MONITORING REPORT MP4

From 01/01/2015 to 30/06/2016
For the verification of Biogas Program for Animal Husbandry Sector of Vietnam

Version 2.1
02/10/2019

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Acronyms

AWMS	Animal Waste Management System
BE	Baseline emission
BFT	Baseline Field Test
BUS	Biogas User Survey
CDM	Clean Development Mechanism
CH_4	Methane Gas
CO_2	Carbon Dioxide
CO_2e	Carbon Dioxide equivalent
EF	Emission factor
ER	Emission reduction
GHG	Greenhouse Gas
GS	Gold Standard
GSPR	Gold Standard Passport Report
GWP	Global Warming Potential
hh (HH)	household
IPCC	Intergovernmental Panel on Climate Change
KPT	Kitchen Peformance Test
LPG	Liquefied Petroleum Gas
LSC	Local Stakeholder Consultation Report
MCF	Methane conversion factor
MS	Manure system (equivalent to AWMS)
MPx	Monitoring Period x (1 to 4)
MRx	Monitoring Report (1 to 4)
N_2O	Nitrous oxide
NRB	Non-Renewable Biomass
PFT	Project Field Test
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

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MONITORING REPORT SUMMARY

Title of the project activity	**Biogas Program for Animal Husbandry Sector of Vietnam**
Gold Standard version	2.1[1]
Gold Standard icon	
Reference number of the project activity	GS1083[2]
Version number of the monitoring report	2.1
Completion date of the monitoring report	02/10/2019
Registration date of the project activity	28/06/2012
Monitoring period number and duration of this monitoring period	Monitoring period number 4 (MP4) 01/01/2015 to 30/06/2016 (both start date and end date are included)
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 [3]
Estimated amount of GHG emission reductions or net anthropogenic GHG removals by sinks for this monitoring period in the registered PDD	965,936 tCO_2e
Actual GHG emission reductions or net anthropogenic GHG removals by sinks achieved in this monitoring period	709,192 tCO_2e

[1] According to GS4GG transition requirement, the projects with a 7-years renewable crediting cycle with less than 24 months remaining on current cycle shall transition at next Renewal of crediting period. As the first crediting period for GS1083 was ended in 27/06/2017 so transition annex is not required for this verification but in the next CP renewal.

[2] https://registry.goldstandard.org/projects/details/61

[3] 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 biogas[4] 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.[5]	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[6]	28 September 2006
PDD Development by Mitsubishi Securities UFJ as bundle CDM project with credit period start date 1-10-2006	2006- 2007

[4] *Domestic biogas is defined as any biogas plant using at household level which 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 N0 4006/QĐ-BNN-KHCN of Ministry of Agriculture and Rural development on 26th December 2006.)*

[5] http://www.natuurenmilieu.nl/pdf/0500_2.1_domestic_biogas_and_cdm_financing_background_paper.pdf

[6] 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
Second GS VER issuance	29 April 2015
Third GS VER issuance	04 April 2018

According to the first, second and third monitoring periods, 510,952 $tCO2_e$, 779,924 $tCO2_e$ and 1,072,197 $tCO2_e$ were issued respectively. For the fourth monitoring period, the emission reduction is 709,192 $tCO2_e$.

A.2. Location of project activity

Vietnam.

Since the inception of the programme has gradually extended its coverage. In 2007 the programme was active in 24 provinces and this has increased to 55 provinces to date. The coordinates of Vietnam are:

Table 2: Vietnam coordinates

	North	Center	South
Latitude	22º00´ North of the Equator	16º00´ North of the Equator	8º50´ North of the Equator
Longitude	100º00´ East of Greenwich	106º00´ East of Greenwich	109º00´ East of Greenwich

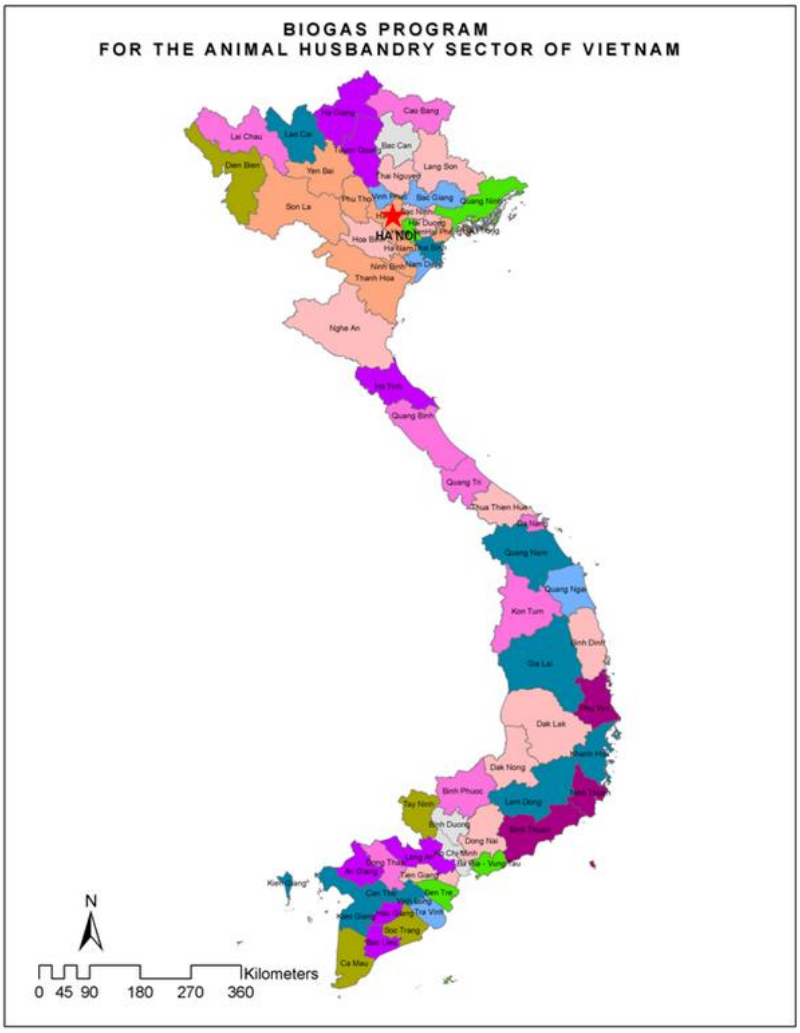


Figure 1: Project's location

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[7]	Longitude[8]	Cumulative installations
1	An Giang	10º30'0"	105º13'0"	1,455
2	Bà Rịa-Vũng Tàu	10º30'0"	107º13'0"	2,398
3	Bạc Liêu	9º17'38"	105º43'40"	36
4	Bến Tre	10º13'59"	106º22'59"	1,470
5	Bình Định	14º7'59"	108º46'59"	6,468
6	Bình Phước	11º45'33"	106º51'5"	46
7	Cần Thơ	10º1'59"	105º46'59"	103
8	Đồng Nai	11º6'0"	107º20'59"	2,170
9	Đồng Tháp	10º40'05"	105º42'05"	172
10	Hậu Giang	9°47′0"	105°28′0"	417
11	Khánh Hòa	10º40'59"	105º10'0"	994
12	Kiên Giang	10º16'59"	104º39'0"	1,274

[7] https://maps.google.com/
[8] https://maps.google.com/

No	Province	Latitude[7]	Longitude[8]	Cumulative installations
13	Long An	10º24'0"	106º19'59"	496
14	Phú Yên	13º07'0"	109º48'0"	128
15	Quảng Bình	17°28'9"	106°35'59"	72
16	Quảng Nam	15º53'8"	108º15'24"	1,820
17	Quảng Ngãi	15º7'0"	108º47'59"	4,076
18	Sóc Trăng	9º36'11"	105º58'48"	61
19	Tây Ninh	11º18'0"	106º5'59"	182
20	Tiền Giang	10º22'0"	106º40'0"	3,148
21	Trà Vinh	9º56'4"	106º20'43"	2,500
22	Vĩnh Long	10º15'0"	105º58'0"	842
Total				**30,328**

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

No	Province	Latitude[9]	Longitude[10]	No of Plants
1.	Bắc Giang	21º16'23"	106º11'40"	4,776
2.	Bắc Ninh	21º11'9"	106º4'34"	6,573
3.	Cao Bằng	22 º 42’0”,	106 º 15’0”	4
4.	Đắc Lắc	20º2'12"	105º34'54"	4,079
5.	Đăk Nông	11 º59’50”	107 º40’0”	14
6.	Điện Biên	21º22'59"	103º1'0"	8
7.	Gia Lai	13º58'59"	108º0'0"	1,342
8.	Hà Giang	22º49'59"	104º58'59"	8
9.	Hà Nam	19º19'0"	105º47'59"	4,482
10.	Hà Nội	21º1'59"	105º50'59"	7,950
11.	Hà Tây	20º50'0"	105º40'0"	3,225
12.	Hà Tĩnh	18º19'59"	105º54'0"	1,309
13.	Hải Dương	20º55'59"	106º19'0"	4,775
14.	Hải Phòng	20º51'21"	106º40'55"	1,936
15.	Hoà Bình	20º48'47"	105º20'17"	1,956
16.	Hưng Yên	20º38'59"	106º4'0"	4,961
17.	Lâm Đồng	11º55'59"	108º25'0"	55
18.	Lạng Sơn	21º49'59"	106º43'59"	1,055
19.	Lào Cai	22º28'59"	103º57'0"	316
20.	Nam Định	20º25'0"	106º10'0"	2,112
21.	Nghệ An	18º40'0"	105º40'0"	6,500
22.	Ninh Bình	20º15'14"	105º58'29"	4,797
23.	Phú Thọ	21º20'0"	105º10'0"	2,622
24.	Quảng Ninh	21º14'00"	107º20'05"	3,861
25.	Quảng Trị	16º45'0"	107º12'0"	93
26.	Sơn La	21º19'0"	103º54'0"	1,041
27.	Thái Bình	20º27'0"	106º19'59"	3,541
28.	Thái Nguyên	21º35'34"	105º50'39"	6,430

[9] https://maps.google.com/
[10] https://maps.google.com/

No	Province	Latitude[9]	Longitude[10]	No of Plants
29.	Thanh Hoá	19°48'0"	105°46'0"	12,528
30.	Thừa Thiên Huế	16°28'0"	107°35'59"	1,870
31.	Tuyên Quang	21°49'23"	105°13'5"	680
32.	Vĩnh Phúc	21°17'59"	105°36'00"	3,234
33.	Yên Bái	21°42'0"	104°52'0"	1,733
Total				**99,866**

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 1,13.
Available online: http://www.cdmgoldstandard.org/wp-content/uploads/2011/10/GS_110411_TPDDTEC_Methodology.pdf

A.5. Crediting period of project activity

The first 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 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 m^3 is depending on the region as below[11]:

Table 5: Daily feedstock[12]

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

[11] 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.
[12] Training material for Biogas Technician, 2011

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^{0}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 reductions from the displacement of grid electricity by these activities will not be accounted for, which is also conservative.

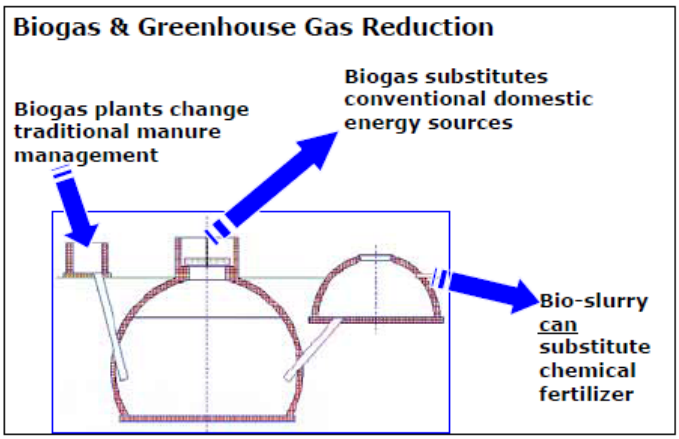


Figure 2: Biogas generation process

The project involves the installation and implementation of model types KT.1 and KT.2 domestic biogas plan or equivalent[13]. 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 standard[14], and in that case the expected lifetime is in the order of 25 years. At the end of this monitoring period around 73.5% of the digesters installed are of KT.1 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 have average size of 11.6 m^3 (average of units built between 01/01/2007 and 30/06/2016). The size histogram is illustrated as below:

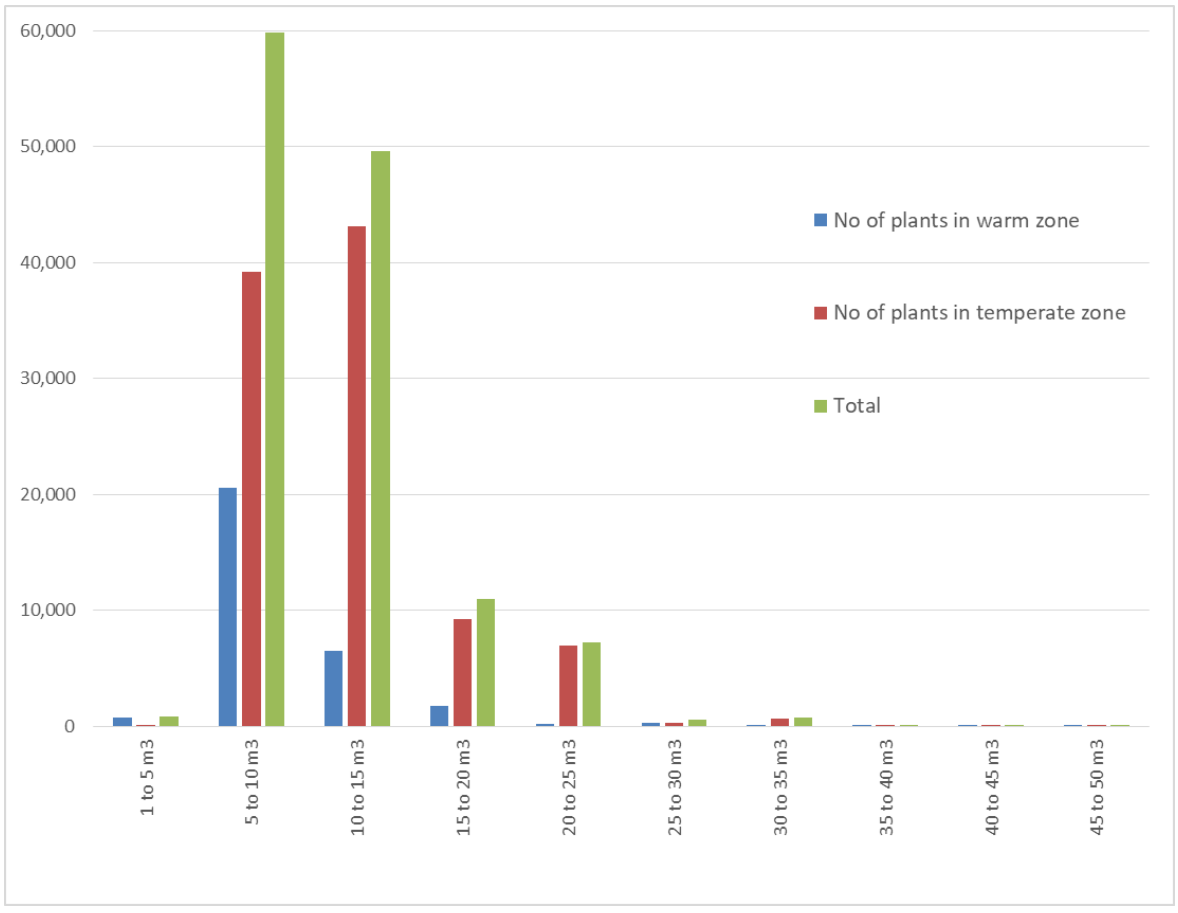


Figure 3: Plants size histogram[15]

The number of installed plants per year are as below:

[13] Biogas plants that are recognized in the MARD biogas standard for small scale biogas

[14] MARD national standard: 10 TCN 97 - 102 – 2006. Issued by decision N^0 4006/QĐ-BNN-KHCN of Ministry of Agriculture and Rural development on 26th December 2006.

[15] Details information is in tab "Size distributions" of the "CMS and KPT_sampling HHs" spreadsheet

Table 7: Installed plants per year[16]

Year	No of plants in warm zone	No of plants in temperate zone	Total
2007	2,168	12,230	14,398
2008	2,548	13,287	15,835
2009	4,063	18,153	22,216
2010	5,493	17,656	23,149
2011	4,168	9,287	13,455
2012	4,910	8,495	13,405
2013	2,786	5,273	8,059
2014	2,417	8,477	10,894
2015	1,774	7,007	8,781
2016 (6 months)	1	1	2
Total	**30,328**	**99,866**	**130,194**

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.

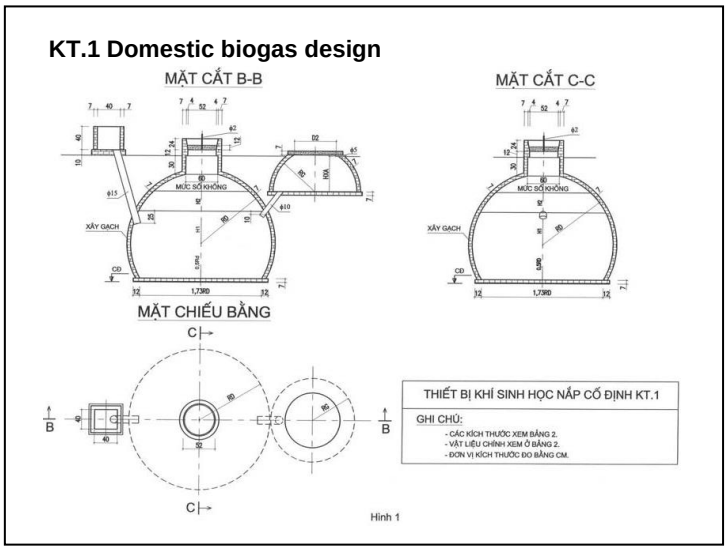


Figure 4: Blueprint of the KT.1 domestic biogas plant

The KT.2 model follows the TG-BP design as applied in the Mekong Delta by the Can Tho University.

[16] Details information is in cells G24:K31 tab “Size distributions” of the “CMS and KPT_sampling HHs” spreadsheet

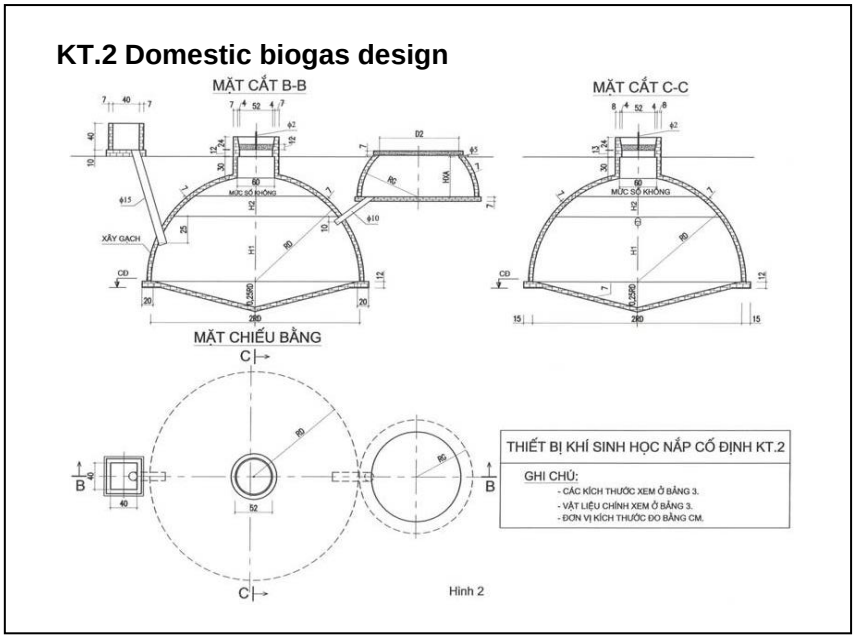


Figure 5: Blueprint of the KT.2 biogas plant design

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

The below change was proposed during MP3, please refer to section C.1 of the MR and section B.7.2 of the PDD version 4 “PDD BPD_Deviation of monitoring plan_v4.0_20170911.pdf”:

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), IQC (Independent Quality Control), 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:

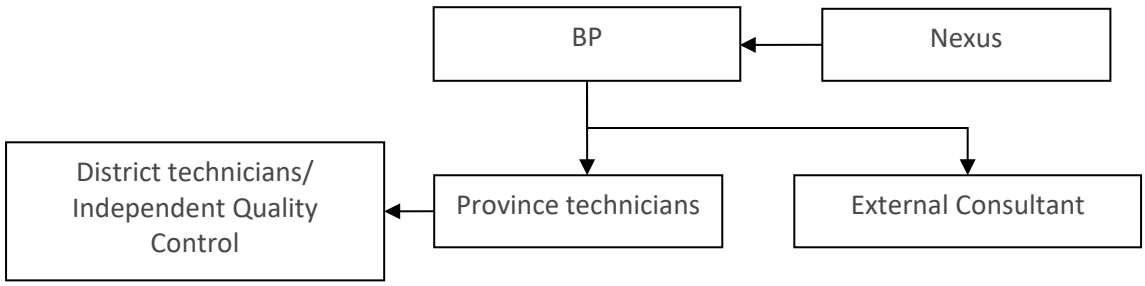


Figure 6: Structure of the monitoring group

From 2014, due to the need in modernizing the monitoring system and move from a paper-based system to an online Monitoring system – which means phasing out the physical QC Forms for each plant, the adapted quality control system has been introduced in the piloted provinces.

Result based finance instead of subsidy

In order to make the final step towards a sustainable biogas sector in Vietnam the subsidies for end users are slowly phased out. The households in provinces that operate under the RBF mechanism currently receive a discount of 350,000VND[17] on a biogas appliance of choice from the biogas enterprise but no longer receive the 1.2 million VND subsidy. The former end user investment subsidy is now provided to the biogas enterprise in the form of a result based finance incentive of 1.2 million VND after the enterprise has delivered a high quality biogas plant and provided end user training. This is done in order to transfer responsibilities from the biogas programme to the biogas enterprises and to increase the capacity of these biogas enterprises.

Existing quality control system (before deviation)

Quality control takes place at three levels: central level (PMU staff), provincial level (provincial technician) and district level (district technician). The biogas digesters are physically checked both while under construction and after construction has been completed.

[17] This discount is anticipated to be phased out in the future

Implementer	Under construction	After construction
District technician	100%	100%
Provincial technician	5%	10%
Biogas project division (central level)	0.5%	1.5%

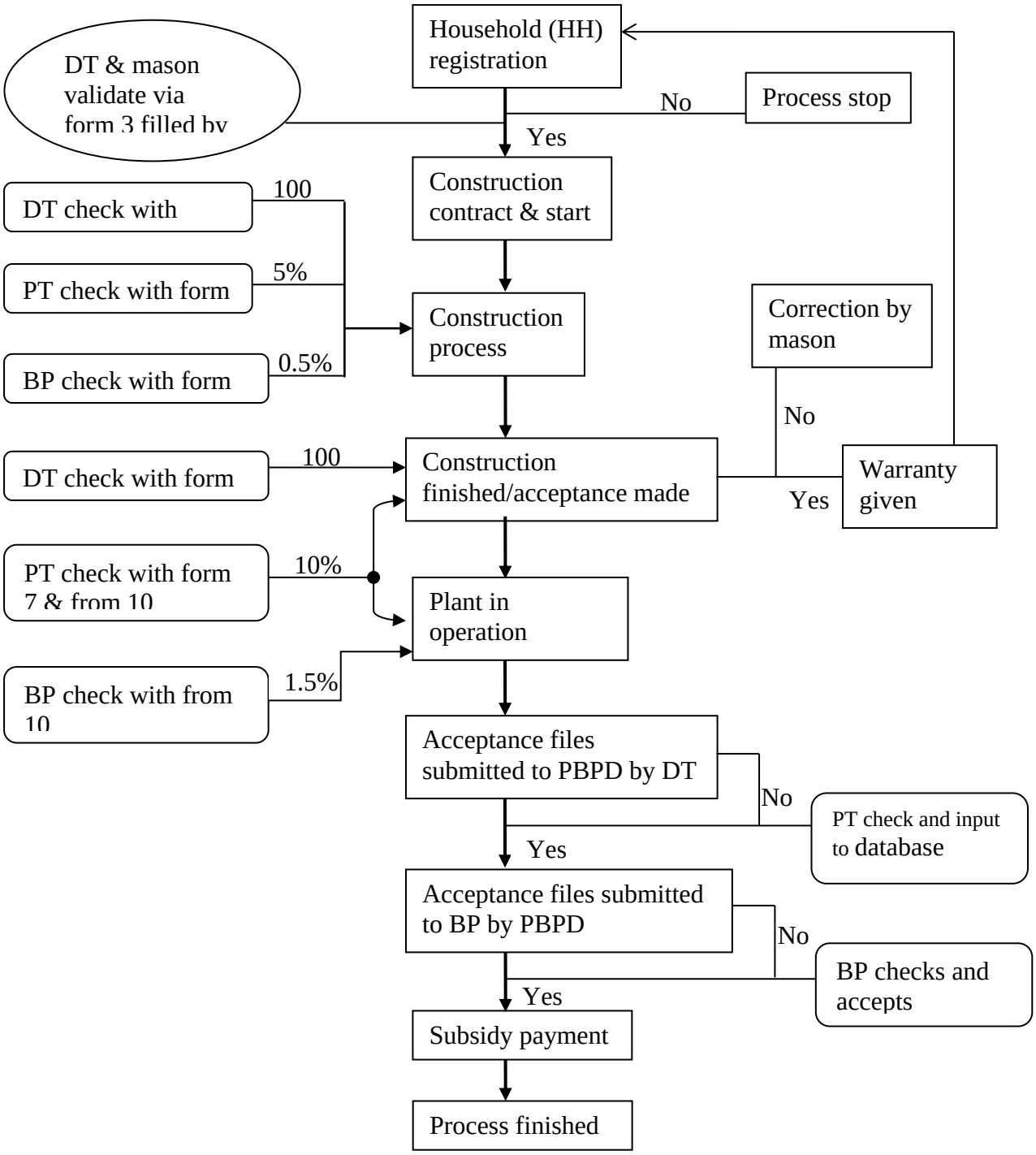


Figure 7: Quality control flow chart enforcement in Biogas Project

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

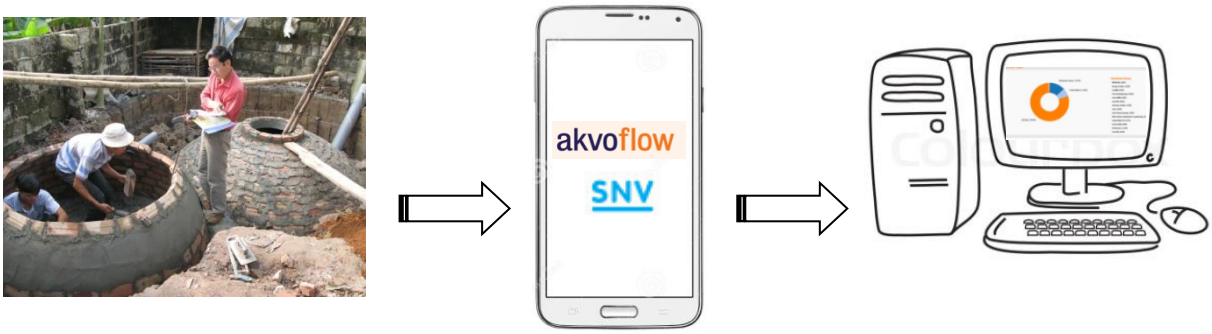
Deviated QC system

In the new QC system the intensity of QC checks for each mason is decided based on the experience and amount of digesters constructed by that specific mason. This is done because more experienced masons have a proven track record of constructing high quality biogas plants while junior masons may still make construction mistakes that can directly be addressed by the quality controller. In the table below the specific quality control percentages from both independent quality controllers and provincial technicians is described for each seniority level for the masons. A division has been made between KT digesters and composite (fibreglass reinforced plastic) biogas digesters.

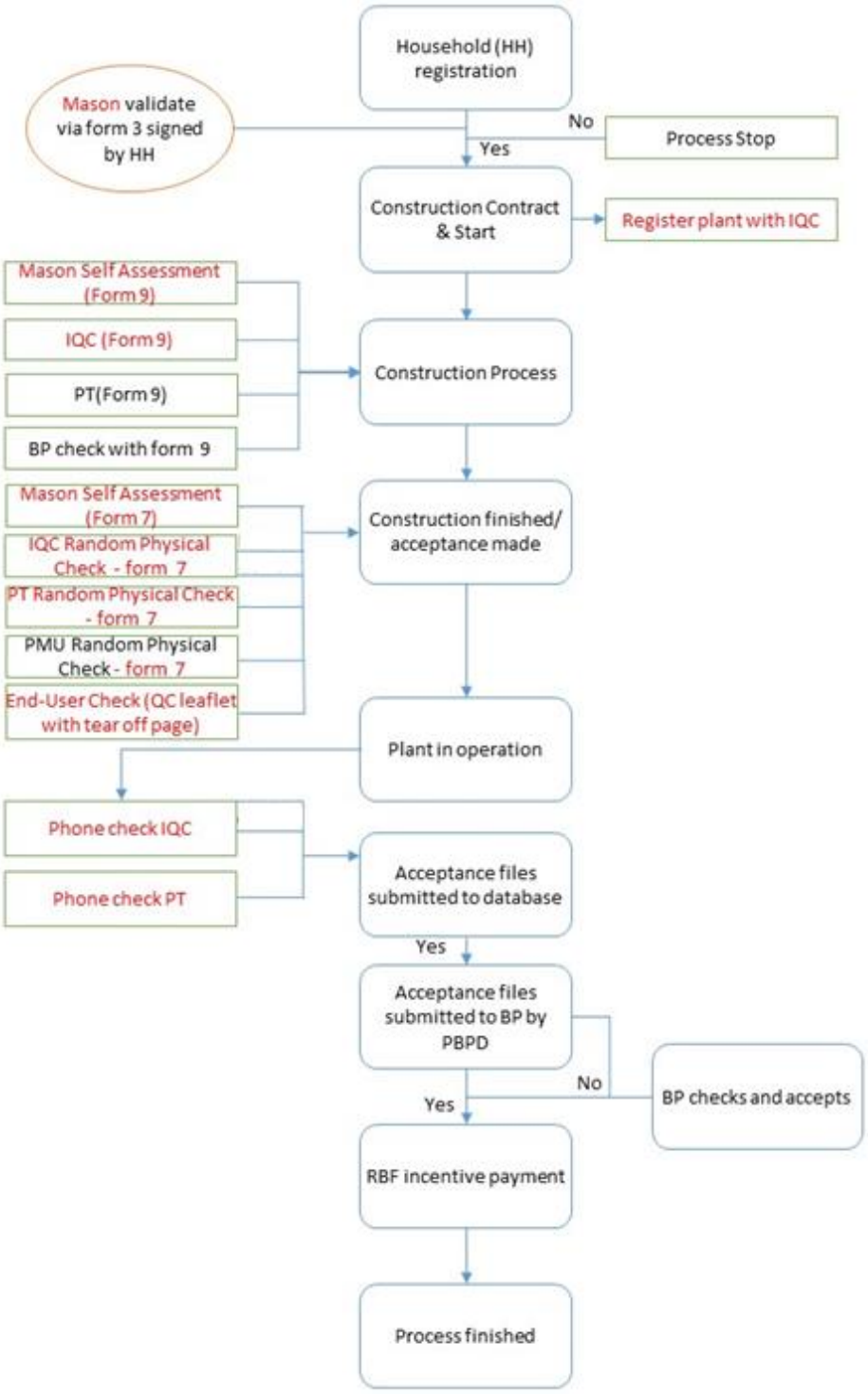
	Experience in years	# of digesters built	IQC quality check KT	IQC quality check composite	Provincial technician quality check KT	Provincial technician quality check Composite
Junior	<2	≤50	Under construction (UC): 30% After Construction (AC): 100%	UC: 10% AC: 100%	UC: 5% AC: 10%	UC: Not required AC: 10%
Mid-level	>2 <5	>50 <200	UC: 10% AC: 25%	UC: 5% AC: 25%	UC: 5% AC: 10%	UC: Not required AC:5%
Senior	>5	>200	UC: 1/year AC: 10%	UC: 1/year AC: 10%	UC: 1/year AC: 5%	UC: Not required AC:2%

(IQC=Independent Quality Control / UC=Under Construction / AC=After Construction / KT=fixed dome digester)

The PMU continues to conduct under construction (0.5%) and operation (1.5%) checks just like in the original scenario.
Biogas enterprises perform self-assessments on 100% of the plants. This self-assessment includes the date of commissioning and is signed by the household if they agree with the quality of the biogas plant. All households receive a quality control phone call from the independent quality controller. In this phone call the IQC verifies if the mason has indeed delivered a biogas digester and if it operates well. After the independent quality controller has performed the QC check, either physical or by phone, the quality control forms are forwarded to the provincial technician. The provincial technician inputs the data into the database after performing a sample based phone check and verifying the QC forms. A final verification of the QC form and database entry, complemented by a 20% phone check takes place at the PMU upon which the result based incentive is transferred to the biogas enterprise.
In order to support all implementers in monitoring works, a phone/table based apps (Akvo flow) has been developed. The masons, IQC could fill in the digesters information (including photos, GPS location, etc.) which could not be done with the old paper based QC system and upload them to the online database.



An advantage of the new QC system is that the performance of individual enterprises can be tracked in a more structured way. Enterprises with proven quality issues will be obligated to follow an additional training. The ranking of enterprises will be made publicly available. This will be a further incentive for enterprises to provide high quality biogas plants. A final benefit is that this activity will reduce the workload of the PMU.


Household (HH) registration
Mason validate via form 3 signed by HH
No
Process Stop
Yes
Construction Contract & Start
Register plant with IQC
Mason Self Assessment (Form 9)
IQC (Form 9)
PT(Form 9)
BP check with form 9
Construction Process
Mason Self Assessment (Form 7)
IQC Random Physical Check - form 7
PT Random Physical Check - form 7
PMU Random Physical Check - form 7
End-User Check (QC leaflet with tear off page)
Construction finished/ acceptance made
Plant in operation
Phone check IQC
Phone check PT
Acceptance files submitted to database
Yes
Acceptance files submitted to BP by PBPD
No
Yes
BP checks and accepts
RBF incentive payment
Process finished

List of the QC steps compared to the registered PDD – see also the attached figures to support this.

	Existing Mechanism (Business As Usual – copied from registered PDD)				**Deviated QC System**
No	**Activity**	**Actor**	**Sample**	**Modality**	
1	Plant commissioning and acceptance	District technician	100% of all plants are checked	Household visits. Plant and household ID. Construction according to standards and training. Proper functioning.	Biogas Enterprise (BE) will do self-assessment instead of acceptance check done by district technician. End-User will do a quality check based on quality control guidance leaflet.
		Provincial Technician	The provincial technicians will visit on average 5% of the plants.		
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.	IQC will check 10 to 30% or one time per year depend on experience of masons PT will check 5% or one time per year depend on experience of masons PMU will check 0.5% of KT plants under construction
3	*Quality control of "construction completed" plant*	Provincial Technician	Based on the received testing & acceptance forms, the provincial technician will visit 5% of the biogas installations.	Household visits. Plant and household ID. Construction according to standards and training. Proper functioning.	10% to 30% of KT is checked by IQC after construction 5% to 10% by a PT For composite this is 70% by IQC and 10% by PT. All plants that did not receive an after construction check receive a verification phone call by IQC. A sample of 10% of all households will receive an additional verification phone call from the provincial technician. An independent auditing firm selects which plants are selected for verification.
		PMU Staff	PMU Staff will check 1 % of the completed plants.	Quality check on the data and information filled in the form by the district technicians.	

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.	Training will be provided by Biogas Enterprises (BE) instead of government technician.
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, s and evaluation of the program's impact.	No Changes

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.

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

B.3. FAR raised in MP3

The FARs from GS issuance review[18] report MP3 were addressed as below

Table 8: FARs from GS issuance review report MP3

Contents	Summary of project participants' response
Forward Action Request # 1: The PP is requested to provide information on the schedule for future implementation for this project. Please note if there is an increase of more than 20% in annual emission reduction comparing with ex ante estimated ER, the PP shall follow GS design change process to update the project implementation and justify the impact.	The project has been implemented as described in the section B.1 above. Please note that compare to the ex-ante emission reduction at registration stage, the emission reduction for this monitoring period reduced 27%. Therefore, the design change as required in this FAR is not applicable.
Forward Action Request #2: For future issuances, PP shall justify that the project scenario energy use does not drastically increase when compared to the baseline. For future issuances, DOE shall provide an opinion on this issue and ensure that this aspect is verified including carrying out necessary	There are 3 baseline scenarios (BS) under this project activities which are: • BS1: LPG only households • BS2: Biomass (fuel wood or agricultural residues) only households. • BS3: Mix fuel (LPG and biomass) households. Due to LPG is a low emission fuel so from this monitoring period, the PP does not claim the emission reduction from the BS1 group (in which the household in the baseline use LPG only for cooking and later install the bio-digester). The emission reduction for this baseline scenario is observable because it is clear that all (or part) of LPG consumption in

[18] No FAR from DOE verification report from MP3

interviews during the site visit pertaining to other uses of biogas as mentioned in PP's response above	BS1 household was replaced by biogas as renewable energy source. However, the emission reduction is not significant, so the emission reduction is ignored from this MP4. Therefore, only 2 baseline scenarios were included in this project activities. The energy balance for baseline and project situation were analyzed and summarized[19] as below: *Unit: MJ/year* Baseline HH | Project HH | Difference between Project HH and Baseline HH | Difference in % BS2 | 7,028 | 7,636 | 607 | 8% BS3 | 7,525 | 7,636 | 110 | 1% The difference in energy consumption for cooking (MJ/year) is only 1% for BS3 and 8% for BS2. Hence it could be confirmed that the project scenario energy use does not drastically increase when compared to the baseline.

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), IQC (Independent Quality Control), 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:

[19] The energy requirement for baseline and project situation were calculated based on the fuel consumption which resulted from the KPT test. Please refer to cell J4:M5, tab "Energy balance" of the ER spreadsheet for detail calculation.

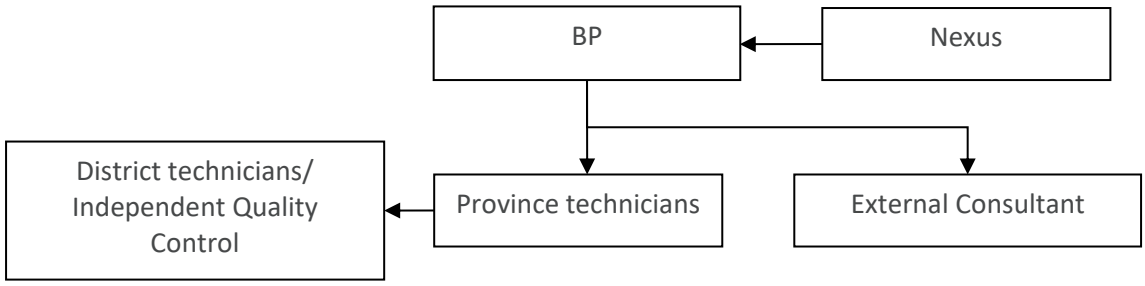


Figure 8: Structure of the monitoring group

From 2014, due to the need in modernizing the monitoring system and move from a paper-based system to an online Monitoring system – which means phasing out the physical QC Forms for each plant, the adapted quality control system has been introduced in the piloted provinces.

Result based finance instead of subsidy

In order to make the final step towards a sustainable biogas sector in Vietnam the subsidies for end users are slowly phased out. The households in provinces that operate under the RBF mechanism currently receive a discount of 350,000VND[20] on a biogas appliance of choice from the biogas enterprise but no longer receive the 1.2 million VND subsidy. The former end user investment subsidy is now provided to the biogas enterprise in the form of a result-based finance incentive of 1.2 million VND after the enterprise has delivered a high-quality biogas plant and provided end user training. This is done in order to transfer responsibilities from the biogas programme to the biogas enterprises and to increase the capacity of these biogas enterprises.

QC system

The intensity of QC checks for each mason is decided based on the experience and number of digesters constructed by that specific mason. This is done because more experienced masons have a proven track record of constructing high quality biogas plants while junior masons may still make construction mistakes that can directly be addressed by the quality controller. In the table below the specific quality control percentages from both independent quality controllers and provincial technicians is described for each seniority level for the masons. A division has been made between KT digesters and composite (fiberglass reinforced plastic) biogas digesters.

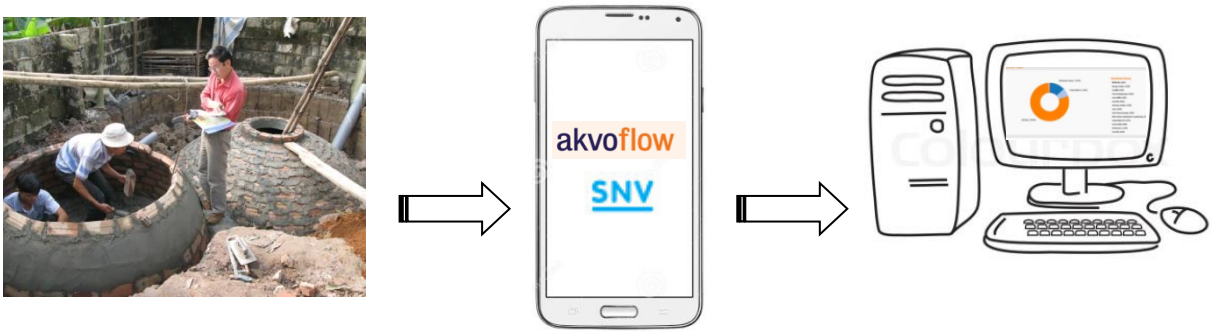
	Experience in years	# of digesters built	IQC quality check KT	IQC quality check composite	Provincial technician quality check KT	Provincial technician quality check Composite	
Junior	<2	≤50	Under construction (UC): 30% After Construction (AC): 100%	UC: 10% AC: 100%	UC: 5% AC: 10%	UC: required AC: 10%	Not
Mid-level	>2 <5	>50 <200	UC: 10% AC: 25%	UC: 5% AC: 25%	UC: 5% AC: 10%	UC: required	Not

[20] This discount is anticipated to be phased out in the future

						AC:5%	
Senior	>5	>200	UC: 1/year AC: 10%	UC: 1/year AC: 10%	UC: 1/year AC: 5%	UC: required AC:2%	Not

(IQC=Independent Quality Control / UC=Under Construction / AC=After Construction / KT=fixed dome digester)

Biogas enterprises perform self-assessments on 100% of the plants. This self-assessment includes the date of commissioning and is signed by the household if they agree with the quality of the biogas plant. All households receive a quality control phone call from the independent quality controller. In this phone call the IQC verifies if the mason has indeed delivered a biogas digester and if it operates well. After the independent quality controller has performed the QC check, either physical or by phone, the quality control forms are forwarded to the provincial technician. The provincial technician inputs the data into the database after performing a sample-based phone check and verifying the QC forms. A final verification of the QC form and database entry complemented by a 20% phone check takes place at the PMU upon which the result-based incentive is transferred to the biogas enterprise.
In order to support all implementers in monitoring works, a phone/tablet-based apps (Akvo flow) has been developed. The masons, IQC could fill in the digesters information (including photos, GPS location, etc.) which could not be done with the old paper-based QC system and upload them to the online database.



Data management and archiving

The hard copies of the main forms 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. 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 April 2019 to June 2019 amongst a representative sample of biogas user in each climate zone[21] 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

[21] 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.

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.

Due to there were FARs from MP2 regarding the monitoring activities to be solved during MP3 issuance review, the PP had to wait until the final conclusion from GS before conducting the next CMS survey for MP4. In Sept 2018, after securing the budgets for the next monitoring activities, verification and issuance cost, the PP published the Request for proposal of the monitoring survey service from third parties. The request for proposal was needed to republish for another 2 times because of the very intensive works with surveying more than 500 households in 20 districts among the country so during the first and second round of request for proposal, there was not any valid application. Please see more detail from the timeline below:

Activity	Time	Note
MP3 CMS field survey	May to Jun 2016	
Finalizing the CMS survey report by the third party	Aug 2016	*Please see supporting document: "MP3_CMS survey report_Aug 2016.pdf"*
Preparing MP3 MR report and setting up budget for DOE verification cost and issuance fee	Sept 2016 to Jul 2017	*It took long time due to the high budget of issuance fee for 1 million credits. The PP must make sure the budget to be available before conducting the verification.*
Signing DOE contract for MP3 verification	Aug 2017	
DOE site visit for MP3	Oct 2017	
Submitting to GS for issuance review	Dec 2017	
Finalizing the MP3 issuance review	Apr 2018	
Setting up budget for monitoring cost, DOE verification cost and issuance fee	May – Aug 2018	*It took long time due to the high budget for monitoring survey throughout the country and high issuance cost of about 800K VERs. The PP must make sure the budget to be available before conducting the verification.*
Designing monitoring activities and developing the questionnaires for MP4 based on GS FARs from MP3 issuance review	May – Aug 2018	
Publishing the request for proposal – 1st time	Sept 2018	*Please see supporting document:* • *Request for proposal of CMS MP4_1st time_1_20180925.png* • *Request for proposal of CMS MP4_1st time_2_20180925.png* • *Result from CMS MP4 tender_1st time_20181015.jpg* Not any application from any third party.

Publishing the request for proposal – 2nd time	Oct 2018	*Please see supporting document:* • *Request for proposal of CMS MP4_2nd time_20181019.jpg* • *Result from CMS MP4 tender_2nd time_20181212.jpg* Only one application but it was an invalid proposal.
Publishing the request for proposal – 1st time	Dec 2018	*Request for proposal of CMS MP4_2nd time_20181019.jpg* • *Request for proposal of CMS MP4_3rd time_20181217.jpg*
Contract negotiation and signing with survey company	Jan to Mar 2019	
MP4 CMS field survey	Apr to Jun 2019	
Finalizing the CMS survey report by the third party	Jul 2019	
Tendering for DOE	Aug 2019	
DOE site visit for MP4	Sept 2019	

After the carbon monitoring survey contract was signed, the selected third party conducted the CMS survey during the period of Apr to Jun 2019. Even the time of survey was in 2019, the questionnaires were designed to ask for the specific information of the monitoring period (Jan 2015 to Jun 2016), for example the number of animal that the households raised, etc. Please find the detail questionnaires in the "Annex 1. Survey questionnaire" of the monitoring survey report ("*MP4-GS1083-BUS report_E_Final.pdf*")

The CMS survey for the previous monitoring period (MP3) was conducted from May to June 2016 which was within this MP4 monitoring period. Comparing to the MP3 survey results, the weight average emission reduction from MP4 was lower as below:

Emission reduction source	MP3[22]	MP4[23]	Changed compare to MP3
AWMS (tCO_2e/unit)	3.45	2.61	-24.3%
Fuel saving (tCO2e/unit)	4.45	3.62	-18.7%

Therefore, it could be concluded that the values collected in 2019 were conservative and representative for the MP4 monitoring period.

C.2.1. 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.

[22] MP3 MR report and MP3 ER calculation
[23] Please find more detail on calculation in the ER spreadsheet

C.2.2. 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.

C.2.3. 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. Below is the example of calibration certificate for a scale using during MP4 carbon monitoring survey.

3D CALIBRATION
ACCURATE - SPEED - CHEAPER

CÔNG TY CỔ PHẦN HIỆU CHUẨN 3D VINA
Địa chỉ: Số 40/251 Nguyễn Khang, Yên Hòa, Cầu Giấy, Hà Nội
Tell: 024.2216 2398 - Hotline: 0902.145.345
Email: hieuchuan3d@gmail.com
Website: www.hieuchan3d.com

GIẤY CHỨNG NHẬN HIỆU CHUẨN
(Calibration Certificate)
Số GCN (No.): 19030514

Tên phương tiện đo (Object): Cân treo điện tử cầm tay
Kiểu (Type): CHS — Số (Serial No): N/A
Nơi sản xuất (Manufacturer): CAS
Đặc tính kỹ thuật (Technical Specification): Phạm vi đo : 0.2 kg ~ 15kg
Độ phân giải: 20g

Cơ sở sử dụng (Customer): CÔNG TY CỔ PHẦN TƯ VẤN EPRO
Địa chỉ (Address): Phòng 406, Khu CC2, Bắc Linh Đàm, phường Đại Kim, quận Hoàng Mai, Hà Nội.

Phương pháp thực hiện (Method of Calibration): ĐLVN 16:2009
Điều kiện môi trường (Environmental Conditions):
Nhiệt độ: 21°C — Độ ẩm: 62% RH
Chuẩn được sử dụng (Standards used):
Bộ quả cân F1, Bộ quả cân M1
(Được liên kết với chuẩn quốc gia)
Địa điểm thực hiện (Location of calibration) : Phòng Lab 3D VINA
Kết quả (Results): Xem trang sau
Ngày hiệu chuẩn (Date of Cal.): 05/03/2019 — Số tem: 19030514
Ngày khuyến nghị hiệu chuẩn tiếp theo (Recalibration Recommended): 05/03/2020

Hà Nội, ngày 05 tháng 03 năm 2019

Trưởng phòng thí nghiệm
(Head of Calibration Laboratory)
Tô Sỹ Lực

Giám Đốc
(Director)
Dương Văn Phong

Trang/Page Num) 1/2

Không được sao chép rời khi giấy chứng nhận có nhiều trang nếu không được sự đồng ý bằng văn bản của 3D VINA
(This certificate shall not be reproduced except in full, without the written approval of 3D VINA)

Figure 9: Example of scale calibration record

C.2.4. Sustainability assessment

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

C.2.5. Leakage emission assessment

This assessment was done at household level as it was based on the MP4 monitoring survey result from the project households (biogas users).

Table 9: Leakage emission assessment

#	Leakage source	Applicability
a	The displaced baseline technologies are reused outside the project boundary in place of lower emitting technology or in a manner suggesting more usage than would have occurred in the absence of the project.	The risk for leakage is very low. The baseline technologies are not reused outside the project boundary as reported by the surveyed biogas households, As reported by the surveyed biogas users, 51.2% of the baseline stoves were broken; 14.0% were kept at home but not used; 23.5% were used as backup for the biogas stove; 5.2% for other purposes and only 2 cases (0.6%) sold them lower than the market price[24].
b	The non-renewable biomass or fossil fuels saved under the project activity are used by non-project users who previously used lower emitting energy sources.	The risk for leakage is very low. The share of household that use a lower emitting energy source, such as LPG, will not switch back to NRB or coal due to the project activity because the saved biomass or fossil fuels would not impact to the supply of fuel in the market as the adoption rate of the project activity is less than 1% of the total number of household (at time of 01/07/2016, the total number of households living in rural area in Vietnam is 15.99 million households[25] so the percentage of households who have access to biogas digester [26] from the proposed project is 90,608/15,990,000 = 0.6%[27]).
c	The project significantly impacts the NRB fraction within an area where other CDM or VER project activities account for NRB fraction in their baseline scenario.	The risk for leakage is very low. No VER or CDM projects that account for NRB fraction in the project boundary of proposed project activity might be impacted because the adoption rate of the project activity is less than 1% of the total number of household (at time of 01/07/2016, the total number of households living in rural area in

[24] MP4 CMS survey result
[25] General Statistics Office of Vietnam: https://gso.gov.vn/Default.aspx?tabid=382&ItemID=16177
[26] See SD indicator #05
[27] Please find the calculation in cell G36, tab "SD" of the ER spreadsheet

		Vietnam is 15.99 million households[28] so the percentage of households who have access to biogas digester [29] from the proposed project is 90,608/15,990,000 = 0.6%[30]).
d	The project population compensates for loss of the space heating effect of inefficient technology by adopting some other form of heating or by retaining some use of inefficient technology	The risk for leakage is very low. The cookstoves are not used for space heating as regarding the location of the baseline stoves, 89.8% of the HHs did not keep the stoves inside the room. Among 35 cases (10.2%) that kept it inside the room, there is only 1 case who used the baseline stove for heating purposes. After installing the household still use the baseline stove for heating in average 5 days of the year and average 2 hours per day.
e	By virtue of promotion and marketing of a new technology with high efficiency, the project stimulates substitution within households who commonly used a technology with relatively lower emissions, in cases where such a trend is not eligible as an evolving baseline.	The risk for leakage is very low. The baseline is not fixed in this project, and the combustion of biogas always leads to lower emissions compared to all baseline fuels as it is 100% renewable.

C.2.6. 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.

[28] General Statistics Office of Vietnam: https://gso.gov.vn/Default.aspx?tabid=382&ItemID=16177
[29] See SD indicator #05
[30] Please find the calculation in cell G36, tab "SD" of the ER spreadsheet

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 generator[31].
III. The generated numbers were linked to the households, i.e. randomly generated number 97 was linked with the household number 97 of the age group, this 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

SECTION D. Data and parameters

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

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

Data / Parameter:	$EF_{b,CO2}$
Data unit:	$kgCO_2/TJ$ fuel
Description:	CO2 emission factor arising from use of fuels in the baseline scenario
Source of data used:	2006 IPCC Guidelines defaults, see chapter 2 Stationary Combustion: http://www.ipcc-nggip.iges.or.jp/public/2006gl/vol2.html
Value applied:	**Fuel *b*** / **EF_{CO2}, (kg/TJ)** LPG: 63100 Charcoal: 112000 Coal: 94 600 Firewood: 112000 Agriculture residues: 100000 Kerosene: 71900 Charcoal production: 1285 gCO_2 /kg charcoal[32]
Any comment:	The CO2 emissions from agricultural residues are considered renewable; hence the CO2 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*** / **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.

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

[32] Averaged CO_2 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 gCO_2/kg charcoal produced, 1285 is the average of that figure. Charcoal kilns are assumed to be similar or better in Thailand compared to Vietnam.

	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 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:	
Any comment:	

Fuel *i*	**NCV_i (TJ/Gg)**
LPG	47.3
Charcoal	29.5
Coal	25.8
Firewood	15.6
Agriculture residues	11.6
Kerosene	43.8

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

Data / Parameter:	**GWP_{N2O}**
Data unit:	tCO_2e per tN_2O
Description:	Global Warming Potential (GWP) of nitrous oxide
Source of data used:	SAR IPCC
Any comment:	298 for second commitment period. 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:	

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:	**$Bo_{(T)}$**
Data unit:	m^3 CH_4 per kg of VS excreted
Description:	Maximum methane production capacity for manure produced by livestock category T
Source of data used:	Volume 4 of the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, chapter 10 (online: http://www.ipcc-nggip.iges.or.jp/public/2006gl/vol4.html)
Value applied:	
Any comment:	

Animal T	$VS_{(T)}$ kg/day	$Bo_{(T)}$ m3CH4/kgVS
Pig	0.3	0.29
Buffalo	3.9	0.1
Dairy cow	2.8	0.13
Cattle	2.3	0.1

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:	$\eta_{biogasstove}$
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:	

Animal T	EF (kgCH4/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%
Monitoring frequency	Once before the start of the crediting period
QA/QC procedures to be applied:	N/A as this is the fixed parameter during CP
Any comment:	Fixed by baseline study for each crediting period

Data / Parameter:	$P_{bs2,y}$
Data unit:	kg/hh/day
Description:	Quantity of fuel that is consumed in the baseline scenario 2 in year y
Source of data to be used:	Original data is in KPT monitoring survey.
Value of data applied for the purpose of calculating expected emission reductions	**Fuel *i*** / **Average per household [33] kg/hh/day** LPG: 0 Firewood: 10.19 Agriculture residues: 2.90
Monitoring frequency	Updated for every 2 years[34]
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.

[33] Please refer to cells F167:H167, tab "BFT_Biomass", "GS1083_MP4_Monitoring database_ER" ER spreadsheet.
[34] The monitoring frequency requirement is every 2 years. However, due to there were FARs from MP2 regarding the monitoring activities to be solved during MP3 issuance review, the PP had to wait until the final conclusion from GS (which finished in Apr 2018) before conducting the next CMS survey for MP4. Please find more detail explanation in the timeline table in section C.2 above.

<table>
<tr><td>Data / Parameter:</td><td>$P_{bs3,y}$</td></tr>
<tr><td>Data unit:</td><td>kg/hh/day</td></tr>
<tr><td>Description:</td><td>Quantity of fuel that is consumed in the baseline scenario 3 in year y</td></tr>
<tr><td>Source of data to be used:</td><td>Original data is in KPT monitoring survey.</td></tr>
<tr><td>Value of data applied for the purpose of calculating expected emission reductions</td><td>
<table>
<tr><th rowspan="2">Fuel i</th><th>Average per household [35]</th></tr>
<tr><th>kg/hh/day</th></tr>
<tr><td>LPG</td><td>0.14</td></tr>
<tr><td>Firewood</td><td>7.67</td></tr>
<tr><td>Agriculture residues</td><td>1.86</td></tr>
</table>
</td></tr>
<tr><td>Monitoring frequency</td><td>Updated for every 2 years[36]</td></tr>
<tr><td>QA/QC procedures to be applied:</td><td>Fuel data is collected by the third party during the monitoring survey.</td></tr>
<tr><td>Any comment:</td><td>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.</td></tr>
</table>

<table>
<tr><td>Data / Parameter:</td><td>$P_{h,y}$</td></tr>
<tr><td>Data unit:</td><td>kg/hh/day</td></tr>
<tr><td>Description:</td><td>Quantity of fuel that is consumed in the project scenario in year y</td></tr>
<tr><td>Source of data to be used:</td><td>Original data is in KPT monitoring survey.</td></tr>
<tr><td>Monitoring frequency</td><td>Updated for every 2 years[37]</td></tr>
<tr><td>Value of data applied for the purpose of calculating expected emission reductions</td><td>
<table>
<tr><th rowspan="2">Fuel i</th><th>Average per household[38]</th></tr>
<tr><th>kg/hh/day</th></tr>
<tr><td>LPG</td><td>0.06</td></tr>
<tr><td>Firewood</td><td>1.07</td></tr>
<tr><td>Agriculture residues</td><td>0.09</td></tr>
</table>
</td></tr>
<tr><td>QA/QC procedures to be applied:</td><td>Fuel data is collected by the third party during the monitoring survey.</td></tr>
<tr><td>Any comment:</td><td>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,</td></tr>
</table>

[35] Please refer to cells F152:H152, tab “BFT_Mix”, “GS1083_MP4_Monitoring database_ER” ER spreadsheet.
[36] The monitoring frequency requirement is every 2 years. However, due to there were FARs from MP2 regarding the monitoring activities to be solved during MP3 issuance review, the PP had to wait until the final conclusion from GS (which finished in Apr 2018) before conducting the next CMS survey for MP4. Please find more detail explanation in the timeline table in section C.2 above.
[37] The monitoring frequency requirement is every 2 years. However, due to there were FARs from MP2 regarding the monitoring activities to be solved during MP3 issuance review, the PP had to wait until the final conclusion from GS (which finished in Apr 2018) before conducting the next CMS survey for MP4. Please find more detail explanation in the timeline table in section C.2 above.
[38] Please refer to cells G106:I106, tab “PFT”, “GS1083_MP4_Monitoring database_ER” ER spreadsheet.

	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
Source of data to be used:	Original data is in Usage survey result, from Group 0-1 to Group 9-10. Summary result in tab "Inputs", cell M132 of the MP4 Monitoring database ER spreadsheet.
Value of data applied for the purpose of calculating expected emission reductions	60.31%
Monitoring frequency	Updated for every year[39]
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:	The usage survey was conducted from Jan 2018 to May 2019 due to the large number of sample sizes (350 samples) and scattered distribution in the country (40 provinces). Compare to the usage survey result of 81.87%[40] which was conducted within this MP4 monitoring period (Apr 2015 until Nov 2015)[41], the current applied usage rate for MP4 of 60.31% is much lower due to the more delaying of the survey, the lower usage rate. Therefore, it is conservative to apply the lower usage rate for the case of delaying the usage monitoring survey.

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	Total: 130,194, in which • Warm zone: 30,328 • Temperate zone: 99,866
Monitoring frequency	Continuously
QA/QC procedures to be applied:	Follow the "Quality control monitoring" as described in Section C.1 above.
Any comment:	

[39] The monitoring frequency requirement is every 2 years. However, due to there were FARs from MP2 regarding the monitoring activities to be solved during MP3 issuance review, the PP had to wait until the final conclusion from GS (which finished in Apr 2018) before conducting the next CMS survey for MP4. Please find more detail explanation in the timeline table in section C.2 above.
[40] Please refer to page 35 of the MP3 MR, version 3.0, dated 30/01/2018
[41] Please refer to page 49 of the MP3 MR, version 3.0, dated 30/01/2018

Data / Parameter:	$MS_{(T,S,k)}$
Data unit:	%
Description:	Fraction of livestock category *T*'s manure fed into the bio-digester *S*, in climate zone *k*
Source of data used:	Raw data is from CMS monitoring survey. The calculated values are presented in the ER spreadsheet[42]
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	97.48%	5.56%	N/A	43.71%
warm	93.40%	N/A	N/A	13.11%

Monitoring frequency	Annual[43]
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[44].
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	2.52%	94.44%	N/A	56.29%
warm	6.60%	N/A	N/A	86.89%

Monitoring frequency	Annual[45]
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[46].

[42] Please refer to cells D16:H16 and cells N16:Q16, tab "ER_AWMS" of the "GS1083_MP4_Monitoring database_ER" ER spreadsheet

[43] The monitoring frequency requirement is annual. However, due to there were FARs from MP2 regarding the monitoring activities to be solved during MP3 issuance review, the PP had to wait until the final conclusion from GS (which finished in Apr 2018) before conducting the next CMS survey for MP4. Please find more detail explanation in the timeline table in section C.2 above.

[44] Please refer to cells D25:G25 and cells N25:Q25, tab "ER_AWMS" of the "GS1083_MP4_Monitoring database_ER" ER spreadsheet

[45] The monitoring frequency requirement is annual. However, due to there were FARs from MP2 regarding the monitoring activities to be solved during MP3 issuance review, the PP had to wait until the final conclusion from GS (which finished in Apr 2018) before conducting the next CMS survey for MP4. Please find more detail explanation in the timeline table in section C.2 above.

[46] Please refer to cells D48:D51 and cells N48:N51, tab "ER_AWMS" of the "GS1083_MP4_Monitoring database_ER" ER spreadsheet

Value of data applied for the purpose of calculating expected emission reductions	

Animal	N(T),h climate zone temperate	N(T),h climate zone warm
T	#	#
Pig	14.06	33.37
Buffalo	0.14	0.00
Dairy cow	0.00	0.00
Cattle	0.47	0.74

Monitoring frequency	Annual[47]
QA/QC procedures to be applied:	Data will be collected according to the CMS sampling plan
Any comment:	The average number of pigs 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:	Updated data wil be applied if there is any change in newer version of methodology
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

[47] The monitoring frequency requirement is annual. However, due to there were FARs from MP2 regarding the monitoring activities to be solved during MP3 issuance review, the PP had to wait until the final conclusion from GS (which finished in Apr 2018) before conducting the next CMS survey for MP4. Please find more detail explanation in the timeline table in section C.2 above.

Description:	Animal waste methane emission factor calculated by average local temperatures, IPCC default values and result of CMS monitoring survey.
Source of data used:	Calculated from following sources[48]: • IPCC default values for input parameter VS(T), Bo(T) (cells D35:E40 and N35:O40) of tab "ER_AWMS", ER spreadsheet) for the region Asia from table 10A-4, 10A-5, 10A-6, 10A-7, chapter 10, 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	

EF AWMS by animal	Zone temperate	Zone Warm
Pig	2.084	2.039
Buffalo	1.431	0.000
Dairy cow	0.000	0.000
Cattle	2.993	1.942

Monitoring frequency	Updated for every 2 years[49]
QA/QC procedures to be applied:	Data will be collected according to the CMS sampling plan
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 MP4 Monitoring database.
Value of data applied for the purpose of calculating expected emission reductions	

Average Bio-slurry emissions			
	Units	CO2e/unit	CO2e
Temperate	99,866	0.024	2,439
Warm	30,328	0.090	2,721
Total	130,194		5,160
Average emissions	**0.04** [50]	tCO2e/year/hh	

[48] Please refer to cells H37:H40 and cells R37:R40, tab "ER_AWMS" of the "GS1083_MP4_Monitoring database_ER" ER spreadsheet

[49] The monitoring frequency requirement is every 2 years. However, due to there were FARs from MP2 regarding the monitoring activities to be solved during MP3 issuance review, the PP had to wait until the final conclusion from GS (which finished in Apr 2018) before conducting the next CMS survey for MP4. Please find more detail explanation in the timeline table in section C.2 above.

[50] Please refer to cells L4:N7, tab "PE_Bioslurry" of the "GS1083_MP4_Monitoring database_ER" ER spreadsheet

Monitoring frequency	Updated for every 2 years[51]
QA/QC procedures to be applied:	Data will be collected according to the CMS sampling plan
Any comment:	

D.3. Implementation of sampling plans

D.3.1. Sampling approach

The next table summarizes the design of the surveys:

Table 10: 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 MP4
Main topics	User characteristics, AWMS and SD survey	Project fuel use	Baseline fuel use	Drop-off rate
Sampling method	Cluster and probability proportional to size sampling	Randomly selection from CMS samples	Selection based on PFT selection criteria	Cluster sampling
Cluster	District	District	District	Age group
Sample size	17 households (including 10% oversampling)	5 households per district [52]	3 households for each baseline scenario in each district (total 9 BFT HHs per district)	35 households (oversampling with 5 households)
Number of clusters	20 (10 for each zone)	20	20	10
Total sample size	340	100	180	350

D.3.2. CMS survey

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

Table 11: CMS survey design

Sampling plan	Sampling MP4

[51] The monitoring frequency requirement is every 2 years. However, due to there were FARs from MP2 regarding the monitoring activities to be solved during MP3 issuance review, the PP had to wait until the final conclusion from GS (which finished in Apr 2018) before conducting the next CMS survey for MP4. Please find more detail explanation in the timeline table in section C.2 above.

[52] 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

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[53]. 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).
Implementation:	The CMS was executed by a selected independent consultant from April to June 2019.
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.

[53] *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.*

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 below[54]:

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

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 12: Minimum sample size per zone[55]

Zone	Classification	N	Calculated n	Round up n
A	Temperate	99,866	164.83	170
B	Warm	30,328	164.46	170
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*10*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

[54] Please refer to the registered PDD for more detail.
[55] Details calculation in range B130:E136 of tab "Inputs" of the "GS1083_MP4_Monitoring database_ER" ER spreadsheet

Warm zone:

- List all districts in the project area and their population in Warm zone (column A and B in tab "Warm" of the "CMS and KPT_Sampling HHs" excel database. There are 217 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 30,228.
- 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 3,033.
- Choose a number between 1 and the SI at random. This is the *Random Start* (RS). In this sample, the RS is 425.
- Calculate the following series: RS; RS + SI; RS + 2SI; RS + 3SI; RS + 4SI; RS + 5SI; RS + 6SI; RS + 7SI; RS + 8SI; RS + 9SI. The results are in the following table:

Table 13: Sampled steps for warm zone[56]

No	Interval	Value
1.	RS	425
2.	RS + 1SI	3,458
3.	RS + 2SI	6,491
4.	RS + 3SI	9,524
5.	RS + 4SI	12,557
6.	RS + 5SI	15,590
7.	RS + 6SI	18,623
8.	RS + 7SI	21,656
9.	RS + 8SI	24,689
10.	RS + 9SI	27,722

- Each of these 10 numbers corresponds to a site on the list of districts. 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 (4668) is contained in district named "Cầu Kè-Trà Vinh", which holds numbers from 4614 to 4910. The third number in the series (7523) is contained in district named "Định Quán-Đồng Nai", which holds numbers from 7442 to 7772.
- Continuing in this manner, the desired number of sites will be selected as below

Table 14: Randomly selected clusters in zone B: Warm[57]

#	Cluster	Number of plants in cluster
1	An Nhơn-Bình Định	1,331
2	CAM LÂM-Khánh Hòa	426
3	Châu Thành-Trà Vinh	503
4	Gò Công Tây-Tiền Giang	528
5	Châu Đức-Bà Rịa-Vũng Tàu	1,107
6	Núi Thành-Quảng Nam	433
7	Mỏ Cày Nam-Bến Tre	193
8	Sơn Tịnh-Quảng Ngãi	763
9	Tây Sơn-Bình Định	1,285
10	Trảng Bom-Đồng Nai	329

[56] Please find more detail in column E of tab "Warm" of the "CMS and KPT_sampling HHs_MP4" spreadsheet
[57] Details calculation in tab "Warm" of the "CMS and KPT_Sampling HHs" excel file

Temperate zone

Similarly, the above steps could be applied to Temperate zone. Details for selection result could be found in tab "Temperate" of the "CMS and KPT_sampling HHs_MP4" spreadsheet.

Table 15: Sampled steps for temperate zone[58]

No	Interval	Value
1.	RS	2,058
2.	RS + 1SI	12,045
3.	RS + 2SI	22,032
4.	RS + 3SI	32,019
5.	RS + 4SI	42,006
6.	RS + 5SI	51,993
7.	RS + 6SI	61,980
8.	RS + 7SI	71,967
9.	RS + 8SI	81,954
10.	RS + 9SI	91,941

The following districts were selected for zone Temperate:

Table 16: Randomly selected clusters in zone A: Temperate[59]

#	Cluster	Number of plants in cluster
1	Bình Giang-Hải Dương	594
2	Đô Lương-Nghệ An	398
3	Hiệp Hoà-Bắc Giang	627
4	Yên Mô-Ninh Bình	1,207
5	Lục Nam-Bắc Giang	996
6	Phú Bình-Thái Nguyên	1,451
7	Sóc Sơn-Hà Nội	2,585
8	Hưng Yên city-Hưng Yên	615
9	Thường Xuân-Thanh Hoá	293
10	Vĩnh Bảo-Hải Phòng	376

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

[58] Please find more detail in column E of tab "Temperate" of the "CMS and KPT_sampling HHs_MP4" spreadsheet
[59] Details calculation in tab "Temperate" of the "CMS and KPT_sampling HHs" excel spreadsheet

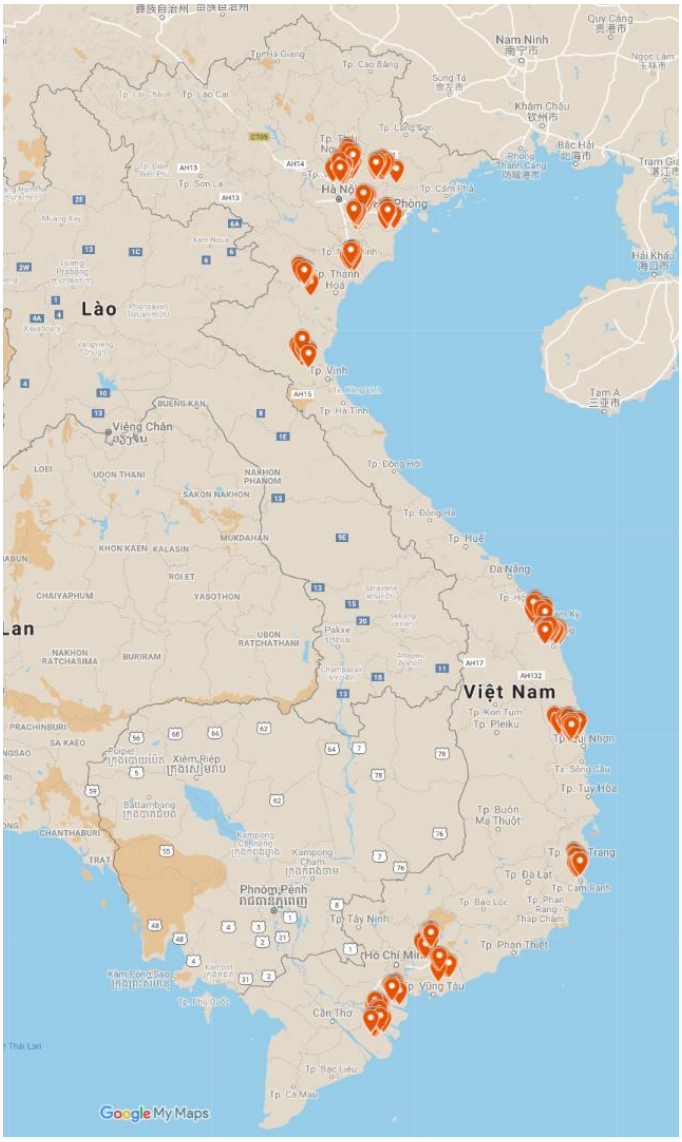


Figure 10: Location of the non-biogas households

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 household owner 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 test (PFT)

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

- Baseline scenario 1: LPG only households
- Baseline scenario 2: Biomass (fuel wood or agricultural residues) only households.
- Baseline scenario 3: Mix fuel (LPG and biomass) households.

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

The KPT is executed according to this protocol[60]:

- 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 totaling 24 hours.
- Cooking practices shall be during 'normal days'.
    - 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).
    - 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 behavior in the kitchen, as if no tests were happening, to feed the usual variation of people with the usual variation of food types.
- To conduct the tests, ensured is that the cook uses fuel only from a designated stock which is pre-weighed.
- During the tests, also was find out how many people have eaten and how many meals each, so that information can be entered 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.
- 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 3D CALIBRATION as an independent third party.

[60] 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.

3D CALIBRATION
ACCURATE - SPEED - CHEAPER

CÔNG TY CỔ PHẦN HIỆU CHUẨN 3D VINA
Địa chỉ: Số 40/251 Nguyễn Khang, Yên Hòa, Cầu Giấy, Hà Nội
Tell: 024.2216 2398 - Hotline: 0902.145.345
Email: hieuchuan3d@gmail.com
Website: www.hieuchuan3d.com

GIẤY CHỨNG NHẬN HIỆU CHUẨN
(Calibration Certificate)
Số GCN (No.): 19030514

Tên phương tiện đo (Object): Cân treo điện tử cơ khí
Kiểu (Type): CHS — Số (Serial No.): N/A
Nơi sản xuất (Manufacturer): CAS
Đặc tính kỹ thuật (Technical Specification): Phạm vi đo: 0.2 kg ~ 15kg; Độ phân giải: 20g

Cơ sở sử dụng (Customer): CÔNG TY CỔ PHẦN TƯ VẤN EPRO
Địa chỉ (Address): Phòng 406, Khu CC2, Hồ Linh Đàm, phường Đại Kim, quận Hoàng Mai, Hà Nội

Phương pháp thực hiện (Method of Calibration): ĐLVN 16:2009
Điều kiện môi trường (Environmental Conditions): Nhiệt độ: 21°C — Độ ẩm: 62% RH
Chuẩn được sử dụng (Standards used): Bộ quả cân F1, Bộ quả cân M1 (Được hiệu chỉnh với chuẩn quốc gia)
Địa điểm thực hiện (Location of calibration): Phòng Lab 3D VINA
Kết quả (Results): Xem trang sau
Ngày hiệu chuẩn (Date of Cal.): 05/03/2019 — Số tem: 19030514
Ngày khuyến nghị hiệu chuẩn tiếp theo (Recalibration Recommended): 05/03/2020

Hà Nội, ngày 05 tháng 03 năm 2019
Trưởng phòng thí nghiệm (Head of Calibration Laboratory) — Giám Đốc (Director)
Tô Sỹ Lực — Dương Văn Phong

Trang/Page Num: 1/2

Không được sao chụp với bất kỳ chứng nhận có nhiều trang nếu không được sự đồng ý bằng văn bản của 3D VINA
(This certificate shall not be reproduced except in full, without the written approval of 3D VINA)

Figure 11 Calibrated scale for survey

The KPT targets two groups:

Table 17: KPT target groups

Group	Sample size
PFT household	100
BFT households (3 groups, each contains 60 HHs)	180
Total sample	280

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 Celsius (°C), in particular 23 °C in temperate zone and 27 °C 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 households for simple random sampling of each group.

b. Design effect[61]: 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

[61] For more details, please referred to the registered PDD

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 each to be select will be:

N_{group} = 30 *1.5*1.1 ~ 50

The total sample size will be at least 50 per group, and at least 4*50 = 200 in total for the KPT.

Number of clusters

According to Purnami et al (2011)[62] a reliable way of cluster selection is with the following equation:

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

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

In the case of GS0183, there are 545 districts[63], one district is one cluster. Therefore, there are 545 clusters. The number of sampled cluster are:

$$k \approx \left(\frac{545}{2}\right)^{\frac{1}{2}} \approx 17$$

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 17 but in 20 clusters. The CMS and KPT were executed by a selected independent consultant (EPRO Consulting JSC[64]) from April to June 2019. The survey was conducted in 20 districts of 18 provinces (Hai Phong, Thanh Hoa, Hung Yen, Ha Noi, Thai Nguyen, Bac Giang, Ninh Binh, Nghe An, Hai Duong, Dong Nai, Binh Dinh, Quang Ngai, Ben Tre, Quang Nam, Ba Ria-Vung Tau, Tien Giang, Tra Vinh, Khanh Hoa) in Vietnam.

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 HHs per BFT group, or 3 HHs per cluster (9 BFT (3 BS1, 3 BS2 and 3 BS3) and 100 HHs for PFT, or 3 HHs per cluster). This is more representative.

[62] 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

[63] According to the project database.

[64] http://www.eprovn.com/Aboutus.html

In case of the CMS there are 17 households per cluster, the 5 PFT households will be randomly selected from those 17. Because these 17 households are randomly selected in each cluster, the randomly selection of these 3 households among them still satisfy the random selecting method.

BFT households:

In the MP4 monitoring period, PP contracted with the 3rd party (EPRO) to conduct the BFT for all 3 baseline scenarios with extra 60 samples for each one (180 baseline samples in total). The criteria for selecting the BFT household of each baseline scenario was proposed and accepted during MP3 verification.

The criteria for selecting the BFT households were below:

Table 18: Questionnaire for selecting a BFT HH

Criteria 1: Does the household have a bio digester?	No → go to next criteria
	Yes → select another similar household
Criteria 2: Is the number of household members from 3 to 6?	**Yes** → Number is **……**→ go to next criteria
	No → select another household
Criteria 3: Does the household fall in one of the below baseline scenarios? • Baseline scenario 1: LPG only households (BS1) • Baseline scenario 2: Biomass (fuel wood or agricultural residues) only households (BS2). • Baseline scenario 3: Mix fuel (LPG and biomass) households (BS3).	**Yes** → Type name of baseline scenario → If BS1 then select household as BFT household If BS2 or BS3, go to next criteria
	No → select another household
Criteria 4: Does the hh have total number of sows and boars from 2 to 4?	**Yes**→ go to criteria 5.1
	No → go to criteria 5.2 or 5.3
Criteria 5.1: Does the hh have total number of fattening pigs and piglets from 16 to 30?	**Yes** → select household as BFT household
	No → select another household
Criteria 5.2: Does the hh have total number of fattening pigs and piglets from 26 to 40?	**Yes** → select household as BFT household
	No → select another household
Criteria 5.3: Does the hh have total number of sows and boars from 6 to 12?	**Yes** → select household as BFT household
	No → select another household

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 19: US Sample plan and objective

Sampling plan	Sampling MP4
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 conducted by the provincial technician for collecting data. The information on survey date for each sample could be found in column C of the MP4 Usage survey result. The usage survey was conducted from Jan 2018 to May 2019 due to the large number of sample sizes (350 samples) and scattered distribution in the country (40 provinces).
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 350 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

Table 20: Usage survey selection by age group[65]

Group	Units included that are at least in use for (years)	From	To	Sample drawn from built units (at random)	Worked normally	Usage rate in group	Units built in that period (age group population)	Operated HHs
0 - 1	0.5	01/07/15	30/06/16	35	33	94.29%	5,118	4,826
1 - 2	1.5	01/07/14	30/06/15	35	30	85.71%	10,259	8,793

[65] For more detail, please refer to the cells A4:I13, tab “Usage rate” of the usage survey results spreadsheet

2 - 3	2.5	01/07/13	30/06/14	35	25	71.43%	8,646	6,176
3 - 4	3.5	01/07/12	30/06/13	35	25	71.43%	9,870	7,050
4 - 5	4.5	01/07/11	30/06/12	35	28	80.00%	15,070	12,056
5 - 6	5.5	01/07/10	30/06/11	35	27	77.14%	18,301	14,118
6 - 7	6.5	01/07/09	30/06/10	35	20	57.14%	23,423	13,385
7 - 8	7.5	01/07/08	30/06/09	35	24	68.57%	18,574	12,736
8 - 9	8.5	01/07/07	30/06/08	35	18	51.43%	17,421	8,959
9 -10	9.5	01/01/07	30/06/07	35	25	71.43%	3,512	2,509
Total of population for sampling or total number of digesters in Age groups							**130,194**	**90,608**
Usage rate								**69.6%**

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 below[66]:

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

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 21: Weighted average uptime[67]

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	0.52	2,637	168,894
1 - 2	1.73	17,782	307,770
2 - 3	1.68	14,525	216,150
3 - 4	4.96	48,955	246,750
4 - 5	1.29	19,376	421,960
5 - 6	2.96	54,225	494,127
6 - 7	3.85	90,179	468,460
7 - 8	5.04	93,644	445,776
8 - 9	3.94	68,716	313,578
9 -10	3.76	13,205	87,800
Sum		**423,244**	**3,171,265**

[66] For more detail, please refer to the MPI monitoring report (page 42).
[67] For more detail, please refer to cells B22:E34, tab "Usage rate" of the usage survey results spreadsheet

Weighted average share of units in operation	86.65%

The parameter "Average number of days that units are not in operation in survey sample" are the average number of days that the household do not have biogas. This happened when the bio-digester units undergo emptying and are therefore not in use for a number of days. In order to monitor this parameter, the PP used the interviewing method that using the questionnaire for asking the households how many days they did not have biogas during the monitoring period.

The result of this parameter is calculated based on the average result from households' responses. The detail calculation could be found in cells B22:E31, tab "Usage rate" of the MP4 usage survey result spreadsheet. This approach is conservative rather than monitoring only the dropped-out rate of digesters and it has been accepted since the first verification.
Therefore, the effective cumulative usage rate is:

$$U_{Fy,h} = U_{y,h} * U_{py,h} = 60.31\%$$ [68]

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 selections 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 22: 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 23: CO_2, CH_4 and N_2O emission factors

Fuel *i*	EF_{CO2}, (kg/TJ)	EF_{CH4}, (kg/TJ)	EF_{N20}, (kg/TJ)
Firewood	112000	1224	11.25
Agriculture residues	100000	2210	9.7

[68] Therefore, the units in use for the ER calculation are 130,194*60.31% =90,608; or the units dropped out are 130,194 - 90,608= 39,586 units.

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 CO_2 emissions from firewood, agricultural residues and charcoal consumption and production. Methane and nitrous oxide emission are 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 second commitment period (from 01/01/2013), the GWP are 25 and 298 for CH_4 and N_20 respectively.[69]

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* consumed in the baseline during year y (kg/household/year) Total amount of fuel type *i* in the baseline scenario (kg/year) of one household
NCV_i	=	Net Calorific Value of fuel type *i* (TJ/ton of fuel)
$EF_{CO2,i}$	=	The CO_2 emission factor per unit of energy of fuel *i* (tCO_{2e}/TJ)
$EF_{nonCO2,i}$	=	The nonCO_2 emission factor per unit of energy of fuel *i* (tCO_{2e}/TJ)

Emission with baseline scenario 2:

$BE_{th,h,,Biomass}$ = 5.61 (tCO_{2e}/ HH/year) [70]

Emission with baseline scenario 3:

$BE_{th,h,,Mix}$ = 4.32 (tCO_{2e}/ HH/year) [71]

Emission for fuel:

According to the TPDDTEC methodology, the 90/30 rule check are applied to all applicable scenarios. For the emission reduction with baseline scenarios 2 and 3 were met[72] (see cell D13 and E13, tab "ER_fuel", "MP4_Monitoring database_ER" spreadsheet) so the mean ER value was used.

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

[70] Please refer to cell I170, tab "BFT_Biomass", "GS1083_MP4_Monitoring database_ER" ER spreadsheet

[71] Please refer to cell I155, tab "BFT_Mix", "GS1083_MP4_Monitoring database_ER" ER spreadsheet

[72] During the GS review for MP2, it was concluded that the baseline information indicates that there is not a single type of baseline users, hence the mixed fuel situation is not the only representative baseline scenario for the project situation. Since, each user group has different fuel consumption pattern and so there should be multiple baseline scenarios, representative of each type of end users corresponding to type of fuel in use. The calculation approach including distribution value (1.28) has been followed the guidance from GS in the email dated 22 Apr 2015 which was submitted to the DOE.

The applied emission reduction for fuel is 3.62 tCO2e/ HH/year[73], therefore the baseline emission is the result from project emission plus the applied emission reduction[74]. The weighted average emission reduction for fuel is:

$$BE_{th,h,} = 4.37 \ (tCO_{2e}/ HH/year)$$

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:

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

Where:

$BE_{awms,h}$	The baseline emissions from handling of animal waste in premise h (tCO_2e/year)
GWP_{CH4}	Global warming potential of methane (tCO_2e per tCH4). The GWP applied for the second commitment period, the GWP are 25 and 298 for CH_4 and N_20 respectively
$N_{(T),h}$	The number of animals of livestock species per category T
$EF_{awms(T)}$	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 region 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 date for each province has been collected and for each province a separate IPCC default factor is obtained. This approach is allowed 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 24: Methane emission factors by climate zone [75]

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.

[73] Please refer to cell C17, tab “ER_fuel”, “GS1083_MP4_Monitoring database_ER” ER spreadsheet
[74] Please refer to cell C19, tab “ER_fuel”, “GS1083_MP4_Monitoring database_ER” ER spreadsheet.
[75] 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)

Table 25: Ex-post BE AWMS emission in the climate zone A: Temperate[76]

Animal T	N(T),h #	$EF_{awms(T)}$ kgCH4/head/year
Pig	14.06	5.00
Buffalo	0.14	2.00
Dairy cow	0.00	23.00
Cattle	0.47	1.00
$BE_{AWMS, temperate}$	$BE_{awms,h} = GWP_{CH4} * \sum_T \left(EF_{awms(T)} * N_{(T),h} \right)$	**1.78 (tCO_2/HH/year)**

And the climate zone warm:

Table 26: Ex-post BE AWMS emission in the climate zone B: Warm[77]

Animal T	N(T),h #	$EF_{awms(T)}$ kgCH4/head/year
Pig	33.37	7.00
Buffalo	0.00	2.00
Dairy cow	0.00	31.00
Cattle	0.74	1.00
$BE_{AWMS, warm}$	$BE_{awms,h} = GWP_{CH4} * \sum_T \left(EF_{awms(T)} * N_{(T),h} \right)$	**5.86 (tCO_2/HH/year)**

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 MP4.

Table 27: Fuel consumption of project HHs[78]

Fuel *i*	Average per household (kg/year)
Firewood	389.9
Agriculture residues	32.8

[76] Details calculation in cells C4:E9 and G10, sheet "ER_AWMS" of the "GS1083_MP4_Monitoring database_ER" spreadsheets.
[77] Details calculation in cells M4:O9 and Q10, sheet "ER_AWMS" of the "GS1083_MP4_Monitoring database_ER" spreadsheets.
[78] Details calculation in row 7 of tab "SD" of the "GS1083_MP4_Monitoring database_ER" spreadsheet

LPG	22.5

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

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

Where

$PE_{th,h}$	=	The total project 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* consumed in the project during year y (kg/household/year) Total amount of fuel type *i* in the project scenario (kg/year) of one household
NCV_i	=	Net Calorific Value of fuel type *i* (TJ/ton of fuel)
$EF_{CO2,i}$	=	The CO_2 emission factor per unit of energy of fuel *i* (tCO_{2e}/TJ)
$EF_{nonCO2,i}$	=	The nonCO_2 emission factor per unit of energy of fuel *i* (tCO_{2e}/TJ)

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

$PE_{th,h,}$ = 0.75 (tCO_{2e}/HH/year)[79]

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.

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 tables 31 and 32 , 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:

[79] Please refer to cell J110, tab “PFT”, “GS1083_MP4_Monitoring database_ER” ER spreadsheet

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

Where:

$PE_{awms,h,y}$	=	Mean emission per household *h* (tCO_2e/year)
$N_{(T),h,y}$	=	Number of animals of livestock category T in year y in premise h
$EFawms_T$	=	Emission factor for the defined livestock category T, (ton CH_4 per animal per year). Estimated using the IPCC TIER 2 approach.
PL_y	=	Physical leakage of the biodigester in year *y* (10 %)[80]
EF_T	=	Annual CO_2 emission factor for livestock category *T*, (tCO_2e $animal^{-1}$ yr^{-1})
GWP_{CH4}	=	Global Warming Potential (GWP) of methane (tCO_2eq per tCH_4): 25 for the second commitment period.
$\eta_{biogasstove}$	=	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.

$$\boldsymbol{EF_{AWMS(T)} = \left(VS_{(T)} \times 365\right) \times \left[Bo_{(T)} \times D_{CH4} \times \sum_k \frac{MCF_{BL,k}}{100} \times MS_{(T,S,k)}\right]}$$

Where:

$EF_{AWMS(T)}$	=	CH_4 emission factor for livestock category T in the project scenario, (tCH_4.$animal^{-1}$)
$VS_{(T)}$	=	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,(m^3 CH_4 kg^{-1} of VS)
D_{CH4}	=	Conversion factor of m^3 methane to kg methane, (0,067 kg/m^3)
$MCF_{(BL,k)}$	=	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)

Table 28: Share of manure management systems in the project scenario in climate zone: Temperate[81]

[80] Default value of the applied methodology is adopted (TPDDTEC page 52)
[81] Details calculation in cells C15:G24, tab "ER_AWMS" of the "GS1083_MP4_Monitoring database_ER" ER spreadsheet

Manure management system	Pig	Buffalo	Dairy cow	Cattle
Bio digester	97.48%	5.56%	0.00%	43.71%
Anaerobic lagoon	0.00%	0.00%	0.00%	0.00%
Slurry/liquid system	0.00%	0.00%	0.00%	0.00%
Solid storage	0.73%	0.00%	0.00%	12.90%
Composting	1.21%	94.44%	0.00%	43.39%
Daily spread	0.00%	0.00%	0.00%	0.00%
Drying in the sun	0.00%	0.00%	0.00%	0.00%
Fish pond	0.00%	0.00%	0.00%	0.00%
Other	0.59%	0.00%	0.00%	0.00%

Table 29: Share of manure management systems in the project scenario in climate zone: Warm[82]

Manure management system	Pig	Buffalo	Dairy cow	Cattle
Bio digester	93.40%	0.00%	0.00%	13.11%
Anaerobic lagoon	0.18%	0.00%	0.00%	0.00%
Slurry/liquid system	0.00%	0.00%	0.00%	0.00%
Solid storage	0.52%	0.00%	0.00%	28.22%
Composting	4.75%	0.00%	0.00%	28.69%
Daily spread	0.00%	0.00%	0.00%	1.85%
Drying in the sun	0.81%	0.00%	0.00%	0.02%
Fish pond	0.00%	0.00%	0.00%	0.00%
Other	0.34%	0.00%	0.00%	28.10%

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

Table 30: Calculated average MCF by climate zone and animal[83]

Animal	Temperate zone MCF.MS	Warm zone MCF.MS
Pig	9.80%	9.58%
Buffalo	1.50%	0.00%
Dairy cow	0.00%	0.00%

[82] Details calculation in cells M15: Q24, tab "ER_AWMS" of the "GS1083_MP4_Monitoring database_ER" ER spreadsheet
[83] Details calculation in tab "ER_AWMS" of the "GS1083_MP4_Monitoring database_ER" spreadsheet

Cattle	5.32%	3.45%

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

Table 31: Calculated emission factor by animal in zone: Temperate[84]

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	2.084
Buffalo	3.9	0.1	1.50%	0.67	1.431
Dairy cow	2.8	0.13	0.00%	0.67	0.000
Cattle	2.3	0.1	5.32%	0.67	2.993

Table 32: Calculated emission factor by animal in zone: Warm[85]

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	9.58%	0.67	2.039
Buffalo	3.9	0.1	0.00%	0.67	0.000
Dairy cow	2.8	0.13	0.00%	0.67	0.000
Cattle	2.3	0.1	3.45%	0.67	1.942

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 33: Physical leakage emission from bio-digester[86]

Animal	Zone Temperate		Zone Warm	
	$PL_{_biodiester}$ ($kgCH_4$/year)	PL_{stove} ($kgCH_4$/year)	$PL_{_bio\text{-}digester}$ ($kgCH_4$/year)	PL_{stove} ($kgCH_4$/year)
Pig	2.929	0.527	6.802	1.224
Buffalo	0.020	0.004	0.000	0.000
Dairy cow	0.000	0.000	0.000	0.000
Cattle	0.140	0.025	0.144	0.026
Total	**3.089**	**0.556**	**6.947**	**1.250**

[84] Details calculation in tab "ER_AWMS" of the "GS1083_MP4_Monitoring database_ER" spreadsheet
[85] Details calculation in tab "ER_AWMS" of the "GS1083_MP4_Monitoring database_ER" spreadsheet
[86] Details calculation in tab "ER_AWMS" of the "GS1083_MP4_Monitoring database_ER" spreadsheet

The project emissions from physical leakage are:

Zone	Classification	Units	LE/unit (tCO_2e/unit)	Total LE (tCO_2e)
A	Temperate	99,866	0.091	9,099
B	Warm	30,328	0.205	6,215
Weighted average project emission from AWMS - $PE_{awms,h,y}$			**tCO_2e/unit**	**0.12** [87]

E.3.2. Emissions from digestate (bio-slurry)

Biogas households were surveyed about their usage of bio-slurry. 195 respondents were not using bio-slurry; 149 respondents are using the bio-slurry fully. Amongst 168 responses on full usage of bio-slurry, 77 respondents used bio-slurry directly, 68 stored it before use and the remaining 4 respondents used bio-slurry partly directly and partly by storing before use.
The following leakage emission source is accounted for in this section: CH_4 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 manure[88].

This emission source is determined through the following steps:

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

[87] Details calculation in cell D71, tab "ER_AWMS" of the "GS1083_MP4_Monitoring database_ER" spreadsheet
[88] http://cdm.unfccc.int/Panels/meth/meeting/11/051/mp51_an13.pdf

Table 34: Daily VS production of the average bio-digester in climate zone temperate[89]

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	14.06	4.22	97.5%	4.11
Buffalo	3.90	0.14	0.53	5.6%	0.03
Dairy cow	2.80	0.00	0.00	0.0%	0.00
Cattle	2.30	0.47	1.07	43.7%	0.47
Sum					**4.61**

Table 35: Daily VS production of the average bio-digester in climate zone warm[90]

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	33.37	10.01	93.4%	9.35
Buffalo	3.90	0.00	0.01	0.0%	0.00
Dairy cow	2.80	0.00	0.00	0.0%	0.00
Cattle	2.30	0.74	1.71	13.1%	0.22
Sum					**9.57**

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%[91]. This means that digestate contains 40-50% of the initial organic dry matter, primarily as fibers.

With other words, it can be assumed that around 55% of the initial concentration of VS is converted into biogas and that around 45% remains in digestate. Or with other words, the $MS_{digester}$ is 55% and the $MS_{digestate}$ is 45% of total VS entering the biogas plant.

[89] Details calculation in cells C34:H40, tab "PE_Bioslurry" of the "GS1083_MP4_Monitoring database_ER" spreadsheet
[90] Details calculation in cells K34:P40, tab "PE_Bioslurry" of the "GS1083_MP4_Monitoring database_ER" spreadsheet
[91] P55 http://www.lemvigbiogas.com/BiogasHandbook.pdf

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 36: Average amount of VS in digester effluent by zone[92]

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	4.61	45%	2.07	2.54
Warm	9.57	45%	4.31	5.27

Assessment of the methane potential of digestate

As the nature of VS has changed during anaerobic conversion, the default methane potential (B_o) value is no longer applicable to VS in digestate. According to EB96 Annex 7 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:

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

Where:

$B_{o,dig,T}$	=	Methane potential of digestate from animal type T manure
$F_{ww,CH4,}$	=	Default factor representing the remaining CH4 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 37: Calculated methane potential of digestate from manure by animal type[93]

Animal T	$F_{ww,CH4,default}$ [94]	Bo(T) (m^3CH4/kgVS)*	$B_{o,dig}$ (m^3CH4/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

[92] Details calculation in tab "PE_Bioslurry" of the "GS1083_MP4_Monitoring database_ER" spreadsheet
[93] Details calculation in cells C1:F7, tab "PE_Bioslurry" of the "GS1083_MP4_Monitoring database_ER" spreadsheet
[94] According to EB96 Annex 7 page 14 for Conventional digesters defaul value

Table 38: Weighed average methane potential of digestate by zone[95]

Zone	Weighed $B_{0,dig}$ ($m^3CH4/kgVS$)
Temperate	0.056
Warm	0.057

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 39: Digestate management systems by type and zone[96]

DMS	Temperate (%)	Warm (%)
Daily spread	20.70%	20.96%
Using in wet form	3.43%	6.03%
Drying without organic matter	3.97%	0.56%
Fish pond	0.49%	1.13%
Discharge into sewer/channel	50.00%	63.37%
Stored under dry conditions with other organic matter	18.18%	7.37%
Other	3.22%	0.58%
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 40: Applicable MCF values to the DMS[97]

DMS	Applicable IPCC MS category	Applicable MCF zone temperate (23◦C)	Applicable MCF zone warm (27◦C)
Daily spread	daily spread	0.10%	0.21%
Using in wet form	slurry	1.89%	4.70%
Drying without organic matter	solid storage	0.16%	0.03%
Fish pond	other	0.00%	0.01%
Discharge into sewer/channel	other	0.50%	0.63%
Stored under dry conditions with other organic matter	solid storage	0.73%	0.37%
Other	other	0.03%	0.01%

[95] Details calculation in cells E30 and M30, tab "PE_Bioslurry" of the "GS1083_MP4_Monitoring database_ER" spreadsheet
[96] Details calculation in tab "PE_Bioslurry" of the "GS1083_MP4_Monitoring database_ER" spreadsheet
[97] Details calculation in tab "PE_Bioslurry" of the "GS1083_MP4_Monitoring database_ER" spreadsheet

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

Table 41: Average MCF by zone[98]

Zone	∑DMSxMCF
Temperate	3.41%
Warm	5.96%

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 96 Annex 7. 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**.

$$EF_{AWMS(T)} = (VS_{(T)} \times 365) \times \left[Bo_{(T)} \times D_{CH4} \times \sum_{k} \frac{MCF_{BL,k}}{100} \times MS_{(T,S,k)} \right]$$

Table 42: Calculated emissions from digestate by zone

Zone	Total VS in bio-slurry kgVS.day^{-1}	$B_{0,dig}$ ($m^3CH4/kgVS$)	∑DM SxMCF	D_{CH4} (kg/m^3CH_4)	Digester emissions (tCO_2/year/hh) [99]
Temperate	2.07	0.056	0.034	0.67	0.024
Warm	4.31	0.057	0.0596	0.67	0.090

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

Table 43: Weighted average emissions from digestate[100]

	No of units in zone
Temperate	99,866
Warm	30,328
Average LE Bio-slurry (tCO2e/year/hh)	**0.04**

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

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

For temperate zone

Table 44: Average annual emission reductions in temperate zone[101]

Emission source	BE (tCO_{2e}/hh/year)	PE (tCO_{2e}/hh/year)	LE[102] (tCO_{2e}/hh/year)	ER (tCO_{2e}/hh/year)

[98] Details calculation in tab "PE_Bioslurry" of the "GS1083_MP4_Monitoring database_ER" spreadsheet
[99] Detail calculation are in cell G51 and O51, tab "PE_Bioslurry" of the "GS1083_MP4_Monitoring database_ER"
[100] Detail calculation is in cell L7, tab "PE_Bioslurry" of the "GS1083_MP4_Monitoring database_ER" and "GS1083_MP4_Monitoring database_ER" spreadsheet, respectively.
[101] Detail calculation is in cells C1:I5, tab "ER_temperate" of the "GS1083_MP4_Monitoring database_ER" spreadsheet
[102] The leakage emissions for the project in this monitoring period is zero as analyzed in section C.2.5

Fuel use	4.37	0.75	0	3.62
AWMS	1.78	0.09	0	1.68
Digestate		0.02	0	-0.02
Sum	**6.15**	**0.87**	**0**	**5.28**

For warm zone

Table 45: Average annual emission reductions in warm zone[103]

Emission source	BE (tCO_{2e}/hh/year)	PE (tCO_{2e}/hh/year)	LE[104] (tCO_{2e}/hh/year)	ER (tCO_{2e}/hh/year)
Fuel use	4.37	0.75	0	3.62
AWMS	5.86	0.20	0	5.65
Digestate		0.09	0	-0.09
Sum	**10.23**	**1.05**	**0**	**9.18**

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

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

Where:

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

The calculated usage rate, $U_{y,h}$ is 69.59%. However the effective usage rate $U_{Fy,h}$ = 60.31% was applied.[105] The next table shows the ER summary.

[103] Detail calculation is in cells C1:I5, tab "ER_warm" of the "GS1083_MP4_Monitoring database_ER" spreadsheet
[104] The leakage emissions for the project in this monitoring period is zero as analyzed in section C.2.5
[105] See explanation in Section 3.4 above

Table 46: Emission reductions in the monitoring period for temperate zone[106]

Date (inclusive of both dates)		Installation in month	Cumulative units	ER	Emission reductions	Percentage in operation	ER/month
		#	#	tCO2e/year	tCO2e/month	%	tCO2e
1-Jan-15	31-Jan-15	189	93,047	5.28	0.44	60.31%	24,636
1-Feb-15	28-Feb-15	261	93,308	5.28	0.44	60.31%	24,687
1-Mar-15	31-Mar-15	329	93,637	5.28	0.44	60.31%	24,756
1-Apr-15	30-Apr-15	451	94,088	5.28	0.44	60.31%	24,843
1-May-15	31-May-15	656	94,744	5.28	0.44	60.31%	24,963
1-Jun-15	30-Jun-15	802	95,546	5.28	0.44	60.31%	25,137
1-Jul-15	31-Jul-15	627	96,173	5.28	0.44	60.31%	25,350
1-Aug-15	31-Aug-15	350	96,523	5.28	0.44	60.31%	25,516
1-Sep-15	30-Sep-15	334	96,857	5.28	0.44	60.31%	25,609
1-Oct-15	31-Oct-15	731	97,588	5.28	0.44	60.31%	25,697
1-Nov-15	30-Nov-15	2179	99,767	5.28	0.44	60.31%	25,891
1-Dec-15	31-Dec-15	98	99,865	5.28	0.44	60.31%	26,469
1-Jan-16	31-Jan-16	0	99,865	5.28	0.44	60.31%	26,495

[106] Detail calculation is in tab “ER_temperate” of the “GS1083_MP4_Monitoring database_ER” spreadsheet

1-Feb-16	29-Feb-16	0	99,865	5.28	0.44	60.31%	26,495
1-Mar-16	31-Mar-16	0	99,865	5.28	0.44	60.31%	26,495
1-Apr-16	30-Apr-16	1	99,866	5.28	0.44	60.31%	26,495
1-May-16	31-May-16	0	99,866	5.28	0.44	60.31%	26,496
1-Jun-16	30-Jun-16	0	99,866	5.28	0.44	60.31%	26,496
Total							**462,526**

Table 47: Emission reductions in the monitoring period for warm zone[107]

Date (inclusive of both dates)		Installation in month	Cumulative units	ER	Emission reductions	Percentage in operation	ER/month
		#	#	tCO2e/year	tCO2e/month	%	tCO2e
1-Jan-15	31-Jan-15	36	28,589	9.18	0.77	60.31%	13,176
1-Feb-15	28-Feb-15	67	28,656	9.18	0.77	60.31%	13,192
1-Mar-15	31-Mar-15	179	28,835	9.18	0.77	60.31%	13,223
1-Apr-15	30-Apr-15	212	29,047	9.18	0.77	60.31%	13,306
1-May-15	31-May-15	283	29,330	9.18	0.77	60.31%	13,404
1-Jun-15	30-Jun-15	200	29,530	9.18	0.77	60.31%	13,534
1-Jul-15	31-Jul-15	203	29,733	9.18	0.77	60.31%	13,627
1-Aug-15	31-Aug-15	154	29,887	9.18	0.77	60.31%	13,720
1-Sep-15	30-Sep-15	112	29,999	9.18	0.77	60.31%	13,791
1-Oct-15	31-Oct-15	129	30,128	9.18	0.77	60.31%	13,843
1-Nov-15	30-Nov-15	175	30,303	9.18	0.77	60.31%	13,903
1-Dec-15	31-Dec-15	24	30,327	9.18	0.77	60.31%	13,983
1-Jan-16	31-Jan-16	0	30,327	9.18	0.77	60.31%	13,994

[107] Detail calculation is in tab “ER_warm” of the “GS1083_MP4_Monitoring database_ER” spreadsheet

1-Feb-16	29-Feb-16	0	30,327	9.18	0.77	60.31%	13,994
1-Mar-16	31-Mar-16	0	30,327	9.18	0.77	60.31%	13,994
1-Apr-16	30-Apr-16	0	30,327	9.18	0.77	60.31%	13,994
1-May-16	31-May-16	0	30,327	9.18	0.77	60.31%	13,994
1-Jun-16	30-Jun-16	1	30,328	9.18	0.77	60.31%	13,994
Total							**246,666**

Table 48: Emission reductions in the monitoring period in both zones[108]

Date (inclusive of both dates)		Installation in month	Cumulative units	ER/month
		#	#	tCO2e
1-Jan-15	31-Jan-15	225	121,636	37,812
1-Feb-15	28-Feb-15	328	121,964	37,879
1-Mar-15	31-Mar-15	508	122,472	37,979
1-Apr-15	30-Apr-15	663	123,135	38,149
1-May-15	31-May-15	939	124,074	38,367
1-Jun-15	30-Jun-15	1002	125,076	38,671
1-Jul-15	31-Jul-15	830	125,906	38,977
1-Aug-15	31-Aug-15	504	126,410	39,236
1-Sep-15	30-Sep-15	446	126,856	39,400
1-Oct-15	31-Oct-15	860	127,716	39,540
1-Nov-15	30-Nov-15	2354	130,070	39,794
1-Dec-15	31-Dec-15	122	130,192	40,452
1-Jan-16	31-Jan-16	0	130,192	40,489
1-Feb-16	29-Feb-16	0	130,192	40,489
1-Mar-16	31-Mar-16	0	130,192	40,489
1-Apr-16	30-Apr-16	1	130,193	40,489
1-May-16	31-May-16	0	130,193	40,490
1-Jun-16	30-Jun-16	1	130,194	40,490
Total				**709,192**

The requested for issuance of carbon credit in MP4 will be ER_{MP4} = 709,192 $tCO2_e$, in which:

- ER_{2015}= 462,526 $tCO2_e$
- ER_{2016} = 246,666 $tCO2_e$

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[109]	Actual values achieved during this monitoring period
Emission reductions or GHG removals by sinks (t CO_2e)	**965,936**	**709,192**

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

>>

The actual ER was 27% lower than the estimated value in registered PDD. The main reason is because of lower usage rate of 60.31% was applied for MP4 while the ex-ante usage rate during registration period was 100%.

[108] Detail calculation is in tab "ER_All" of the "GS1083_MP4_Monitoring database_ER" spreadsheet

[109] Please refer to the cell P131, tab "ER database" of the registered ER spreadsheet "25 Sep 2012 ER worksheet BP VGS v3.1.xlsx".

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 49: Scoring on SD indicator Air quality

No		1
Indicator		Air quality
Mitigation measure		N/A
Chosen parameter		*Reduction in fuel (wood, agricultural residues, kerosene and coal) consumption (kg of fuel reduced/year)*
Situation at 31/12/2011[110]		Charcoal: 65.3 Coal: 67.9 Firewood: 966.6 Agriculture residuals: 322.8 Kerosene: 32.4
Situation at 30/06/2013[111]		Charcoal: 0 Coal: 0 Firewood: 1,643.2 Agriculture residuals: 584.4 Kerosene: 0
Situation at 31/12/2014[112]		Charcoal: 0 Coal: 0 Firewood: 2,950.6 Agriculture residuals: 941.2 Kerosene: 0
Situation at 30/06/2016[113]		Charcoal: 0 Coal: 0 Firewood: 2,415.1 Agriculture residuals: 704.9 Kerosene: 0
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 in the biennial fuel monitoring 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 2: Soil condition

[110] According to the Monitoring report of MP3
[111] According to the Monitoring report of MP3
[112] According to the Monitoring report of MP3
[113] According to the KPT survey in MP4. Tab “SD” of the “GS1083_MP4_Monitoring database_ER” spreadsheet

The next table shows the scoring on the SD indicator soil condition.

Table 50: Scoring on SD indicator soil condition

<table>
<tr><td>No</td><td colspan="3">2</td></tr>
<tr><td>Indicator</td><td colspan="3">Soil condition</td></tr>
<tr><td>Mitigation measure</td><td colspan="3">N/A</td></tr>
<tr><td>Chosen parameter</td><td colspan="3">Usage of bio-slurry</td></tr>
<tr><td>Situation at 31/12/2011</td><td colspan="3"><table>
<tr><th>Zone</th><th>Fertilizer</th><th>Don't use</th><th>Fish feed</th><th>Other</th></tr>
<tr><td>Temperate</td><td>75.2%</td><td>19.2%</td><td>5.6%</td><td>0.0%</td></tr>
<tr><td>Warm</td><td>54.5%</td><td>19.0%</td><td>24.8</td><td>1.7%</td></tr>
</table></td></tr>
<tr><td>Situation at 30/06/2013</td><td colspan="3"><table>
<tr><th>Zone</th><th>Fertilizer</th><th>Don't use</th><th>Fish feed</th><th>Other</th></tr>
<tr><td>Temperate</td><td>42.17%</td><td>53.41%</td><td>3.25%</td><td>1.17%</td></tr>
<tr><td>Warm</td><td>36.51%</td><td>61.18%</td><td>1.69%</td><td>0.62%</td></tr>
</table></td></tr>
<tr><td>Situation at 31/12/2014 [114]</td><td colspan="3"><table>
<tr><th>Zone</th><th>Fertilizer</th><th>Don't use</th><th>Fish feed</th><th>Other</th></tr>
<tr><td>Temperate</td><td>14.11%</td><td>47.40%</td><td>2.82%</td><td>35.67%</td></tr>
<tr><td>Warm</td><td>2.55%</td><td>56.25%</td><td>1.02%</td><td>40.18%</td></tr>
</table></td></tr>
<tr><td>Situation at 30/06/2016[115]</td><td colspan="3"><table>
<tr><th>Zone</th><th>Fertilizer</th><th>Don't use</th><th>Fish feed</th><th>Other</th></tr>
<tr><td>Temperate</td><td>20.70%</td><td>50.00%</td><td>0.49%</td><td>28.80%</td></tr>
<tr><td>Warm</td><td>20.96%</td><td>63.37%</td><td>1.13%</td><td>14.53%</td></tr>
</table></td></tr>
<tr><td>Estimation of baseline situation of parameter</td><td colspan="3">0</td></tr>
<tr><td>Future target for parameter</td><td colspan="3">Most households use bio-slurry as fertilizer</td></tr>
<tr><td rowspan="3">Way of monitoring</td><td>How</td><td colspan="2">Conduct the CMS survey.</td></tr>
<tr><td>When</td><td colspan="2">Updated for every 2 years or more frequently</td></tr>
<tr><td>By who</td><td colspan="2">A third party conducted the monitoring commissioned by BP[116], the data are reported in a monitoring report and is made available for each verification.</td></tr>
</table>

ID 3: Biodiversity

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

Table 51: Scoring on SD indicator Biodiversity

No	3
Indicator	Biodiversity

[114] According to the Monitoring report of MP3
[115] Tab "SD" of the "GS1083_MP4_Monitoring database_ER" spreadsheet
[116] The CMS was executed by a selected independent consultant (EPRO) from April to June 2019.

Mitigation measure		N/A
Chosen parameter		*Cumulative savings of wood (tons/year)*
Situation at 31/12/2011		84,879
Situation at 30/06/2013		148,859
Situation at 31/12/2014 [117]		294,170
Situation at 30/06/2016[118]		189,624
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 52: Scoring on SD indicator Quality of Employment

No	4
Indicator	**Quality of Employment**
Mitigation measure	N/A
Chosen parameter	*Number of masons and technicians participating in the trainings*
Situation at 13/09/2011[119]	Number of masons: 922 Number of technicians: 622
Situation at 31/12/2011[120]	Number of masons: 922 Number of technicians: 622
Situation at 30/06/2013	Number of masons: 1038 Number of technicians: 707
Situation at 31/12/2014 [121]	Number of masons: 1156 Number of technicians: 790
Situation at 30/06/2016[122]	Number of masons[123]: 1275 Number of technicians[124]: 865
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

[117] According to the Monitoring report of MP3
[118] Tab "SD" of the "GS1083_MP4_Monitoring database_ER" spreadsheet
[119] According to the Monitoring report of MP3.
[120] According to the Monitoring report of MP3
[121] According to the Monitoring report of MP3
[122] Tab "SD" of the "GS1083_MP4_Monitoring database_ER" spreadsheet
[123] There were 119 additional masons were trained from Sept 2015 to Nov 2015. Please find more detail in the mason training list.
[124] There were 75 additional technician were trained from Aug 2015 to Sept 2015. Please find more detail in the technician training list.

Way of monitoring	How	The PP keeps track on the number of trained masons and technicians
	When	Annually
	By who	BP

ID 5: Livelihood of the poor

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

Table 53: Scoring on SD indicator "Livelihood of the poor"

No		5
Indicator		**Livelihood of the poor**
Mitigation measure		N/A
Chosen parameter		*Number of people having access to an improved waste management system*
Situation at 31/12/2011		436,962
Situation at 30/06/2013		427,539
Situation at 31/12/2014		482,279[125]
Situation at 30/06/2016		391,404[126]
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 54: 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
Chosen parameter	*Total amount of energy replaced by biogas (MJ/hh/year)*
Situation at 31/12/2011	33,232
Situation at 30/06/2013	33,840
Situation at 31/12/2014 [127]	46,954
Situation at 30/06/2016[128]	37,662
Estimation of baseline situation of parameter	0

[125] According to the Monitoring report of MP3

[126] 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 MP4, 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 130,194*69.59% =90,608.

[127] According to the Monitoring report of MP3

[128] Tab "SD" of the "GS1083_MP4_Monitoring database_ER" spreadsheet

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.

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 55: Scoring on SD indicator "Technology transfer and technological self-reliance"

No		7
Indicator		**Technology transfer and technological self-reliance**
Mitigation measure		N/A
Chosen parameter		*Number of masons trained in the construction of KT1 or KT2 bio-digesters*
Situation at 13/09/2011[129]		Number of masons: 922
Situation at 31/12/2011[130]		Number of masons: 922
Situation at 30/06/2013[131]		Number of masons: 1038
Situation at 31/12/2014[132]		Number of masons: 1156
Situation at 30/06/2016[133]		Number of masons[134]: 1275
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 MP4, there were 119 new masons trained under the program activity to meet the future target of at least 2 biogas masons per district provided with training.

[129] According to the Monitoring report of MP3
[130] According to the Monitoring report of MP3
[131] According to the Monitoring report of MP3
[132] According to the Monitoring report of MP3
[133] Tab "SD" of the "GS1083_MP4_Monitoring database_ER" spreadsheet
[134] There were 119 additional masons were trained from Sept 2015 to Nov 2015. Please find more detail in the mason training list.

SECTION G. Grievance Mechanism

The grievance mechanism has been in place. There has been no comment from stakeholder regarding the project implementation thought the grievance mechanism

	Method Chosen (include all known details e.g. location of book, phone, number, identity of mediator)	Monitoring result up to end of MP4	Required action
Continuous Input / Grievance Expression Process Book	Stakeholder could give the direct feedback to the Grievance Expression Process Book available at the below address: Room 104, Bldg 2G, Van Phuc Compound, 298 Kim Ma, Hanoi	No comments	NA
Telephone access	04 3726 1771	No comments	NA
Internet/e mail access	PP's email: bpovn@biogas.org.vn GS email: info@goldstandard.org	No comments	NA
Nominated Independent Mediator (optional)	NA	NA	NA

Annex 1: Contact details of the Project Participants

Organization:	Biogas Program for the Animal Husbandry Sector of Vietnam
Street/P.O.Box:	298 Kim Ma
Building:	Room 104, Bldg 2G, Van Phuc Compound
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State/Region:	N/A
Postcode/ZIP:	1000
Country:	Vietnam
Telephone:	04.3726 1771
FAX:	04.3726 1773
E-Mail:	bpovn@biogas.org.vn
URL:	www.biogas.org.vn
Represented by:	Mr. Tong Xuan Chinh
Title:	Director
Salutation:	N/A
Last name:	Tong
Middle name:	Xuan
First name:	Chinh
Department:	Department of Livestock Production – Ministry of Agricultural and Rural Development (DLP-MARD)
Mobile:	
Direct FAX:	04.3734 4829
Direct tel:	04.3734 4829
Personal e-mail:	

Organization:	SNV Netherlands Development Agency
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State/Region:	
Postcode/ZIP:	
Country:	Vietnam
Telephone:	
FAX:	
E-Mail:	
URL:	www.snvworld.org
Represented by:	Bastiaan Teune
Title:	Energy Sector Leader
Salutation:	Mr
Last name:	Teune
Middle name:	
First name:	Bastiaan
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