,077	8,623	77,036
01/10/2018	31/10/2018	27,120	8,641	85,677
01/11/2018	30/11/2018	27,164	8,654	94,331
01/12/2018	31/12/2018	27,231	8,669	103,000

1.7 DOUBLE COUNTING IN THE CONTEXT OF GREEN CERTIFICATE SCHEMES

The NBP warrants it has, and continues to have full legal and beneficial title to any Units listed by User in accordance with the Gold Standard Registry Terms of Use and the underlying Environmental Benefits corresponding to such Units and it has not sold, transferred, assigned, licensed, disposed of, granted or otherwise created any interest or encumbrance in or agreed to sell, assign, license, dispose of, grant or otherwise create any interest or encumbrance in the Units or the underlying Environmental Benefits corresponding to such Units other than as contemplated under the Gold Standard Registry Terms of Use. NBP has uploaded a signed letter to the registry that is valid until 31/12/2018, the end of this crediting period.

1.8 FORWARD ACTION REQUESTS

No FARs applicable to this MP were identified by the DOE and GS during MPVI review (the review of the previous monitoring report).

2. MONITORING ACTIVITIES

2.1 ORGANIZATIONAL SETUP OF THE CARBON AND SD MONITORING

As per registered PDD and passport a number of monitoring activities were undertaken for this monitoring period. The person in charge of all these monitoring activities and this report is Eric Buysman, the selected consultant by NBP and HIVOS. The surveys that were executed and the entities involved are shown in the next figure:

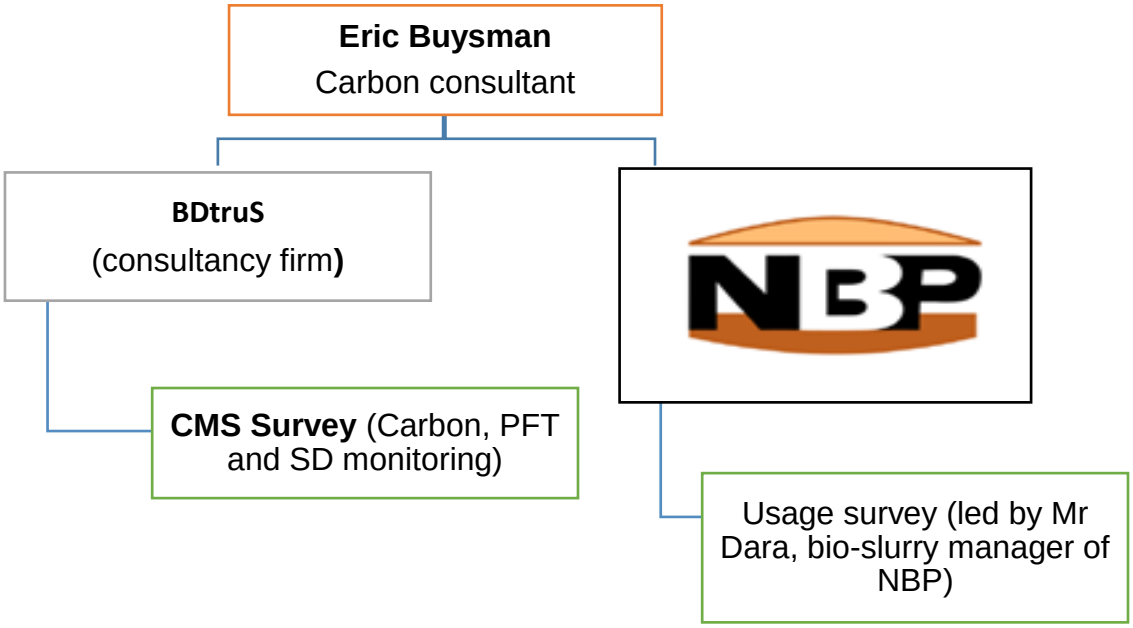

Figure 3: Surveys executed in this MP and entities involved

2.2 DESCRIPTION OF HUMAN RESOURCES

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

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

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

if not by the quality control technicians. The usage survey is executed in the same manner as the last MR.

2.3 SURVEY DESIGN

The next table summarizes the designs of the surveys on which this MR is based. The baseline fuel test (BFT) was executed during MPI and is valid for the whole CPII.

Table 6: Survey design summary

Item	CMS survey	KPT (PFT)	KPT (BFT)	Usage survey
Target group	Users with a biodigester	Users with a biodigester	Households without a biodigester	Households with a biodigester that has been in use for at least 6 months before the end of MPVII of CPII
Main topic(s)	User characteristics, AWMS and SD survey	Project fuel use	Baseline fuel use	Drop-off rate
Sampling method	Cluster sampling	Cluster sampling	Simple random sampling using PFT sampling frame of 2013	Cluster sampling
Cluster	District	CMS district	N/A	Age group
Cluster size	11 households (including 10% oversampling)	All 11 CMS households in each selected district	N/A	35 households (including oversampling with 5 households)
Number of clusters	15	15	N/A	12
Total sample size	165	165	50	420 +13[5]
Validity	MPVII	MPVI and MPVII	CPII	MPVII

[5] *13 follow up plants of households that indicated they would restore their plant in the previous MP*

2.4 USAGE SURVEY

Background

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

Usage survey design (US)

The usage survey is designed based on the following guidelines as per PDD:

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

After random selection of the households by age group, the obtained drop-off rate of each year will be weighted per the numbers of units built in that period. The drop-off rate will be applied to discount the overall calculated ER.

The US monitoring procedure applied in this MP will consist of the following steps:

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

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

[6] *See page 24 of the methodology*
[7] *http://www.graphpad.com/quickcalcs/index.cfm*
[8] *Unless there is no bio-slurry advisor employed by the PBPO (Provincial Biogas Programme Office)*

Table 7: Usage survey selection by age group

Age group	Period, inclusive of begin and end date		Units built in that period (age group population)	Sample drawn from units built (at random)
11 to 12	13/03/06	30/06/07	666	35
10 to 11	01/07/07	30/06/08	1956	35
9 to 10	01/07/08	30/06/09	2504	35
8 to 9	01/07/09	30/06/10	3079	35
7 to 8	01/07/10	30/06/11	4793	35
6 to 7	01/07/11	30/06/12	4450	35
5 to 6	01/07/12	30/06/13	2232	35
4 to 5	01/07/13	30/06/14	1527	35
3 to 4	01/07/14	30/06/15	1906	35
2 to 3	01/07/15	30/06/16	1892	35
1 to 2	01/07/16	30/06/17	1092	35
0 to 1	01/07/17	30/06/18	832	35
			Total	**420**

Of each age group 35 units were selected randomly, for example, in age group 11 to 12 out of the 666 35 units were selected. Age group 10 to 11 is a little longer than 1 year, 1 year and 3 months and 17 days. In the period 13/03/2006 to 30/06/2006 only 103 units were built and given that the number of units is much smaller than any other age group, it was decided to include those units in age group 10 to 11. During the last verifications that was accepted by both the GS and the DOE and therefore again implemented in this MP. The next table shows the sampling plan of the US.

Table 8: Usage survey design summary

Item	Conversion in US
Sampling objective	The objective of the sampling effort is to obtain reliable data for the US survey
Field Measurement Objectives and Data to be collected	The survey will consist of household visit in random selected end-users to collect usage data
Target Population and Sampling Frame	The sampling frame will be drawn from the database of each age group
Sampling method (approach)	Simple random sampling in each age group, each observation is chosen randomly and entirely by chance, such that each observation has the same probability of being chosen. Age groups can be considered clusters and the sampling method is therefore cluster sampling
Implementation	The US was executed in January - February 2019 by trained PBPO staff under supervision of NBP

Desired Precision/Expected Variance and Sample Size	The minimum total sample size is 100, with at least 30 samples for project technologies of each age being credited. The applied methodology does not prescribe a desired precision. By surveying 420 households, it is ensured that the minimum requirements were easily met.
Procedures for Administering Data Collection and Minimizing Non-Sampling Errors	The survey was executed by bio-slurry supervisors or coordinators and not by quality control technicians to minimize conflict of interest. Furthermore, data was entered and checked by another party, the NBP national office.

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

A simple two-page questionnaire was developed for this purpose and available for DOE inspection. Although they are very knowledgeable about the programme and the technology, a training was nevertheless organized on the 4th of January 2019.

On top of this, the households that did not have a digester in operation during MPVI *and* claimed that they would restore their digester were re-visited. In total these were 13 households

2.5 CARBON AND SUSTAINABLE DEVELOPMENT MONITORING SURVEY

A carbon and sustainable development monitoring survey (CMS) was executed in January - March 2019 amongst a representative sample of biodigester households with the objective to obtain reliable and unbiased data on the impact of the program on sustainable development (SD) and on GHG emission modalities, such as fossil and fuel wood consumption and manure management practices. The CMS can combine up to 6 project studies according to the PDD, but not all studies are necessary for each MP. The next table shows the CMS studies and the studies included in MPVII.

Table 9: Carbon Monitoring Survey (CMS) studies

#	Name of study	Monitoring interval	Conversion in MPVII CPII
1	Project non-renewable biomass (NRB) assessment;	Not defined	fNRB is updated in MRII and adopted
2	Project studies (PS) of target population characteristics;	Annual	Included in CMS MPVII
3	Monitoring of the SD parameters.	Annual	Included in CMS MPVII
4	Leakage emission assessment	Every two year, after first verification	MPVI verified results are still valid and adopted
5	Maintenance of total sale record and project database	Continuous	Continuous activity

1. NRB Assessment

Over the course of a project activity the project proponent may at any time choose to re-examine renewability by conducting a new NRB assessment. In case of a renewal of the crediting period and as per Gold Standard rules, the NRB fraction must be reassessed as any other baseline parameters and updated in line with most recent data available.

2. Project survey (PS) of the target population characteristic

In addition to the parameters monitored as per PDD and Gold Standard Passport Report (GSPR), the CMS survey includes a set of target population parameters, such as household size, digester size, ID code.

3. Sustainability assessment

The CMS survey includes the monitoring of the SD parameters where it applies to biogas households. Chapter 4 details the results of the SD monitoring and the sources of data used.

4. Leakage emission assessment

A leakage investigation will be conducted every 2 years as per page 49 of the applied methodology. Chapter 3.25 details the leakage emission assessment.

5. Maintenance of total sale record and project database

All data sale records are collected and stored in a central database that is continuously updated. Excerpts of this database will be made available in the excel workbook belonging to this report (see sheet DB).

2.5.1 CMS SURVEY DESIGN

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)[9], see the next table:

Table 10: CMS survey design

#	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 a 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) a number of households is chosen from each cluster at the second stage[10]. The primary sampling units, the clusters, are randomly selected districts and the second sampling units are randomly selected

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

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

		households belonging to the target group in the clusters. PPS sampling is statistically the most significant sampling method as it ensures that each household has the same probability to be selected[10].
3.1	Number of clusters	The selection of clusters involves three primary considerations[11]: **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 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[12] 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. A total cluster number of 15 considered suitable for this project. This is conservative as according to Purnami et al (2011) a reliable way of cluster selection is with the following equation: $$k \approx \left(\frac{n}{2}\right)^{1/2}$$

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

[12] 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)

		Where k is the minimum sample of clusters and n the total population of clusters. There are 129 districts in the NBP project, the minimum number of clusters would therefore be according to Purami: (129/2)^0.5 =8. In this project however 15 clusters are selected which is more precise and more conservative.
3.2	Design effect and oversampling	D= 1.5: Usually the design effect (D) of 1 to 3[13] 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) 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 5). 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 69 Annex 5) which prescribes a 90% confidence interval with a 10 % error margin. The sample size is calculated using the next equation[14]. $$n = \frac{N}{1 + N(e)^2} \times D \times 110\%$$ Where: n = minimal sample size e = level of precision (10%) N = the biogas population D = design effect 110% = Oversampling of 10% N is 27,231 in this case, the calculated n is (27,231 / (1+27,231*10%^2)*1.5*110% = 164 ~ 165. The sample size per cluster is then calculated as:

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

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

		$$n_{cl} = \frac{n}{\#CL}$$ 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 cluster to ensure that the cluster contains 11 or more households. This did not happen in this MP.
3.4	Back up households	It may happen that households are not at home and in that case the household is replaced from a list of backup households. This was made possible by randomly selecting not 11 but 25 households per district, where the first 11 are surveyed and the other 14 are back up households.
4	Sampling frame	The sampling frame is a random selection of households that belong to the target population in the selected cluster

2.5.2 SURVEY IMPLEMENTATION

Survey selection and survey teams

The BDtruS Research Team consisted of a lead consultant and 6 trained and experience surveyors. All of the surveyors have had extensive experiences in interviewing household and vendors in the rural areas. Specifically, five of them have had experiences in biodigester related work and projects, and among them one is actually a biodigester user and one used to join the previous CMS. In total 3 survey teams each of which consisted of 2 surveyors were set up and worked under an overall supervision of the lead consultant. To ascertain that all surveyors have the same understanding and to update their knowledge on the subject a training was organized on 15-17 February 2019 and this included a test in the field. A separate training report and participant list is available at request.

Data collection tools

Questionnaire: The questionnaire was developed by the carbon consultant together with BDtruS and is based on previous questionnaires that were used for the monitoring. This year the questionnaire was administered digitally using the application KoBoCollect. The aim of using this method was to improve data collection, data consistency and to reduce costs. The questionnaire was pilot tested during the surveyor training using tablets or mobile phones on which the application was installed. Feedback from the field was used to finalize and improve the questionnaire. Subsequently, the questionnaire was translated into Khmer.

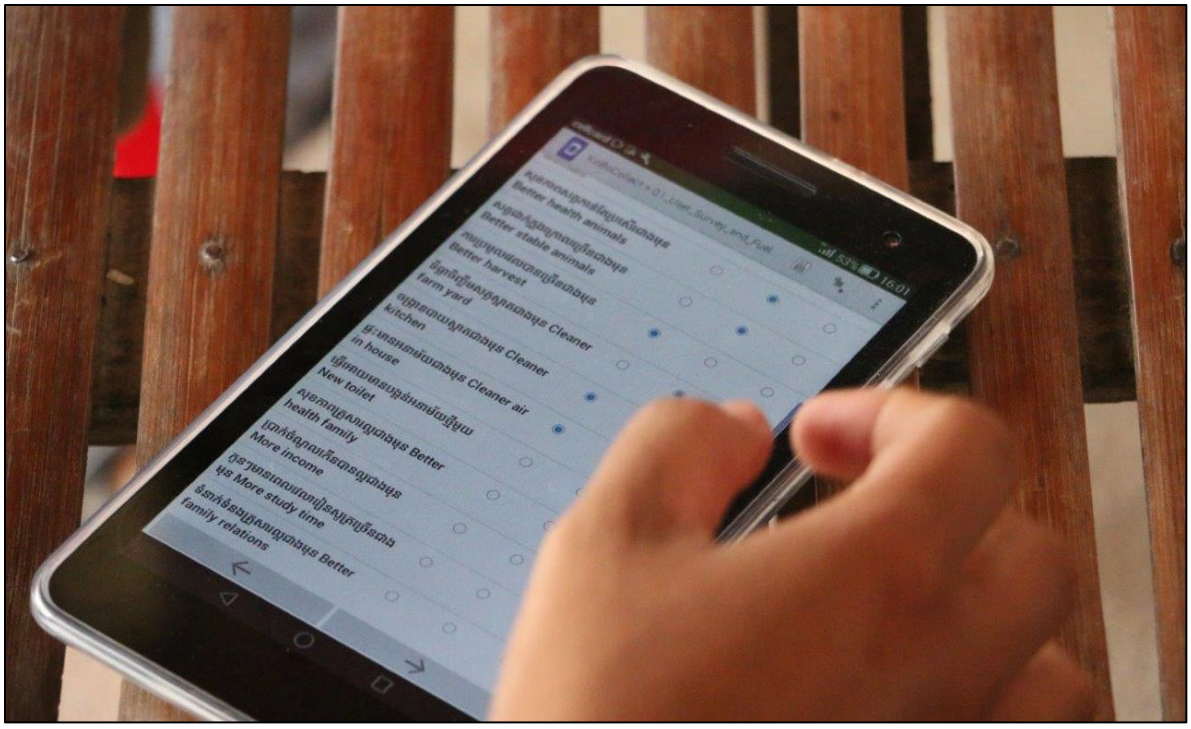

Figure 4: Tablet with questionnaire in KoboCollect

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

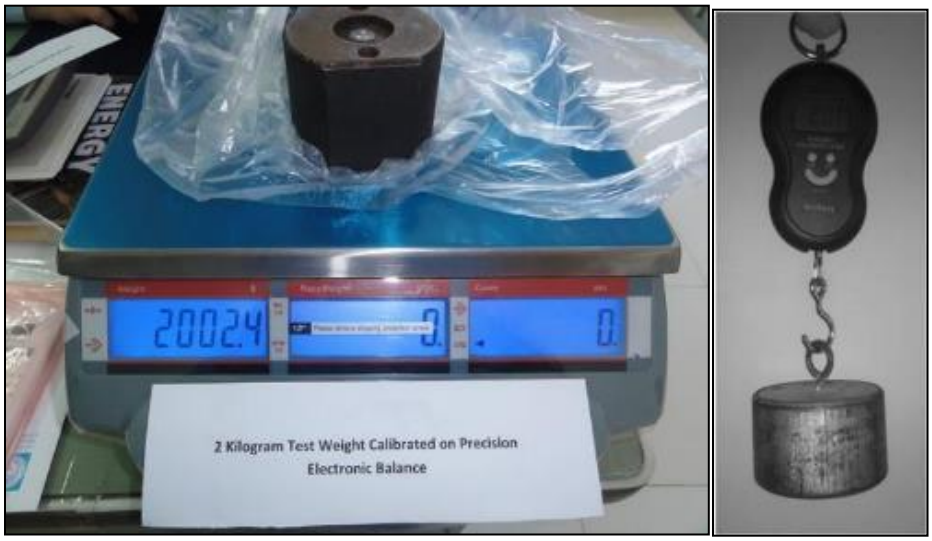

Figure 5: Weight check on Electronic Balance and the electronic Newton scale

The weight stone calibration report is included in Annex II.

Execution

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

Table 11: PPS randomly selected districts in the NBP project area

# District	Province	District name	Samples in district	
			Surveyed	Spare
1	Rolea B'ier	Kampong Chhnang	11	14
2	Kong Pisei	Kampong Spue	11	14
3	Kampong Svay	Kampong Thom	11	14
4	Kampong Trach	Kampot	11	14
5	Dang Tong	Kampot	11	14
6	Kang Meas	Kompomg Cham	11	14
7	Svay Antor	Prey Veng	11	14
8	Svay Chrum	Svay Rieng	11	14
9	Romeas Haek	Svay Rieng	11	14
10	Svay Rieng Municipality	Svay Rieng	11	14
11	Kampong Rou	Svay Rieng	11	14
12	Angkor Borei	Takeo	11	14
13	Tram Kak	Takeo	11	14
14	Bati	Takeo	11	14
15	Samraong	Takeo	11	14
		sum	**165**	**210**

Of the total 165 selected HHs, only 89 were interviewed. Of the total 142 spare households (visited) which were visited, only 76 were interviewed. Of the visited but not interviewed households:

- 85% no longer using the biodigester due to certain reasons (technical problems, no more animals, moving/renovating houses)
- 4% or 5 households not found/known
- 11% or 15 households having no adult at home at the time of the survey (due to migration or going to work)

It was necessary to sample extra households in the district Svay Rieng Municipality, Tram Kak, and Romheas Heak as not enough households on the list were available or still using their biodigester. Sampling of those additional households was done at random.

2.6 BASELINE FUEL TEST (BFT) AND THE PROJECT PERFORMANCE FIELD (PFT)

The baseline performance field tests (BFT) and 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 KPT is executed according to this protocol:

- Test period shall be 1 days[15] = the measurement campaign (MC).
- The selected test day will span fuel measurement consumption for human food cooking and boiling water totaling 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).
- Households are instructed that they cook normally during the test. The aim is to capture their usual behavior 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.
- For practical reasons, it is often best to provide fuel for the tests (to help control the weighing and use of fuel), rather than have the subjects use fuel they are buying themselves. Nevertheless, it is important that the fuel is typical of the fuel normally used through the year, particularly in terms of moisture content. It is also important that the subjects are paying for fuel, or have an incentive to conserve it, otherwise they may use excessive amounts due to the free hand-out. Subjects can be told they will be rewarded for their effort and time at the end of the test, once it is successfully completed.

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

2.61 KPT SURVEY DESIGN

The KPT includes two groups:

Table 12: KPT target groups

Group	Description of target group	Sample size
PFT_update	Randomly selected household from the project database with a biodigester in MPVI	165
BFT household	Executed in 2013. BFT where the nearest equivalent households[16] to the randomly selected PFT households	50
	Total sample	**215**

Only after data collection it can be known if the data meets the required precision, this is per Annex 4 of the applied methodology.

Table 13: PFT update survey design

Item	Conversion in PFT update
Sampling objective:	The objective of the sampling effort is to obtain reliable fuel use data of project and equivalent baseline households
Field Measurement Objectives and Data to be collected:	The survey will consist of a 24 hour measurement campaign amongst PFT households
Target Population and Sampling Frame:	The sampling frame are the selected CMS households
Sampling method (approach):	See the CMS sampling method
Implementation:	The PFT was executed in February to March 2018
Implementer	Patrick Kooijman
Desired Precision/Expected Variance and Sample Size.	90/30 rule of the applied methodology
Procedures for Administering Data Collection and Minimizing Non-Sampling Errors:	The survey data was entered by the survey team leader and served as an independent check on the data

Representativeness of the PFT update

The PFT_update is executed for one day instead of the recommended 3-day minimum testing period by the Gold Standard. The GS confirmed that a one-day testing period is possible as long as it is representative. The next table details how representativeness is safeguarded.

[16] *Equivalent households are defined as a household with comparable characteristics as the selected project households in terms of the number of animals owned and socio-economic characteristics (type of house). The selected baseline household may be slightly poorer as once they adopt a biodigester they often improve their livelihood.*

Table 14: KPT representativeness issues and conversion

<table>
<tr><th>#</th><th>Issue</th><th>Conversion</th></tr>
<tr><td>1</td><td>Questionnaire design</td><td>The questionnaire includes a question on if this is a normal day without extra eaters. If there are extra eaters, an appointment would be made with the household for a day with normal cooking conditions. A non-normal day is also a holiday but not necessarily a weekend day; a typical week/weekend rhythm does not exist in Cambodia for most rural households.</td></tr>
<tr><td>2</td><td>Seasonality</td><td>People indicated in the CMS survey of MPI that they do not cook more during the dry season. The dry season can therefore be assumed to be representative for the year, see chapter 3.21 of MRI</td></tr>
<tr><td>3</td><td>Replacement</td><td>The Gold Standard allows to replace an isolated[17] household with one closer to the other KPT households. In order to warrantee conservativeness, the selected replacement has either the same or a smaller digester size. No replacements were made because of travel distance this year.</td></tr>
<tr><td>4</td><td>Applicability</td><td>The KPT is basically a test designed for improved cook stoves. As these stoves typically only reduce 20% of fuel a longer test period is necessary. Biogas project on the other hand replace typically 90 to 100% of the baseline fuel and it is therefore much easier to measure savings in a shorter period.</td></tr>
<tr><td>5</td><td>Biodigester size distribution (compared to the MPVI database)</td><td>Random sampling can result in a different size distribution than in the project database. Therefore, the sampling is done a couple of times to ensure a good match with the size distribution of the project database. As the table hereunder demonstrates, the average digester is the sample is smaller than in the project database, the results therefore will be conservative as households may use more fuels as they have less biogas compared to the whole population of households with a biodigester.
<table>
<tr><th>Size (m^3)</th><th>% in Sample</th><th>% in Project database</th></tr>
<tr><td>2</td><td>0.0%</td><td>0.18%</td></tr>
<tr><td>3</td><td>7.9%</td><td>2.22%</td></tr>
<tr><td>4</td><td>50.3%</td><td>57.23%</td></tr>
<tr><td>6</td><td>38.2%</td><td>35.85%</td></tr>
<tr><td>8</td><td>3.6%</td><td>3.22%</td></tr>
<tr><td>10</td><td>0.0%</td><td>0.90%</td></tr>
<tr><td>15</td><td>0.0%</td><td>0.40%</td></tr>
</table></td></tr>
<tr><td>6</td><td>Sample size</td><td>The chosen sample size is, for MPVI and also MPVII, significantly above the minimum requirements (30 hh) with 165 households. The chance that results are influenced by coincidence is as a result minimized.</td></tr>
</table>

[17] *i.e. surveying one household in a faraway province would be disproportionally expensive and time consuming*

2.62 PFT_UPDATE IMPLEMENTATION

- This occurred in MPVI and the results are verified and valid for this MP

Questionnaire development and training

The survey supervisor, the coordinator and the lead consultant developed a questionnaire based on the Berkeley Air Kitchen Performance test questionnaire which was also administered using the Tablets. This document is also referenced in the applied TPDDEC methodology. The questionnaire used for this MP was also used in MPI, MPIII and, MPIV. The questionnaire was subsequently translated into Khmer. The 6 selected surveyors received a 3-day training was provided at the NBP premises and in the field. The lead trainers were Mr Patrick Kooijman (survey coordinator) and Mr Savuth (survey supervisor) under guidance of Eric Buysman. A separate training report is available at request.

Figure 6: Scale in action

Data collection tools

As discussed above, the questionnaire was based on Berkeley Air KPT questionnaire. The same weight stones were used as the CMS survey to ensure that the newton scale was providing accurate survey results.

3. RESULTS

3.1 USAGE SURVEY RESULTS

MPVII Usage results

The following data sources have been used in this section:

Table 15: Data sources used in this section

Item	Source	Type	Soft copy	Hard copy
Usage data	Usage survey	Primary data	Spreadsheet USAGE Sampling and data entry MPVII usage_final.xlsx.	Questionnaires, stored at NBP office
Household data	Project database	Secondary data	ER database sheet MRVII	Form 09, stored at the NBP office

The outcome of the usage survey is depicted in the following table:

Table 16: Usage Survey results

Age group	Period, inclusive of all dates		Percentage in operation (A)	Units built in that period (B)	Number of biogas plants in operation (A*B)
0 to 1	01/07/17	30/06/18	100%	832	832
1 to 2	01/07/16	30/06/17	100%	1092	1092
2 to 3	01/07/15	30/06/16	100%	1892	1892
3 to 4	01/07/14	30/06/15	91%	1906	1743
4 to 5	01/07/13	30/06/14	91%	1527	1396
5 to 6	01/07/12	30/06/13	86%	2232	1913
6 to 7	01/07/11	30/06/12	77%	4450	3433
7 to 8	01/07/10	30/06/11	60%	4793	2876
8 to 9	01/07/09	30/06/10	69%	3079	2111
9 to 10	01/07/08	30/06/09	66%	2504	1645
10 to 11	01/07/07	30/06/08	57%	1956	1118
11 to 12	13/06/06	30/06/07	43%	666	285
			sum	**26,929**	**20,336**

The weighted average of units in operation is then simply calculated by dividing the units in operating with the total population, which is **75,52%.** The next figure shows the development of the usage rate over the years, which is slowly declining with age.

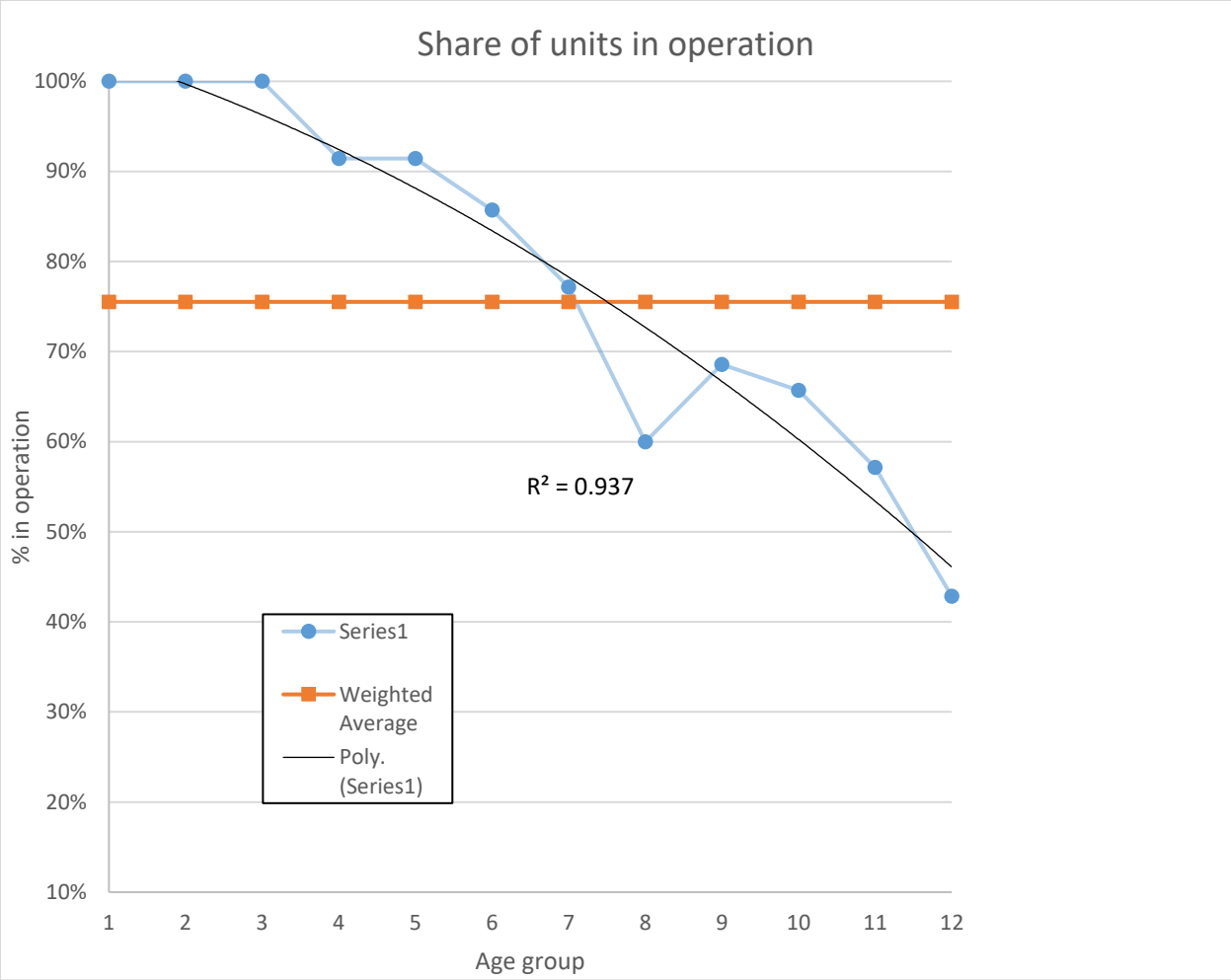

Figure 7: Share of units in operation by age group

Inquiry on reasons why households are not using their digester anymore led to the following results:

Table 17: Reasons for stop using the plant[18]

Reason	count	Percentage
Sold all animals	73	80%
Technical	57	63%
Migration	20	22%
Other	35	38%

[18] The total is more than 100% as households often provided 2 or more reasons

UPTIME

Uptime is defined as the percentage of the time that a biodigester in operation is actually in use. Biodigesters could be temporarily out of operation, for example a farmer has temporarily has no animals or that there is a technical issue. In those cases, the uptime is not 100% and the emission reductions has to be discounted with that percentage.

In total 208 days, or 0.759 years, plants were temporarily out of operation. This is on average 0.17% of all plant years in this MP, thus 99.83% is the uptime

UPTIME plants that stopped working during MPVII

A large number of plants that stopped working in 2018 worked for a number of months in 2018. In total these plants were in operation for 277days or 0.759 years. 0.759 years is 0.18% of all plant-years in the usage sample, thus the calculated usage rate has to be multiplied by 100.18% in order to obtain the correct percentage of plants in operation.

Table 18: Effective usage rate

Item	Item
Usage rate	75.52%
Uptime	99.83%
Correction for plants that worked partly in 2018	100.18%
Effective usage rate (multiplication)	**75.53%**

3.2 CMS AND KPT RESULTS

Table 19: Data sources used in this section

Item	Source	Chapter	Soft copy	Hard copy
CMS user characteristics	CMS survey	3.21	ER Database sheet 'MRVII report;	NBP office
Parameters not monitored	PDD	3.22	PDD v2.3	N/A

The emission reductions are calculated based on the data collected during the CMS survey, the project database containing baseline data and the results from the US.

3.21 CMS USER CHARACTERISTICS

Respondent

The average age of the respondent is 51 years old and lives in a household with 4.60 members. The survey was well gender balanced with around 57% of the respondents were female.

Biodigester

The average plant size is 4.83 m^3 in the CMS sample, a little bit smaller than the project database average (4.92 m^3).

Biogas stoves in use

Households own on average 1.36 NBP round stoves, 0.25 NBP square stoves, 0.03 rice cookers, 0.05 imported double burners

Baseline fuels in the project boundary

Household continue to use baseline fuels for cooking and water boiling as the next table depicts

Table 20: Baseline fuel used in the project [19]

Fuel	n	%
Firewood	17	10.3%
Charcoal	1	0.6%

The most common baseline fuel that is continued to be in used is firewood

The next table shows the type of stove that is used for these fuels.

[19] sheet PFT_update of MPVI – verified results

Table 21: Baseline stoves owned

Stove	Percentage
Traditional Lao Stove	22%
New Lao Stove	22%
Thai	13%
NKS	5%
Three stone stove	28%
Homemade stove	9%
Electric rice cooker	13%

People keep their baseline stoves for various reasons, 22% that continue to have their stove as back-up, 20% for special occasions (Buddhist festivals), 88% grilling meat or fish, 64% boiling water.

The average LPG consumption in MPVII 18.77 kg/year, higher than the baseline of 7.3 kg/year. The project results therefore in a net GHG emission source from LPG. The baseline and project emissions of LPG are therefore accounted in this MR.

3.22 PARAMETERS MONITORED

Table 22: Parameters monitored

Parameter	Data unit	Description	Applied value		Source
Pp,y	kg/ project household-year	Quantity of fuel that is consumed in the project scenario in year y	Fuel	Kg/year/hh	ER database sheet ER_fuel
			LPG	18.77	
			Charcoal in wood equivalent	10.35	
			Firewood	72.49	
fNRB	%	Fraction of Non-Renewable Biomass	77%		EB77 [20]
Up,y	%	Effective usage rate	75.53		usage survey, see chapter 3.1
$LE_{p,y}$	tCO2e/year	Leakage emission in project scenario during year y	See table 39 and 40		
$N_{p,y}$	units	Number of biogas plants commissioned	27,231		See ER Database sheet MRVII report
$MS_{(P,s,k)}$	[-]	Fraction of livestock category T's manure fed in the biodigester and the	See table 37		Sheet MS_AWMS of

[20] *SSC WG 43 Annex 4 as approved in EB77 meeting report paragraph 58.*

<table>
<tr><td></td><td></td><td>fraction of other types of MS</td><td colspan="2"></td><td>spreadsheet ER Database</td></tr>
<tr><td>N(T)</td><td>#</td><td>Number of livestock of category T</td><td>Category T</td><td>LC_T</td><td rowspan="4">See ER Database sheet MRVII report</td></tr>
<tr><td></td><td></td><td></td><td>Cow</td><td>4.988</td></tr>
<tr><td></td><td></td><td></td><td>Pig</td><td>2.465</td></tr>
<tr><td></td><td></td><td></td><td>Buffalo</td><td>0.685</td></tr>
<tr><td rowspan="4">EF_{awmsT}</td><td rowspan="4">kgCH4 per animal per year for livestock type T in project scenario</td><td>Category T</td><td colspan="2">EF (kgCH4/head/year)</td><td rowspan="4">See ER Database sheet MRVII report</td></tr>
<tr><td>cow</td><td colspan="2">3.990</td></tr>
<tr><td>Pig</td><td colspan="2">7.241</td></tr>
<tr><td>Buffalo</td><td colspan="2">6.187</td></tr>
<tr><td>Bio-slurry</td><td>%</td><td>MS of the end use of bio-slurry</td><td colspan="3">See table 45</td></tr>
<tr><td>PL</td><td>Methane leakage from the biodigester</td><td>10% of total methane production</td><td colspan="3">10%</td></tr>
<tr><td>W(site)</td><td>Kg/pig type</td><td>Average pig weight at the project site by pig type (sow, boar, fattening pig and piglet (kg) at the site</td><td colspan="3"><table><tr><th>Pig type</th><th>W (site)</th></tr><tr><td>Sow</td><td>131.59</td></tr><tr><td>Boar</td><td>160.44</td></tr><tr><td>Fattening pig bought as piglet</td><td>34.44</td></tr><tr><td>Fatting pig born at farm</td><td>36.10</td></tr><tr><td>Piglet producer</td><td>3.40</td></tr></table>See ER Database sheet MRVII report</td></tr>
</table>

In PDD section 6.2 the data and parameters not monitored are mentioned. This value was updated as per decision of the Gold Standard to adopt the GWP of methane and nitrous dioxide of the second commitment period. The new GWP values are described in the table hereunder.

Table 23: Updated GWP values of CH_4 and N_2O

Data/ parameter	Description	Applied Value	Source
GWP_{CH4}	Global Warming Potential of Methane	25 $tCO_2e/tCH4$	Updated as per GS decision: http://www.cdmgoldstandard.org/wp-content/uploads/2011/09/Global-Warming-Potentials-for-Gold-Standard-Project-Activities-2013.pdf
GWP_{N2O}	GWP of N_2O	298 tCO_2e/tN_2O	

3.23 EMISSION REDUCTION COMPONENT 1: FUEL SWITCH

Emissions obtained from the BFT and PFT are calculated as per equation 2 of the applied methodology:

Equation 1: 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
$N_{p,y}$	=	Cumulative number of project technology days included in the project database for project scenario p in against baseline scenario b in year y
$U_{p,y}$	=	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 CO_2 emission savings for an individual technology of project p against an individual technology of baseline b in year y, in tCO_2/day, and as derived from the statistical analysis of the data collected from the field tests
$ER_{b,p,y,non\text{-}CO_2}$	=	Specific non-CO_2 emission savings for an individual technology of project p against an individual technology of baseline b in year y, in tCO_2/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 (tCO_2e/yr)

The next table shows the outcome of the BFT, fuel used and the amount of energy.

Table 24: Baseline fuel use and calculated thermal energy demand

Fuel *i*	Average per household (kg/year)	NCV_i (TJ/Gg)	Thermal energy demand (TJ/year)
LPG	7.300	47.3	0.0003453
Charcoal (in wood eq)*	215.496	15.6	0.0033617
Firewood	1435.107	15.6	0.0223877

** as per page 23 of PDD v2.3 charcoal consumption is converted into wood equivalents (1kg charcoal = 6 kg wood), the EF of wood is applied to the converted amounts.*

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, see the next table.

Table 25: CO_2, CH_4 and N_2O emission factors

Fuel *i*	EF_{CO2}, (kg/TJ)	EF_{CH4}, (kg/TJ)	EF_{N20}, (kg/TJ)
LPG	63100	11.95	2.1
Firewood (and charcoal expressed in wood equivalents	112,000	1,224	11.25

The baseline emission is the baseline thermal energy consumption multiplied by emission factors, the fNRB and the global warming potential of each GWP. The calculated ex-post baseline emissions are shown in next table:

Table 26: Ex-post baseline emission of each fuel and total from thermal energy use

Fuel *i*	Baseline emissions from CO_2 (tCO_2e/hh/yr)	Baseline emission from CH_4 (tCO_2e/hh/yr)	Baseline emission from N_2O (tCO_2e/hh/yr)	Total (tCO_2e/hh/yr)
LPG	0.022	0.00	0.000	0.022
Charcoal	0.290	0.10	0.011	0.404
Firewood	1.931	0.69	0.075	2.691
Total	**2.2424**	**0.7880**	**0.0865**	**3.1170**

Not all fuels will be replaced by biogas. The fuels that people continue to use in the project scenario is sourced from the KPT-PFT.

Table 27: Project fuel use of baseline fuels

Fuel	Average per household (kg/year)	NCV_i (TJ/Gg)	Thermal energy demand (TJ)
LPG	18.77	47.300	0.000888
Charcoal (in wood eq)	10.35	15.60	0.000162
Firewood	72.49	15.60	0.001131

The calculated emissions from fuel use in the project scenario are depicted in the following table:

Table 28: Ex-post project emissions of each fuel and total from thermal energy use

Fuel *i*	Emissions from CO_2 (tCO_2e/yr)	Emission from CH_4 (tCO_2e/yr)	Emission from N_2O (tCO_2e/yr)	Total (tCO_2e/yr)
LPG	0.056	0.000	0.001	0.057
Charcoal	0.000	0.004	0.001	0.005
Firewood	0.098	0.035	0.004	0.136
Total	**0.1535**	**0.0390**	**0.0049**	**0.1974**

Emission reductions from fuel savings are the difference between the BFT and the PFT, provided that the mean emission reductions are satisfy the 90/30 rule, i.e. the endpoints of the 90% confidence interval lie within +/-30% of the estimated mean. The check is calculated using the approved method that was communicated with the Gold Standards and is based on:

- GHG emission from all fuels of BFT and PFT excluding LPG[21]
- fNRB of 77%

The calculations itself are based on the reference in the TPPDEC methodology[22] and based on two independent samples. Paired sampling in the case of a market-oriented biogas programme is not possible as it is not known who will adopt the technology beforehand. The next table shows if the fuel savings meet the 90/30 rule

Table 29: 90/30 rule check (sheet PFT_update MPVI – verified figures)

	Project	Baseline
Mean value	0.10	2.02
Standard deviation	0.37	1.00
COV	3.62	0.50
Sample size (n)	165	50
Mean ER (tCO2e/hh)		1.92
Standard Error		0.14
Precision level achieved		10%
Satisfy the 90/30 rule		TRUE

The KPT test meets the 90/30 rule, the confidence/prevision interval is much higher at 90/10. This means that the mean savings can be used in the ER calculations, see the next table:

[21] LPG was not part of the PFT and BFT, but was added only to this MR as LPG consumption turned out to be higher than the baseline.

[22] http://www.climatecare.org/media/documents/pdf/ClimateCare_Guidelines_for_Performance_Tests_and_KPTsx.pdf

Table 30: Emission reductions from fuel switch

Baseline emissions from fuel use (tCO_2e/yr)	Project emissions from fuel use (tCO_2e/yr)	Emissions from fuel switch to biogas (tCO_2e/yr)
3.1170	0.1974	2.9196

3.24 Emission reduction component 2: AMWS

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 formula is used to estimate the animal waste management emissions.

$$BE_{(awms,h)} = N_{T,h} \times (VS_{\mathrm{T}} \times 365) \times GWP_{CH_4} \times \left[Bo_{\mathrm{T}} \times D_{CH4} \times \sum \frac{MCF_{BL,k}}{100} \times MS_{\mathrm{T}} \right]$$

Equation 2: Emission calculation from animal waste management by animal category T (see equation 16 of the applied methodology)

Where:

$BE_{awms,h}$	=	The baseline emissions from handling of animal waste in premise h (tCO_2e/year) of animal category T
$N_{T,h}$	=	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 tCH_4): 25
Bo_T	=	Maximum methane producing capacity for manure produced by animal T m^3 CH_4 kg^{-1} of VS
D_{CH4}	=	CH_4 density (0.00067 t per m^3 at room temperature (20ºC) and 1 atm pressure
$MCF_{BL,k}$	=	Methane conversion factors for the animal waste handling system *k* in the baseline situation
MS_T	=	Fraction of livestock category T's manure treated in the animal waste management system k

Step 1: Determination Baseline Emission from AWMS

The baseline survey, see PDD, 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% during stabling. 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):

Table 31: Manure management systems (source PDD)

Animal	Anaerobic Lagoon	slurry	Solid storage	Compost	daily spread	drying	fishpond	other	Pasture
Cow	0.28%	14.61%	40.26%	0.50%	3.93%	0.00%	0.06%	0.00%	1.85%
Pig	43.78%	7.13%	26.19%	0.29%	5.10%	0.00%	0.21%	1.04%	9.58%
Buffalo	0.00%	17.27%	29.74%	0.00%	10.55%	0.00%	0.00%	0.00%	0.00%
MCF*	**80%**	**78%**	**5%**	**1.5%**	**1%**	**1%**	**1%**	**1%**	**2%**

** IPCC default for 27ºC*[23]

VS from pigs

During the second verification NBP of CPI the PP was requested to convert 2 small pigs into 1 large pig as it was questioned if the average weight of the pig population is 28 kilo; the weight on which the IPCC 2006 default VS value for pigs is based upon. As VS excretion is proportional to pig weight, a lower weight than 28 kilo would result in a lower VS excretion.

For that reason, the CMS survey included the measurement of pig weight. In the case of fattening pigs, as these are not held for more than 3-4 months at the farm the average weight was determined by asking the birth weight (or weight when they arrive at the farm, in case the farmer buys piglets for fattening) and the weight when they leave. The average weight is then 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[24]. This is possible with the following equation:

Equation 3: Weight a pig without scale

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

Where:

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

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

[23] *The IPCC default value depends on the average annual temperature. The average annual temperature in Cambodia is 27.7ºC, see PDD section B.6.2 parameters not monitored*

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

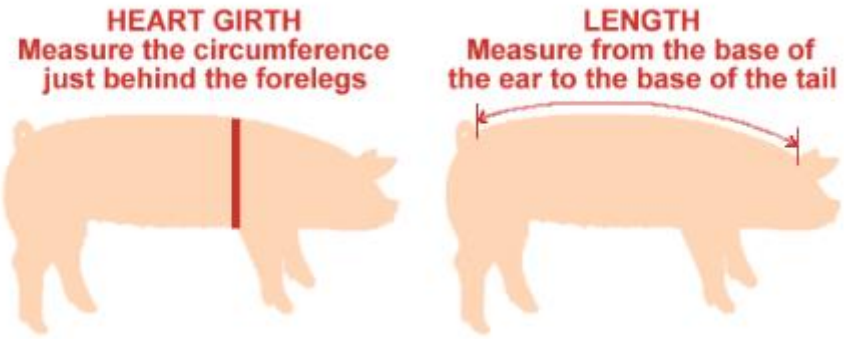

Figure 8: Hearth girth and length measurement

The table below shows the calculated weight, the population and the number of samples taken.

Table 32: Calculated weight of sows and boars

Animal type	Calculated average weight	Population	Samples
Sow	131.59	79	39
Boar	160.44	8	2

The calculated weight, which is deemed to be accurate within 3% by the Pig Site[25]. The next table shows the weights of the different pig categories, average ownership and the average pig weight.

Table 33: Average weight of pig by pig type

Type of pig	#/hh (A)	Average weight (B)	Total weight (AxB)
Sow	0.50	131.59	65.80
Boar	0.05	160.44	7.78
Fattening pig (bought)[26]	0.73	34.44	25.02
Fattening pig (Born)[26]	0.93	36.10	33.61
Piglet (piglet producer)	0.26	3.40	0.89
sum	2.47		133.10
	average weight (Wsite)	**Sum A/Sum (AxB)**	**53.93**

The weighted average weight is with 53.93 very similar to the one calculated in MRVI (55.12). The average pig weight is much higher than what the IPCC assumes and therefore the VS

[25] *http://www.thepigsite.com/articles/541/weighing-a-pig-without-a-scale/*

[26] *There are two types of fattening pigs; ones that are born at the farm and ones that are bought from the piglet producer. The fattening pigs from the piglet producer arrive at a much higher weight at the farm and their average weight is therefore lower.*

excretion can be proportionally adjusted upward. That is possible as per the CDM methodology AMS-III.D v19 paragraph 16 equation 2, pasted hereunder:

Equation 4: 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)
$VS_{default}$	=	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

This is assumed to be allowed as during the second monitoring period the PP was requested to adjust VS excretion rate downward by assuming that 2 small pigs are one big pig. This method was approved by the GS. With the equation above the adjusted VS value is calculated for this MP:

Table 34: IPCC 2006 default values for VS and Bo

Animal T	VS (kg/day)	Bo (m^3/kg)
Cow	2.30	0.1
Pig	0.58	0.29
Buffalo	3.90	0.1

The VS of pigs is 0.58 instead of the 0.3 default for Asia of the IPCC. This is more than 50% higher and this also means that the ERs of CPII MPI, MPII and MPIII, during which the IPCC default value was applied instead, are substantially underestimated and unnecessarily conservative.

Baseline AWMS emissions

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

Table 35: The calculated baseline emission factor of animal *T*

Animal T	EF_T ($kgCH_4$/yr/animal T)
Cow	8.139
Pig	17.288
Buffalo	15.173

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 CMS survey and based on the EF_T from the baseline survey the ex-post baseline emissions from AWMS are calculated.

Table 36: Ex-post Baseline emission from animal waste management

Animal T	Average population N_T/hh	EF_T ($kgCH_4$/year)	GWP_{CH4}	$BE_{awms,T,h}$ (tCO_2e/year)
Cow	4.988	8.139	25.000	1.015
Pig	2.465	17.288	25.000	1.065
Buffalo	0.685	15.173	25.000	0.260
			Total	**2.340**

AWMS project emissions

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 and emissions from bio-slurry storage.

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. The manure management categories (MS) for each climate zone and applicable MCF are shown in the next table, where $MS_{(P,S,k)}$ is the fraction of manure not fed into the biogas plants, which are the sum of manure management systems which are not biogas plant and $MS_{(T,S,k)}$ is the MS system biogas plant.

The MS is simply calculated by dividing the amount of manure fed in a system by the total amount of manure, i.e. if 2 kilo is put in a slurry system out of the 100 kilo available daily, then the MS slurry is 2% (2/100). Another example, MS pasture is the fraction of time that the animals are in the field, i.e. if this is 6 hours/day, then it is assumed that 25% (6/24) of manure is left in the field. Thus, in this case, if the amount of manure *measured* is 100 kilo/day, then this amount measured

comprises 75% (or 18 hours) of the total as 25% (6 hours) cannot be measured as it is excreted in the field. The total amount of manure is in that case: 1+ (25%/75%)*100 = 133 kilo/day. The next table shows the share of animal manure that ends up in each of the systems.

Table 37: Share of manure management systems in the project scenario

Animal	Biodigester	Slurry system	Anaerobic lagoon	Dry lot	Daily spread	Solid storage	Other	Pasture
Cow	56.48%	0.28%	0.00%	0.44%	0.66%	13.56%	3.51%	**25.08%**
Pig	46.22%	3.42%	11.14%	2.23%	1.59%	26.40%	8.92%	**0.09%**
Buffalo	52.67%	0.00%	0.00%	0.37%	0.30%	10.67%	4.36%	**31.64%**

The next two tables depict the calculated emission factor by type of animal.

Table 38: Calculated emission factor by animal

Animal	Volatile Solids (VS) (kg/day)	Maximum Methane potential (Bo_T)	∑(MCF.MS)	Density methane (kg/m^3)	$EF_{AWMS\ (P)}$ ($kgCH_4$/head/ year)
cow	2.300	0.100	7.093%	0.670	3.990
Pig	0.578	0.290	17.670%	0.670	7.241
Buffalo	3.900	0.100	6.487%	0.670	6.187

Leakage emissions are calculated based on the calculated EF. In the next table the physical leakage emissions from the biogas plant are shown which are calculated by multiplying the EF per head with the average number of head for each climate zone.

Possible emission from incomplete combustion are also calculated. The combustion efficiency is estimated to be at 99.4%[27] as per PDD:

Table 39: Physical leakage emission from biodigester and incomplete combustion by animal type in the household

Animal	$PL_{\_biodigester}$ ($kgCH_4$//year)	PL_{stove} ($kgCH_4$/ year)
Cow	1.990	0.011
Pig	1.785	0.010
Buffalo	0.424	0.002
Total	**4.199**	**0.023**

[27] *see PDD section B.6.2 parameters not monitored*

The total leakage emissions and emission from AWMS are then calculated next (Sheet ER_AWMS).

Table 40: Physical leakage and emissions from incomplete combustion

Emission source	($kgCH_4$/hh/year)	tCO2e/hhh/year
Physical leakage	4.199	0.105
Incomplete combustion	0.023	0.001
Sum	**4.221**	**0.106**

The emission reductions from AWMS are the difference between the baseline and the project, see the next table:

Table 41: Emission reductions from AMWS

BE AWMS tCO_2e/hh/year	PE AWMS tCO_2e/hh/year	ER AWMS tCO_2e/hh/year
2.3401	0.1055	2.2346

3.25 LEAKAGE EMISSIONS

The project proponent investigated the following potential sources of leakage during MPVI, the verified results are also valid for MPVII.

- **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**

  Assessment: Unlikely
  Explanation: Only 5 people gave away their stove out of 165 households. In all cases it is thought that the household uses less fuel now.

  In conclusion, the impact is negligible and neutral.

- **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.**

  Assessment: Very unlikely
  Explanation: The only feasible lower emitting energy source in Cambodia is LPG Penetration of LPG however is very low and limited to rural towns and cities. It is very unlikely that household that use this lower emitting energy source, such as LPG, would

switch to NRB because of this project. In fact, LPG consumption is increasing in Cambodia every year with in 2010 a growth rate of 7% [28], much faster than the population growth.

- **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.**

Assessment: Very unlikely
Explanation: The state of the forest is worse than previously predicted and for that reason is recently updated from 76% to 77% (EB77 p58. The percentage of dense forest stands at just 11% nowadays compared to 72% in 1973. A Cambodian newspaper, the Phnom Penh post, rightfully named their article on this, 'can't see the forest'[29]. This is also summarized in a YouTube video which shows very graphically the forest loss over the years: http://www.youtube.com/watch?v=7d6d1KKyW8E. In the period of 2010 until 2013, the state of the forest continues to worsen, as this figure shows from ODC:

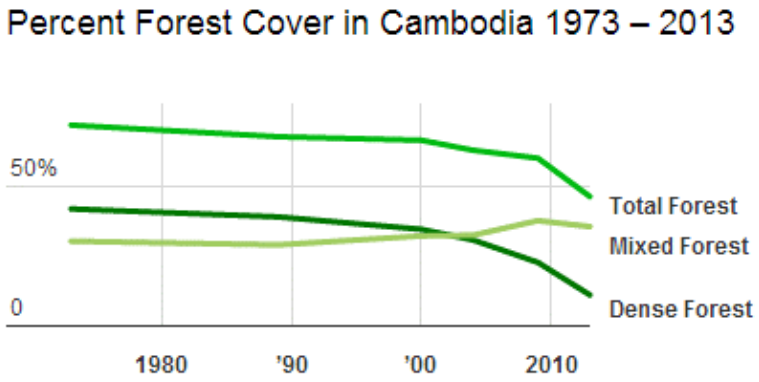

Figure 9: Forest cover change 1973-2013[30]

A 2015 update by the university of Maryland reported that deforestation in Cambodia has accelerated faster than any other country in the world since 2001[31]. The annual percentage increase of deforestation rate was in that period 14.4%. In 2014 alone 117,969 hectare of forest was lost. This situation has continued into this MP[32]

Irrespective of other projects, deforestation is continuing at high pace and the fNRB is likely an underestimate with current developments.

There is one project registered in Cambodia that has a NRB component in the project. The ICS project of GERES. It is not likely that the NRB fraction is impacted significantly especially because that project focusses on urban areas.

[28] *http://www.quandl.com/UN/LIQUEFIEDPETROLEUMGASLPGCONSUMPTIONBYHOUSEHOLDS_KHM-Liquefied-Petroleum-Gas-lpg-Consumption-By-Households-Cambodia*
[29] *http://www.phnompenhpost.com/national/can%E2%80%99t-see-forest-%E2%80%A6*
[30] http://www.opendevelopmentcambodia.net/briefings/forest-cover/
[31] http://www.phnompenhpost.com/national/cambodia-logs-top-spot
[32] https://news.mongabay.com/2017/01/nasa-releases-images-of-dramatic-cambodia-deforestation/

- **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**

  Assessment: Not applicable
  Explanation: Space heating does not occur in Cambodia

- **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**.

  Assessment: Unlikely
  Explanation: 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.

- **Physical leakage emissions** (see chapter 3.24)

- **Emissions from bio-slurry** (see chapter 3.26)

3.26 EMISSIONS FROM DIGESTATE (BIO-SLURRY)

The following leakage emission source is accounted for in this section: CH_4 emissions from anaerobic decay of the residual organic content of digestate subjected to anaerobic storage. 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[33]. This approach has been approved by the GS for the project GS1083 and is therefore followed.

This emission source is 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. **<u>Estimation of the total amount of VS entering the biodigester</u>**

[33] http://cdm.unfccc.int/Panels/meth/meeting/11/051/mp51_an13.pdf

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. The share of manure fed into the biogas plant can be found in section 3.23, and is calculated as:

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

Where, $MS_{fed\ in\ digester}$ is the share of manure fed into the digester and $MS_{not\ fed}$ the share not fed into the digester of animal category T. The emission from the share not fed are calculated in the previous section. The next tables depict the total amount of VS that enters the average biodigester which is calculated by multiplying the amount of VS excreted by the average number of animals and the $MS_{fed\ in\ digester}$ into the biodigester by climate zone.

Table 42: Daily VS production of the average biodigester (see sheet Bio-slurry)

Animal T	**VS excretion kgVS/hd/day**	**Head/average biodigester**	**Total amount of VS excreted kgVS.day^{-1}**	**$MS_{fed\ in\ digester}$ Share fed into biodigester**	**Total VS entering the biodigester kgVS.day^{-1}**
	A	B	AxB =C	D	CxD
Cow	2.30	4.99	11.47	56%	6.48
Pig	0.58	2.47	1.42	46%	0.66
Buffalo	3.90	0.68	2.67	53%	1.41
				Sum	**8.54**

2. Assessment of remaining VS content of digestate

During anaerobic digestion VS is converted into biogas. The efficiency of that process determines how much VS remains in bio-slurry. The efficiency depends on many factors and are difficult to estimate, such as retention time, dilution ratio, temperature C/N ratio etc.

According to the Biogas Handbook (2008) of Big East, the digestion efficiency of agricultural biogas plants is typically in the range 50-60%[34]. This means that digestate contains 40-50% of the initial organic dry matter, primarily as fibers. With other words, it can be assumed that around 55% of the initial concentration of VS is converted into biogas and that around 45% remains in digestate. Or with other words, the $MS_{digester}$ is 55% and the $MS_{digestate}$ is 45% of total VS entering the biogas plant.

The remaining VS however has a different composition than VS in manure, it is more fibrous and therefore it will more slowly degrade under continued anaerobic conditions. Some compounds,

[34] *P55 http://www.lemvigbiogas.com/BiogasHandbook.pdf*

could even be recalcitrant to further anaerobic biodegradation. The next table shows the calculated amount of VS that leaves the average biodigester per day:

Table 43: Average amount of VS in digester effluent

(A) Total VS entering the biodigester kgVS.day^{-1}	Digester efficiency	(B) Total VS destroyed in the biodigester kgVS.day^{-1}	AxB Total VS in bio-slurry kgVS.day^{-1}
8.5442	55%	45%	3.8449

3. Assessment of the methane potential of digestate

As the nature of VS has changed during anaerobic conversion, the default methane potential (B_o) value is no longer applicable to VS in digestate. According to EB66 Annex 32[35] the remaining fraction of the original methane potential is 20% for the liquid digestate of conventional digesters. The effluent from biodigesters in Cambodia is liquid and therefore this fraction was applied. The B_0 of digestate is calculated with the following equation:

$$B_{o,dig,T} = F_{ww,CH4,default} \times B_{0,T}$$

Equation 5: Calculation of methane potential of digestate

Where:

$B_{o,dig,T}$	=	Methane potential of digestate from animal type T manure
$F_{ww,CH4,}$	=	Default factor representing the remaining CH_4 production capacity of liquid digestate
$B_{0,T}$	=	Methane potential of manure from animal type T

With this equation it is possible to calculate for each animal the remaining methane potential.

Table 44: Calculated methane potential of digestate from manure by animal type

Animal T	$F_{ww,CH4,}$	Bo(T) (m^3CH4/kgVS)	$B_{o,dig}$ (m^3CH4/kgVS)
Cow	20%	0.1	0.0200
Pig	20%	0.29	0.0580
Buffalo	20%	0.1	0.0200

[35] *Top page 9 for parameter $F_{ww,CH4,\ default}$:http://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-14-v1.pdf*

However, since farmers often have a mix of animals it is necessary to calculate the average methane potential of digestate from mixed sources and that average has to be weighted as the population of cows is, for example, much larger than the other animals, relevant calculations can be found in the monitoring database.

Based on this, the weighted averaged $B_{0,dig}$ is 0.0315 ($m^3CH4/kgVS$)

All calculations can be found in the excel workbook sheet 'bio-slurry'.

4. MCF of the digestate management systems (DMS)

The monitoring survey investigated the storage systems of slurry by the households. The results are shown in the table below:

Table 45: Digestate management systems by type

DMS	Percentage	Applicable IPCC category	Applicable MCF zone warm (27.7◦C)
% Direct use	5.5%	Daily spread	1.0%
Anaerobic lagoon	0.4%	Anaerobic lagoon	80.0%
Slurry system	10.7%	Slurry	78.0%
Solid storage	47.3%	solid storage	5.0%
sun dry	1.7%	composting passive windrow	1.5%
in Compost hut with roof	9.6%	composting passive windrow	1.5%
in compost hut no roof	22.0%	composting passive windrow	1.5%
I sell it	0.3%	other	1.0%
Don't use it /run off/to large water body	1.6%	other	1.0%
Other	0.8%	other	1.0%

Each DMS has a different methane conversion factor (MCF). MCFs are sourced from the IPCC 2006 guidelines, volume 4 chapter 10, for each AWMS that is similar to the DMS.

The sum of the MCF times the %DMS is the average MCF. The summations are presented in the next table:

Table 46: Averaged MCF of the DMF systems

∑DMSxMCF
11.33%

5. Calculation of PE_{dig} using the information obtained in the previous steps

F_{ww} and $Bo_{, dig}$ is a default factor and applicable to the remaining VS in the digestate, see equation 6 of EB 66 Annex 32. However, as it is now known what the COD concentration of liquid digestate is, the proxy VS remaining in bio-slurry is used. The next table shows the calculated emissions from digestate using the IPCC tier 2 approach. The emissions are calculated using **equation 16** of the applied GS methodology **as per registered PDD**.

Table 47: Calculated emissions from digestate

Total VS in bio-slurry kgVS.day^{-1}	$B_{0,dig}$ ($m^3CH4/kgVS$)	∑DMSxMCF	D_{CH4} (kg/m^3CH_4)	Digester emissions (tCO_2/year/hh)
3.845	0.032	0.1133	0.670	0.084

The emissions from bio-slurry are minimal. During the second verification NBP was requested to assess emissions from bio-slurry if the bio-slurry is not handled aerobically and causing significant GHG emissions. The check is executed here below (see sheet bio-slurry

ER/unit	**5.154**	**tCO2/hh**
Larger than 1%	*TRUE*	
Applied value	**0.084**	**tCO2/hh**

The emissions are more than 1% and therefore included

3.27: EX-POST ESTIMATE OF THE EMISSION REDUCTIONS

The next table shows the ex-post estimate of the emission reductions for each biogas unit:

Table 48: Average annual emission reductions

Emission source	BE (tCO_2e/h/year)	PE (tCO_2e/h/year)	ER (tCO_2e/h/year)
Fuel use	3.117	0.197	2.920
AWMS	2.340	0.106	2.235
Bio-slurry	0.000	0.084	-0.084
Sum	**5.457**	**0.387**	**5.070**

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

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

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 (fraction)
$BE_{y,h}$	=	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 uptime adjusted usage rate is used to discount the ERs and is calculated in section 3.1. The next table shows the ER by month.

Table 49: Emission reductions realized by the VGS project of NBP (sheet ER database)

Month of program	Period, begin and end date inclusive		Units installed	ER (tCO_2e)	Cumulative ER (tCO_2e)
143	01-01-18	31-01-18	26670	8,484	8,484
144	01-02-18	28-02-18	26726	8,511	16,995
145	01-03-18	31-03-18	26787	8,529	25,523
146	01-04-18	30-04-18	26835	8,548	34,072
147	01-05-18	31-05-18	26878	8,564	42,635
148	01-06-18	30-06-18	26929	8,577	51,212
149	01-07-18	31-07-18	26972	8,594	59,806
150	01-08-18	31-08-18	27021	8,607	68,413
151	01-09-18	30-09-18	27077	8,623	77,036
152	01-10-18	31-10-18	27120	8,641	85,677
153	01-11-18	30-11-18	27164	8,654	94,331
154	01-12-18	31-12-18	27231	8,669	103,000

The table shows that the total number of ERs estimated is **103,000 tCO_2e** for the monitoring period VII.

4. SUSTAINABILITY MONITORING CONFORM MONITORING PLAN IN PASSPORT

4.1 SAFEGUARD PRINCIPLES

The next table summarizes the outcome of the 'Do no Harm' Assessment in the GSPR, and lists the safeguard principles for which mitigation principles have been identified, if any.

Table 50: Safeguarding principles

Safeguarding principles	Application of mitigation measure
1. The project respects internationally proclaimed human rights including dignity, cultural property and uniqueness of indigenous people. The project is not complicit in Human Rights abuses.	Not required
2. The project does not involve and is not complicit in involuntary resettlement.	Not required
3. The project does not involve and is not complicit in the alteration, damage or removal of any critical cultural heritage	Not required
4. The project respects the employees' freedom of association and their right to collective bargaining and is not complicit in restrictions of these freedoms and rights	Not required
5. The project does not involve and is not complicit in any form of forced or compulsory labour	Not required
6. The project does not employ and is not complicit in any form of child labour	Not required
7. The project does not involve and is not complicit in any form of discrimination based on gender, race, religion, sexual orientation or any other basis.	Not required
8. The project provides workers with a safe and healthy work environment and is not complicit in exposing workers to unsafe or unhealthy work environments.	Not required
9. The project takes a precautionary approach in regard to environmental challenges and is not complicit in practices contrary to the precautionary principle.	Not required
10. The project does not involve and is not complicit in significant conversion or degradation of critical natural habitats, including those that are (a) legally protected, (b) officially proposed for protection, (c) identified by authoritative sources for their high conservation value, or (d) recognized as protected by traditional local communities.	Not required
11. The project does not involve and is not complicit in corruption.	Not required
Additional relevant critical issues for my project type	
Environmental protection	Not required

The safeguard principles identified by the Gold Standard are relevant for all projects, however for this project no mitigation measures are to be monitored according to the GSPR.

4.2 SUSTAINABILITY DEVELOPMENT ASSESSMENT

4.21 SD MONITORING AS PER GS AND NBP SPHERE

Indicator 1: Air Quality

All, 100%, CMS surveyed households report an improved indoor air quality. They also all indicate that they have less health problems. This clearly shows that due to the switch to biogas there are less or no more hazardous pollutants that affect human health for fuel combustion. The next table shows the scoring on the SD indicator air quality.

Table 51: Scoring on SD indicator Air quality

No		**1**
Indicator		**Air quality**
Mitigation measure		N.A.
Repeat for each parameter		
Chosen parameter		Reduction in wood consumption for cooking in the project compared to the baseline.
Situation at 31/12/2011		81.1%% of wood (GSPR V2.1)
Situation at 31/12/2012		97% wood reduction (source KPT)
Situation at 31/12/2013		97% wood reduction (source KPT)
Situation at 31/12/2014		83% wood reduction (source KPT)
Situation at 31/12/2015		89% wood reduction (PFT update)
Situation at 31/12/2016		89% wood reduction (PFT update MPIV, conducted in 2015)
Situation at 31/12/2017		95% wood reduction (PFT MPVI, conducted in 2018)
Situation at 31/12/2018		95% wood reduction (PFT update MPVI, conducted in 2018 and valid for MPVII)
Estimation of baseline situation of parameter		Wood fuel use of 1435.1 kilo wood (BFT MPI of CPII)
Future target for parameter		Fuel switch to biogas with a minimal remaining consumption of wood
Way of monitoring	How	Monitoring is part of the Carbon Monitoring Survey (CMS), see MR section 2.5 on more details of this survey and PDD section B.7.2
	When	As per CMS interval, annual.
	By who	A third party commissioned by NBP will be responsible for the monitoring, the data will be reported in a monitoring report and is made available for each verification.

Indicator 2: Water quality and quantity

Table 52: Scoring on the SD indicator water quality and water quantity

No		2
Indicator		**Water quality and quantity**
Mitigation measure		N.A.
Repeat for each parameter		
Chosen parameter		Cumulative number of toilets connected to the biodigester
Situation at 31/12/2011		1753 (MRII of CPI)
Situation at 31/12/2012		2352 (project database)
Situation at 31/12/2013		2513 (project database)
Situation at 31/12/2014		2698 (project database)
Situation at 31/12/2015		2887 (Project database)
Situation at 31/12/2016		2981 (Project database)
Situation at 31/12/2017		3023 (Project database)
Situation at 31/12/2018		3028 (Project database)
Estimation of baseline situation of parameter		0% of the households have a toilet connected to the biodigester
Future target for parameter		All biodigester households that do not have a toilet before investing in a biodigester have a new toilet installed and connected to the biodigester
Way of monitoring	How	Plant completion report which is the output of the commissioning of the biodigester to the household
	When	After the completion of the biogas plants before commissioning
	By who	NBP will provide the data to the consultant who will put in a monitoring report that is made available for each verification

The performance of this parameter over the last 8 years is shown in the next table:

Table 53: Number of toilets connected in the period 2010-2018

Year	MP	Toilets connected	% connected in that year	Cumulative toilets connected	% of all biodigesters
2010	N/A	490	13.1%	1028	10.13%
2011	N/A	725	15.0%	1753	11.71%
2012	MPI	599	14.3%	2352	12.27%
2013	MPII	171	14.4%	2513	12.39%
2014	MPIII	185	10.0%	2698	12.20%
2015	MPIV	189	9.3%	2887	11.95%
2016	MPV	94	6.8%	2981	11.67%
2017	MPVI	42	3.0%	3023	11.37%
2018	MPVII	5	0.5%	3028	11.12%

The number of households that have connected a toilet is slightly lower in percentage point compared do the other years. This is the result of market saturation, many households nowadays have a toilet, which is the result of many campaigns on sanitation. In absolute numbers, the numbers of households that have access to sanitation due to NBP continues to grow.

Indicator 3: Soil condition – Bio-slurry usage

All biogas users use bio-slurry according to the CMS survey.

Table 54: Scoring on SD indicator soil condition

No		**3**
Indicator		**Soil condition**
Mitigation measure		N.A.
Repeat for each parameter		
Chosen parameter		Cumulative number of households that use bio-slurry Calculation: Share of digesters in operation x total number of digesters x share of households that use bio slurry
Situation at 31/12/2011		13,511 users use bio-slurry as fertilizer (MRIII of CPI)
Situation at 31/12/2012		16,963
Situation at 31/12/2013		18,410
Situation at 31/12/2014		18,056
Situation at 31/12/2015		21,217
Situation at 31/12/2016		21,406
Situation at 31/12/2017		20,693
Situation at 31/12/2018		20,230
Estimation of baseline situation of parameter		None of the households used bio-slurry in the baseline
Future target for parameter		All households use bio-slurry as fertilizer
Way of monitoring	How	Monitoring is part of the Carbon Monitoring Survey (CMS), see MR section 2.5 on more details of this survey and PDD section B.7.2
	When	As per CMS, at least annually
	By who	A third party commissioned by NBP will be responsible for the monitoring, the data will be reported in a monitoring report and is made available for each verification.

This year the scoring is lower compared to MPVI. This is because the digester usage rate has dropped significantly.

Indicator 4: Biodiversity

The next table show the positive impact on biodiversity by reducing deforestation. It should also be noted that by applying bio-slurry the soil does not heat up as it would be with chemical fertilizers due to higher water retaining capacity. That in combined with the improved fertilization has positive impacts on soil microbes. Whereas this is normally not considered to be in the realm of biodiversity, soil microbes are key to a healthy environment and biodiversity.

Table 55: Scoring on the SD indicator biodiversity

No		**4**
Indicator		**Biodiversity**
Mitigation measure		N/A
Repeat for each parameter		
Chosen parameter		Cumulative savings of wood Calculation is as follows: average consumption of fuelwood per household ($FW_{baseline,hh}$) in the baseline - average consumption of fuelwood in the project is the reduction of fuelwood per average household, that times the number of biodigesters ($N_{biodigester}$) $\mathbf{RE_{fuel} = (\sum FW_{baseline,hh} - \sum FW_{project,hh}) \times N_{biodigester}}$
Situation at 31/12/2011		Cumulative saving of around 71 Gg wood (MRIII of CPI)
Situation at 31/12/2012		Cumulative saving of 24.3 Gg in MPI of CPII totalling 95.3 Gg wood from the start of project
Situation at 31/12/2013		Cumulative saving of 27.5 Gg in MPII of CPII totalling 122.8 Gg wood from the start of project
Situation at 31/12/2014		Cumulative saving of 25.3 Gg in MPIII of CPII totalling 148.1 Gg wood from the start of project
Situation at 31/12/2015		Cumulative saving of 26.8 Gg in MPIV of CPII totalling 173.9 Gg wood from the start of project
Situation at 31/12/2016		Cumulative saving of 27.4 Gg in MPV of CPII totalling 201.3 Gg wood from the start of project
Situation at 31/12/2017		Cumulative saving of 28.3 Gg in MPVI of CPII totalling 229.6 Gg wood from the start of project
Situation at 31/12/2018		Cumulative saving of 27.7 Gg in MPVII of CPII totalling 257.3 Gg wood from the start of project
Estimation of baseline situation of parameter		No savings
Future target for parameter		200 Gg by 2018
Way of monitoring	How	Monitoring is part of the Carbon Monitoring Survey (CMS), see MR section 2.5 on more details of this survey and PDD section B.7.2
	When	As per CMS, at least annually

	By who	A third party will conduct the monitoring commissioned by NBP, the data will be reported in a monitoring report and is made available for each verification.

Indicator 5: Quality of Employment

The next table shows the impact on the quality of employment.

Table 56: Scoring on SD indicator quality of Employment

No		**5**
Indicator		**Quality of Employment**
Mitigation measure		N/A
Repeat for each parameter		
Chosen parameter		Number of trained masons and supervisors (quality inspectors of biodigesters)
Situation at 31/12/2012		635 masons followed the training course, of them 533 are certified (certification is successful completion of the training and having built 2 biodigesters) and 119 supervisors are certified.
Situation at 31/12/2013		540 are certified (certification is successful completion of the training and having built 2 biodigesters) and 123 supervisors are certified
Situation at 31/12/2014		578 and 135 masons and supervisors are respectively certified
Situation at 31/12/2015		604 masons and 142 supervisors are respectively certified
Situation at 31/12/2016		771 masons and 146 supervisors are respectively certified
Situation at 31/12/2017		799 masons and 149 supervisors are respectively certified
Situation at 31/12/2018		801 masons and 154 supervisors are respectively certified
Estimation of baseline situation of parameter		Training is inherent to the NBP activities; consequently, before NBP there were no training activities.
Future target for parameter		700 additional masons trained and 180 supervisors by 2018
Way of monitoring	How	NBP keeps track of the number of trained masons and supervisors
	When	As specified in the Biodigester methodology, at least annually
	By who	A third party will conduct the monitoring commissioned by NBP, the data will be reported in a monitoring report and is made available for each verification.

Indicator 6: Livelihood of the Poor

The next table shows the impact on the livelihood of the poor.

Table 57: Scoring on the SD indicator livelihood of the poor

No		**6**
Indicator		**Livelihood of the poor**
Mitigation measure		N/A
Repeat for each parameter		
Chosen parameter 1		**Cumulative number of users that use biogas for cooking** **This is determined by simply multiplying the share of households that use the gas daily by the usage rate and the number of installations**
Situation at 31/12/2015		21,231 families
Situation at 31/12/2016		21,466 hh use biogas daily
Situation at 31/12/2017		20,825hh use biogas daily
Situation at 31/12/2018		19,943 hh use daily
Estimation of baseline situation of parameter		0%, all household depend on other fuels than biogas
Future target for parameter		100% usage of biogas as main cooking fuel
Way of monitoring	How	Monitoring is part of the Carbon Monitoring Survey (CMS), see MR section 2.5 on more details of this survey and PDD section B.7.2
	When	As per CMS, at least annually
	By who	A third party will conduct the monitoring commissioned by NBP, the data will be reported in a monitoring report and is made available for each verification.

The number of households that use biogas daily has dropped due to a decrease in usage rate of the biodigesters.

Chosen parameter 2	**Number of household members that benefit from having an improved waste management system**
Current situation of parameter	93,561 Calculation: Number of plants x share of plants in use x number of household members
Situation at 31/12/2015	104,226
Situation at 31/12/2016	100,997
Situation at 31/12/2017	98,888
Situation at 31/12/2018	94,607

Estimation of baseline situation of parameter		0
Future target for parameter		150,000 people that benefit by 2018
Way of monitoring	How	Using survey methods on the household size and the total sales records
	When	As per CMS, at least annually
	By who	A third party will conduct the monitoring commissioned by NBP, the data will be reported in a monitoring report and is made available for each verification.

Idem as the reason above, the drop is caused by a decrease in usage rate, the reasons why the usage rate dropped is outlined in table 17 in chapter 3.1.

Indicator 7: Access to affordable and clean energy services

The next table shows the increased access to affordable and clean energy services.

Table 58: Scoring on the SD indicator Access to affordable and clean energy services

No	**7**
Indicator	**Access to affordable and clean energy services**
Mitigation measure	N/A
Repeat for each parameter	
Chosen parameter	**Total reduction in cooking fuel expenditure compared to the baseline calculated at current prices** The score on this parameter will be calculated by multiplying the amount of fuel saving times the current prices of the fuel times the number of digesters in operation times the share of plants in operation times the total number of plants.
Current situation of parameter	$7.91 savings per month (MRIII of CPI)
Situation at 31/12/2015	$10.74 savings per month per hh (MPIV) and $2.72 million in 2015
Situation at 31/12/2016	$13.18 savings per month per hh (MPV) and $3.44 million in 2016
Situation at 31/12/2017	$11.96 savings per month per hh (MPVI) and $3.03 million in 2017
Situation at 31/12/2018	$13.32[36] savings per month per hh (MPVII) and $3.29 million

[36] *Charcoal savings were averaged the two most common sale units, by bag and by kilo. See spreadsheet MPVII fuel prices*

Estimation of baseline situation of parameter		0
Future target for parameter		2.5 million USD saving per year by 2018
Way of monitoring	How	Monitoring is part of the Carbon Monitoring Survey (CMS), see MR section 2.5 on more details of this survey and PDD section B.7.2
	When	As per CMS, at least annually
	By who	A third party will conduct the monitoring commissioned by NBP, the data will be reported in a monitoring report and is made available for each verification.

The savings have increased compared to MPVII due to a more favourable exchange rate mostly, $1 is 3990 riel compared to 3998 riel in MPVI.

Indicator 8: Human and institutional capacity

The next table shows the impact on human and institutional capacity.

Table 59: Scoring on the SD indicator human and institutional capacity

No		**8**
Indicator		**Human and institutional capacity**
Reported values		
Mitigation measure		N/A
Repeat for each parameter		
Chosen parameter		**Cumulative number of established and active Biogas Construction Companies (BCC)[37]**
Situation at 31/12/2011		44 (MRIII of CPI)
Situation at 31/12/2012		66, of which 63 are in operation
Situation at 31/12/2013		66, of which 52 are in operation
Situation at 31/12/2014		81, of which 61 are in operation
Situation at 31/12/2015		93, of which 63 are in operation
Situation at 31/12/2016		99, of which 51 are in operation
Situation at 31/12/2017		106, of which 52 are in operation
Situation at 31/12/2018		107, of which 53 are in operation
Estimation of baseline situation of parameter		0
Future target for parameter		135 BCC established by 2018 of which 70 are active
Way of monitoring	How	The PP keeps track on the number of BCC established
	When	As specified in the Biodigester methodology, at least annually

[37] *The NBP refers to BCA (Biodigester Construction Agents) instead of BCC since the last MP*

	By who	A third party will conduct the monitoring commissioned by NBP, the data will be reported in a monitoring report and is made available for each verification.

There are fewer BCCs active in 2018. This is the result of a lower demand for biodigester as per reasons outlined in chapter 1.5.

Indicator 9: Quantitative employment and income generation

Table 60: Scoring on SD indicator Quantitative employment and income generation

No		**9**
Indicator		**Quantitative employment and income generation**
Mitigation measure		N/A
Repeat for each parameter		
Chosen parameter		Cumulative number of masons working years
Situation at 31/12/2014		2,131 man-years at the end of 2014
Situation at 31/12/2015		2,323 man-years
Situation at 31/12/2016		2,434 man-years
Situation at 31/12/2017		2,508 man-years
Situation at 31/12/2018		2,550 man-years
Estimation of baseline situation of parameter		No NBP related jobs
Future target for parameter		2,500 man-years of employment by 2018
Way of monitoring	How	The number of digesters built as per total sales records times the default number of days required for the construction divided by the number of days worked per year (220)
	When	continuously
	By who	Supervisor and NBP staff

Calculation of number of mason working days

As per bill of quantities, there are 4,5,10,11,13,15 and 20 working days required for the 2,3,4, 6,8,10 and 15 m^3 biodigester respectively of both skilled and unskilled masons. The number of digesters of each digester size times the number of working days of the respective digester gives the total number of days worked of each size, see the next table:

Table 61: Cumulative number of working mason working days

Digester size	**2**	**3**	**4**	**6**	**8**	**10**	**15**	**sum**
Days required/unit	4	5	10	11	13	15	20	
Skilled mason	200	3,025	155,830	107,371	11401	3690	2180	283,697
Unskilled mason	200	3,025	155,830	107,371	11,401	3,690	2,180	283,697

Total (skilled+ unskilled)	400	6,050	311,660	214,742	22,802	7,380	4,360	560,944

The total sum of working days are 560,944 days, roughly equivalent to 2,550 working years at 220 working days per year. This however is merely an indication as it is not known how many days masons actually work, many also have a farm to take care of and during the rainy season it is not always possible to construct a biodigester. Nevertheless, based on discussion with the DOE and NBP this figure was considered appropriate, but remains by default a rough estimate.

Indicator 10: Balance of payments and investments

Table 62: Scoring on the SD indicator Balance of payments and investments

No		**10**
Indicator		**Balance of payments and investments**
Mitigation measure		N/A
Repeat for each parameter		
Chosen parameter		**Net cash inflow**: sum of cash inflows – cash outflows. Cash inflow is VER income, foreign direct investment; the cash outflow is the expenditure on materials and equipment not available in Cambodia, DOE and GS fees
Situation at 31/12/2011		The total net cash inflow is $1,826,430 MRIII of CPI
Situation at 31/12/2012		The total net cash inflow is $1,534,180.69 in MP
Situation at 31/12/2013		The total net cash inflow is $1,357,578.08
Situation at 31/12/2014		The total net cash inflow is $1,013,040.34
Situation at 31/12/2015		The total net cash inflow is $2,015,739.32
Situation at 31/12/2016		The total net cash inflow is $594,523.57
Situation at 31/12/2017		The total net cash inflow is $754,723.25
Situation at 31/12/2018		The total net cash inflow is $546,629.75
Estimation of baseline situation of parameter		$0 for biogas activities
Future target for parameter		At least 1 million USD per year
Way of monitoring	How	Accounting activities record these inflows and outflows
	When	The cash inflow and outflow will be reported for each monitoring interval and will be based on data provided by the NBP financial manager
	By who	NBP financial manager

This year the net cash inflow is much lower compared to the other years. This is the results from much smaller ODA support to NBP, lower VER prices and higher GS fees.

Indicator 11: Technology transfer and technological self-reliance

Table 63: Scoring on SD indicator Technology Transfer and Technological self-reliance

No		**11**
Indicator		**Technology transfer and technological self-reliance**
Mitigation measure		N/A
Repeat for each parameter		
Chosen parameter 1		**Number of biodigesters built**
Situation at 31/12/2011		14,970 at the end of 2011 (14,144 in CPI provinces and 826 in the new provinces)
Situation at 31/12/2012		19,171 biodigester units are built
Situation at 31/12/2013		20,286
Situation at 31/12/2014		22,117
Situation at 31/12/2015		24,159
Situation at 31/12/2016		25,542
Situation at 31/12/2017		26,585
Situation at 31/12/2018		27,231
Estimation of baseline situation of parameter		0 for biogas activities
Future target for parameter		estimated to be 33,287 by 2018
	How	The PP keeps track of the total number of biogas plants built in a database
	When	continuously
	By who	A third party will conduct the monitoring commissioned by NBP, the data will be reported in a monitoring report and is made available for each verification.

5. STAKEHOLDER FEEDBACK

NBP is an open and transparent programme, and offers a variety of opportunities that can be utilized to comment on the programme or to provide feedback. Besides offering feedback opportunities, all information concerning NBP can be found on her website: www.nbp.org.kh and on the Gold Standard website.

These opportunities to provide feedback are, inter alia:

1. Telephone:
    a. NBP
    b. PBPO
2. Phone numbers of PBPO staff can be found on the same webpage;
3. Comment form on the website: http://nbp.org.kh/feedback.aspx
4. Facebook page: https://www.facebook.com/nbp.org.kh?fref=ts
5. NBP and PBPO phone numbers are given in the user manuals and leaflets

The following comments were received by the programme director: 0. Relevant Facebook comments have been translated and provided to the DOE. Most comments were compliments and questions.

The programme director has received many emails but none of them were comments related to the project.

Assessment of comments: No complaints were received and therefore no action was undertaken.

6. DATA QUALITY CONTROL AND ASSURANCE

6.1 HOUSEHOLD SELECTION

Each household is visited prior to the installation of a biodigester by NBP provincial staff using 'Form 02'. With help of form 02 it is assessed whether or not the households have the right conditions for a biodigester, i.e. feedstock, space, animal husbandry system. This is the first step in the quality control as here it is ensured that the biodigester has the right 'fit' within the household's farming system.

Based on this a contract is drafted between the household, the BCC and the PBPO, form 03. The details of form 03 are entered into the database. By signing form 03, the households transfer their carbon rights to NBP.

6.2 QUALITY CONTROL ON BIODIGESTER CONSTRUCTION

NBP implements an elaborate QC/QA mechanism on the construction of the biodigester. This process consists of 4 layers:

1. **Mason**
   Each mason is trained and certified before they are allowed to construct a biodigester under their name.
2. **Biodigester Construction Company (BCC)**
   A BCC has to perform 100% of the under-construction plants. This check is informal, there is no specific form developed for this.
3. **PBPO**
   a. Under construction quality check (form 06)
   b. 100% after construction quality checks (form 09)
      If the biodigester is approved, the plant is handed over to the households. Only at that moment the household can receive subsidy. The data from form 09 are entered in the database.
4. **NBP**
   NBP technicians perform on a random sample quality control on quality control.

Each household receive an after-guarantee certificate. This certificate details the 2 year warrantee period and keeps track of the after sales visits.

6.3 QUALITY CONTROL ON DATA COLLECTION METHODS

The emission reductions and the impact on sustainable development are monitored at least biennially using survey methods, see chapter 2. The DOE plays an important role to verify the quality of these monitoring activities as a third party independent verifier.

- **Quality Assurance of Questionnaire distribution and collection**

The emission reduction is based on field questionnaires administered to a sample of users, the quality assurance lies in the design of the questionnaires, their reliable administration and calculations based on the data analysis. It is therefore of high importance that the questionnaires are administered by specially trained personnel with extensive experience. Quality Assurance of this process is carried out by Eric Buysman who with success secured two of the previous NBP credit issuances.

- **Quality assurance of questionnaire design**

The main tool to capture information required for this report is the household survey questionnaire. Chapter 2 details the QC on the questionnaire design and other data collection tools.

- **QC/QA on monitoring report**

The monitoring report is developed by an independent consultant with relevant experience of CDM and carbon monitoring of domestic biogas projects, his name is Eric Buysman. The consultant is selected in a tender process, and selected based on a quality cost basis. The selected consultant has considerable experience as the consultant all carbon documents for NBP and has developed the sister VGS project in Viet Nam, Biogas Program for Animal Husbandry Sector of Viet Nam (GS1083). The monitoring report is checked before release by NBP staff and HIVOS, no comments were received. The contracted DOE will assess the report on compliance and final approval after review on compliance with the GS procedures and the PDD will be provided by the GS.

- **Data Storage**

All data is stored in a project database. On a daily basis a backup is made on an external hard disk and every month a copy is made which is stored at a separate location (IT and database Management officer's house). In a case of an emergency, the most recent back up will be used to restore the project database.

ANNEX I: CONTACT DETAILS OF THE PROJECT PARTICIPANTS

Organisation:	National Biodigester Programme
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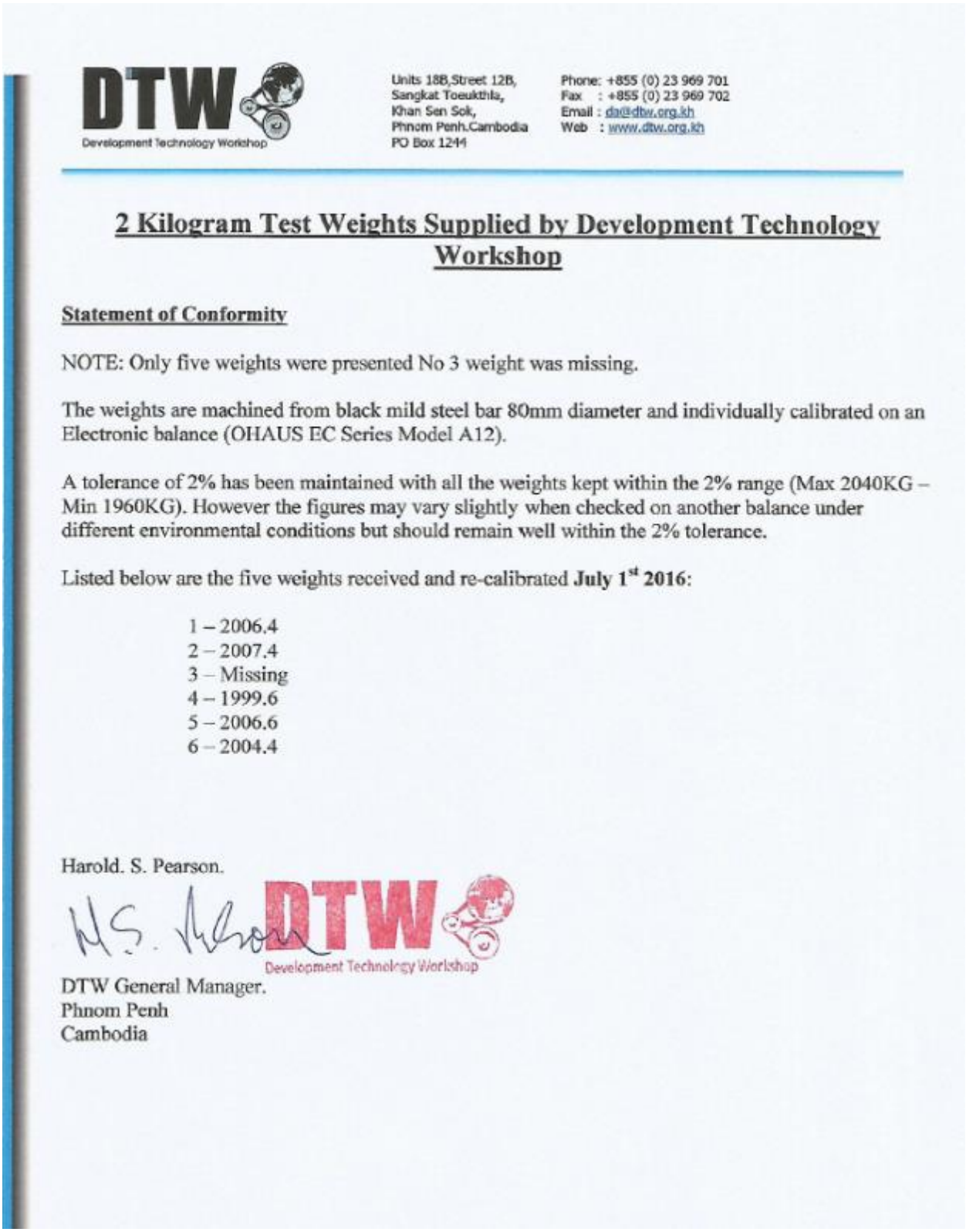
ANNEX II: WEIGHT STONE CALIBRATION STATEMENT

On the 1st of July 2017 DTW checked the weight of the weight stones. All the stones were still weighting 2 kilos as they did in 2011. Weight stone 3 is missing and was also not used for MPVII.



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2 Kilogram Test Weights Supplied by Development Technology Workshop

Statement of Conformity

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

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

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

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

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

Harold. S. Pearson.

DTW
Development Technology Workshop

DTW General Manager.
Phnom Penh
Cambodia