

MONITORING REPORT II

From 01/01/2012 to 30/06/2013

For the verification of Biogas Program for Animal Husbandry Sector of
Vietnam



Version 3.2

22/04/2015

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Acronyms

AWMS	Animal Waste Management System
BE	Baseline emission
BUS	Biogas User Survey
CDM	Clean Development Mechanism
CH ₄	Methane Gas
CO ₂	Carbon Dioxide
CO ₂ eq	Relative potency of non-CO ₂ gases compared to CO ₂
EF	Emission factor
ER	Emission reduction
GBM	Gold Standard Bio-digester Methodology
GHG	Greenhouse Gas
GS	Gold Standard
GSPR	Gold Standard Passport Report
GWP	Global Warming Potential
hh (HH)	household
IPCC	Intergovernmental Panel on Climate Change
LPG	Liquefied Petroleum Gas
LSC	Local Stakeholder Consultation Report
MCF	Methane conversion factor
MS	Manure system (equivalent to AWMS)
MPx	Monitoring Period x (I or II)
MRx	Monitoring Report (I or II)
N ₂ O	Nitrous oxide
NRB	Non-Renewable Biomass
PDD	Project Description Document
PE	Project Emission
SNV	Netherlands Development Organization
UNFCCC	United Nation Framework Convention on Climate Change
VER	Voluntary emission reduction
VGS	Voluntary Gold Standard

CONTENTS

MONITORING REPORT II	1
MONITORING REPORT SUMMARY	4
SECTION A. DESCRIPTION OF PROJECT ACTIVITY.....	5
A.1. PURPOSE AND GENERAL DESCRIPTION OF PROJECT ACTIVITY	5
A.2. LOCATION OF PROJECT ACTIVITY.....	6
A.3. PARTIES AND PROJECT PARTICIPANT(S).....	9
A.4. REFERENCE OF APPLIED METHODOLOGY	9
A.5. CREDITING PERIOD OF PROJECT ACTIVITY	9
SECTION B. IMPLEMENTATION OF PROJECT ACTIVITY	10
B.1. DESCRIPTION OF IMPLEMENTED REGISTERED PROJECT ACTIVITY	10
B.2. POST REGISTRATION CHANGES.....	14
B.3. FAR RAISED IN MPI	15
SECTION C. DESCRIPTION OF MONITORING SYSTEM	17
C.1. QUALITY CONTROL MONITORING.....	17
C.2. CARBON MONITORING SURVEY (CMS)	20
C.3. USAGE SURVEY (US).....	22
SECTION D. DATA AND PARAMETERS	23
D.1. DATA AND PARAMETERS THAT ARE AVAILABLE AT VALIDATION	23
D.2. DATA AND PARAMETERS MONITORED	26
D.3. IMPLEMENTATION OF SAMPLING PLANS.....	31
SECTION E. CALCULATION OF EMISSION REDUCTIONS OR GHG REMOVALS BY SINKS	44
E.1. CALCULATION OF BASELINE EMISSIONS OR BASELINE NET GHG REMOVALS BY SINKS	44
E.2. CALCULATION OF PROJECT EMISSIONS OR ACTUAL NET GHG REMOVALS BY SINKS	48
E.3. CALCULATION OF LEAKAGE	48
E.4. SUMMARY OF CALCULATION OF EMISSION REDUCTIONS OR NET ANTHROPOGENIC GHG REMOVALS BY SINKS.....	58
E.5. COMPARISON OF ACTUAL EMISSION REDUCTIONS OR NET ANTHROPOGENIC GHG REMOVALS BY SINKS WITH ESTIMATES IN REGISTERED PDD.....	62
E.6. REMARKS ON DIFFERENCE FROM ESTIMATED VALUE IN REGISTERED PDD.....	62
SECTION F. RESULTS OF MONITORING SUSTAINABLE DEVELOPMENT INDICATOR.....	62
F.1. SAFEGUARD PRINCIPLES.....	62
F.2. SUSTAINABILITY MONITORING PLAN	63
ANNEX 1: CONTACT DETAILS OF THE PROJECT PARTICIPANTS	69

Monitoring report summary

Title of the project activity	Biogas Program for Animal Husbandry Sector of Vietnam
Gold Standard version	2.1
Gold Standard icon	
Reference number of the project activity	GS1083 ¹
Version number of the monitoring report	3.2
Completion date of the monitoring report	22/04/2015
Registration date of the project activity	28/06/2012
Monitoring period number and duration of this monitoring period	Monitoring period number 2 (MPII) 01/01/2012 to 30/06/2013
Project participant(s)	1. Biogas Program for the Animal Husbandry Sector of Vietnam 2. SNV Vietnam
Host Party(ies)	Vietnam
Sectoral scope(s) and applied methodology(ies)	Sectoral scope: 1 and 13 Methodology: Technologies and practices to displace decentralized thermal energy consumption version 1.0 ²
Estimated amount of GHG emission reductions or net anthropogenic GHG removals by sinks for this monitoring period in the registered PDD	868,817 tCO ₂ e
Actual GHG emission reductions or net anthropogenic GHG removals by sinks achieved in this monitoring period	779,924 tCO ₂ e

¹ http://mer.markit.com/br-reg/public/project.jsp?project_id=103000000001847

² http://www.cdmgoldstandard.org/wp-content/uploads/2011/10/GS_110411_TPDDTEC_Methodology.pdf

SECTION A. Description of project activity

A.1. Purpose and general description of project activity

The Biogas Program for the Animal Husbandry Sector of Vietnam (BP) is implemented by Livestock Production Department the Biogas Project Division (BPD) (under the Ministry of Agriculture and Rural Development (MARD)) in partnership with the Netherlands Development Organization (SNV). Overall objectives of BP are (i) effectively exploiting biogas technology and developing a commercial viable biogas sector in Vietnam; and (ii) contributing to rural development and environmental protection via provision of clean and affordable energy to rural households, improvement of community's sanitation and rural people's health, creation of jobs for rural labor and reduction of greenhouse gas emissions (GHG).

The purpose of the project activity is to (further) develop the commercial and structural deployment of domestic biogas³ in Vietnam. To that extent, the project will:

- Promote the long-term utilization of renewable energy produced in an environmentally compatible and economically viable way;
- Increase the awareness of prospective livestock smallholder households and extension workers on the full extent of the potential costs and benefits of domestic biogas installations;
- Strengthen the supporting capacity of involved Biogas Construction Teams (BCTs) and (non-) Government officials regarding all aspects of marketing, construction, after sales service and quality management of domestic biogas installations;
- Support the development of a commercially viable, market oriented domestic biogas sector in Vietnam;
- Strengthen the institutional infrastructure for coordination and implementation of sustained dissemination of domestic biogas at national, provincial and district level.

With implementation of this Project, greenhouse gas (GHG) emissions will be reduced, both from the displacement of non-renewable biomass (NRB) and fossil fuels currently used in stoves with clean and efficient biogas technology, but also by introducing a proper animal waste management system (AWMS). The key milestones of project developments are as below:

Carbon finance activities	Year
Carbon feasibility study: Study Domestic Biogas and CDM financing –Proof consideration of carbon for 2006 onwards. ⁴	November 2005
Start date of VGS project (first application for a biogas plant, date of completion was on 1/1/2007)	19 July 2006
PIN Reception of Letter of Endorsement (LoE) from Vietnam DNA ⁵	28 September 2006
PDD Development by Mitsubishi Securities UFJ as bundle CDM project with credit period start date 1-10-2006	2006- 2007

³ Domestic biogas is defined as any biogas plant with a volume between 4 to 50 m³, the minimum daily feedstock requirement of the smallest size is manure from 6 pigs or two bovines (20 kg/day) and the largest digester can treat around 300 kg/manure/day (MARD national standard: 10 TCN 97 -102 – 2006. Issued by decision NO 4006/QĐ-BNN-KHCN of Ministry of Agriculture and Rural development on 26th December 2006.)

⁴ http://www.natuurenmilieu.nl/pdf/0500_2.1_domestic_biogas_and_cdm_financing_background_paper.pdf

⁵ http://www.noccop.org.vn/Data/profile/Airvariable_Projects_75233Tong%20hop%20PIN.pdf

Baseline development and GS PDD development by SNV (Felix ter Heegde) (draft PDD developed: Nov 2008, start date crediting period 1-1-2008)	January 2008
Approval on the QSEAP-BDP by MARD with consideration of CDM revenue in financing mechanism	20 November 2008
Local Stakeholder Workshop in Phu Tho and Nghe An	April 2009
GS consultant contract signed between BPD and Nexus – Carbon for Development	September 2011
Registration date of the project activity	28 June 2012
First GS VER issuance	26 February 2013

According to the first monitoring period, 510,952 credits were issued. For the second monitoring period, the expected emission reduction is 779,924 GS VER.

A.2. Location of project activity

Vietnam.

Since the inception of the first phase (BP I) the programme has gradually extended its coverage. In 2007 the programme was active in 24 provinces and this has increased to 52 provinces in 2013. The coordinates of Vietnam are:

Table 2: Vietnam coordinates

	North	Center	South
Latitude	22°00' North of the Equator	16°00' North of the Equator	8°50' North of the Equator
Longitude	100°00' East of Greenwich	106°00' East of Greenwich	109°00' East of Greenwich

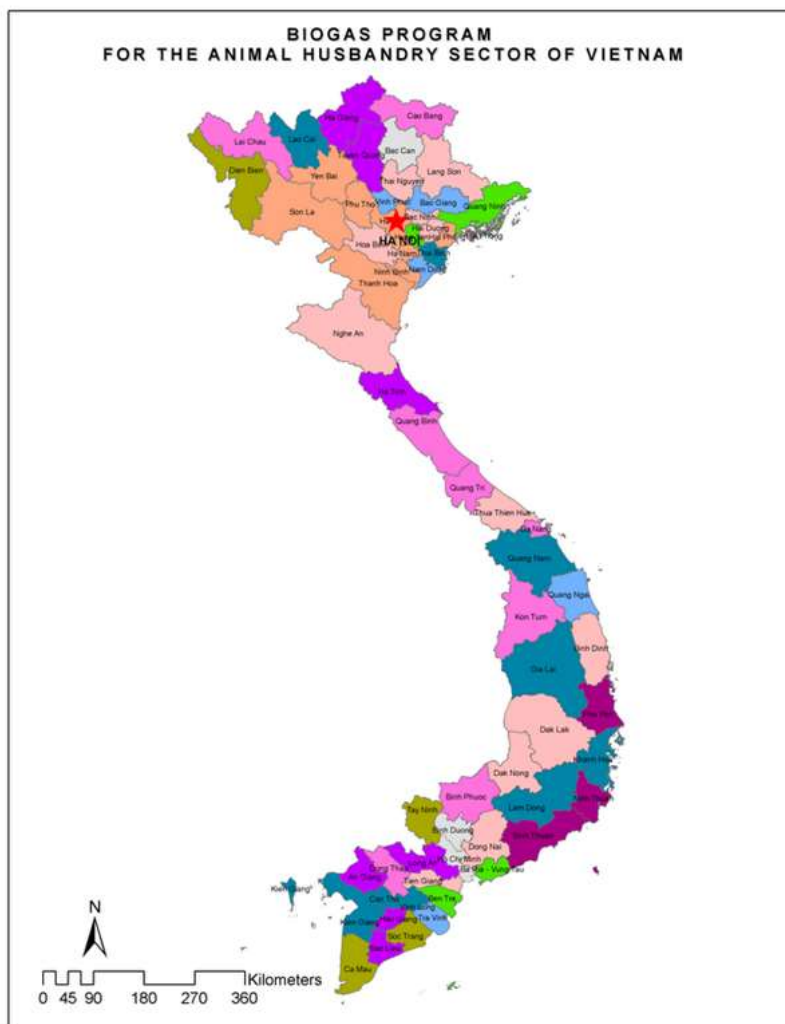


Figure 1: Project's location

The list of active provinces and its installed plants are showed in the following table.

Table 3: Number of plants installed by province in the warm zone

No	Province	Latitude ⁶	Longitude ⁷	Cumulative installations
1	An Giang	10°30'0"	105°13'0"	1025
2	Bà Rịa-Vũng Tàu	10°30'0"	107°13'0"	1457
3	Bạc Liêu	9°17'38"	105°43'40"	20
4	Bến Tre	10°13'59"	106°22'59"	1470
5	Bình Định	14°7'59"	108°46'59"	5864
6	Bình Phước	11°45'33"	106°51'5"	9
7	Cần Thơ	10°1'59"	105°46'59"	89
8	Đồng Nai	11°6'0"	107°20'59"	1888

⁶ <https://maps.google.com/>

⁷ <https://maps.google.com/>

No	Province	Latitude ⁶	Longitude ⁷	Cumulative installations
9	Đồng Tháp	10°40'05"	105°42'05"	73
10	Hậu Giang	9°47'0"	105°28'0"	217
11	Khánh Hòa	10°40'59"	105°10'0"	720
12	Kiên Giang	10°16'59"	104°39'0"	900
13	Long An	10°24'0"	106°19'59"	427
14	Quảng Bình	17°28'9"	106°35'59"	20
15	Quảng Nam	15°53'8"	108°15'24"	1367
16	Quảng Ngãi	15°7'0"	108°47'59"	3218
17	Sóc Trăng	9°36'11"	105°58'48"	52
18	Tây Ninh	11°18'0"	106°5'59"	96
19	Tiền Giang	10°22'0"	106°40'0"	3148
20	Trà Vinh	9°56'4"	106°20'43"	1759
21	Vĩnh Long	10°15'0"	105°58'0"	547
Total				24366

Table 4: Number of plants installed by province in the temperature zone

No	Province	Latitude ⁸	Longitude ⁹	No of Plants
1	Bắc Giang	21°16'23"	106°11'40"	4776
2	Bắc Ninh	21°11'9"	106°4'34"	5473
3	Đắc Lắc	20°2'12"	105°34'54"	3095
4	Điện Biên	21°22'59"	103°1'0"	8
5	Gia Lai	13°58'59"	108°0'0"	966
6	Hà Giang	22°49'59"	104°58'59"	5
7	Hà Nam	19°19'0"	105°47'59"	3403
8	Hà Nội	21°1'59"	105°50'59"	6212
9	Hà Tây	20°50'0"	105°40'0"	3225
10	Hà Tĩnh	18°19'59"	105°54'0"	1212
11	Hải Dương	20°55'59"	106°19'0"	3892
12	Hải Phòng	20°51'21"	106°40'55"	1936
13	Hoà Bình	20°48'47"	105°20'17"	1687
14	Hưng Yên	20°38'59"	106°4'0"	3583
15	Lâm Đồng	11°55'59"	108°25'0"	55
16	Lạng Sơn	21°49'59"	106°43'59"	826
17	Lào Cai	22°28'59"	103°57'0"	294
18	Nam Định	20°25'0"	106°10'0"	2052
19	Nghệ An	18°40'0"	105°40'0"	5590

⁸ <https://maps.google.com/>

⁹ <https://maps.google.com/>

No	Province	Latitude ⁸	Longitude ⁹	No of Plants
20	Ninh Bình	20°15'14"	105°58'29"	4253
21	Phú Thọ	21°20'0"	105°10'0"	2622
22	Quảng Ninh	21°14'00"	107°20'05"	2653
23	Quảng Trị	16°45'0"	107°12'0"	40
24	Sơn La	21°19'0"	103°54'0"	1041
25	Thái Bình	20°27'0"	106°19'59"	2718
26	Thái Nguyên	21°35'34"	105°50'39"	3951
27	Thanh Hoá	19°48'0"	105°46'0"	9604
28	Thừa Thiên Huế	16°28'0"	107°35'59"	1646
29	Tuyên Quang	21°49'23"	105°13'5"	365
30	Vĩnh Phúc	21°17'59"	105°36'00"	2889
31	Yên Bái	21°42'0"	104°52'0"	1733
Total				81805

A.3. Parties and project participant(s)

Party involved	Private and/or public entity(ies) project participants (as applicable)	Indicate if the Party involved wishes to be considered as project participant (Yes/No)
Vietnam (host)	- Biogas Program for the Animal Husbandry Sector of Vietnam - SNV Vietnam	Yes

A.4. Reference of applied methodology

Technologies and practices to displace decentralized thermal energy consumption, version 1.0 Sectoral scope 1,3,13.

Available online: http://www.cdmgoldstandard.org/wp-content/uploads/2011/10/GS_110411_TPDDTEC_Methodology.pdf

A.5. Crediting period of project activity

The crediting period of the Project is from 28/06/2010 to 27/06/2017 (Renewable).

SECTION B. Implementation of project activity

B.1. Description of implemented registered project activity

BP is supporting the installment of biogas units of volumes between 4 to 50 m³ in households with livestock (cattle, buffalos or pigs). The smallest digester has a minimum feedstock requirement of around 20 kg/day, roughly equivalent to 2 bovines or 6 pigs, the largest digester can treat around 300 kilo of manure per day. The amount of the daily feedstock per digestion m³ is depending on the region as below¹⁰:

Table 5: Daily feedstock¹¹

Region	Local	Daily feeding (kg/day/m ³)
I	The North mountainous region	6 - 9
II	The South Vietnam	11 - 16
III	Other locations	8 - 12

The detail feedstock by each capacity could also be found in the “Training material for Biogas Technician, 2011”. The table below gives some examples for daily waste requirement:

Table 6. Example of daily feedstock for KT1 type for area with mean temperature from 15 to 20°C

Parameters	Unit	Size							
Size	m ³	5.3	7.9	10.5	13.2	15.9	21.2	26.5	31.8
Daily supply of waste	kg/day	50	75	100	125	150	200	250	300

In this way the manure management is improved leading to less GHG emissions and improved hygienic and environmental living conditions. The installed biogas units are of fixed dome type. The produced biogas is used to replace conventional fuels like firewood, coal, LPG, kerosene and agricultural residues for cooking. Apart from cooking, biogas lamps are installed that can replace conventional light bulbs (usually in the kitchen), or are used when power cuts occur. Apart from biogas, the slurry produced from the digestion process can replace fertilizers.

The installed biogas units contribute to the reduction of GHG emission in 3 ways:

1. Avoidance of methane emissions from the baseline manure management system by capturing and destroying methane for energy services;
2. Fuel switch from non-sustainable energy sources for cooking and lighting to biogas;
3. The effluent from a biogas system, bio-slurry (digestate), replaces chemical fertilizers.

However, due to the lack of data and for simplification reasons, the emission reductions for the fertilizer substitution will not be accounted for, which increases conservativeness of the calculations. In addition, some household will use biogas for water heating, stable heating and electricity generation. The emission

¹⁰ The higher the temperature the faster the digestion, therefore the volumetric feeding rate can be higher in warm zones compared to areas with lower temperatures such as the North of Vietnam.

¹¹ Training material for Biogas Technician, 2011

reductions from the displacement of grid electricity by these activities will not be accounted for, which is also conservative.

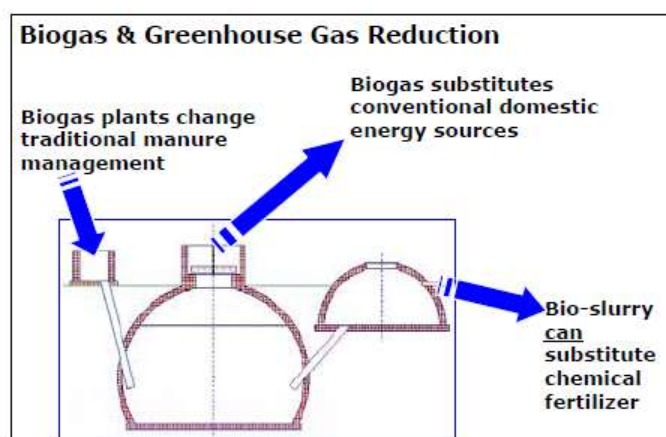


Figure 2: Biogas generation process

The project involves the installation and implementation of model types KT.1 and KT.2 domestic biogas plant or equivalent¹². In case other domestic biogas technologies are included; a detailed description of the equivalent technology will be included in the monitoring report. Each installation will be installed according to the MARD national standard¹³, and in that case the expected lifetime is in the order of 25 years. At the end of this monitoring period around 74.7% of the digesters installed are of KT.1 type and 25.3% of KT.2 type. The KT.1, KT.2 and other models of biogas plants have been developed after 1990s in Vietnam. Development is done by the Institute of Energy as well as others based on earlier Chinese and German design. Design, construction and fitting has been standardized in MARD's "Standards for small size biogas plants # 10 TCN 497 – 2005 - Part 6".

The hemi-spherical fixed dome plants are made on-site, entirely out of brick work. The materials required for construction, including bricks, cement, iron bars, fitting materials etc. are all locally manufactured. Basic appliances, which are also widely available, consist of gas pipe, main valves, stoves and gas lamps. Biogas plants will be installed in the range of 4 m³ to 50 m³ with a current average size of 11.26 m³ (average of units built between 01/01/2007 and 30/06/2013). The size histogram is illustrated as below:

¹² Biogas plants that are recognized in the MARD biogas standard for small scale biogas

¹³ MARD national standard: 10 TCN 97 - 102 – 2006. Issued by decision N^o 4006/QĐ-BNN-KHCN of Ministry of Agriculture and Rural development on 26th December 2006.

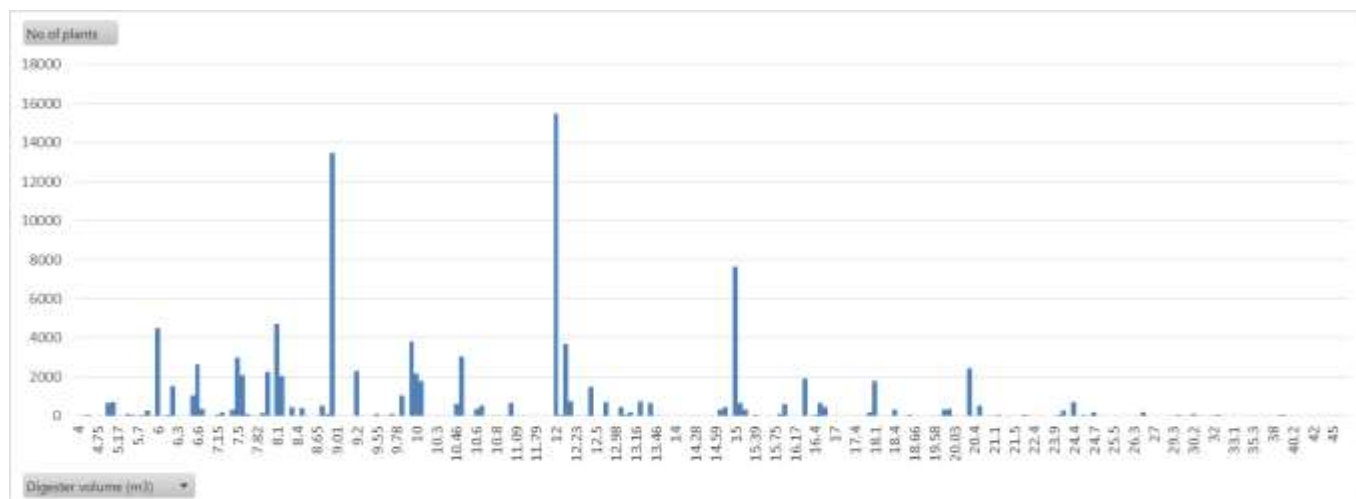


Figure 3: Plants size histogram¹⁴

The number of installed plants per year are as below:

Table 7: Installed plants per year¹⁵

Year	No of plants
2007	14398
2008	15835
2009	22216
2010	23149
2011	13455
2012	13405
2013 (up to 30 Jun 2013)	3713
Total	106171

Both designs need a fair amount of construction skills, but have otherwise proven to be robust and virtually maintenance-free. With feeding of on-farm produced manure of pigs, cattle or buffalo to the digester, biogas will be produced to meet the energy demand of the household. The residue of the digestion process can be used as organic fertilizer.

The KT.1 model is a further development of the model NL.5 of the Institute of Energy and has been accepted widely in the programme.

¹⁴ Details information is in tab "PlansInProvinces" of the "CMS and KPT_sampling HHs" spreadsheet

¹⁵ Details information is in tab "Summary" of the "Usage survey_Sampling HHs" spreadsheet

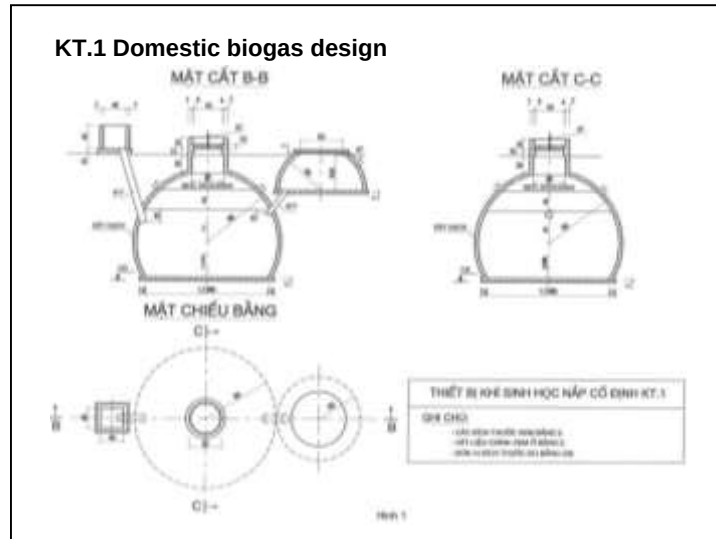


Figure 4: Blueprint of the KT.1 domestic biogas plant

The **KT.2** model follows the TG-BP design as applied in the Mekong Delta by the Can Tho University. Similar to KT.1, the revised design for KT.2 accommodates digester volumes of 4 to 50 m³.

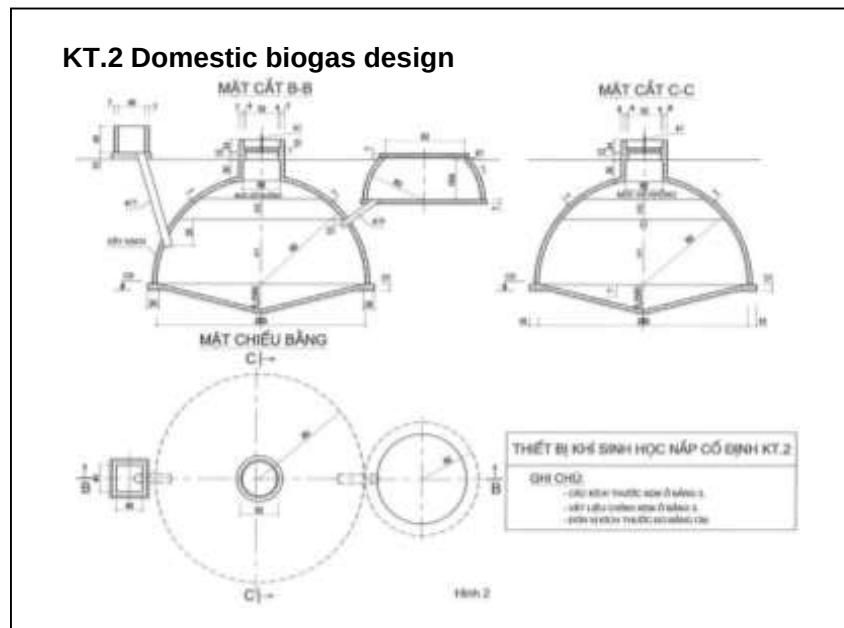


Figure 5: Blueprint of the KT.2 biogas plant design

Although the KT.1 model optimizes material economy best, it needs deeper excavation. For areas with a high water table or rocky ground, the KT.2 is then better suited.

For both models, design variations allow for the type of manure (pig and cattle/buffalo), the dilution ratios of water and manure (1/1, 2/1 and 3/1) and the specific climatic conditions (the North with a cold winter

and the South with a warm winter). The programme uses an elaborate design manual, combining over 100 design variations

B.2. Post registration changes

B.2.1. Temporary deviations from registered monitoring plan or applied methodology

>> N/A

B.2.2. Corrections

>> N/A

B.2.3. Permanent changes from registered monitoring plan or applied methodology

Baseline Field Test (BFT) & Project Field Test (PFT)

According to the registered monitoring plan, the BFT and PFT should be conducted annually for updating the related baseline parameters as well as the parameters in the project scenario. According to the GS issuance review dated 26/02/2013, page 4, and PP response round 2 proposed that “the BFT will only be organized once for the crediting period and the PFT will be biennial”¹⁶. There was a typo mistake from the DOE for MPI between two words “biennial” (which means every two years) and “bi-annually” (which is 2 times per year) in the DOE response round 2. Please find the confirmation in the supporting document named “Confirmation about PFT from GS”.

In summary, the BFT will be conducted once for each crediting period while the PFT will be conducted biennial for the remaining monitoring periods. The BFT and PFT were not conducted during MPI and the result from MPII will be applied retroactively to the MPI credit.¹⁷ Any difference will be deducted/added from the MPII.

B.2.4. Changes to project design of registered project activity

>> N/A

B.2.5. Changes to start date of crediting period

>> N/A

B.2.6. Types of changes specific to afforestation or reforestation project activity

>> N/A

¹⁶ This approach is in accordance to Annex 5 of TPDDTEC methodology, page 49 which states clearly that the PFT should be conducted every two years after first verification.

¹⁷ Refer to the Verification Report No. 01 996 9105066812-GS 1stVeri, Version No. 01.4, 2013-02-21 by TÜV Rheinland (China) Ltd and GS issuance review report date 26/02/2013

B.3. FAR raised in MPI

During the MPI, 5 FARs were raised in DOE Verification Report (Version No. 01.4, dated 21/02/2013) and 1 Forward Action Request was raised in the GS issuance review (dated 26/02/2013).

The FARs from GS issuance review report was addressed as below

Table 8: FARs from GS issuance review report

Contents	Summary of project participants' response
Forward Action Request 1 In future monitoring period, the PP shall report if the trained masons and technicians were chosen in line with the defined rules and the DOE shall verify this	According to the SD indicator number 4 of Quality of Employment, the future target for SD4 is that: "At least 2 district biogas technicians and 2 biogas masons per district provided with training". In order to meet the defined rules, during its implementation, the BP program has been expanding to new districts as well as trained new masons and technician who based in these new districts. In the meantime, the new masons and technicians in existing districts which have only 1 trained mason or technician have also been selected for training to meet the target. In the MPII period (from 01/01/2012 to 30/06/2013), the program provided training for masons and technicians as below¹⁸: For masons: By end of MPI, districts which have at least 1 trained masons were 381 districts (accounted 74.6% of the total 511 districts which have biogas plants). The percentage of district which met the target of having at least 2 masons per district in MPI was 45.6%. During MPII, there were 29 new districts added to the programme and 116 new masons were trained so the total trained masons increased from 922 in MPI to 1038 masons in MPII. The percentage of districts with at least 1 trained mason and districts which met target increased to 80.2% and 49.1%, respectively. For technicians: By the end of MPI, districts which have at least 1 trained technicians were located in 383 districts (accounted 75.0% of the total 511 districts which have biogas plants). The percentage of district which met the target of having at least 2 technicians per district in MPI was 28.0%. During MPII, there were 27 new districts added to the programme and 85 new technicians were trained so the total trained technicians increased from 622 in MPI to 707 technicians in MPII. The percentage of districts with at least 1 trained technician and districts which met target increased to 80.2% and 33.1%, respectively.

The FARs from DOE Verification Report were addressed as below

¹⁸ Detail information are from the training records for masons and technicians.

Table 9: FARs from DOE Verification Report

Contents	Summary of project participants' response
FAR01 Please confirm if any double-counting of the biogas digester households between the VGS and potential subsequent CPA in the CDM PoA under the UNFCCC	During the MPII, there is not any double counting of the biogas digesters between the VGS and the CPA in the CDM PoA under UNFCCC because the soonest start of crediting period of the CPA ¹⁹ is 10/01/2014 while the MPII period is from 01/01/2012 to 30/06/2013.
FAR02 Please ensure the trained masons and technicians were chosen in line with the defined rules in the monitoring of SD parameter of Quality of Employment as requested by GS during the 1st verification.	Please find the response in the table 08 above to the FAR raised by GS.
FAR03 Please ensure the digestate management system implemented by the biogas users in project scenario is monitored and the project emissions is taken account for the methane emissions from digestate as requested by GS during the 1st verification	The project emission from digestate was monitored and calculated in the Section D.2 below.
FAR04 Please ensure the GS approved emission factor of charcoal production is applied as requested by GS during the 1st verification	As from CMS result, there are only 2% of households e using charcoal for the business purpose therefore the emission factor of charcoal production is not applied in the MPII. In future monitoring period if the households using charcoal, the GS approved emission factor will be applied accordingly.
FAR05 Please ensure BFT is conducted once for each crediting period and PFT is carried out biannually ²⁰ for the project activity as approved by GS during the 1st verification referring to Annex 5 of the applied GS methodology	A carbon monitoring survey (CMS) which included the BFT for the first crediting period was executed from January 2014 to April 2014 amongst a representative sample of biogas user with the objective to obtain reliable and unbiased data on the impact of the program on sustainable development and on GHG emission modalities, such as fossil and fuel consumption and manure management practices. According to the Annex 5 of the GS methodology, the PFT should be conducted every two years after the first verification. The first verification was conducted in 2013 and the PFT was conducted in beginning of 2014 or one year after the first verification. The next PFT will also be conducted in beginning of 2016 following the Annex 5 of the GS methodology.

¹⁹ http://cdm.unfccc.int/ProgrammeOfActivities/cpa_db/3TFCA4GQYRDZSBIOPWUMV5086XEN79/view

²⁰ This word "biannually" was a typo mistake from the DOE in their MPI verification report. It was corrected as "biennial" as explained in Section B.2.3 above.

SECTION C. Description of monitoring system

BPD applies three monitoring methods

- Quality control measures
- Carbon monitoring survey
- Usage survey

C.1. Quality control monitoring

The Quality control (QC) on construction is executed by a number of persons: DT (District Technician), PT (Provincial Technician), BPD (Biogas Project Division), PBPD (Provincial Biogas Project Division), the masons and through the independent Biogas user survey. The objectives are:

- Guarantee the accomplishment of a unique standard for the unification of all steps of QC at all levels;
- Manage QC in accordance with the project requirements, at all levels;
- Make sure that biogas plants are constructed under the project standard in terms of design;
- Ensure subsidy provision for each household.

Roles and responsibilities for monitoring

The structure of the monitoring group is as follows:

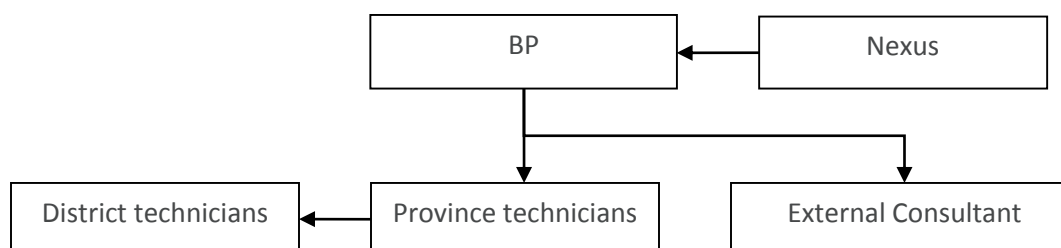


Figure 6: Structure of the monitoring group

The roles and responsibilities are described in the below table.

Table 10: Roles and responsibilities

No	Activity	Roles	Responsibility	Modality
1	Plant commissioning and acceptance	District technician Provincial Technician	District Technicians ensure 100% of all plants are checked The provincial technicians will visit on average 5% of the plants on random sampling basis.	Household visits. Plant and household ID. Construction according to standards and training. Proper functioning.

2	Quality control of “under construction” plant	District technician	The district technicians will visit each and every plants being constructed.	Household visits. Plant and household ID. Construction according to standards and training. Feedback given to the masons to ensure the quality compliance of quality standards.
3	Quality control of “construction completed” plant	Provincial Technician	Based on the received testing & acceptance forms, the provincial technician will, at random, visit 10% of the biogas installations.	Household visits. Plant and household ID. Construction according to standards and training. Proper functioning. Quality check on the data and information filled in the form by the district technicians.
		BP Staff	BP Staff will randomly check 1.5% of the completed plants.	
4	Provisions of after-sale-services and complaints mechanisms	District technician/ Provincial technician will be involved if a problem cannot be solved	100% biogas users will receive post-construction training. The household visit will be implemented upon receiving complaints from biogas users.	Household visit. Plant and household ID, functionality.
5	Biogas User Survey (BUS)	External Consultant	Stratified Random Sample, annual	Household visit. Plant and household ID, functionality and operation. User’s satisfaction, applied benefits and evaluation of the program’s impacts ²¹ .
6	Carbon monitoring and reporting	Nexus	GS monitoring	Household sampling, questionnaire, emission reduction calculation, monitoring report.

The next figure shows a flow chart of the activities number 1, 2 and 3 of the table above. The percentages in the flow chart refer to the percentage of units checked.

²¹ From the MPII, the BUS survey is combined with the carbon monitoring survey (CMS)

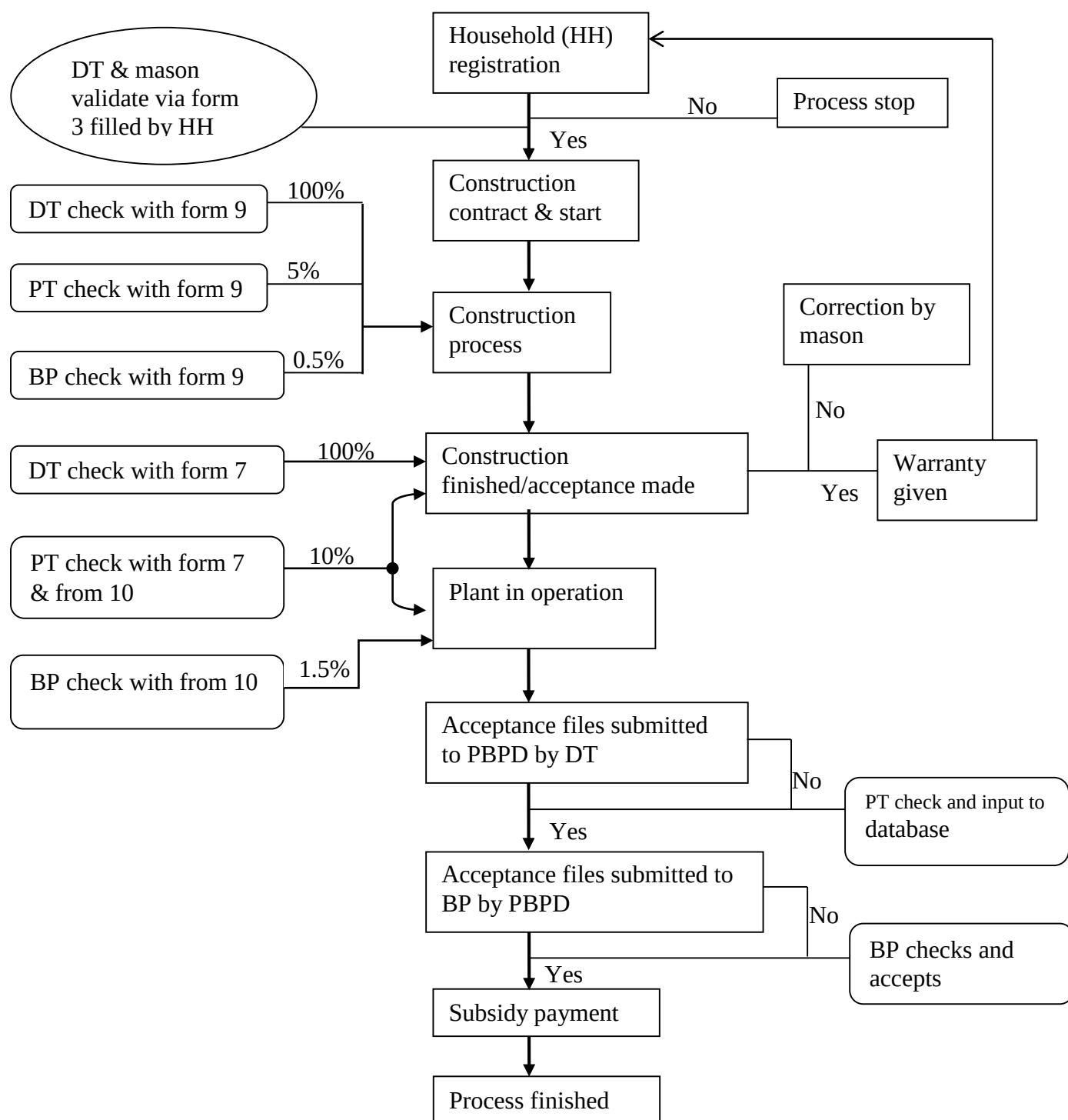


Figure 7: Quality control flow chart enforcement in Biogas Project

Where: DT=District Technician, PT = provincial technician, PBPD= Provincial Biogas Programme Department

Data management and archiving

The hard copies of the main forms above (7 and 9) are entered into the online program database. All the hard copies will be stored at least 5 years after the end of the project activity.

Emergency procedures

The data server has a backup server to avoid deletion or corruption of data. The server service supplier is FPT telecom²² and data will be backed up every 2 days. Besides, the list of plants with household, plants code and other detail information will be extracted to the excel database regularly for each crediting period as an offline backup database.

C.2. Carbon Monitoring Survey (CMS)

A Carbon Monitoring Survey (CMS) was executed from January 2014 to April 2014 amongst a representative sample of biogas user in each climate zone²³ with the objective to obtain reliable and unbiased data on the impact of the program on sustainable development and on GHG emission modalities, such as fossil and fuel wood consumption and manure management practices. Data obtained from each zone will be used to calculate the emission reductions and weighted by the proportion of households that are situated in each zone. The next table shows the CMS studies and the studies included in MPII.

Table 11: Carbon Monitoring Survey (CMS) studies and KPT

#	Name of study	Monitoring interval	MPII
1	Project non-renewable biomass (NRB) assessment;	Once for the first crediting period	fNRB is established once for the first crediting period. The figure from the PDD is adopted for MPII.
2	Project studies (PS) of target population characteristics;	Annual	Included in CMS MPII
3	Baseline Fuel Test and Project Performance Field Test (PFT) of fuel consumption;	Biennial for PFT and once for BFT in this crediting period ²⁴	Included in CMS MPII and retroactively applied to MPI
4	Monitoring of the SD parameters.	Annual	Included in CMS MPII
5	Leakage emission assessment	Every two year after first verification	Not included in CMS MPII as the first verification was conducted in 2013, the leakage emission assessment will be conducted in 2015.

²² <http://www.fpt.vn/en/>

²³ The IPCC provides values for 3 climate zones (cool <15°C, temperate ≥15, < 26°C and warm ≥ 26°C), see Chapter 10: Emissions from Livestock and Manure Management, Volume 4 - AGRICULTURE, FORESTRY AND OTHER LAND USE, 2006 IPCC Guidelines for National Greenhouse Gas Inventories.

²⁴ This is an approved deviation from the Goldstandard during the first monitoring period.

6	Maintenance of total sale record and project database	Continuous	Continuous activity
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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. According to Annex 5 of the applied methodology the NRB assessment shall be updated as proposed by the project proponent (PP). The PP chooses to update the f_{NRB} for each crediting period.

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

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

3. Baseline Fuel Test (BFT) and the Project Performance Field (BFT)

The baseline performance field tests (BFT and project performance field test (PFT) measure real, observed technology performance in the field.

BFT: The BFT will measure baseline fuel consumption. The degree is measured in kg/hh/day.

PFT: The PFT will measure the performance of the biogas plant, which is defined as degree that biogas displaces baseline fuels. The degree is measured in kg/hh/day of baseline fuel).

The measurements will be conducted with calibrated scales. The consultant who conducting the site survey have to maintain and get it calibrated before the expired date or using the new scale. Every scale should have the certification of verification which the expired date is still valid at time of conducting the field survey.

4. Sustainability assessment

The CMS survey includes the monitoring of the SD parameters where it applies to biogas households.

5. Leakage emission assessment

A leakage investigation will be conducted every 2 years after the first verification as per page 49 of the applied methodology. As the first verification was conducted in 2013 so the leakage assessment is not conducted in the current MPII which is taken placed in 2014.

6. Maintenance of total sale record and project database

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

C.3. Usage survey (US)

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.

For example, if only technologies in the first year of use (age 0-1) are being credited, a usage parameter must be established through a usage survey for technologies age 0-1. If an unequal number of technologies in the first year of use (age 0-1) and second year of use (age 1-2) are credited, a usage parameter is required that is weighted to be equally representative of drop off rates for technologies age 0-1 and age 1-2 . The minimum total sample size is 100, with at least 30 samples for project technologies of each age being credited

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

To ensure conservativeness, participants in a usage survey with technologies in the first year of use (age 0-must have technologies that have been in use on average longer than 0.5 years. For technologies in the second year of use (age 1-2), the usage survey must be conducted with technologies that have been in use on average at least 1.5 years, and so on.

The US monitoring procedure applied 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 generator²⁵. Screenshots were made of the generated numbers and 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. BP personal surveyed the sampled households, and the gathered data was entered into a database at the head office after inspection of the quality.
- V. The obtained drop-off rate will be used to discount emission reductions

²⁵ <http://www.graphpad.com/quickcalcs/index.cfm>

SECTION D. Data and parameters

D.1. Data and parameters that are available at validation

Data / Parameter:	EF_{b,CO2}		
Data unit:	kgCO ₂ /TJ fuel		
Description:	CO ₂ emission factor arising from use of fuels in the baseline scenario		
Source of data used:	2006 IPCC Guidelines defaults, see chapter 2 Stationary Combustion: http://www.ipcc-nggip.iges.or.jp/public/2006gl/vol2.html		
Value applied:	Fuel <i>b</i>	EF_{CO2}, (kg/TJ)	
	LPG	63100	
	Charcoal	112000	
	Coal	94 600	
	Firewood	112000	
	Agriculture residues	100000	
	Kerosene	71900	
	Charcoal production	1285 gCO ₂ /kg charcoal ²⁶	
Any comment:	The CO ₂ emissions from agricultural residues are considered renewable; hence the CO ₂ emission will be zero.		

Data / Parameter:	EF_{i,CH4}		
Data unit:	kgCH ₄ /TJ fuel		
Description:	CH ₄ emission factor arising from use of fuels in the baseline scenario		
Source of data used:	2006 IPCC Guidelines defaults see chapter 2 Stationary Combustion: http://www.ipcc-nggip.iges.or.jp/public/2006gl/vol2.html , table 2.9 and for Charcoal production Good Practice Guidance and Uncertainty Management in National GHG inventories: http://www.ipcc-nggip.iges.or.jp/public/gp/bgp/2_2_Non-CO2_Stationary_Combustion.pdf table 1		
Value applied:	Fuel <i>i</i>	EF_{CH4}, (kg/TJ)	
	LPG	11.95	
	Charcoal	330.5	
	Coal	1458.5	
	Firewood	1224	
	Agriculture residues	2210	
	Kerosene	12.6	
	Charcoal production	1000	
Any comment:	Some of the EF values in table 2.9 are ranges; in that case the average value is taken.		

²⁶ Averaged CO₂ emissions from Kirk R. Smith, David M. Pennise (1999) Charcoal-Making Kilns in Thailand. Smith et al reported the CO₂ emission as being between 970-1600 gCO₂/kg charcoal produced, 1285 is the average of that figure. Charcoal kilns are assumed to be similar or better in Thailand compared to Vietnam.

Data / Parameter:	EF_{i,N2O}																
Data unit:	kgN ₂ O/TJ fuel																
Description:	N ₂ O emission factor arising from use of fuels in the baseline scenario																
Source of data used:	2006 IPCC Guidelines defaults, see chapter 2 Stationary Combustion, table 2.9 http://www.ipcc-nggip.iges.or.jp/public/2006gl/vol2.html																
Value applied:	<table border="1"> <thead> <tr> <th>Fuel <i>i</i></th><th>EF_{N2O}, (kg/TJ)</th></tr> </thead> <tbody> <tr> <td>LPG</td><td>2.1</td></tr> <tr> <td>Charcoal</td><td>5.45</td></tr> <tr> <td>Coal</td><td>NA</td></tr> <tr> <td>Firewood</td><td>11.25</td></tr> <tr> <td>Agriculture residues</td><td>9.7</td></tr> <tr> <td>Kerosene</td><td>1.55</td></tr> <tr> <td>Charcoal production</td><td>NA</td></tr> </tbody> </table>	Fuel <i>i</i>	EF _{N2O} , (kg/TJ)	LPG	2.1	Charcoal	5.45	Coal	NA	Firewood	11.25	Agriculture residues	9.7	Kerosene	1.55	Charcoal production	NA
Fuel <i>i</i>	EF _{N2O} , (kg/TJ)																
LPG	2.1																
Charcoal	5.45																
Coal	NA																
Firewood	11.25																
Agriculture residues	9.7																
Kerosene	1.55																
Charcoal production	NA																
Any comment:	Some of the EF values in table 2.9 are ranges; in that case the average value is taken.																

Data / Parameter:	NCV_i														
Data unit:	TJ/Gg														
Description:	Net calorific value of the fuel <i>i</i> used in the baseline														
Source of data used:	2006 IPCC Guidelines defaults, see chapter 1 Energy table 1.2 http://www.ipcc-nggip.iges.or.jp/public/2006gl/vol2.html														
Value applied:	<table border="1"> <thead> <tr> <th>Fuel <i>i</i></th><th>NCV_i (TJ/Gg)</th></tr> </thead> <tbody> <tr> <td>LPG</td><td>47.3</td></tr> <tr> <td>Charcoal</td><td>29.5</td></tr> <tr> <td>Coal</td><td>25.8</td></tr> <tr> <td>Firewood</td><td>15.6</td></tr> <tr> <td>Agriculture residues</td><td>11.6</td></tr> <tr> <td>Kerosene</td><td>43.8</td></tr> </tbody> </table>	Fuel <i>i</i>	NCV _i (TJ/Gg)	LPG	47.3	Charcoal	29.5	Coal	25.8	Firewood	15.6	Agriculture residues	11.6	Kerosene	43.8
Fuel <i>i</i>	NCV _i (TJ/Gg)														
LPG	47.3														
Charcoal	29.5														
Coal	25.8														
Firewood	15.6														
Agriculture residues	11.6														
Kerosene	43.8														
Any comment:															

Data / Parameter:	GWP_{CH4}
Data unit:	tCO ₂ e per tCH ₄
Description:	Global Warming Potential (GWP) of methane
Source of data used:	SAR IPCC
Any comment:	21 and 25 for the first and second commitment period, respectively. Shall be updated to any future COP/MOP decisions

Data / Parameter:	GWP_{N2O}
Data unit:	tCO ₂ e per tN ₂ O
Description:	Global Warming Potential (GWP) of nitrous oxide
Source of data used:	SAR IPCC
Any comment:	310 and 298 for the first and second commitment period, respectively. Shall be updated to any future COP/MOP decisions

Data and parameters not monitored AWMS

Data / Parameter:	VS_(T)												
Data unit:	kg dry matter per animal per day												
Description:	Daily volatile solid excreted for livestock category T												
Source of data used:	Volume 4 of the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, chapter 10 (online: http://www.ipcc-nggip.iges.or.jp/public/2006gl/vol4.html)												
Value applied:	<table border="1"> <thead> <tr> <th>Animal</th><th>VS_(T)</th></tr> <tr> <th>T</th><th>kg/day</th></tr> </thead> <tbody> <tr> <td>Pig</td><td>0.3</td></tr> <tr> <td>Buffalo</td><td>3.9</td></tr> <tr> <td>Dairy cow</td><td>2.8</td></tr> <tr> <td>Cattle</td><td>2.3</td></tr> </tbody> </table>	Animal	VS _(T)	T	kg/day	Pig	0.3	Buffalo	3.9	Dairy cow	2.8	Cattle	2.3
Animal	VS _(T)												
T	kg/day												
Pig	0.3												
Buffalo	3.9												
Dairy cow	2.8												
Cattle	2.3												
Any comment:	Any comment: 365 = basis for calculating annual VS production, days per year												

Data / Parameter:	Bo(τ)		
Data unit:	m³ CH₄ per kg of VS excreted		
Description:	Maximum methane production capacity for manure produced by livestock category T		
Source of data used:	Volume 4 of the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, chapter 10 (online: http://www.ipcc-nggip.iges.or.jp/public/2006gl/vol4.html)		
Value applied:	Animal	VS(τ)	Bo(τ)
	T	kg/day	m3CH4/kgVS
	Pig	0.3	0.29
	Buffalo	3.9	0.1
	Dairy cow	2.8	0.13
	Cattle	2.3	0.1
Any comment:			

Data / Parameter:	MCF_(k)
Data unit:	[-]
Description:	Methane conversion factor for each manure management system by climate region k
Source of data used:	Volume 4 of the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, chapter 10 (online: http://www.ipcc-nggip.iges.or.jp/public/2006gl/vol4.html)
Value applied:	10% for bio-digester systems
Any comment:	

Data / Parameter:	η_{biogasstove}
Data unit:	[-]%
Description:	Combustion efficiency of the biogas stove

Source of data used:	98%, the default value from the GS methodology: Indicative Programme, baseline, and monitoring methodology for Small Scale Bio-digester
Value applied	98%
Any comments	

Data / Parameter:	EF _{awms(T)}																			
Data unit:	kgCH ₄ per animal per year for livestock type T																			
Description:	Animal waste methane emission factor by average temperature																			
Source of data used:	IPCC default values for the region Asia from volume 4 of the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, chapter 10 (online: http://www.ipcc-nggip.iges.or.jp/public/2006gl/vol4.html)																			
Value applied:	<table><tr><th rowspan="2">Animal T</th><th colspan="2">EF (kgCH₄/head/year)</th></tr><tr><th>Temperate zone</th><th>Warm zone</th></tr><tr><td>Pig</td><td>5.00</td><td>7.00</td></tr><tr><td>Buffalo</td><td>2.00</td><td>2.00</td></tr><tr><td>Dairy cow</td><td>23.00</td><td>31.00</td></tr><tr><td>Cattle</td><td>1.00</td><td>1.00</td></tr></table>			Animal T	EF (kgCH ₄ /head/year)		Temperate zone	Warm zone	Pig	5.00	7.00	Buffalo	2.00	2.00	Dairy cow	23.00	31.00	Cattle	1.00	1.00
Animal T	EF (kgCH ₄ /head/year)																			
	Temperate zone	Warm zone																		
Pig	5.00	7.00																		
Buffalo	2.00	2.00																		
Dairy cow	23.00	31.00																		
Cattle	1.00	1.00																		
Any comment:	For baseline emission calculation. The IPCC default value depends on the average annual temperature, and for each zone an average is calculated based on the temperature in participating provinces in the respective zone. The EF values for buffalo and cattle were the same in each province for the temperature ranges observed.																			

D.2. Data and parameters monitored

Data / Parameter:	$f_{NRB,y}$
Data unit:	Fraction of non-renewability
Description:	Non-renewability status of woody biomass fuel in scenario I during year y
Source of data to be used:	Literature review, surveys
Value of data applied for the purpose of calculating expected emission reductions	67%
QA/QC procedures to be applied:	
Any comment:	Fixed by baseline study for each crediting period

Data / Parameter:	$P_{b,y}$
Data unit:	kg/hh/day
Description:	Quantity of fuel that is consumed in the baseline scenario in year y

Source of data to be used:	Original data is in KPT monitoring survey ²⁷ tab “FuelSaving”. Summary result in tab “ER_fuel” of the MPII Monitoring database.		
Value of data applied for the purpose of calculating expected emission reductions	Fuel <i>i</i>		Average per household kg/hh/day
	LPG	0.10	
	Firewood	5.26	
	Agriculture residues	1.88	
QA/QC procedures to be applied:	Fuel data is collected by the third party during the monitoring survey.		
Any comment:	Vietnam consists of two climatic zones, temperate and warm. The average temperature between the zones differs with only around 4 degrees (23 degrees average in temperate zone and 27 in the warm zone). Therefore it is reasonable to assume that fuel use for cooking is independent of temperature and therefore it is not necessary to differentiate in the KPT by climate zone. This is different for the carbon monitoring survey as this includes questions on manure management where certain parameters are temperature dependent.		

Data / Parameter:	P _{h,y}		
Data unit:	kg/hh/day		
Description:	Quantity of fuel that is consumed in the project scenario in year y		
Source of data to be used:	Original data is in KPT monitoring survey tab “FuelSaving”. Summary result in tab “ER_fuel” of the MPII Monitoring database.		
Value of data applied for the purpose of calculating expected emission reductions	Average per household		
	Fuel <i>i</i>	kg/hh/day	
	LPG	0.01	
	Firewood	0.76	
	Agriculture residues	0.28	
QA/QC procedures to be applied:	Fuel data is collected by the third party during the monitoring survey.		
Any comment:	Vietnam consists of two climatic zones, temperate and warm. The average temperature between the zones differs with only around 4 degrees (23 degrees average in temperate zone and 27 in the warm zone). Therefore it is reasonable to assume that fuel use for cooking is independent of temperature and therefore it is not necessary to differentiate in the KPT by climate zone. This is different for the carbon monitoring survey as this includes questions on manure management where certain parameters are temperature dependent.		

Data / Parameter:	U_{p,y}
Data unit:	Percentage
Description:	Percentage of bio-digesters in use in monitoring period y

²⁷ The KPT monitoring survey for this proposed project which include the PFT and the BFT for fuel consumption is required by the methodology as well as requested by the GS during the first verification.

Source of data to be used:	Original data is in Usage survey result, from Group 0-1 to Group 5-6. Summary result in tab “US_results” of the MPII Monitoring database.
Value of data applied for the purpose of calculating expected emission reductions	85.32%
QA/QC procedures to be applied:	Conservative sample of 35 household per year for each programme year was taken instead of 30. All data was collected by provincial or district technicians (expert persons) and checked at national level by BP before entering into the database.
Any comment:	

AWMS data and parameters monitored over the crediting period

Data / Parameter:	$N_{p,y}$
Data unit:	Units
Description:	Number of biogas plants commissioned
Source of data to be used:	BPD database
Value of data applied for the purpose of calculating expected emission reductions	106,171
QA/QC procedures to be applied:	100% of all plants are checked after completion of the construction by the district technician on compliance with the MARD biogas standard. 5% of the plants were visited by the provincial technician for the same check (QC on random sampling basis).
Any comment:	

Data / Parameter:	MS _(T,S,k)				
Data unit:	[-]&				
Description:	Fraction of livestock category <i>T</i> 's manure fed into the bio-digester <i>S</i> , in climate zone <i>k</i>				
Source of data used:	CMS monitoring survey, tab “Data”				
Value of data applied for the purpose of calculating expected emission reductions	The next table shows the share in % of manure fed into the bio-digesters.				
	Climate zone	Pig	Buffalo	Dairy cow	Cattle
	temperate	97.77	25.00	N/A	60.87
	warm	97.63	100.00	N/A	31.78
QA/QC procedures to be applied:	Data will be collected according to the CMS sampling plan				
Any comment:					

Data / Parameter:	$MS_{(P,S,k)}$
Data unit:	[-]&

Description:	Fraction of livestock category T 's manure not fed into the bio-digester S , in climate zone k				
Source of data used:	CMS monitoring survey, tab “Data”				
Value of data applied for the purpose of calculating expected emission reductions	The next table shows the share of manure not fed into the bio-digesters.				
	Climate zone	Pig	Buffalo	Dairy cow	Cattle
	temperate	2.23	75.00	N/A	39.13
	warm	2.37	0.00	N/A	68.22
Monitoring frequency	Annual				
QA/QC procedures to be applied:	Data will be collected according to the CMS sampling plan				
Any comment:	None of the farmers in the sample owned dairy cows				

Data / Parameter:	N(T)		
Data unit:	[-]		
Description:	Number of animals of livestock category T		
Source of data used:	CMS monitoring survey, tab "Data"		
Value of data applied for the purpose of calculating expected emission reductions	Animal T	N(T),h climate zone temperate #	N(T),h climate zone warm #
	Pig	24.94	28.18
	Buffalo	0.05	0.01
	Dairy cow	0	0
	Cattle	0.23	1.98
Monitoring frequency	Annual		
QA/QC procedures to be applied:			
Any comment:	The average number of pig is based on AMS-III.D paragraph 16 (g) with equation 3 on the calculation of average animals held over the year: $N_{LT,y} = N_{da,y} \times \left(\frac{N_{p,y}}{365} \right)$ Where: $N_{da,y}$ = Number of days animal is alive in the farm in the year y (numbers) $N_{p,y}$ = Number of animals produced annually of type LT for the year y (numbers) Source: https://cdm.unfccc.int/UserManagement/FileStorage/U3VXM2PADRFH7YOJBL94ENI18W0CZ5		

Data / Parameter:	PL
Data unit:	%
Description:	Physical leakage of the bio-digester

Source of data to be used:	Default value of the applied methodology is adopted (TPDDTEC page 52)
Value of data applied for the purpose of calculating expected emission reductions	10%
Monitoring frequency	Updated with new IPCC guidance, the PP will check annually if there are new IPCC default values applicable
QA/QC procedures to be applied:	
Any comment:	The physical leakage is not monitored, this is not possible.

Data / Parameter:	EF _{awms,T} ,															
Data unit:	kgCH ₄ per animal per year for livestock type T in the project															
Description:	Animal waste methane emission factor calculated by average local temperatures, IPCC default values and result of CMS monitoring survey.															
Source of data used:	IPCC default values for the region Asia from volume 4 of the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, chapter 10 (online: http://www.ipcc-nggip.iges.or.jp/public/2006gl/vol4.html) CMS monitoring Local temperatures (tab “Input”, monitoring database spreadsheet)															
Value of data applied for the purpose of calculating expected emission reductions	<table><tr><th>EF AWMS by animal</th><th>Zone temperate</th><th>Zone Warm</th></tr><tr><td>Pig</td><td>2.086</td><td>2.171</td></tr><tr><td>Buffalo</td><td>4.530</td><td>9.537</td></tr><tr><td>Dairy cow</td><td>0.000</td><td>0.000</td></tr><tr><td>Cattle</td><td>3.791</td><td>2.731</td></tr></table>	EF AWMS by animal	Zone temperate	Zone Warm	Pig	2.086	2.171	Buffalo	4.530	9.537	Dairy cow	0.000	0.000	Cattle	3.791	2.731
EF AWMS by animal	Zone temperate	Zone Warm														
Pig	2.086	2.171														
Buffalo	4.530	9.537														
Dairy cow	0.000	0.000														
Cattle	3.791	2.731														
Any comment:	For project emission calculation. The IPCC default value depends on the average annual temperature. EF _{awms,T} is calculated from average local temperature, the IPCC default values such as VS(T), Bo(T), MCF(k) and also the actual waste management practice MS _(T,S,k) from CMS monitoring.															

Data / Parameter:	PE _{bio-slurry}															
Data unit:	tCO ₂ /year															
Description:	Emissions from anaerobic disposal of bio-slurry															
Source of data used:	Original data is in CMS monitoring survey, tab “Data”. Summary result in tab “PE_Bioslurry” of the MPII Monitoring database.															
Value of data applied for the purpose of calculating expected emission reductions	For 2012 vintage: <table><tr><th colspan="4">Average Bio-slurry emissions</th></tr><tr><th></th><th>Units</th><th>CO2e/unit</th><th>CO2e</th></tr><tr><td>Temperate</td><td>81,805</td><td>0.011</td><td>921</td></tr></table>				Average Bio-slurry emissions					Units	CO2e/unit	CO2e	Temperate	81,805	0.011	921
Average Bio-slurry emissions																
	Units	CO2e/unit	CO2e													
Temperate	81,805	0.011	921													

	Warm	24,366	0.016	394
	Total	106,171		1315
	Average emissions	0.012	tCO ₂ e/year/hh	
	For 2013 vintage:			
	Average Bio-slurry emissions			
		Units	CO₂e/unit	CO₂e
	Temperate	81,805	0.013	1097
	Warm	24,366	0.019	469
	Total	106,171		1566
	Average emissions	0.015	tCO ₂ e/year/hh	
Any comment:				

D.3. Implementation of sampling plans

D.3.1. Sampling approach

The next table summarizes the design of the surveys:

Table 12: Survey designs summary

Item	CMS survey	PFT	BFT	Usage survey
Target group	Users with a bio-digester	Users with a bio-digester	Households without a bio-digester	Households with a bio-digester that has been in use for at least 6 months before the end of MPII
Main topics	User characteristics, AWMS and SD survey	Project fuel use	Baseline fuel use	Drop-off rate
Sampling method	Cluster sampling	Probability proportional to size sampling	Selection based on PFT sampling frame	Cluster sampling
Cluster	District	District	PFT cluster	Age group
Sample size	17 households (including 10% oversampling)	3 households per district ²⁸	3 households per district	35 household (oversampling with 5 households)

²⁸ The BFT and PFT were combined with the CMS survey. The 3 PFT households will be randomly selected from those 17 households of each CMS cluster

Number of clusters	20 (10 for each zone)	20	20	6
Total sample size	340	60	60	210

D.3.2. CMS survey

The CMS sampling plan is implemented according to the registered monitoring plan as follow:

Table 13: CMS survey design

Sampling plan	Sampling MPII
Sampling objective:	The objective of the sampling effort is to obtain reliable data for the CMS survey;
Field Measurement Objectives and Data to be collected:	The survey will consist of household visit in random selected end-users to collect data described in PDD section B.7.1. Data will be collected using interview methods;
Target Population and Sampling Frame:	As Vietnam consists of two climate zones, temperate and warm, the CMS will study each zone separately ²⁹ . The ERs are calculated based on the information gathered from both zones, and in case one zone contains more households than the other, a proportional weight is applied to the larger zone to adjust for the size difference. The sampling frame for each climate zone will be drawn from the database; all households in the sampling frame represent the target population. Target population membership is recorded in the database and uniquely identifiable based on the ID code of the biogas plant.
Sampling method (approach):	Clustered random sampling in each climate zone, in each climate zone 10 clusters will be selected randomly for each monitoring interval. One cluster is one district. The clusters are selected by applying the Probability-Proportional-to-size (PPS) random cluster sampling using 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 are chosen from each cluster at the second stage. The primary sampling units, the clusters, are randomly selected districts and the second sampling units are randomly selected households belonging to the target group in the clusters. PPS sampling is statistically the most significant sampling method as it ensures that each household has the same probability to be selected. The two zones are based on IPCC climatic classification: temperate and warm. Data obtained from both zones will be aggregated proportionally (a weight will be applied to the data of each zone based on the total number of biogas households in each zone i.e. if zone A is has only 25% of the households in zone B, the weight of zone B is 3 and zone A 1).

²⁹ The IPCC distinguishes 3 climate zones: cool <15°C, temperate ≥15, ≤ 25°C and warm > 25°C, see Chapter 10: Emissions from Livestock and Manure Management, Volume 4 - AGRICULTURE, FORESTRY AND OTHER LAND USE, 2006 IPCC Guidelines for National Greenhouse Gas Inventories.

Implementation:	The CMS was executed by a selected independent consultant in from Feb to Apr 2014.
Desired Precision/Expected Variance and Sample Size.	The confidence precision level will be based on the VGS methodology guidance.
Procedures for Administering Data Collection and Minimizing Non-Sampling Errors:	The standard procedure for conducting the data collection is the following steps (1) Development of questionnaire; (2) Training and selection of surveyors; (3) Pilot testing of the questionnaire to ascertain that the questionnaire is appropriate and yields the required information. (4) Field survey.

Sample size:

The sample size equation which was mentioned in the registered PDD, page 57 was:

$$n = \frac{Nx}{1 + Nx(e)^2}$$

Where:

- n = minimal sample size
- e = level of precision (10%)
- Nx = the BP biogas population in zone x
- x = Temperature zone (warm or temperature)

The above formulae is for calculating the minimum number of samples. In the following section of the PDD (page 58, 59) the designed effect (D=1.5) and rate of oversampling (10%) was also discussed to cover the loss of effectiveness when conduct cluster sampling and non-responses of surveyed households.

Therefore in this current monitoring report, the sample size equation was combined all above factors together to one formulae as below³⁰:

$$n = \frac{Nx}{1 + Nx(e)^2} * D * 110\%$$

Where:

- n = minimal sample size
- e = level of precision (10%)
- Nx = the BP biogas population in zone x
- x = Temperature zone (warm or temperature)
- D = Design effect (1.5 according to the approved PDD page 59)
- 110% = Oversampling rate (according to the approved PDD page 59)

Table 14: Minimum sample size per zone³¹

Zone	Classification	N	Calculated n	Round up n
A	Temperate	81,805	164.80	170
B	Warm	24,366	164.33	170

³⁰ Please refer to the registered PDD for more detail.

³¹ Details calculation in row 133 of tab "Input" of the "MPII_Monitoring database" spreadsheet

Total

340

The calculated n is 170 households for each zone. According to the registered PDD, in each climate zone 10 clusters will be selected randomly for each monitoring interval, one cluster is one district. Therefore, the cluster sample size is consequently $170/10 = 17$.

The total sample size, in the two zones and 10 clusters per zone, will then be $17 \times 10 \times 2 = 340$ households.

Sampling procedure – cluster selection

The sampling procedure of the district selection consisted of the following steps:

- Drafting a list of districts by zone;
- Random selection of 10 districts in each zone base on the probability proportional to size method using a random number generator;
- In case a district does not contain enough samples, the neighboring district was also included in the cluster. This can happen as continuously new districts are included in the program. Initial installation rates are very low in the newest districts.

Sampling results

Warm zone:

- List all districts in the project area and their population in Temperate zone (column A and B in tab “Warm” of the “CMS and KPT_Sampling HHs” excel database. There are 191 districts in total.
- Calculate the running cumulative population (Column D). The last number in this column is the total population of the project area. In this project case, the total population is 24,366.
- Determine the number of sites which is 10 according to the approved PDD
- The Sampling Interval (SI) will be determined by dividing the total population of the project area by the number of sites which results 2,437.
- Choose a number between 1 and the SI at random. This is the *Random Start* (RS). In this sample, the RS is 1,689.
- Calculate the following series: RS; RS + SI; RS + 2SI; RS + 3SI; RS + 4SI; RS + 5SI; RS + 6SI; RS + 7SI; RS + 8SI; RS + 9SI. The result are in the following table:

Table 15: Sampled steps for warm zone

No	Interval	Value
1.	RS	1,689
2.	RS + 1SI	4,126
3.	RS + 2SI	6,563
4.	RS + 3SI	9,000
5.	RS + 4SI	11,437
6.	RS + 5SI	13,874
7.	RS + 6SI	16,311
8.	RS + 7SI	18,748
9.	RS + 8SI	21,185
10.	RS + 9SI	23,622

- Each of these 10 numbers corresponds to a site on the list of district. The districts selected are those for which Column D, the cumulative population, contains the numbers in the series calculated above. For example, the second number in the series (4,126) is contained in district named “CAM RANH-Khanh Hoa”, which holds numbers from 4,048 to 4,136. The third number in

the series (6,563) is contained in district named “Dien Khanh-Khanh Hoa”, which holds numbers from 6,519 to 6,619.

- Continuing in this manner, the desired number of sites will be selected as below

Table 16: Randomly selected clusters in zone B: Warm³²

#	Cluster	Number of plants in cluster
1	Ba Tri-Ben Tre	457
2	CAM RANH-Khanh Hoa	88
3	Dien Khanh-Khanh Hoa	100
4	H. Go Cong Tay-Tien Giang	528
5	Huyen Chau Phu-An Giang	231
6	Huyen Phu Tan-An Giang	144
7	Nhon Trach-Dong Nai	80
8	Tay Son-Binh Dinh	1185
9	Thi xa Tan Chau-An Giang	96
10	Van Canh-Binh Dinh	85

Temperate zone

Similarly, the following districts were selected for zone Temperate. Details for selection result could be found in tab “Temperate” of the CMS and KPT excel database.

Table 17: Randomly selected clusters in zone A: Temperate³³

#	Cluster	Number of plants in cluster
1	Binh Luc-Ha Nam	905
2	Dong Hung-Thai Binh	392
3	Hoang Hoa-Thanh Hoa	428
4	Kim Bang-Ha Nam	704
5	Luong Tai-Bac Ninh	644
6	Phu Luong-Thai Nguyen	364
7	Tam Duong-Vinh Phuc	505
8	Thanh pho Yen Bai-Yen Bai	239
9	Tinh Gia-Thanh Hoa	392
10	Yen Binh-Yen Bai	385

The next figure shows the selected districts in Vietnam. Evidences of the random selection and screenshots are available to DOE at verification.

³² Details calculation in tab “Warm” of the “CMS and KPT_Sampling HHs” excel file

³³ Details calculation in tab “Temperate” of the “CMS and KPT_sampling HHs” excel spreadsheet

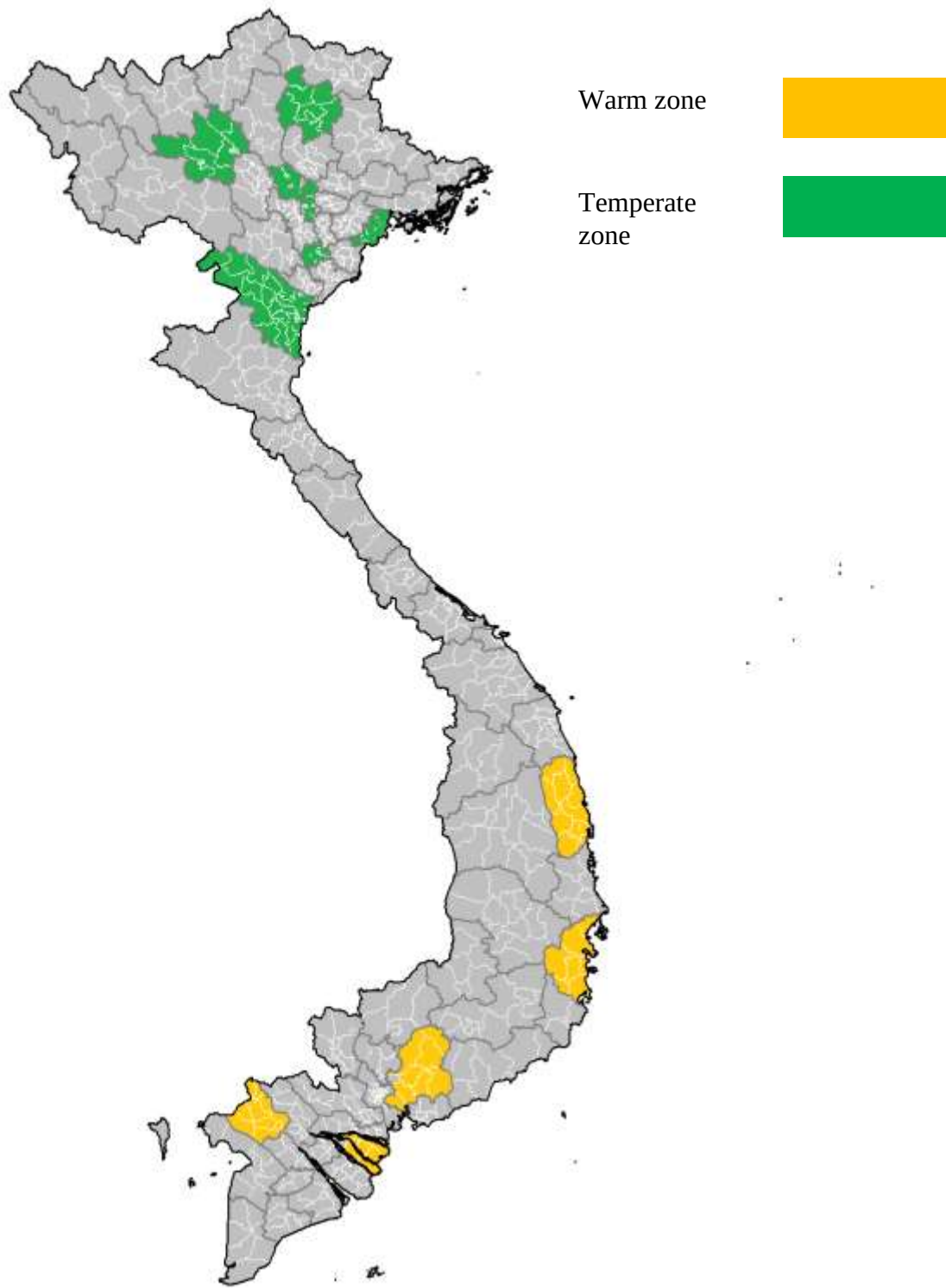


Figure 8: Selected provinces by climate zone

Sampling procedure – household selection

The households are selected according to the following procedure:

- Gathering of all biogas user data of the selected clusters by zone;

- Random selection of 17 households in each cluster using a random number generator;
- Gathering the selected households in a list for survey execution.

Since the list is very large, 340 households, it is not attached as Annex. The list of the randomly selected households is available at request for inspection.

Back up households

For each cluster, 17 backup households which are randomly selected were also prepared. It may happen that households are not at home and in that case the household is replaced from a list of backup households.

D.3.3. 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 protocol³⁴:

- Test period shall be 1 days = the measurement campaign (MC).
- The selected test day will span fuel measurement consumption for human food cooking, boiling water and animal feed preparation totalling 24 hours.
- Cooking practices shall be during 'normal days'.
 - o Normal days are defined as periods outside festivals or holidays and during the week. The MC can take place in the weekend if it can be demonstrated that fuel use is not higher during these days (i.e. the same number of people eat meals as during the week). This was for example the case in GS751.
 - o Pig farming has a cyclic nature with continued successive cycles of pig breeding – fattening – breeding. Only the number of sows is stable throughout the year. Normal days for pig farming are defined as the moment that the farmer has the average or a lower number of pigs.
- The KPT questionnaire also addressed seasonality by asking if the selected day is representative for the whole year. If the majority responds that the day is not representative, the KPT will be executed during the season with the lowest fuel use.
- Households are instructed that they cook normally during the test. The aim is to capture their usual behaviour in the kitchen, as if no tests were happening, to feed the usual variation of people with the usual variation of food types.
- To conduct the tests, ensured is that the cook uses fuel only from a designated stock which is pre-weighed.
- During the tests, also was find out how many people have eaten and how many meals each, so that you can enter into the data sheet the number of "person-meals" (individual meals as opposed to meals shared) cooked with the weighed fuel each day. Note that this count can include meals sold commercially as well as meals consumed in the domestic environment. The number of people eating meals shall be recorded using the following categories: Child 0-14 years, Female over 14 years, male 15-59 and male over 59 years old.

³⁴ The KPT protocol is based on the approved guidelines used by GS751 project. This protocol was sent to GS on 27/09/2013 for approval before implementation.

- The fuel is typical of the fuel normally used through the year. It is also important that the subjects are paying for fuel so they have an incentive to conserve it. Subjects can be told they will be rewarded for their effort and time at the end of the test, once it is successfully completed.
- A quality control phone call will be made in the evening to ensure that the household properly understands the purpose and method of the KPT.

The measurements were conducted with calibrated scales of 15 ± 0.02 kg. The figures below showed the scale and its certificate of calibration by the Quality Assurance And Testing Center 1 (QUATEST 1).



Figure 9 Calibrated scale for survey

The KPT targets two groups:

Table 18: KPT target groups

Group	Description of target group	Sample size
PFT household	Randomly selected household from the project database with a bio-digester	60
BFT household	Nearest equivalent households to the randomly selected project household by a selection criteria of non-biogas household in perception of similar cook stoves, difference in number of animals as below: • Similar number of household members: ± 2 people • Similar cooking stove type: either open stove (3,4 legs), closed stove (cement, brick, clay), home comb stove, LPG stove, kerosene stove • Similar house appearance or economic wealth: relative impression • Similar types and quantities of animals: same type, each type of animals, $\pm 30\%$ in quantity each type	60
	Total sample	120

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

KPT survey design

Vietnam consists of two climatic zones, temperate and warm. The average temperature between the zones differs with only around 4 degrees, 23 degrees average in temperate zone and 27 in the warm zone. Therefore fuel use for cooking is not dependent of temperature and it is not necessary to differentiate in the KPT by climate zone. This is different for the carbon monitoring survey as this includes questions on manure management for which important emission parameters, such as MCF, are temperature dependent.

The KPT will therefore target all the provinces where GS1083 is active. The KPT consists of 2 target groups which are PFT households and BFT households.

Sampling method: Cluster sampling with probability proportional to cluster size random sampling. This method is chosen as simple random sampling is impractical in a country the size of Vietnam. Hereunder it will be discussed how conservativeness and precision is warranted with that approach.

Sizing of the sample:

- a. As per methodology, at least 30 BFT and 30 PFT households for simple random sampling
- b. Design effect³⁵: Usually the design effect (D) of 1 to 3 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 bio-digester 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 BP as the households to be surveyed are known. It is good practice to employ oversampling not only to compensate for any attrition, outliers or non-response associated with the sample but also for the reason that in the event the required reliability is not achieved additional sampling efforts would be required to determine the parameter value (CDM EB 65 Annex 2). Oversampling is employed by increasing the sample size by 10%.
- c. The total HHs in PFT to be select will be:

$$N_{PFT} = 30 * 1.5 * 1.1 \sim 50$$

$$N_{BFT} = 50$$

The total sample size will be 50 per group, and 100 in total for the PFT.

Number of clusters

According to Purnami et al (2011)³⁶ a reliable way of cluster selection is with the following equation:

$$k \approx \left(\frac{n}{2}\right)^{1/2}$$

³⁵ For more details, please referred to the registered PDD

³⁶ International Journal of Database Theory and Application Vol 4 No.1 March 2011. Available online:
http://www.sersc.org/journals/IJDTA/vol4_no1/3.pdf

Where k is the minimum sample of clusters and n the total population of clusters.

In the case of GS0183, there are 511 districts³⁷, one district is one cluster. Therefore there are 511 clusters. The number of sampled cluster are:

$$k \approx \left(\frac{511}{2} \right)^{1/2} \approx 16$$

Combining CMS and KPT

The carbon monitoring survey of GS1083 also performs cluster sampling and selects 10 clusters in each climate zone (temperate and warm). The total number of clusters for the CMS is therefore 20. The KPT is executed in the same clusters as the CMS, which is conservative as it would mean surveying not in 16 but in 20 clusters.

CMS and KPT Households per cluster (Sampling frame)

The minimum number of households is 50 for the PFT and BFT. Since it is not possible to divide 50 households over 20 clusters the project participant increased the sample size to 60, or 3 per cluster (3 BFT and 3 PFT). This is conservative.

In case of the CMS there are 17 households per cluster, the 3 PFT households will be randomly selected from those 17. Because these 17 households are randomly selected in each cluster, the random selection of these 3 households among them still satisfy the random selecting method.

BFT households: As the baseline households are not known ex-ante and because there is no national database to sample from, the sample frame of the PFT is used for the BFT. The BFT household will be a matching neighboring household to the PFT household. The match, or equivalence, will be checked in the BFT questionnaire as below.

Table 19: Questionnaire for selecting a BFT HH

Area of comparison	Non-biogas HH (BFT)	Biogas HH (PFT)	Criteria for non-biogas HH	Criteria met (Y/N)?
No of member			± 2 to biogas HH	
Cooking stove type			Similar to biogas HH used	
House appearance/ economic status			indicator for relative wealth	
Type and quantity of animal			same as PFT HH ±30% (pigs, cow, buffalo)	
Reason for considering this HH as equivalent to PFT HH				

³⁷ According to the project database.

Following the GS comments during issuance review, the following baseline scenarios were segregated:

- Baseline scenario 1: LPG only households (22 household). Among them, 5 household are outlier so they are removed from the ER estimation.
- Baseline scenario 2: Biomass (fuel wood or agricultural residues) only households. There are 19 households.
- Baseline scenario 3: Mix fuel (LPG and biomass) households. There are 19 households. Among them, 1 household is outlier so it is removed from the ER estimation.

90/30 rule check

The precision has been calculated and the 90/30 rule according to the GS methodology was checked. In case the 90/30 check of emission reduction of any baseline scenario was fail, it will be applied the 90% confidence rule.

D.3.4. Usage survey design (US)

The table below summarize the sampling plan for usage survey

Table 20: US Sample plan and objective

Sampling plan	Sampling MPII
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, each observation is chosen randomly and entirely by chance, such that each observation has the same probability of being chosen.
Implementation:	The US was executed in Dec 2013 and will be executed annually after the first verification ³⁸
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 210 households, BP ensured that the minimum requirements were easily met.
Procedures for Administering Data Collection and Minimizing Non-Sampling Errors:	Data was checked by the BP staff at the head office

The next table shows the number of households selected by age group and the population of units that belongs to that age group. Of each age group 35 units were selected randomly

³⁸ According to Annex 5 of the methodology "Technologies and Practices to Displace Decentralized Thermal Energy Consumption"

Table 21: Usage survey selection by age group

Year	Age group	Units included that are at least in use for (years)	Period inclusive of both dates		Units built in that period (age group population)	Sample drawn from units built (at random)	Numbers in use	Usage rate
2012	0-1	0.5	01/01/12	31/12/12	13,455	35	34	97.1%
2011	1-2	1.5	01/01/11	31/12/11	13,455	35	31	88.6%
2010	2-3	2.5	01/01/10	31/12/10	23,149	35	31	88.6%
2009	3-4	3.5	01/01/09	31/12/09	22,216	35	31	88.6%
2008	4-5	4.5	01/01/08	31/12/08	15,835	35	32	91.4%
2007	5-6	4.5	01/01/07	31/12/07	14,398	35	31	88.6%
Weight average of usage rate								90.1%

Among the units which are in operation, some of the bio-digester units may undergo periodically emptying and are therefore not in use for a number of days. Other causes of temporarily non-use of the digester are repairs. Therefore the days without biogas were taken into account in the effective usage rate which calculated as below³⁹:

$$U_{Fy,h} = U_{y,h} \times U_{py,h}$$

Where:

$U_{Fy,h}$ = Effective 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)

$U_{y,h}$ = 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)

$U_{py,h}$ = Uptime (having biogas)

The weighted average uptime was calculated according to the table below:

Table 22: Weighted average uptime⁴⁰

Age group	Average number of days that units are not in operation in survey sample (days/unit)	Number of not working days in group	Total number of days in group
0 - 1	0.029	383	455,770
1 - 2	0.829	11,148	417,105
2 - 3	2.200	50,928	717,619
3 - 4	2.143	47,606	688,696
4 - 5	2.229	35,289	506,720
5 - 6	1.886	27,151	446,338

³⁹ For more detail, please refer to the MPI monitoring report (page 42).

⁴⁰ For more detail, please refer to the tab "US_results" of the "MPII_Monitoring database" spreadsheet

Sum	172,505	3,232,248
Weighted average share of units in operation		94.66%

Therefore the effective cumulative usage rate is:

$$U_{Fy,h} = U_{y,h} * U_{py,h} = 85.32\%^{41}$$

D.3.5. Household characteristics

Roles of respondents in households

The majority of biogas respondents are plant owners then his/her wife/husband, children and parents. There were 3 biogas households with responses from a brother/sister of the household owner. The graph below presents the relation of respondents to the head of the surveyed households in all surveyed biogas households, in biogas households with PFT.

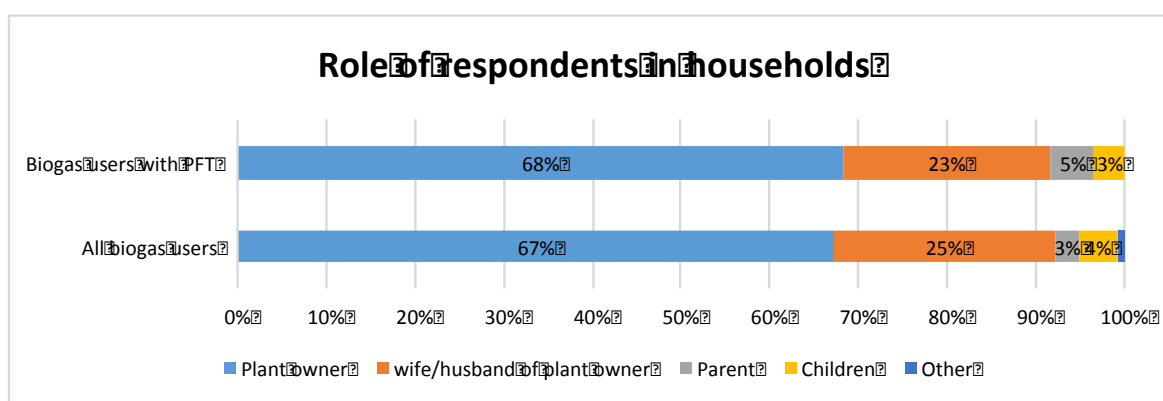


Figure 10: Role of respondents in households

Gender and age of respondents

65% of the biogas respondents were male and 35% were female. Respondents are from 19 to 87 years old, in which the majority is from 40 to 60. The graph below shows the distribution of respondents by gender.

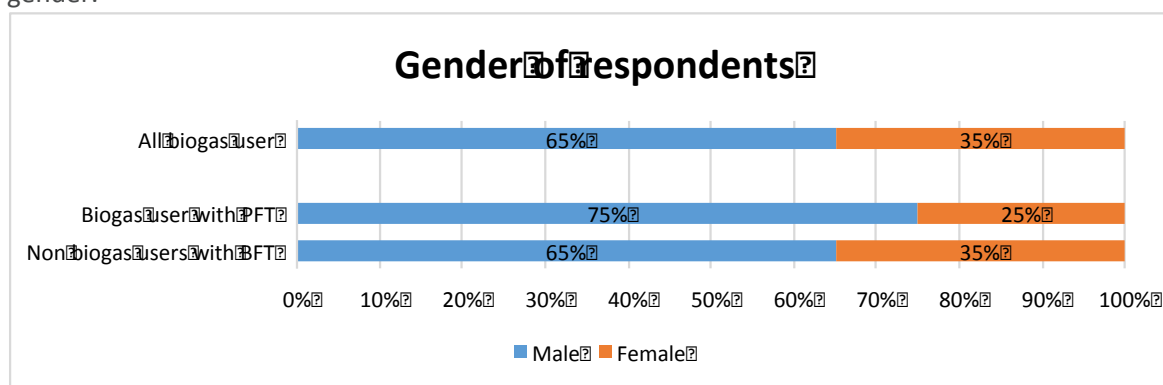


Figure 11: Gender of household respondents

⁴¹ Therefore the units in use for the ER calculation are $106,171 * 85.32\% = 90,589$; or the units dropped out are $106,171 - 90,589 = 15,582$ units.

Family size

The family size is identified with number of people living in the surveyed households at the surveying time. The size of surveyed households ranged from 1 to 16 members. There were 97% of surveyed households (biogas and non-biogas users) with from 1 to 7 members living in the house.

On average, each biogas household had 4.47 people. This number in biogas households with PFT and non-biogas households were 4.45 and 4.37

Size of bio-digesters

The average value of 340 surveyed bio-digesters and 106,171 bio-digesters in the period 2007-2013 from database was 10.26m³ and 11.26 m³ respectively.

Fuel type

The surveyed households use many types of fuel such as firewood, coal/honeycomb coal, charcoal, LPG, agriculture residues and biogas for their preparation of human food (including boiling water), animal feeds and of other businesses (as wine, tofu, etc.). Firewood is most often seen and being used as main fuel for cooking. There was no HHs using kerosene for these purposes.

SECTION E. Calculation of emission reductions or GHG removals by sinks

The CMS and KPT survey were conducted with the representative samples of end users in the project scenario and the baseline scenario. These selection follow the random method as well as addressed the abnormal situation, seasonality issues therefore the results are representative for the whole monitoring period.

E.1. Calculation of baseline emissions or baseline net GHG removals by sinks

E.1.1. Ex-post Baseline emission from thermal energy demand

Table 23: NCV of fuels

Fuel_i	NCV_i (TJ/Gg)
LPG	47.3
Firewood	15.6
Agriculture residues	11.6

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 24: CO₂, CH₄ and N₂O emission factors

Fuel <i>i</i>	EF_{CO2}, (kg/TJ)	EF_{CH4}, (kg/TJ)	EF_{N2O}, (kg/TJ)
----------------------	--------------------------------------	--------------------------------------	--------------------------------------

Firewood	112000	1224	11.25
Agriculture residues	100000	2210	9.7

The f_{NRB} is estimated to be 67%, the NRB assessment can be found in Annex 3 of the registered PDD. The f_{NRB} value is applicable to CO₂ emissions from firewood, agricultural residues and charcoal consumption and production. Methane and nitrous oxide emission is 100% non-renewable by definition. The baseline emission is the baseline thermal energy consumption multiplied by emission factors and the global warming potential of each GWP. The GWP applied for the first commitment period (before 2013) were taken from the Second Assessment Report of the IPCC, 21 and 310 for CH₄ and N₂O respectively. For the second commitment period (from 01/01/2013), the GWP are 25 and 298 for CH₄ and N₂O respectively.⁴²

The ex-post baseline emissions will be calculated as follow:

$$BE_{th,h} = \sum_i (f_{NRB,y} F_{i,bl,h} \times NCV_i \times EF_{CO2,i} + F_{i,bl,h} \times NCV_i \times EF_{nonCO2,i})$$

Where

$BE_{th,h}$	=	The total baseline emissions from the thermal energy demand of one household (tCO _{2e} /year)
$f_{NRB,y}$	=	Fraction of biomass during year y that is non-renewable (100% for fossil fuels)
$F_{i,bl,h}$	=	Quantity of fuel <i>i</i> consumed in the baseline during year y (kg/household/year) Total amount of fuel type <i>i</i> in the baseline scenario (kg/year) of one household
NCV_i	=	Net Calorific Value of fuel type <i>i</i> (TJ/ton of fuel)
$EF_{CO2,i}$	=	The CO ₂ emission factor per unit of energy of fuel <i>i</i> (tCO _{2e} /TJ)
$EF_{nonCO2,i}$	=	The nonCO ₂ emission factor per unit of energy of fuel <i>i</i> (tCO _{2e} /TJ)

Emission reduction with baseline scenario 1:

For 2012 vintage:⁴³

$$BE_{th,h,LPG,(2012\ vintage)} = 0.16 \text{ (tCO}_{2e}\text{/year)}$$

For 2013 vintage⁴⁴:

$$BE_{th,h,LPG\ (2013\ vintage)} = 0.16 \text{ (tCO}_{2e}\text{/year)}$$

Emission reduction with baseline scenario 2:

For 2012 vintage:⁴⁵

$$BE_{th,h,Biomass,(2012\ vintage)} = 6.56 \text{ (tCO}_{2e}\text{/year)}$$

For 2013 vintage⁴⁶:

$$BE_{th,h,Biomass\ (2013\ vintage)} = 6.92 \text{ (tCO}_{2e}\text{/year)}$$

⁴² http://www.ipcc.ch/publications_and_data/ar4/wg1/en/ch2s2-10-2.html

⁴³ Details calculation in cell V68, sheet "BFT_LPG" of the "MPII_Monitoring database_2012 vintage" spreadsheet.

⁴⁴ Details calculation in cell V68, sheet "BFT_LPG" of the "MPII_Monitoring database_2013 vintage" spreadsheet

⁴⁵ Details calculation in cell V68, sheet "BFT_Biomass" of the "MPII_Monitoring database_2012 vintage" spreadsheet.

⁴⁶ Details calculation in cell V68, sheet "BFT_Biomass" of the "MPII_Monitoring database_2013 vintage" spreadsheet

Emission reduction with baseline scenario 3:

For 2012 vintage:⁴⁷

$$BE_{th,h,Mix,(2012\ vintage)} = 4.15 \text{ (tCO}_2\text{e/year)}$$

For 2013 vintage⁴⁸:

$$BE_{th,h,Mix,(2013\ vintage)} = 4.44 \text{ (tCO}_2\text{e/year)}$$

Emission reduction for fuel:

The weighted average emission reduction for fuel is:

For 2012 vintage:⁴⁹

$$BE_{th,h,Mix,(2012\ vintage)} = 3.14 \text{ (tCO}_2\text{e/year)}$$

For 2013 vintage⁵⁰:

$$BE_{th,h,Mix,(2013\ vintage)} = 3.33 \text{ (tCO}_2\text{e/year)}$$

E.1.2. Ex-post Estimation of baseline emissions from AWMS

The following equation is applied to estimate the baseline emissions from animal waste management systems:

$$BE_{awms,h} = GWP_{CH_4} * \sum_T (EF_{awms(T)} * N_{(T),h})$$

Where:

$BE_{awms,h}$

GWP_{CH_4}

$N_{(T),h}$

$EF_{awms(T)}$

The baseline emissions from handling of animal waste in premise h (tCO₂e/year)
Global warming potential of methane (tCO₂e per tCH₄). The GWP applied for the first commitment period (before 2013) were taken from the Second Assessment Report of the IPCC, 21 and 310 for CH₄ and N₂O respectively. For the second commitment period, the GWP are 25 and 298 for CH₄ and N₂O respectively
The number of animals of livestock species per category T⁵¹
Emission factor for the defined livestock population category T, (ton CH₄ per head per yr). The relevant Default methane emission factor for livestock for default animal waste methane emission factors by temperature and region can be found in tables 10.14, 10.15 & 10.16 in Chapter 10: Emissions from Livestock and Manure Management, Volume 4 - AGRICULTURE, FORESTRY AND OTHER LAND USE, 2006 IPCC Guidelines for National Greenhouse Gas Inventories.

The IPCC lists for each regions default values for methane emissions from AWMS at various average temperatures in chapter 10 volume 4 of the IPCC 2006 guidelines. As Vietnam has more than 1 climate zones, a determination of the IPCC default value for each climate zone is required. Climate data for each

⁴⁷ Details calculation in cell V68, sheet "BFT_Mix" of the "MPII_Monitoring database_2012 vintage" spreadsheet.

⁴⁸ Details calculation in cell V68, sheet "BFT_Mix" of the "MPII_Monitoring database_2013 vintage" spreadsheet

⁴⁹ Details calculation in cell G2, sheet "ER" of the "MPII_Monitoring database_2012 vintage" spreadsheet.

⁵⁰ Details calculation in cell G2, sheet "ER" of the "MPII_Monitoring database_2013 vintage" spreadsheet

⁵¹ Excluding households which treat the waste of more than 5 pigs/m³ digester volume. These households are not included in the calculation of baseline emissions as per registered PDD.

province has been collected and for each province a separate IPCC default factor is obtained. This approach allows for maximum precision. Once the average annual temperature was determined for each province and the respective IPCC default value was obtained; the average weighted emission factor could be determined in Vietnam.

Table 25: Methane emission factors by climate zone

Animal	Zone A: Temperate	Zone B: Warm
Pig	5.00	7.00
Buffalo	2.00	2.00
Dairy cow	23.00	31.00
Cattle	1.00	1.00

The table shows that the EF for pig and dairy cows are temperature dependent, the EF of the other animals are the same for the temperature ranges observed in Vietnam. The next table shows the calculated BE from AWMS and the animal population obtained from the CMS.

Table 26: Ex-post BE AWMS emission in the climate zone A: Temperate⁵²

Animal	N(T),h	EF _{awms(T)}
T	#	kgCH ₄ /head/year
Pig	24.94	5.00
Buffalo	0.05	2.00
Dairy cow	0	23.00
Cattle	0.23	1.00
BE _{AWMS} , temperate, (2012 vintage)		2.63
BE _{AWMS} , temperate, (2013 vintage)		3.13

And the climate zone warm:

Table 27: Ex-post BE AWMS emission in the climate zone B: Warm⁵³

Animal	N(T),h	EF _{awms(T)}
T	#	kgCH ₄ /head/year
Pig	28.18	7.00
Buffalo	0.01	2.00

⁵² Details calculation in cell G10, sheet "ER_AWMS" of the "MPII_Monitoring database_2012 vintage" and the "MPII_Monitoring database_2013 vintage" spreadsheets, respectively.

⁵³ Details calculation in cell Q10, sheet "ER_AWMS" of the "MPII_Monitoring database_2012 vintage" and the "MPII_Monitoring database_2013 vintage" spreadsheets, respectively.

Dairy cow	0.00	31.00
Cattle	1.98	1.00
BE _{AWMS, warm, (2012 vintage)}	$BE_{awms,h} = GWP_{CH4} * \sum_T (EF_{awms(T)} * N_{(T)h})$	4.18
BE _{AWMS, warm, (2013 vintage)}		4.98

The average weighted annual emissions from AWMS are⁵⁴:

BE_{AWMS, (2012 vintage)} = 2.98 tCO₂ per household.

BE_{AWMS, (2013 vintage)} = 3.55 tCO₂ per household.

E.2. Calculation of project emissions or actual net GHG removals by sinks

Project Emissions from Thermal Energy demand

Not all fuels will be replaced by biogas. The fuels that people continue to use in the project scenario will be obtained from the monitoring surveys. The next table shows the estimated remaining fuel consumptions sourced from KPT survey for MPII.

Table 28: Fuel consumption of project HHs⁵⁵

Fuel <i>i</i>	Average per household (kg/year)
Firewood	277.40
Agriculture residues	101.23
LPG	5.23

Similarly to the baseline emission for thermal energy demand, the ex-post baseline emissions will be calculated as follow:

For 2012 vintage:⁵⁶

$$PE_{th,h,(2012 \text{ vintage})} = 0.52 \text{ (tCO}_{2e}\text{/year)}$$

For 2013 vintage⁵⁷:

$$PE_{th,h,(2013 \text{ vintage})} = 0.56 \text{ (tCO}_{2e}\text{/year)}$$

E.3. Calculation of leakage

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

⁵⁴ Details calculation in cell D70, sheet "ER_AWMS" of the "MPII_Monitoring database_2012 vintage" and the "MPII_Monitoring database_2013 vintage" spreadsheets, respectively.

⁵⁵ Details calculation in row 7 of tab "SD" of the "MPII_Monitoring database" spreadsheet

⁵⁶ Details calculation in sheet "ER_fuel" of the "MPII_Monitoring database_2012 vintage".

⁵⁷ Details calculation in sheet "ER_fuel" of the "MPII_Monitoring database_2013 vintage".

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 bio-digester. The manure management categories (MS) for each climate zone and applicable MCF are shown in the next two tables, 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.

E.3.1. Physical leakage and incomplete combustion of biogas

The project emissions from the bio-digester system has been calculated as below:

$$\begin{aligned}
 PE_{awms,h,y} &= GWP_{CH_4} \\
 &\times \sum (N_{(T),h,y} \times EF_{awms(T)}) \cdot PL_y \\
 &+ \sum (LC_{(T),h,y} \times EF_{awms(T)}) \times (1 - \eta_{biogasstove})(1 - PL_y) PE_{awms,h,y} \\
 &= GWP_{CH_4} \\
 &\times \sum (N_{(T),h,y} \times EF_{awms(T)}) \cdot PL_y + \sum (LC_{(T),h,y} \times EF_{awms(T)}) \times (1 - \eta_{biogasstove})(1 - PL_y)
 \end{aligned}$$

Where:

$PE_{awms,h,y}$	=	Mean emission per household h (tCO ₂ e/year)
$N_{(T),h,y}$	=	Number of animals of livestock category T in year y in premise h
EF_{awms_T}	=	Emission factor for the defined livestock category T , (ton CH ₄ per animal per year). Estimated using the IPCC TIER 2 approach.
PL_y	=	Physical leakage of the biodigester in year y (10 %) ⁵⁸
EF_T	=	Annual CO ₂ emission factor for livestock category T , (tCO ₂ e animal ⁻¹ yr ⁻¹)
GWP_{CH_4}	=	Global Warming Potential (GWP) of methane (tCO ₂ eq per tCH ₄): 21 and 25 for the first and second commitment period, respectively.
$\eta_{biogasstove}$	=	Combustion efficiency of the biogas stove

The EF_{AWMS} will be calculated using the IPCC tier 2 approach:

The following formula is used from the Voluntary Gold Standard Biodigester Methodology to estimate the animal waste management emissions.

⁵⁸ Default value of the applied methodology is adopted (TPDDTEC page 52)

$$EF_{AWMS(T)} = (VS_{(T)} \times 365) \times \left[Bo_{(T)} \times D_{CH_4} \times \sum_k \frac{MCF_{BL,k}}{100} \times MS_{(T,S,k)} \right] EF_{AWMS(T)}$$

$$= (VS_{(T)} \times 365) \times \left[Bo_{(T)} \times D_{CH_4} \times \sum_k \frac{MCF_{BL,k}}{100} \times MS_{(T,S,k)} \right]$$

Where:

- $EF_{AWMS(T)}$ = CH₄ emission factor for livestock category T in the project scenario, (tCH₄.animal⁻¹)
- $VS_{(T)}$ = Daily volatile solid excreted for livestock category T, (kg VS per animal.day⁻¹)
- 365 = Basis for calculating annual VS production, (days yr⁻¹)
- $Bo_{(T)}$ = Maximum methane producing capacity for manure produced by livestock category T, (m³ CH₄ kg⁻¹ of VS)
- D_{CH_4} = Conversion factor of m³ methane to kg methane, (0,067 kg/m³)
- $MCF_{(BL,k)}$ = Methane conversion factors for the animal waste handling system in the baseline situation, bl, by climate zone k, %
- $MS_{(T,S,k)}$ = Fraction of livestock category T's manure treated in the animal waste management system S, in climate region k, (dimensionless)

For 2012 vintage:

Table 29: Share of manure management systems in the project scenario in climate zone: Temperate⁵⁹

Manure management system	Pig	Buffalo	Cattle	MCF factor by system from IPCC guidelines Volume 4, chapter 10 at 23 degrees
Bio digester	97.77%	25.00%	60.87%	10.0%
Anaerobic lagoon	0.00%	0.00%	0.00%	79.0%
Slurry/liquid system	0.00%	0.00%	0.00%	55.0%
Solid storage	0.16%	50.00%	8.70%	4.0%
Composting	1.54%	25.00%	26.09%	1.0%
Daily spread	0.09%	0.00%	0.00%	0.5%
Drying in the sun	0.00%	0.00%	0.00%	0.0%
Fish pond	0.00%	0.00%	0.00%	0.0%
Other	0.44%	0.00%	4.35%	1.0%

⁵⁹ Details calculation in tab "ER_AWMS" of the "MPII_Monitoring database_2012 vintage" spreadsheet

Total	100%	100%	100%
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Table 30: Share of manure management systems in the project scenario in climate zone: Warm⁶⁰

Manure management system	Pig	Buffalo	Cattle	MCF factor by system from IPCC guidelines Volume 4, chapter 10 at 27 degrees
Bio digester	97.63%	100.00%	31.78%	10.0%
Anaerobic lagoon	0.39%	0.00%	0.00%	80.0%
Slurry/liquid system	0.13%	0.00%	1.20%	78.0%
Solid storage	0.22%	0.00%	0.00%	5.0%
Composting	0.28%	0.00%	29.09%	1.5%
Daily spread	0.29%	0.00%	1.79%	1.0%
Drying in the sun	0.00%	0.00%	7.14%	0.0%
Fish pond	0.59%	0.00%	0.00%	0.0%
Other	0.46%	0.00%	29.00%	1.0%

The calculated MCF by taking into account the share in each MS is shown in the next table by climate zone:

Table 31: Calculated average MCF by climate zone and animal⁶¹

Animal	Temperate zone MCF.MS	Warm zone MCF.MS
Pig	9.80%	10.20%
Buffalo	4.75%	10.00%
Dairy cow	0.00%	0.00%
Cattle	6.74%	4.86%

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

Table 32: Calculated emission factor by animal in zone: Temperate⁶²

⁶⁰ Details calculation in tab "ER_AWMS" of the "MPII_Monitoring database_2012 vintage" spreadsheet

⁶¹ Details calculation in tab "ER_AWMS" of the "MPII_Monitoring database_2012 vintage" spreadsheet

⁶² Details calculation in tab "ER_AWMS" of the "MPII_Monitoring database_2012 vintage" spreadsheet

Animal	Volatile Solids (VS) (kg/day)	Maximum Methane potential (Bo _T)	MCF x MS	Density methane (kg/m ³)	EF _{AWMS (P)} (kgCH ₄ /year)
Pig	0.3	0.29	9.80%	0.67	2.086
Buffalo	3.9	0.1	4.75%	0.67	4.530
Dairy cow	2.8	0.13	0.00%	0.67	0.000
Cattle	2.3	0.1	6.74%	0.67	3.791

Table 33: Calculated emission factor by animal in zone: Warm⁶³

Animal	Volatile Solids (VS) (kg/day)	Maximum Methane potential (Bo _T)	MCF x MS	Density methane (kg/m ³)	EF _{AWMS (P)} (kgCH ₄ /year)
Pig	0.3	0.29	10.19%	0.67	2.171
Buffalo	3.9	0.1	10.00%	0.67	9.537
Dairy cow	2.8	0.13	0.00%	0.67	0.000
Cattle	2.3	0.1	4.77%	0.67	2.731

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.

Table 34: Physical leakage emission from bio-digester⁶⁴

Animal	Zone Temperate		Zone Warm	
	PL _{biodigester} (kgCH ₄ /year)	PL _{stove} (kgCH ₄ /year)	PL _{bio-digester} (kgCH ₄ /year)	PL _{stove} (kgCH ₄ /year)
Pig	5.202	0.936	6.117	1.101
Buffalo	0.021	0.004	0.006	0.001
Dairy cow	0.000	0.000	0.000	0.000
Cattle	0.087	0.016	0.541	0.097
Total	5.310	0.956	6.664	1.200

The emissions from physical leakage are:

⁶³ Details calculation in tab "ER_AWMS" of the "MPII_Monitoring database_2012 vintage" spreadsheet

⁶⁴ Details calculation in tab "ER_AWMS" of the "MPII_Monitoring database_2012 vintage" spreadsheet

Zone	Classification	Units	LE/unit (tCO ₂ e/unit)	Total LE (tCO ₂ e)
A	Temperate	81,805	0.132	10,764
B	Warm	24,366	0.165	4,024
Weighted average $PE_{awms,h,y\ 2012\ vintage}$			tCO ₂ e/unit	0.14

For 2013 vintage⁶⁵:

Similarly,

$$PE_{awms,h,y\ 2013\ vintage} = 0.17 \text{ (tCO}_2\text{e/unit)}$$

E.3.1. Emissions from digestate (bio-slurry)

Biogas households were surveyed about their usage of bio-slurry. 183 respondents were not using bio-slurry, 20 are using it partially and 137 respondents are using the bio-slurry fully. Amongst 137 responses on full usage of bio-slurry, 106 respondents used bio-slurry directly, 21 stored it before use and the remaining 10 respondents used bio-slurry partly directly and partly by storing before use.

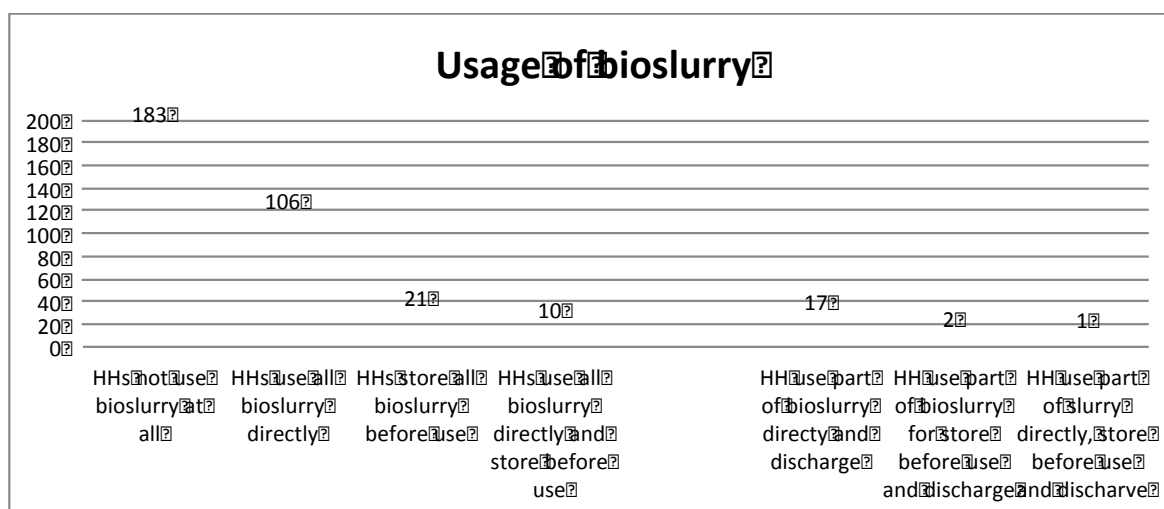


Figure 12. Usage of bio-slurry

The following leakage emission source is accounted for in this section: CH₄ emissions from the 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 manure⁶⁶.

This emission source is determined through the following steps:

1. Estimation of the total amount of VS entering the bio-digester

⁶⁵ Details calculation is on cell D71, sheet "ER_AWMS" of the "MPII_Monitoring database_2013 vintage" spreadsheet

⁶⁶ http://cdm.unfccc.int/Panels/meth/meeting/11/051/mp51_an13.pdf

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

Estimation of the total amount of VS entering the bio-digester

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 tables below, 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 $MS_{no\ fed}$ the share not fed into the digester of animal category T.

The next tables depict the total amount of VS that enters the average bio-digester which is calculated by multiplying the amount of VS excreted by the average number of animals and the $MS_{fed\ in\ digester}$ into the bio-digester by climate zone.

Table 35: Daily VS production of the average bio-digester in climate zone temperate⁶⁷

Animal T	VS excretion kgVS/hd/day	Head/average bio-digester	Total amount of VS excreted kgVS.day ⁻¹	$MS_{fed\ in\ digester}$ Share fed into bio-digester	Total VS entering the bio-digester kgVS.day ⁻¹
	A	B	AxB =C	D	CxD
Pig	0.30	24.94	7.48	97.8%	7.32
Buffalo	3.90	0.05	0.18	25.0%	0.05
Dairy cow	2.80	0.00	0.00	0.0%	0.00
Cattle	2.30	0.23	0.53	60.9%	0.32
Sum					7.68

Table 36: Daily VS production of the average bio-digester in climate zone warm⁶⁸

Animal T	VS excretion kgVS/hd/day	Head/average bio-digester	Total amount of VS excreted kgVS.day ⁻¹	$MS_{fed\ in\ digester}$ Share fed into bio-digester	Total VS entering the bio-digester kgVS.day ⁻¹
	A	B	AxB =C	D	CxD
Pig	0.30	28.18	8.45	97.6%	8.25

⁶⁷ Details calculation in tab "PE_Bioslurry" of the "MPII_Monitoring database_2012 vintage" spreadsheet

⁶⁸ Details calculation in tab "PE_Bioslurry" of the "MPII_Monitoring database_2012 vintage" spreadsheet

Buffalo	3.90	0.01	0.02	100.0%	0.02
Dairy cow	2.80	0.00	0.00	0.0%	0.00
Cattle	2.30	1.98	4.56	31.8%	1.45
Sum					9.72

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%⁶⁹. 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 $MS_{\text{digestate}}$ 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, could even be recalcitrant to further anaerobic biodegradation. The next table shows the calculated amount of VS that leaves the average bio-digester per day:

Table 37: Average amount of VS in digester effluent by zone⁷⁰

Zone	(A) Total VS entering the bio-digester kgVS.day ⁻¹	Digester efficiency	(B) Total VS destroyed in the bio-digester kgVS.day ⁻¹	A-B Total VS in bio-slurry kgVS.day ⁻¹
Temperate	7.68	45%	3.46	4.23
Warm	9.72	45%	4.38	5.35

Assessment of the methane potential of digestate

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

$$B_{0,\text{dig},T} = F_{\text{ww,CH}_4,\text{default}} \times B_{0,T}$$

Where:

⁶⁹ P55 <http://www.lemvigbiogas.com/BiogasHandbook.pdf>

⁷⁰ Details calculation in tab "PE_Bioslurry" of the "MPII_Monitoring database_2012 vintage" spreadsheet

$B_{0,dig,T}$	=	Methane potential of digestate from animal type T manure
F_{ww,CH_4}	=	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 38: Calculated methane potential of digestate from manure by animal type⁷¹

Animal T	$F_{ww,CH_4,default}$ ⁷²	$B_0(T)$ (m ³ CH ₄ /kgVS)*	$B_{0,dig}$ (m ³ CH ₄ /kgVS)
Pig	20%	0.290	0.058
Buffalo	20%	0.100	0.02
Dairy cow	20%	0.130	0.026
Cattle	20%	0.100	0.02

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 pigs is, for example, much larger than the other animals, relevant calculations can be found in the monitoring database. The following table shows the weighted averaged methane potential for digestate by climate zone

Table 39: Weighed average methane potential of digestate by zone⁷³

Zone	Weighed $B_{0,dig}$ (m ³ CH ₄ /kgVS)
Temperate	0.058
Warm	0.055

All calculations can be found in the excel workbook.

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 40: Digestate management systems by type and zone⁷⁴

DMS	Temperate (%)	Warm (%)
Flow to farm yield	33.32%	29.72%
Flow into sufficient size storage area	0.00%	0.00%

⁷¹ Details calculation in tab "PE_Bioslurry" of the "MPII_Monitoring database_2012 vintage" spreadsheet

⁷² According to EB66 Annex 32 page 1

⁷³ Details calculation in tab "PE_Bioslurry" of the "MPII_Monitoring database_2012 vintage" spreadsheet

⁷⁴ Details calculation in tab "PE_Bioslurry" of the "MPII_Monitoring database_2012 vintage" spreadsheet

Stored dry with hut	0.00%	0.00%
flow into large pond	0.00%	0.00%
Flow into river, channel	53.41%	61.18%
Stored under dry conditions with other organic matter	8.94%	7.35%
Other	4.33%	1.75%
Sum	100%	100.0%

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

Table 41: Applicable MCF values to the DMS⁷⁵

DMS	Applicable IPCC MS category	Applicable MCF zone temperate (23°C)	Applicable MCF zone warm (27°C)
Flow to farm yield	daily spread	0.5%	1.0%
Flow into sufficient size storage area	slurry	55.0%	78.0%
Stored dry with hut	solid storage	4.0%	5.0%
flow into large pond	other	1.0%	1.0%
Flow into river, channel	other	1.0%	1.0%
Stored under dry conditions with other organic matter	solid storage	4.0%	5.0%
Other	other	1.0%	1.0%

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

Table 42: Average MCF by zone⁷⁶

Zone	$\Sigma \text{DMS} \times \text{MCF}$
Temperate	1.10%
Warm	1.29%

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 by each zone using the IPCC tier 2 approach. The emissions are calculated using **equation 16** of the applied GS methodology as per registered PDD.

⁷⁵ Details calculation in tab "PE_Bioslurry" of the "MPII_Monitoring database_2012 vintage" spreadsheet

⁷⁶ Details calculation in tab "PE_Bioslurry" of the "MPII_Monitoring database_2012 vintage" spreadsheet

$$EF_{AWMS(T)} = (VS_{(T)} \times 365) \times \left[Bo_{(T)} \times D_{CH_4} \times \sum_k \frac{MCF_{BL,k}}{100} \times MS_{(T,S,k)} \right] EF_{AWMS(T)}$$

$$= (VS_{(T)} \times 365) \times \left[Bo_{(T)} \times D_{CH_4} \times \sum_k \frac{MCF_{BL,k}}{100} \times MS_{(T,S,k)} \right]$$

Table 43: Calculated emissions from digestate by zone

Zone	Total VS in bio-slurry kgVS.day ⁻¹	B _{0,dig} (m ³ CH ₄ /kgVS)	ΣDMSx MCF	D _{CH₄} (kg/m ³ CH ₄)	Digester emissions (tCO ₂ /year/ hh) (2012 vintage) ⁷⁷	Digester emissions (tCO ₂ /year/ hh) (2013 vintage) ⁷⁸
Temperate	3.46	0.058	0.011	0.67	0.011	0.013
Warm	4.38	0.055	0.013	0.67	0.016	0.019

The weighted emissions from digestate are, taking into account the proportion of units built in each zone, shown in the next table:

Table 44: Weighted average emissions from digestate⁷⁹

	No of units in zone
Temperate	81805
Warm	24366
Average LE Bio-slurry (tCO ₂ e/year/hh) (2012 vintage)	0.012
Average LE Bio-slurry (tCO ₂ e/year/hh) (2013 vintage)	0.015

E.4. Summary of calculation of emission reductions or net anthropogenic GHG removals by sinks

The next table shows the ex-ante estimate of the emission reductions for each biogas unit:
For 2012 vintage

Table 45: Average annual emission reductions for 2012 vintage⁸⁰

Emission source	BE (tCO _{2e} /h/year)	PE (tCO _{2e} /h/year)	ER (tCO _{2e} /h/year)
Fuel use	3.62	0.52	3.10
AWMS	2.98	0.12	2.86
Digestate	NA	0.012	-0.012

⁷⁷ Detail calculation are in cell G51 and O51, tab "PE_Bioslurry" of the "MPII_Monitoring database_2012 vintage"

⁷⁸ Detail calculation are in cell G51 and O51, tab "PE_Bioslurry" of the "MPII_Monitoring database_2013 vintage"

⁷⁹ Detail calculation is in cell L7, tab "PE_Bioslurry" of the "MPII_Monitoring database_2012 vintage" and "MPII_Monitoring database_2013 vintage" spreadsheet, respectively.

⁸⁰ Detail calculation is in cell G5, tab "ER" of the "MPII_Monitoring database_2012 vintage" spreadsheet

Sum	6.61	0.65	5.95
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For 2013 vintage

Table 46: Average annual emission reductions for 2013 vintage⁸¹

Emission source	BE (tCO _{2e} /h/year)	PE (tCO _{2e} /h/year)	ER (tCO _{2e} /h/year)
Fuel use	3.83	0.56	3.28
AWMS	3.55	0.14	3.41
Digestate	0.00	0.015	-0.015
Sum	7.38	0.72	6.67

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

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

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 calculated usage rate, $U_{y,h}$ is 90.13%. However the effective usage rate $U_{Fy,h} = 85.32\%$ was applied.⁸² The next table shows the ER summary.

⁸¹ Detail calculation is in cell G5, tab "ER" of the "MPII_Monitoring database_2013 vintage" spreadsheet

⁸² See explanation in Section 3.4 above

Table 47: Emission reductions in the monitoring period⁸³

Date (inclusive of both dates)		Installation in month	Cumulative units	ER fuel	ER AWMS	PE Bio slurry	ER	Emission reductions	Percentage in operation	ER/month
		#	#	tCO2/year	tCO2/year	tCO2/year	tCO2/year	tCO2/month	%	tCO2
1-Jan-12	31-Jan-12	191	89,244	3.14	2.84	0.01	5.97	0.5	85.32%	37,818
1-Feb-12	29-Feb-12	436	89,680	3.14	2.84	0.01	5.97	0.5	85.32%	37,900
1-Mar-12	31-Mar-12	1181	90,861	3.14	2.84	0.01	5.97	0.5	85.32%	38,085
1-Apr-12	30-Apr-12	1701	92,562	3.14	2.84	0.01	5.97	0.5	85.32%	38,586
1-May-12	31-May-12	2183	94,745	3.14	2.84	0.01	5.97	0.5	85.32%	39,309
1-Jun-12	30-Jun-12	1556	96,301	3.14	2.84	0.01	5.97	0.5	85.32%	40,236
1-Jul-12	31-Jul-12	1187	97,488	3.14	2.84	0.01	5.97	0.5	85.32%	40,896
1-Aug-12	31-Aug-12	1230	98,718	3.14	2.84	0.01	5.97	0.5	85.32%	41,401
1-Sep-12	30-Sep-12	905	99,623	3.14	2.84	0.01	5.97	0.5	85.32%	41,923
1-Oct-12	31-Oct-12	862	100,485	3.14	2.84	0.01	5.97	0.5	85.32%	42,307
1-Nov-12	30-Nov-12	842	101,327	3.14	2.84	0.01	5.97	0.5	85.32%	42,673
1-Dec-12	31-Dec-12	1131	102,458	3.14	2.84	0.01	5.97	0.5	85.32%	43,031
1-Jan-13	31-Jan-13	288	102,746	3.33	3.39	0.01	6.70	0.56	85.32%	48,821
1-Feb-13	28-Feb-13	252	102,998	3.33	3.39	0.01	6.70	0.56	85.32%	48,958
1-Mar-13	31-Mar-13	396	103,394	3.33	3.39	0.01	6.70	0.56	85.32%	49,079
1-Apr-13	30-Apr-13	791	104,185	3.33	3.39	0.01	6.70	0.56	85.32%	49,267
1-May-13	31-May-13	949	105,134	3.33	3.39	0.01	6.70	0.56	85.32%	49,644
1-Jun-13	30-Jun-13	1037	106,171	3.33	3.39	0.01	6.70	0.56	85.32%	50,096
Total										780,030

⁸³ Detail calculation is in tab "ER" of the "MPII_ER from both vintages" spreadsheet

In line with the FAR05 above, the KPT result will be retroactively applied to the carbon credit from MPI. Besides, there was an error in calculation of the project emission from incomplete combustion from stove in MPI, so it was updated and adjusted in MP11. The retroactive GS VER result is 510,846 GS VER. Because 510,952 credits were issued for the MPI, an amount of 106 credit will be deducted in MP11.

Monitoring period	Credits (GS VER)
MPI (issued credit from first verification)	510,952
MPI (retroactive calculation)	510,846
Difference	-106

The requested for issuance of carbon credit in MP11 will be

$$ER_{MP11} = 780,030 - 106 = 779,924 \text{ GS VER}$$

E.5. Comparison of actual emission reductions or net anthropogenic GHG removals by sinks with estimates in registered PDD

Item	Values estimated in ex-ante calculation of registered PDD	Actual values achieved during this monitoring period
Emission reductions or GHG removals by sinks (t CO ₂ e)	868,817	779,924

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

>>

The actual ER was less than the estimated value in registered PDD. The main reason is because of the reducing in biogas usage rate. In the PDD, the usage rate was 100% and in the MPII, it is 85.32%.

Besides, the KPT result in MPII showed that the average fuel consumption is slightly less than in MPI and it was retroactively applied to the MPI ER calculation. The difference between the issued credit for MPI and the retroactive result has been deducted in the requested for issuance in MPII.

SECTION F. Results of monitoring sustainable development indicator

F.1. Safeguard Principles

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

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 labor	Not required
6. The project does not employ and is not complicit in any form of child labor	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.

F.2. Sustainability monitoring plan

This section assesses the performance of the VGS project on the sustainability indicators by indicator (ID) identified according to the monitoring plan described in the GSPR using survey methods where applicable.

ID 1: Air quality

The next table shows the scoring on the SD indicator air quality.

Table 48: Scoring on SD indicator Air quality

No	1
Indicator	Air quality
Mitigation measure	N/A
<i>Repeat for each parameter</i>	
Chosen parameter	<i>Reduction in fuel (wood, agricultural residues, kerosene and coal) consumption (kg of fuel reduced/year)</i>
Situation at 31/12/2011 ⁸⁴	Charcoal: 65.3 Coal: 67.9 Firewood: 966.6 Agriculture residuals: 322.8 Kerosene: 32.4
Situation at 30/06/2013 ⁸⁵	Charcoal: 0 Coal: 0 Firewood: 1,643.2 Agriculture residuals: 584.4 Kerosene: 0

⁸⁴ According to the Monitoring report of MPI

⁸⁵ According to the KPT survey in MPII

Estimation of baseline situation of parameter		Charcoal: 0 Coal: 0 Firewood: 0 Agriculture residuals: 0 Kerosene: 0
Future target for parameter		Displacement of all fuels used for cooking inside the house by biogas
Way of monitoring	How	Conduct the PFT for measuring the consumed fuel.
	When	Updated for every 2 years or more frequently
	By who	A third party conducted the monitoring commissioned by BP, the data are reported in a monitoring report and is made available for each verification.

ID 2: Soil condition

The next table shows the scoring on the SD indicator air quality.

Table 49: Scoring on SD indicator soil condition

No		2				
Indicator		Soil condition				
Mitigation measure		N/A				
Repeat for each parameter						
Chosen parameter		Usage of bio-slurry				
Situation at 31/12/2011		Zone	Fertilizer	Don't use	Fish feed	Other
		Temperate	75.2%	19.2%	5.6%	0.0%
		Warm	54.5%	19.0%	24.8	1.7%
Situation at 30/06/2013		Zone	Fertilizer	Don't use	Fish feed	Other
		Temperate	42.17%	53.41%	3.25%	1.17%
		Warm	36.51%	61.18%	1.69%	0.62%
Estimation of baseline situation of parameter		0				
Future target for parameter		Most households use bio-slurry as fertilizer				
Way of monitoring	How	Conduct the CMS survey.				
	When	Updated for every 2 years or more frequently				
	By who	A third party conducted the monitoring commissioned by BP, the data are reported in a monitoring report and is made available for each verification.				

ID 3: Biodiversity

The next table shows the scoring on the SD indicator Biodiversity.

Table 50: Scoring on SD indicator Biodiversity

No		3
Indicator		Biodiversity
Mitigation measure		N/A
<i>Repeat for each parameter</i>		
Chosen parameter		<i>Cumulative savings of wood (tons/year)</i>
Situation at 31/12/2011		84,879
Situation at 30/06/2013		148,859
Estimation of baseline situation of parameter		0
Future target for parameter		Significant reduction of wood demand realized by the provision of a clean and sustainable fuel: biogas
Way of monitoring	How	Conduct the PFT for measuring the consumed fuel.
	When	Updated for every 2 years or more frequently
	By who	A third party conducted the monitoring commissioned by BP, the data are reported in a monitoring report and is made available for each verification.

Due to the BP project activities a significant amount of wood is saved per household. The reduction in wood use will help to keep habitat intact which will have a positive effect on biodiversity.

ID 4: Quality of Employment

The next table shows the scoring on the SD indicator Quality of Employment.

Table 51: Scoring on SD indicator Quality of Employment

No		4
Indicator		Quality of Employment
Mitigation measure		N/A
<i>Repeat for each parameter</i>		
Chosen parameter		<i>Number of masons and technicians participating in the trainings</i>
Situation at 13/09/2011 ⁸⁶		Number of masons: 922 Number of technicians: 622
Situation at 31/12/2011 ⁸⁷		Number of masons: 922 Number of technicians: 622
Situation at 30/06/2013		Number of masons: 1038 Number of technicians: 707
Estimation of baseline situation of parameter		0
Future target for parameter		At least 2 district biogas technicians and 2 biogas masons per district provided with training
Way of monitoring	How	The PP keeps track on the number of trained masons and technicians

⁸⁶ According to the GS passport version 3.1, dated 25/09/2012.

⁸⁷ There was not any training course during 13/09/2011 to 31/12/2011, therefore the number of trained masons and technicians stayed the same.

	When	Annually
	By who	BP

In order to meet the defined rules, during its implementation, the BP program has been expanding to new districts as well as trained new masons and technician who based in these new districts. In the meantime, the new masons and technicians in existing districts which have only 1 trained mason or technician have also been selected for training to meet the target of at least 2 masons or technicians per district. During the MP11, there were 116 new masons and 85 new technicians trained under the program activity. The figures below show the ongoing trend to meet the target:

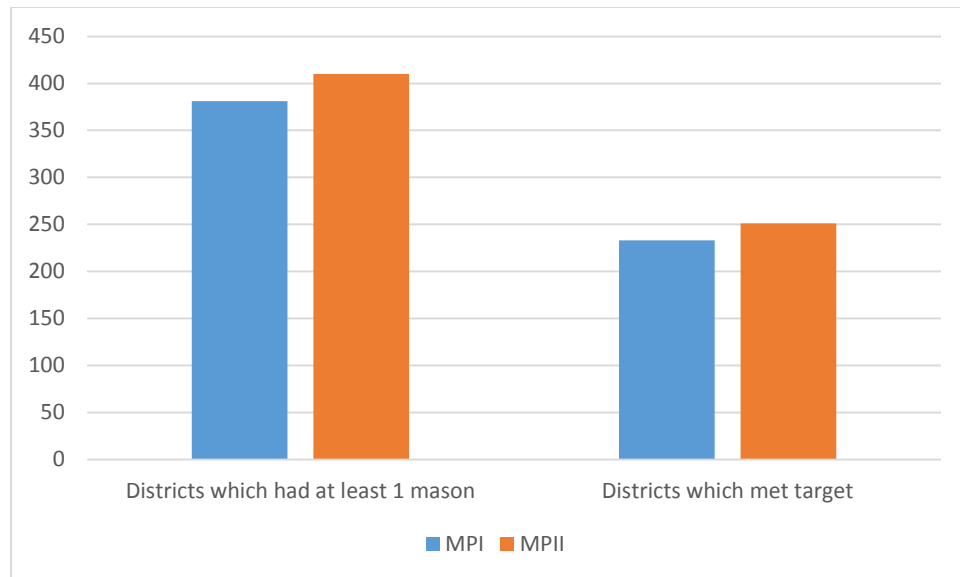


Figure 13: Number of masons in MPI and MP11

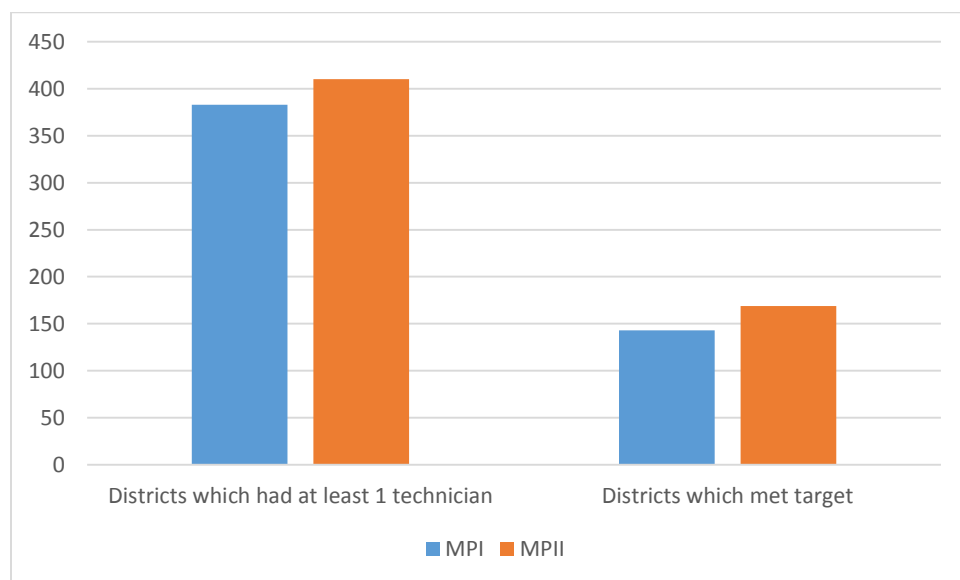


Figure 14: Number of technicians in MPI and MP11

ID 5: Livelihood of the poor

The next table shows the scoring on the SD indicator Livelihood of the poor

Table 52: Scoring on SD indicator “Livelihood of the poor”

No		5
Indicator		Livelihood of the poor
Mitigation measure		N/A
<i>Repeat for each parameter</i>		
Chosen parameter		<i>Number of people having access to an improved waste management system</i>
Situation at 31/12/2011		436,962
Situation at 30/06/2013		427,539 ⁸⁸
Estimation of baseline situation of parameter		0
Future target for parameter		625,470
Way of monitoring	How	The PP keeps track on the number of households with bio-digesters and conduct the CMS survey for the average number of people in a household.
	When	Updated for every 2 years or more frequently
	By who	BP

ID 6: Access to affordable and clean energy services

The next table shows the scoring on the SD indicator “Access to affordable and clean energy services”

Table 53: Scoring on SD indicator Access to affordable and clean energy services

No		6
Indicator		Access to affordable and clean energy services
Mitigation measure		N/A
<i>Repeat for each parameter</i>		
Chosen parameter		<i>Total amount of energy replaced by biogas (MJ/hh/year)</i>
Situation at 31/12/2011		33,232
Situation at 30/06/2013		33,840
Estimation of baseline situation of parameter		0
Future target for parameter		Displacement of all fuels used for cooking inside the house by biogas
Way of monitoring	How	Conduct the PFT for measuring the consumed fuel.
	When	Updated for every 2 years or more frequently
	By who	A third party will conduct the monitoring commissioned by BP, the data will be reported in a monitoring report and is made available for each verification.

⁸⁸ Number of people having access to an improved waste management system is calculated by multiply the number of units which are still in operation with the average number of people per households. In this MPII, the number of units which are still in operation was adjusted to exclude the drop off based on the user survey results the drop-off rate. The number of in use are 106,171*90.13% =95,697; or the units dropped out are 10,474 units.

ID 7: Technology transfer and technological self-reliance

The next table shows the scoring on the SD indicator Technology transfer and technological self-reliance

Table 54: Scoring on SD indicator “Technology transfer and technological self-reliance”

No		7
Indicator		Technology transfer and technological self-reliance
Mitigation measure		N/A
<i>Repeat for each parameter</i>		
Chosen parameter		<i>Number of masons trained in the construction of KT1 or KT2 bio-digesters</i>
Situation at 13/09/2011 ⁸⁹		Number of masons: 922
Situation at 31/12/2011 ⁹⁰		Number of masons: 922
Situation at 30/06/2013		Number of masons: 1038
Estimation of baseline situation of parameter		0
Future target for parameter		At least 2 biogas masons per district provided with training
Way of monitoring	How	The PP keeps track on the number of trained masons
	When	Annually
	By who	BP

During the MP11, there were 116 new masons trained under the program activity to meet the future target of at least 2 biogas masons per district provided with training.

⁸⁹ According to the GS passport version 3.1, dated 25/09/2012.

⁹⁰ There was not any training course during 13/09/2011 to 31/12/2011, therefore the number of trained masons and technicians stayed the same.

Annex 1: Contact details of the Project Participants

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