

MONITORING REPORT

For the verification of National Biodigester Programme Cambodia

Monitoring period II (01/09/2010 – 31/12/2011)



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for the National Biodigester Programme Cambodia



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Acronyms

AWMS	Animal Waste Management System
BE	Baseline emission
BUS	Biogas User Survey
CDM	Clean Development Mechanism
CH ₄	Methane Gas
CMDG	Cambodian Millennium Development Goals
CO ₂	Carbon Dioxide
CO ₂ eq	Relative potency of non-CO ₂ gases compared to CO ₂
DAPH	Department of Animal Production and Health
EF	Emission factor
ER	Emission reduction
GBM	Gold Standard Biodigester Methodology
GHG	Greenhouse Gas
GS	Gold Standard
GSPP	Gold Standard Passport
GWP	Global Warming Potential
hh	household
IPCC	Intergovernmental Panel on Climate Change
LPG	Liquefied Petroleum Gas
LSC	Local Stakeholder Consultation Report
MCF	Methane conversion factor
MS	Manure system (equivalent to AWMS)
MPx	Monitoring Period x (I or II)
MRx	Monitoring Report (I or II)
N ₂ O	Nitrous oxide
NBP	National Biodigester Programme
NIS	National Institute for Statistics
NRB	Non-Renewable Biomass
PBPO	Provincial Biodigester Programme Office
PDD	Project Description Document
PE	Project Emission
SNV	Netherlands Development Organisation
TLS	Traditional Lao Stove
UNDP	United Nations Development Program
UNFCCC	United Nation Framework Convention on Climate Change
VER	Voluntary emission reduction
VGS	Voluntary Gold Standard

Table of Contents

1. Introduction	5
1.1 VGS project characteristics.....	5
1.2 Technical Project Description.....	7
1.3 Units disseminated.....	11
1.4 Forward action Requests.....	13
2. Monitoring activities	14
2.1 Gold Standard and methodological guidelines	14
2.2 Survey approach.....	15
2.3 Non responsiveness and phantom plants	18
3. Carbon monitoring conform the monitoring plan in PDD.....	20
3.1 Data and parameter not to be monitored.....	20
3.2 Data and parameters monitored.....	23
3.3 Emission reductions.....	24
3.4 Emission reduction claim monitoring period 2	29
4. Sustainability monitoring conform monitoring plan in Passport.....	30
4.1 Safeguard Principles.....	30
4.2 Sustainability monitoring plan	32
5. Stakeholder feedback	40
6. Data quality control and assurance	41
Annex I: Contact details of the Project Participants.....	43
Annex II: Training report	44
Annex III: Carbon Motoring Survey sampling.....	46

1. INTRODUCTION

The National Biodigester Programme (NBP) of Cambodia is a joint undertaking the Ministry of Agriculture, Forestry and Fisheries (MAFF) and the Dutch Development Organisation (SNV) in close collaboration with a number of implementing stakeholders, aiming to establish a permanent domestic biodigester sector on a commercial, market oriented basis for the dissemination of biodigesters as an indigenous, sustainable energy source in selected provinces in Cambodia. This report presents the monitoring activities of NBP according to the modalities and procedures set by the Gold Standard (GS) for the monitoring period II (MPII), 01-09-2010 to 31-12-2011.

The NBP VGS project in this document will be referred to as 'the VGS project'. Any reference, in this report, to the PDD, GSPP or LSC refers to the GS approved and registered versions. The next table shows the timeline of this project:

Table 1: Status of Gold Standard accreditation of the VGS project

Activity	Date	Outcome/comments
Pre-feasibility assessment by the GS	12/2009-04/2010	The Gold Standard Foundation has the opinion that the project can be retroactively registered
Registration	24/05/2011	Approval by the GS
Verification monitoring period I	11/11/2011	Approval by the GS and the DOE SQS

1.1 VGS PROJECT CHARACTERISTICS

The table hereunder details the characteristics of the VGS projects.

Table 2: NBP VGS project characteristics

Item	Data
Host country	Cambodia
Project title	National Biodigester Programme Cambodia
Project size	Large scale
Gold standard project animal icon	 Pelican
GS project ID	GS751
GS website link	https://gs1.apx.com/mymodule/ProjectDoc/EditProjectDoc.asp?id1=751
Project scope according to UNFCCC categories	Renewably energy delivery to the user and methane avoidance
Applied methodology	Gold Standard, Indicative programme, baseline, and monitoring methodology for Small Scale Biodigester Voluntary Gold Standard ¹ .
Crediting period	7 years (renewable)
Start date of project	13/03/2006

¹http://www.cdmgoldstandard.org/fileadmin/editors/files/6_GS_technical_docs/manuals_and_methodologie/s/GS_Methodology_Biodigester.pdf

Start date of crediting period	24/05/2009
Registration	24/05/2011
Monitoring period I (MPI)	24 May 2009 to 31 August 2010
Monitoring period II (MPII)	01 September 2010 to 31 December 2011

The methodology Gold Standard, Indicative programme, baseline, and monitoring methodology for Small Scale Biodigester Voluntary Gold Standard, will be referred to as the 'GS Biodigester Methodology' (GBM) in this document. The VGS project targets 8 provinces in South-east Cambodia see the table 3 and the next figure.

Table 3: Project location by provinces in Cambodia and GPS coordinates of provincial capitals

no.	Province	Latitude (xx° xx' xx" N)	Longitude (xx° xx' xx" W)
1	Kandal	11° 78' 3" N	104° 81' 7" E
2	Takeo	10° 59' 0" N	104° 47' 0" E
3	Svay Rieng	11° 05' 0" N	105° 48' 0" E
4	Kampong Chhnang	12° 00' 0" N	104° 30' 0" E
5	Kampong Cham	11° 59' 0" N	105° 27' 0" E
6	Kampong Speu	11° 27' 0" N	104° 30' 0" E
7	Kampot	10° 36' 0" N	104° 10' 0" E
8	Prey Veng	11° 29' 0" N	105° 19' 0" E

:

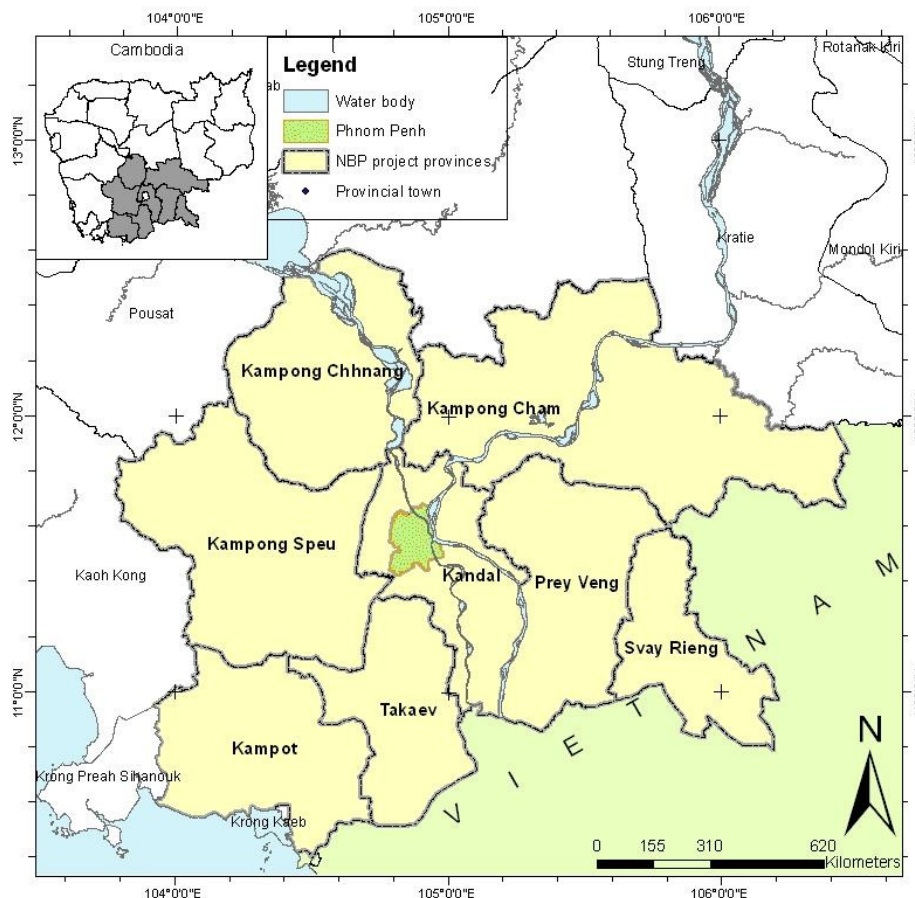


Figure 1: The 8 provinces targeted by the VGS project of NBP

1.2 TECHNICAL PROJECT DESCRIPTION

The National Biodigester Programme

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

The scenario existing prior to the project activity

Before the onset of the project activities, most households with the technical potential for a biodigester relied primarily on wood to meet their thermal energy demand for cooking and kerosene for lighting. The reliance on these fuels causes substantial indoor air pollution which can lead to respiratory and eye ailments, especially women and children are mostly at risk here. Furthermore, the collection of wood contributes to deforestation which is rampant in Cambodia with a conservative UNFCCC fNRB default value of 76%. A substantial part of the fuel wood is collected, which is both drudgery and significant time expenditure for especially women. Bought wood on the other hand is a burden on the limited household's revenues. In addition, unhygienic

animal waste management practices and the lack of access to basic sanitation result in pollution of farmyards and surface water, foul odour, methane emissions and a relatively high prevalence of hygiene related diseases, such as diarrhoea.

The purpose of the National Biodigester Programme

The overall objective of the first phase of the National Biodigester Programme is the development of a commercial, market oriented, biodigester sector for the dissemination of domestic biodigesters as an indigenous, sustainable energy source through in eight selected provinces of Cambodia. The programme activities aim to resolve the issues sketched above; by hygienically treating animal and human waste in a biodigester to produce a clean, convenient and renewable cooking and lighting fuel, biogas, whereas the treated waste is to be used as a potent and safe organic fertiliser.

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

1. To disseminate 18,500 family sized, quality biodigesters in 8 selected provinces by 2012²;
2. To ensure the continued maintenance and operation of all biodigesters installed under the Biodigester Programme;
3. To maximize the benefits of the operated biodigesters, in particular the optimum use of digester effluent;
4. Technical and promotional capacity development for further wide scale deployment of biodigester technology in Cambodia;
5. To strengthen and facilitate establishment of institutions for the continued and sustained development of the biodigester sector.

Technology and emission reductions

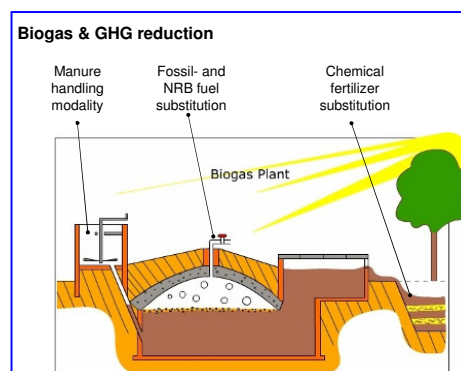
Deployed technology: Domestic household digesters, in this document referred to as '*biodigesters*'. In a biodigester, manure is anaerobically degraded by a consortium of microbes, whereby biogas is released by methanogenic microbes. The released biogas is subsequently captured in an integrated gasholder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

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

² Ex-ante defined target, actual numbers will vary as they rely on market conditions. The programme will continue after 2012.

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

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



The emission reductions are realised by installing biodigesters in 8 selected provinces. The biodigesters have a digester size, of either, 4, 6, 8, 10 or 15 m³ depending on the amount of manure available on a daily basis.

Contribution to sustainable development

Social benefits

- Avoided health hazards associated with unmanaged waste in farmyards;
- Reduced drudgery and time expenditure on wood collection especially for women;
- Avoided health hazards associated with indoor air pollution and open fires from wood fired stoves, especially for women and children;
- Hygiene: hygienic anaerobic treatment of waste and less foul odour;
- Sanitation: access to basic sanitation by attaching a toilet, energy for sterilising drinking water;
- Energy security: continuous provision of a renewable energy resource;
- Bright light from biogas lamps enables educational activities and household works in the evening;
- Increase in rate of enrolment of girls in school because of the liberty from fuel collection.

Environmental benefits

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

Economic benefits

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

Technological benefits

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

1.3 UNITS DISSEMINATED AND SUMMARY OF EMISSION REDUCTIONS

The next table shows the units built in the period from 13-03-2006 to 31-12-2011 in the eight provinces under the VGS project.

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

year	Installation/year	Cumulative installations
2006	294	294
2007	1,150	1,444
2008	2,327	3,771
2009	2,605	6,376
2010	3,545	9,921
2011	4,223	14,144

In total 14,144 biodigesters were constructed as of 31 December 2011 in the VGS project area. The next figure shows the cumulative number of installed biodigesters, the number of units that are installed each month and the 2014 forecast.

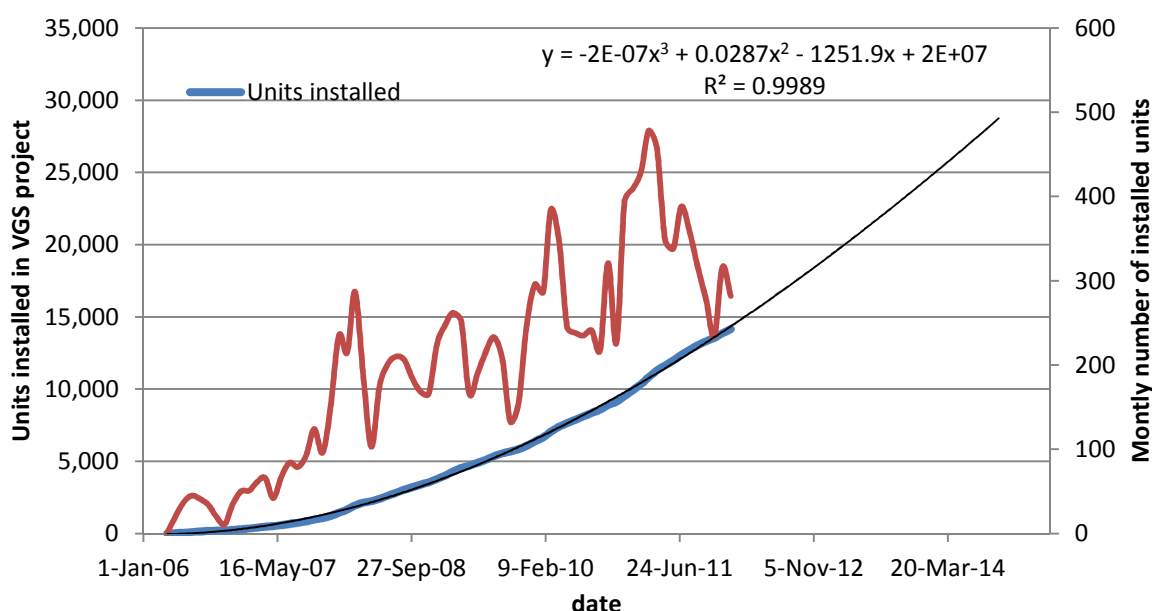


Figure 2: Cumulative and the per month number of units installed

Figure 2 shows that the number of units installed is steadily increasing and constantly accelerating. This indicates that the programme is gradually becoming more popular. The trend line plotted in the figure forecasts, based on the best fit (r^2 of 0.99) with the existing progress, a population of 30,000 in 2015.

The figure also shows that there are seasonal effects affecting the number of units installed. The dip in September 2009 was caused by the massive garment factory layoffs which severely

impacted the remittance flow to households in rural villages. Other causes of monthly fluctuations are:

- Ploughing and harvest seasons will take up time of farmers and technicians;
- Need for agricultural inputs like chemical fertiliser and pesticides will take the families financial means during the ploughing season;
- Heavy rain and high water tables can impede plant construction;
- The disastrous flooding of Aug – Sep 2011 ;
- The 2 most important festivals of the year, Khmer new year and Pchum Ben, stop all activities for a week each;
- Certain events like national elections or the outbreak of avian flu in a province can take the Government staff away from their normal biogas duties;
- The selling of the harvest in the months of December, January and February give a big increase in demand, the market price of paddy is a large determining factor.

NBP installs 5 different digester sizes; the next figure shows the popularity of each digester size expressed in fraction of total number of digesters built:

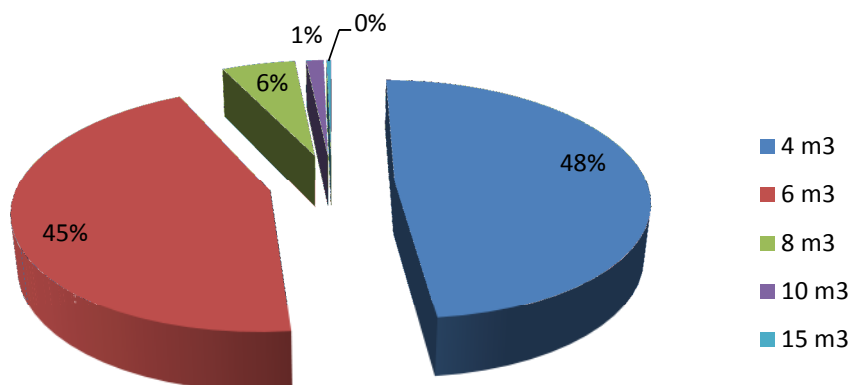


Figure 3: Share of digester volume in total digester population (as per 31-12-2011)

The most proliferated digester has a volume of 4 m³, followed by the 6 m³; according to the VGS database Other digester sizes are built to a much smaller extent; totalling around 7% of all the digesters built. The average digester size built has a volume of 5.23 m³, a bit smaller than at the end of monitoring period I (MPI) (5.46 m³). This indicates that the technology is becoming more popular with smaller farmers. The VGS project has a cumulative digester volume of 73,968 m³.

The cumulative number of units installed at the end of MP II is 14,144 units. The total number of VERs generated during MP II is 61,261.

1.4 FORWARD ACTION REQUESTS

The following FARs were raised by the GS and the DOE

Table 5: Forward Action Requests and GS proposals

#	Forward Action Requests	Conversion in this report
1	The randomised sample evaluation should be documented.	see chapter 2.2
2	A standardized calibrating procedure will be in force	see annex II
3	The QA/QC shall be implemented as described in MR section 6.2 (As in MRI)	see chapter 6
#	GS proposal	Conversion in this report
1	For Soil Condition, the parameter to be monitored will be the use of bio-slurry on farming practices rather the use of chemical fertilizers.	see chapter 4.2
2	For Reliance on Biogas Lighting it is recommended to provide absolute figures.	see chapter 4.2

2. MONITORING ACTIVITIES

2.1 GOLD STANDARD AND METHODOLOGICAL GUIDELINES

Gold Standard toolkit version 2.1 stipulates that the monitoring for large scale activities consist a monitoring report with sections on:

1. Carbon monitoring conform PDD;
2. Sustainability monitoring conform sustainability monitoring plan in Passport.

The carbon monitoring conform PDD is described in Chapter 3 and the sustainability monitoring conform sustainability monitoring plan in Passport is described in Chapter 4. The next table shows the general GS guidelines on monitoring.

Table 6: Gold Standard guidelines for monitoring³

 ▪ CDM or JI monitoring conform PDD ▪ GS monitoring report conform sustainability monitoring plan in Passport	 GS Monitoring report with sections: Carbon monitoring conform PDD Sustainability monitoring conform sustainability monitoring plan in Passport
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Monitoring requirements according to applied methodology

The methodology Gold Standard, Indicative programme, baseline, and monitoring methodology for Small Scale Biodigester Voluntary Gold Standard⁴ version 1 is applied for the monitoring activities as stipulated in the PDD. This methodology remains applicable to the NBP activities as specified in the next table:

Table 7: Condition that apply to the application of methodology

Condition	Application to the NBP activities
The biodigester programme promotes the wide-scale use of biogas as substitute for wood, agricultural residues, animal dung and fossil fuels that are presently used for the cooking, space heating and lighting needs of most rural households;	The NBP disseminates small scale household digesters where the use of biogas substitutes predominantly wood for cooking and kerosene for lighting. Chapter 3 will elaborate on that.
The methodology applies to projects with biodigesters with a maximum total biodigester volume of 20m ³ ;	The NBP only constructs digesters smaller than 20 m ³ , only 4/6/8 10 & 15m ³
The biodigesters in the programme are not included in another CDM or voluntary market project	This condition is easily satisfied as there is no other CDM or VER household biogas project in Cambodia
If more than one climate zone is included in the project, the project should make a distinction per climate zone.	There is only one climate zone in Cambodia

Source: Page 2 of the Methodology

³ <http://www.cdmgoldstandard.org/Gold-Standard-Version-2-1.355.0.html>

⁴ http://www.cdmgoldstandard.org/fileadmin/editors/files/6_GS_technical_docs/manuals_and_methodologies/GS_Methodology_Biodigester.pdf

The next table shows the data to be monitored according to the methodology used.

Table 8: Monitoring content according to the biodigester methodology⁵

#	Data collection	Conversion in this report
1	Ex-post identification of the number of households that part of the programme at the beginning of monitor interval y	Monitor interval 2 is 1-9-2010 to 31-12-2011. All households participating are enlisted in the database and available for review by DOE.
2	Identification of the households that are randomly selected for the project sample	150
3	Ex-post collection of data on fuel use and input of excrements and biomass into digester	see chapter 3.2
4	Ex-post calculation of the mean and standard variation of baseline and project emissions and ex-post calculation of emission reductions	see chapter 3.3
6	All monitored data should be stored in the electronic database. A complete extract of the database should be made available with each monitoring report	The SPSS and excel sheets will be stored on the NBP server with electronic copies guarded in an outside location as well.
7	All measurement equipment should be calibrated and maintained and checked for its functioning according to the manufacturer's specification and relevant national and international standards	Main measurement tool is a newton scale. These are each time calibrated and checked for functioning before the activity data on fuel consumption was obtained by measuring, see Annex II.
8	Check that the biodigesters are in working order	This is checked in the survey, see chapter 3.
9	Determine the share of biogas used for cooking and space heating	In Cambodia none of the household use biogas for space heating due to climatic conditions.

2.2 SURVEY APPROACH

A carbon monitoring survey (CMS) and SD survey was executed in January 2012 amongst a representative sample of biogas user with the objective to obtain reliable and unbiased data on the impact of the program on sustainable development and on GHG emission modalities, such as fossil and fuel wood consumption and manure management practices.

The GS Biodigester Methodology (GBM) sums up 9 steps that shall be followed, these are, inter alia:

Step 1: Determination of project area i

The project area encompasses 8 provinces as described in chapter 1.1.

Step 2: Establishment of a project activity implementation plan

The GBM specifies that this step is to be documented and determined in the PDD. The PDD describes the project activity implementation plan.

⁵ page 20 of the methodology applied

Step 3: Determination of the size of the sample group

The sample size is based on a sample with a confidence level of 95% and a level of precision of 10%. The following equation is used to determine the sample size out of a population of 14,144 biodigesters.

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

Equation 1: Sample size equation⁶

Where:

n	=	sample population
N	=	survey population (biogas users)
e	=	level of precision (10%)

The calculated sample population is 99 households, to account for missing values, outliers and non-responsiveness the sample size is increased to 150. This sample size is two and a half times the minimum requirement of the GBM, which stipulates a minimum sample size of 60 at a confidence interval of 95%.

Sampling strategy

The sampling approach is the same as during the first verification, which was approved by the GS and validated by the DOE. The CMS sample is based on a multi stage random selection. The primary elements in the sampling approach are the districts and the secondary the biogas households. In the first stage 12 primary elements were randomly selected out of a sample of 81 districts that the 8 provinces comprise. This strategy was chosen to limit the travelling time as the area is very large. The random selection was ascertained by using a random selection tool⁷. The 12 districts span 7 provinces out of 8 covered in the VGS project. The selected districts show a good geographical distribution over the 8 Provinces, see the next figure:

⁶ Yamane, Taro. 1967. *Statistics, An Introductory Analysis*, 2nd Ed., New York: Harper and Row.

⁷ <http://www.graphpad.com/quickcalcs/randomSelect1.cfm>

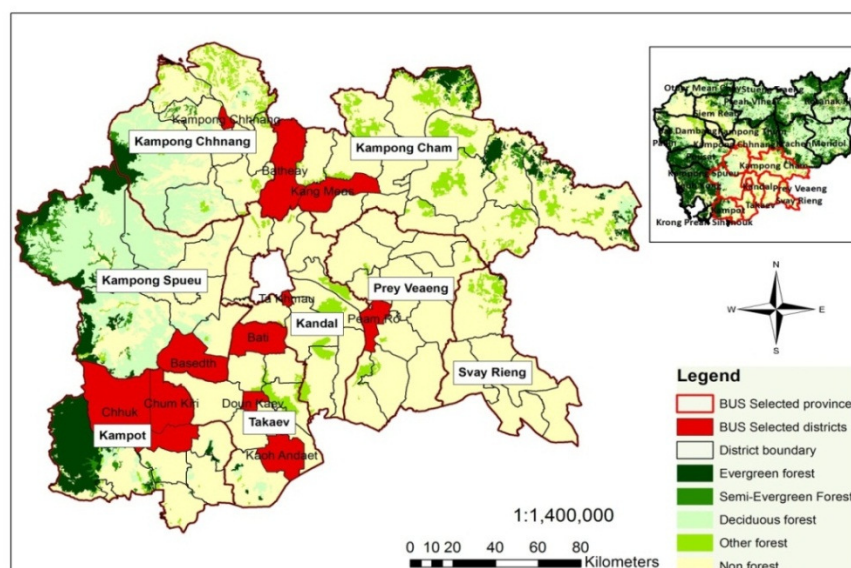


Figure 4: Geographical distribution of the selected districts

Annex III contains the screenshots of the random selection tool and the selected districts.

Step 4: Selection of households to be included in the project sample group

A total of 1681 families were identified in the 12 random selected districts, out of these population 150 household were randomly selected, see the next table and Annex III for the screenshots of the selection.

Table 9: Biodigester population of the randomly selected districts

Sequence #	Provinces	District	Number installed biodigesters	of	# samples
1	Kampong Cham	Batheay	218		12
2	Kampong Cham	Kang Meas	240		25
3	Kampong Chhnang	Kampong Chhnang	31		3
4	Kampong Speu	Basedth	214		19
5	Kampot	Angkor Chey	154		14
6	Kampot	Chhuk	230		26
7	Kampot	Chum Kiri	203		15
8	Kandal	Ta Khmau	6		1
9	Prey Veng	Peam Ro	55		3
10	Takeo	Bati	218		19
11	Takeo	Doun Kaev	45		6
12	Takeo	Kaoh Andaet	67		7
Total	7	12	1681		150

Step 5: Establishment of a project database

A project database has been established since the beginning of the program. The database contains the following data for each biogas unit installed:

Table 10: Data contained by the database by biodigester

Data code	Explanation
BIODIGESTER_CODE	Unique plant code: xx/xx/xx/xxxx (province code/district code/construction year/plant code)
HEAD_NAME	Name of head of household
MASON_NAME	Name of mason that constructed the biodigester
STAFF_NAME	Name of the PBPO supervisor that checked the biodigester
PLANT_SIZE	Volume of biodigester in m ³
PROVINCE_NAME	Geographical details where the biodigester is built
DISTRICT_NAME	
COMMUNE_NAME	
VILLAGE_NAME	
DATE_START_CONSTRUCTION	Start date of construction
DATE_COMPLETION	Date when the biodigester was inspected and commissioned

Step 6: Collect baseline questionnaire

This step has been initiated and finalized for the PDD development and therefore relevant of this report.

Step 7: Collect project questionnaire

A questionnaire has been developed at the end of the monitoring period the monitoring survey took place. A modified version of the questionnaire of MPI is used for MPII.

Step 8: Calculation of the mean and standard deviation of project and baseline emissions

Executed and explained in chapter 3.3

Step 9: Calculation of fuel consumption and emission reductions

Executed and explained in chapter 3.3

2.3 NON RESPONSIVENESS AND PHANTOM PLANTS

As households for the survey were ex-ante identified for this monitoring survey, it may occur that the biodigester owner is not available, no qualified respondent⁸ is available or the respondent does not want to be interviewed. In those cases the surveyors were instructed to

⁸ Respondent with intrinsic knowledge of the biodigester operation and cooking activities. Typically this is either the head of the household or the wife of the head of household

proceed to the next households on the list of ex-ante identified households during sampling. In total, this happened 11 times, the reasons were, in all cases, no qualified respondent was available. The total sample size is therefore 139, which is still significantly higher than the required minimum sample size of 99 households (see step 3 in chapter 2.2). In case a phantom plant was discovered during the survey, NBP would be contacted. NBP would take immediate action on this. The persons involved will not only lose their position in the programme, but also a complaint will be filed with the police. This happened 0 times during the survey activities, all biodigesters selected for the survey did exist.

3. CARBON MONITORING CONFORM THE MONITORING PLAN IN PDD

3.1 DATA AND PARAMETER NOT TO BE MONITORED

The section summarises the data and parameters that are **not to be monitored** and that are available during the verification according to the approved PDD.

The data and parameters not to be monitored have been grouped in three groups:

1. Data and parameters relevant for baseline 1: fuel switch
2. Data and parameters relevant for baseline 2: Methane emission avoidance from manure management systems
3. Other data

A complete extract of the data is available in PDD, from page 46.

1. Data and parameters relevant for baseline 1: fuel switch

The next table shows the data originating from the PDD relevant for baseline 1: fuel switch.

Table 11: Data and parameters not monitored for baseline 1: fuel switch

Fuel i	Purpose	kg/year/household	NCV (TJ/Gg)	EF (kgCO ₂ /TJ)
Firewood	Cooking	2389	15.6	112000
Firewood non-cooking	Animal feed preparation	318	15.6	112000
Charcoal	Cooking	226.6	29.5	112000
LPG	Cooking	22.3	47.3	63100
Kerosene	Lighting	8.3*	43.8	71900

*litre

All data originates from the PDD page 46 to 50. Domestic fuels in Cambodia are only used for cooking and lighting, space heating does not occur in Cambodia.

2. Data and parameters relevant for baseline 2: Methane avoidance from animal manure management systems

Table 12: Summary of data and parameters not monitored for baseline 2: Methane Avoidance

Data/parameter	Description	Applied Value	
MS _i & MCF ⁹	Average Manure management system of animal category <i>and her methane conversion factor</i>	Category <i>T</i>	$\sum \text{MCF} \cdot \text{MS}_i$
		non-dairy cow	20.6%
		Pig	38.2%
		Buffalo	12.9%
LF	Methane leakage from the biodigester	10% of total AWMS baseline emissions	
VS _T	Volatile solids excretion of animal category <i>T</i>	Category <i>T</i>	VS (kg/day)
		non-dairy cow	2.3
		Pig	0.3
		Buffalo	3.9
Bo	Maximum Biochemical Methane Potential	Category <i>T</i>	Bo (m ³ .kg VS)
		non-dairy cow	0.1
		Pig	0.29
		Buffalo	0.1
GWP _{CH₄}	Global Warming Potential of Methane	21 tCO ₂ e/tCH ₄	
0.67	Methane density (kg/m ³)	0.67	
$\eta_{\text{biogasstove}}$	Combustion efficiency of the biogas stove	98%	
EF _T	Emission factor (tCO ₂ e/yr/animal T)	Category <i>T</i>	EF _T
		non-dairy cow	0,2426
		Pig	0,1677
		Buffalo	0,2562

The methane conversion factor (MCF) of the baseline animal management systems (MS) is shown described in PDD page 55.

⁹ The $\sum \text{MCF} \cdot \text{MS}_i$ value is based on the MCF and MS reported in the PDD v17.1

3. Data and parameters relevant for: other data

The next table shows the other data not monitored from page 50 of PDD.

Table 13: Data and parameters not monitored: Stove efficiency

Stove	Efficiency wood	Efficiency with charcoal
New Lao stove	25%	30%
Traditional Lao stove	11%	14%
Thai bucket stove	14%	16%
Three stone stove	10%	Na
LPG stoves	60% (only LPG)	

Other data not monitored are:

1. ID2: Number of households in the baseline sample group: ID2 is data that cannot be changed, the baseline survey has already been conducted, and hence this data cannot be monitored.
2. ID 6: Cooking and lighting fuel consumption *i in baseline option 1*. is obtained from the baseline survey required to establish a baseline, this is executed once before the implementation of the program in a sample of the target population, conform the used Methodology (page 5).
3. Data applied for ID 12, physical leakage, is a default value provided by the Methodology (page 44) and hence cannot be monitored. See the next table for the values for ID2, ID6 and ID 12

Table 14: Other data that is not monitored

ID	Data unit	Description	Applied value	Source
ID 2 / n_{bl}	-	Number of households in the baseline sample group	300, see chapter 3.1 point 3	PDD page 37
ID 6 / $F_{i,bl1}$	kg or m^3	Cooking and lighting fuel consumption <i>i in baseline option 1</i>	See Table 11: Data and parameters not monitored for baseline 1: fuel switch	PDD page 49
ID 12 / PL	%	Physical leakage of the biodigester	10%	GBM default value, PDD page 45

3.2 DATA AND PARAMETERS MONITORED

The next table shows a summary of the values that were monitored during the MPII survey.

Table 15: Values of data and parameters monitored

ID	Data unit	Description	Applied value		Source
ID 1 / Area <i>i</i>	km ²	Project Area	45,224 km ²		PDD page 62
ID 3 / n _{pj}	#	Number of households in project sample group	150		see chapter 2.2
ID 5 / n _{hh,y}	#	Total number of households participating in the program in year y	14,144 household as of 31-12-2011		see chapter 1.5
ID8	Kg/year	Project fuel emissions	See table 17		MPII survey
ID 9 / I	ton/year	Annual biomass increment on the project area _i	1285077 ton		PDD page 100 presents the latest up to date information and is therefore adopted
ID 10 / H	ton/year	Annual biomass harvest on the project area	4390148 ton		
ID 11/ MS _{T,S,k}	%	fraction of livestock's category T's manure fed into the biodigester	87%, of the dung fed to the biogas plant		MPII survey workbook cell AF143
ID 13 / LC _T	#	Number of livestock of category T	Category T	LC _T	MPII survey workbook sheet BEaw ex-post
			non-dairy cow	3.71	
			Pig	2.72	
			Buffalo	0.22	
ID 16 / GWP _{CH₄}	tCO ₂ e/tC H ₄	Global Warming Potential (GWP) of methane	21		The value will be updated by permission of the GS

Fraction of Non Renewable Biomass

The fraction of Non-Renewable biomass is also updated as per CDM SSC WG 35 Annex 20¹⁰. In that meeting the SSC proposed conservative fNRB default values for LDCs, including Cambodia. The conservative default value recommended by the UNFCCC is 76%. This value is adopted and used in this report.

Performance ratio

Out of the 139 valid samples, the biodigester of 5 households were not in operation. Four of them were not in operation as the owner gave up the farming business and one did not work because of flooding. The total sample size over which the emission reductions are calculated are therefore 134 times and then discounted with a performance ratio of ((139-5)/139) 96.4%.

¹⁰ http://cdm.unfccc.int/Panels/ssc_wg/meetings/035/ssc_035_an20.pdf

3.3 EMISSION REDUCTIONS

Baseline emissions

The baseline emissions are the emission from cooking and lighting fuel consumption related emissions and the AWMS.

Ex-post Baseline emissions from thermal energy

The baseline emissions from fuel use are updated using the fNRB of 76% (see chapter 3.2). The total CO_{2e} emission from thermal energy services in the pre-project situation is calculated using the formula below:

$$BE_{th,h} = \left(\mu_{BE,th,h} - z \times \frac{\sigma_{BE,th}}{\sqrt{n_{bl}}} \right)$$

Equation 2: Baseline emissions from thermal energy demand

Where:

- BE_{th,h} = The average baseline emissions from thermal energy (tCO_{2e}/hh)
- σ_{BE} = Standard deviation of CO_{2e} emissions in the baseline situation
- μ_{BEth,h} = Mean of CO₂ emission of households of the baseline sample group (tCO₂/year)
- z = Standard normal for a confidence level of 95% (1.96)

The standard deviation σ_{BE,th}, is calculated as follows:

$$\sigma_{BE,th} = \sqrt{\frac{\sum (BE_{th,h} - \mu_{BE_{th,h}})^2}{n_{bl} - 1}}$$

Where n_{bl} is the number of valid cases in the baseline situation (n_{bl}=288)¹¹.

To solve this equation, both average household emission from thermal energy demand and the concurrent standard deviation have to be determined. The average baseline emission from thermal energy demand is calculated as:

$$\mu_{BE_{th,h}} = \sum_i (F_{i,bl,h} \times NCV_i \times EF_{CO2,i})$$

Equation 3: Baseline emissions from thermal energy demand by household

Where:

- μ_{BE_{th,h}} = The total baseline emissions from the thermal energy demand of one household (tCO₂/year)
- F_{i,bl,h} = Total amount of fuel type *i* (kg/year) of one household
- NCV_i = Net Calorific Value of fuel type *i* (TJ/ton of fuel)

¹¹ The baseline survey has a sample size of 300, of which 288 are valid cases.

$EF_{CO_2,i}$ = The CO_2 emission factor per unit of energy of fuel i (tCO_2/TJ)

The amount of fuel type i entered in the above equation is adjusted with the share of NRB. With a calculated standard deviation of 3.63, the ex-post baseline emissions from thermal energy demand are on a 95% confidence interval 3.57 $tCO_{2e}/household/year$.

Ex-post Baseline emission from AWMS

The ex-post AWMS emissions are calculated using the number of animals obtained from the monitoring survey and the EF for each type of animal obtained from the PDD. The calculation of the average ex-post annual emissions per household from the baseline animal waste management system is done using the next formula:

$$\mu_{aw,h} = \sum_T (LC_{T,h} \times EF_T)$$

Equation 4: Average baseline emission of average livestock holdings per household

Where:

$\mu_{aw,h}$ = Ex-post baseline emission from AWMS ($tCO_{2e}/year/hh$)
 $LC_{T,h}$ = Average animal holding (animal T / hh)
 EF_T = Emission factor for animal T ($tCO_{2e}/year/animal\ T$)

The calculated $\mu_{aw,h,y}$ is 1.44 $tCO_2/household/year$. To adjust the average baseline emissions for the sampling error, the next equation is used

$$BE_{aw,h} = \left(\mu_{aw,h} - z \times \frac{\sigma_{BEaw}}{\sqrt{n_{pj}}} \right)$$

Equation 5: Ex-post baseline emission from animal waste management on a 95% confidence interval

Where:

$BE_{aw,h}$ = Average household ex-post CO_{2e} emission from the animal waste management systems ($tCO_{2e}/year/hh$)
 σ_{BEaw} = Standard deviation of CO_{2e} emissions in the baseline situation
 $\mu_{aw,h}$ = Mean of CO_{2e} emission of the average household included in the baseline sample group ($tCO_{2e}/year$)
 z = Standard normal for a confidence level of 95% (1.96)
 n_{pj} = Number of valid cases in the project survey sample (134)

To solve this equation, both average household emission from the animal waste management systems μ_{aw} and the concurrent standard deviation σ_{aw} have to be determined.

With a calculated standard deviation of 0.88 and with 134 valid cases out of the survey sample of 150, the ex-post baseline emissions from AWMS are on a 95% confidence interval 1.262 tCO_{2e}/household/year.

Ex-post baseline emissions

The next table shows the baseline emissions of MPII.

Table 16: Baseline emissions of MPII

Emission source	Acronym	Baseline emissions (tCO₂/hh/year)
Baseline cooking and lighting fuels for thermal energy	BEth	3.569
Animal waste management systems	BEaw	1.262
Total baseline emissions	BE	4.831

The rounded annual average household baseline emission is 4.831 tCO_{2e}/year in the VGS project area.

Project and leakage Emissions

Methodology

The methodology applied is similar as applied to the ex-post baseline calculation in the PDD: Gold Standard, Indicative programme, baseline, and monitoring methodology for Small Scale Biodigester Voluntary Gold Standard¹². This is a large scale project methodology¹³ for Small scale biodigester technologies. The data used for the ex-post project emission calculation originate from the monitoring survey, details on the survey can be found in chapter 2.2.

Two project emissions are identified by the methodology used:

1. Project emission from thermal energy demand;
2. Project emission from physical leakage and incomplete combustion.

1. Project emission calculation from thermal energy demand

The establishment of the project emissions (PE_{th}) from fuels used in the project scenario is ex-post determined using the following equations.

¹²http://www.cdmgoldstandard.org/fileadmin/editors/files/6_GS_technical_docs/manuals_and_methodologies/GS_Methodology_Biodigester.pdf

¹³ Confirmed by the GS, the term small scale in the methodology refers to the technology size, not the project

$$PE_{th,h} = \sum (F_{i,h} \times NCV_i \times EF_i \times fNRB)$$

Equation 6: Calculation of emission from thermal energy demand

Where:

$PE_{th,h}$	=	The project emissions from the thermal energy in the project sample (tCO _{2e} /year/hh);
$F_{i,h}$	=	Total amount of fuel type <i>i</i> in the project scenario (kg/year/hh)
NCV_i	=	Net Calorific Value of fuel type <i>i</i> (TJ/Gg)
EF_i	=	The CO ₂ emission factor per unit of energy of fuel <i>i</i> (tCO ₂ /TJ)
$fNRB$	=	Fraction Non-Renewable Biomass

The value for kerosene consumption was expressed in litres. The conversion to the weight of kerosene used was calculated by multiplying the litres consumed with the density (ρ): $F_{kerosene} \text{ (l/year)} \times \rho_{kerosene} \text{ (kg/liter)} = F_{kerosene} \text{ (kg/year)}$. The density (ρ) of kerosene is: 817,15 kg/m³ or expressed in litres and rounded off to 0,817 kg/l. The next table elaborates the GHG emissions by fuel:

Table 17: Average Project emission by fuel and household

Fuel i	F (kg/year)	fNRB (%)	NCV (TJ/Gg)	EF (tCO ₂ /GJ)	μP_{eth} (tCO ₂ /year)
Firewood for cooking	63.79	76%	15.6	112	0.085
firewood other	448.20	76%	15.6	112	0.595
Charcoal	15.76	76%	29.5	112	0.040
LPG	0.54	100%	47.3	63.1	0.002
Kerosene**	3.69	100%	43.8	71.9	0.012
				Total	0.733

The standard deviation of CO₂ emission in the baseline situation is calculated as follows:

$$\sigma_{PE,th} = \sqrt{\frac{\sum (PE_{th,h} - \mu PE_{th})^2}{n_{ps} - 1}}$$

Equation 7: Calculation of the Standard Deviation

The mean average household emissions from thermal energy demand in the project are calculated are a 95% confidence interval: 0.467 tCO_{2e}.

2. Project emission from physical leakage and incomplete combustion

The adopted value is 10% for the physical leakage emission (PL) from the biodigester by default of the GS biodigester methodology, see ID 12 chapter 3.2. The value of 98% (μ) is adopted as the biogas stove efficiency, see Table 12.

The next equation from the methodology is used to calculate the project emissions from the biodigester system, the emission resulting from physical leakage (PL_y) and resulting from incomplete combustion.

$$\mu PE_{leakage} = \sum \left((LC_{T,h} \times EF_T) \cdot PL_y \right) + \sum \left((LC_{T,h} \times EF_T) \times (1 - \eta_{biogasstove}) (1 - PL_y) \right)$$

Equation 8: Calculation of the average physical leakage emissions

Where:

$\mu PE_{leakage}$	=	Mean of leakage emissions per household (tCO _{2e} /year)
$LC_{T,h}$	=	The per household mean number of animal of livestock category T
EF_T	=	Annual CO _{2e} emission factor for livestock category T , (tCO _{2e} animal ⁻¹ yr ⁻¹)
PL_y	=	Physical leakage of the biodigester y (10 %)
$\eta_{biogasstove}$	=	Combustion efficiency of the biogas stove (98%)

The EF_T originates from the data not monitored; see table 14 and the PDD on page 55 for the calculation. The standard deviation is calculated as follows:

$$\sigma_{PL} = \sqrt{\frac{\sum (PE_{leakage,h} - \mu PE_{leakage,h})^2}{n_{pl} - 1}}$$

Where:

σ_{PL}	=	Standard deviation of leakage emission in project
$\mu PE_{leakage,h}$	=	Mean of CO _{2e} emission of the average household included in the baseline sample group
$PE_{leakage,h}$	=	The amount of CO _{2e} emission of household h in the project sample group
n_{pl}	=	Total number of household included in the project sample group

Applying this calculation in excel resulted in the standard deviation (σ_{PL}) = 0.104 (dimensionless). The leakage emission on a 95% confidence interval are calculated as 0.149 tCO_{2e} per household per year

Total Project emissions

The average per household project emissions from physical leakage and fuel emissions are ex-post determined for monitoring period 2 as 0.616 tCO_{2e}/year

Emission reductions

The annual average emission reductions per household (ER_{h,y}) are presented in the table below.

Table 18: Annual per household emission reductions

Baseline	Baseline emissions tCO _{2e} /household	Project emissions tCO _{2e} /household	Emission reductions tCO _{2e} /household
Thermal energy demand	3.569	0.467	3.102
Methane emissions	1.262	0.149	1.113
Total	4.831	0.616	4.215

The ex-post annual average emission reductions are 4.215 tCO_{2e}/household.

3.4 EMISSION REDUCTION CLAIM MONITORING PERIOD 2

The next table shows the emission reductions realized by the VGS project of NBP MP11 and is developed using the information from the previous sections. The ERs are calculated on a per month basis, where the emission reductions of month m are only accounted for in month m+1, to ensure a conservative estimation of the ERs.

Table 19: Emission reductions realized by the VGS project of NBP

No	Period		Units built	Cumulative units	ERs/month/unit*	Percentage in operation	ERs	Cumulative ERs monitoring period II
57	1-Sep-10	30-Sep-10	321	8,892	0.351	96%	2,902	2,902
58	1-Oct-10	31-Oct-10	226	9,118	0.351	96%	3,011	5,914
59	1-Nov-10	30-Nov-10	394	9,512	0.351	96%	3,087	9,001
60	1-Dec-10	31-Dec-10	409	9,921	0.351	96%	3,221	12,223
61	1-Jan-11	31-Jan-11	430	10,351	0.351	96%	3,359	15,582
62	1-Feb-11	28-Feb-11	478	10,829	0.351	96%	3,505	19,087
63	1-Mar-11	31-Mar-11	457	11,286	0.351	96%	3,667	22,755
64	1-Apr-11	30-Apr-11	349	11,635	0.351	96%	3,821	26,576
65	1-May-11	31-May-11	338	11,973	0.351	96%	3,940	30,517
66	1-Jun-11	30-Jun-11	388	12,361	0.351	96%	4,054	34,571
67	1-Jul-11	31-Jul-11	358	12,719	0.351	96%	4,185	38,757
68	1-Aug-11	31-Aug-11	315	13,034	0.351	96%	4,307	43,064
69	1-Sep-11	30-Sep-11	278	13,312	0.351	96%	4,413	47,478

70	1-Oct-11	31-Oct-11	234	13,546	0.351	96%	4,507	51,986
71	1-Nov-11	30-Nov-11	316	13,862	0.351	96%	4,587	56,573
72	1-Dec-11	31-Dec-11	282	14,144	0.351	96%	4,694	61,267

The table shows that the total number of ERs realized is **61,267** tCO₂ for the monitoring period II.

4. SUSTAINABILITY MONITORING CONFORM MONITORING PLAN IN PASSPORT

4.1 SAFEGUARD PRINCIPLES

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

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

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

4.2 SUSTAINABILITY MONITORING PLAN

This section will assess the performance of the VGS project on the sustainability indicators by indicator (ID) identified in the GPSR.

ID 1: Air quality

The chosen parameter for ID1 is:

Reduction in wood and charcoal consumption for cooking and kerosene consumption for lighting in the project compared to the baseline.

The performance of this indicator is measured by comparing the fuel consumption in MRII with the baseline as included in the PDD.

Table 20: Performance of VGS project on ID 1: Air quality

Moment of measurement	Wood**		Charcoal		Kerosene	
	(ton/year/hh)	Reduction compared to the baseline	(ton/year/hh)*	Reduction compared to the baseline	(l/year/hh)	Reduction compared to the baseline
Baseline	2.71	N/A	0.22	N/A	8.31	N/A
GPSR	N/A	50	N/A	50	N/A	N/A
MRI	0.40	85.3	0.01	93.5	2.91	64.9
MRII	0.51	81.1	0.02	92.84	0.00	100,0
Future target	Fuel switch to biogas with a minimal remaining consumption of wood and charcoal for non-food preparation purposes which take place outside the kitchen (i.e. pig feed preparation, palm sugar, rice wine production)					

* In wood equivalents, 1 kg of charcoal equals 6 kg of wood, PDD

** includes both wood use for cooking and non-cooking purposes

The VGS project effectively reduces the reliance on wood and charcoal by 81.1% and 92.84% compared to the baseline. This is a tremendous reduction on the reliance of biomass and will significantly improve the indoor air quality. The remaining use of fuel wood is limited to boiling water, preparation of soup, cooking for large families, during parties and visitors and grilling activities. These activities consume, compared to the baseline situation, only a fraction of wood.

Kerosene consumption for lighting has also decreased significantly, with almost 100%. This means that people have access to other sources of light, such as biogas lamps.

ID 2: Water quality and quantity

The chosen parameter for ID 2 is:

Number of toilets built (connected to the biodigester)

The performance on this indicator is sourced from the NBP user database. As a result of the NBP activities at the end of MPII 1613 toilets were connected to the biogas plant. The number of households that connect a toilet to the biogas plant is slowly increasing, from 0% to 9.2% at the end of MRI to 11.4% at the end of MPII, see the next table.

Table 21: Project performance on ID2

Cumulative number as of	D2: Number of toilets built (connected to the biogas plant)	
	#	%
Baseline	0	0%
1-1-2009	208	5.5%
GSPR (31-08-2010)	451	8.8%
1-1-2010	536	8.4%
MRI	792	9.2%
MRPI	1613	11.4%
Future target	50% have a toilet connect to the biogas plant	

ID 3: Soil conditions

The chosen parameter for ID 3 is:

Number of users that use bio-slurry as fertilizers

The performance of this indicator is obtained through the MRPI user survey. The next table shows that practically all users use bio-slurry as fertilizer. In the survey population 94% of the biogas plant owners used slurry, around 13,336 biogas owners in total.

Table 22: Project performance on ID 3

Cumulative number as of	ID3: Number of users that use bio-slurry as fertilizer*	
	#	%
Baseline	0	0%
1-1-2009	N/A	N/A
GSPR	N/A	N/A
MRI	N/A	N/A
MRPI	13,336	96%
Future target	All biogas household use bio-slurry as their fertilizer	

*parameters has changed from MPI at request of the GS, see table 6

Since this is a new parameter (see table 6), the values for GSPR and MRI are not available.

ID 4: Biodiversity

The chosen parameter for ID 4 is:

Reduction (RE) in firewood (F_{fw}) and charcoal (F_c) consumption for cooking compared to the baseline

The savings are calculated by subtracting the amount of wood and charcoal consumed in MRII from the baseline as described in the PDD. The next table shows the savings in MRII.

Table 23: Performance on ID4: Total wood, fuel wood and charcoal savings

Month #	from	to	Cumulative units	wood savings (t/month)	charcoal savings (t/month)	total wood* (t/month)
55	01/09/2011	30/09/2011	8892	1627	151	2535
56	01/10/2011	31/10/2011	9118	1668	155	2599
57	01/11/2011	30/11/2011	9512	1740	162	2711
58	01/12/2011	31/12/2011	9921	1815	169	2828
59	01/01/2012	31/01/2012	10351	1893	176	2950
60	01/02/2012	29/02/2012	10829	1981	184	3087
61	01/03/2012	31/03/2012	11286	2064	192	3217
62	01/04/2012	30/04/2012	11635	2128	198	3316
63	01/05/2012	31/05/2012	11973	2190	204	3413
64	01/06/2012	30/06/2012	12361	2261	210	3523
65	01/07/2012	31/07/2012	12719	2327	216	3625
66	01/08/2012	31/08/2012	13034	2384	222	3715
67	01/09/2012	30/09/2012	13312	2435	227	3794
68	01/10/2012	31/10/2012	13546	2478	231	3861
69	01/11/2012	30/11/2012	13862	2536	236	3951
70	01/12/2012	31/12/2012	14144	2587	241	4032
			total	34113	3174	53158

* expressed in wood equivalents, 1 kilo of charcoal is produced from 6 kilo of wood as per registered PDD sourced from IPCC 1996 revised guidelines

The cumulative savings are in MPII around 53 Gg wood, from the start of the program, the total savings are, from the start until the end of MPII : 71 Gg wood.

The next figure shows the cumulative impact of NBP on saved fuel wood and the hectares of avoided deforestation for: (a) intact forests of 136.7 ton biomass/hectare¹⁴ and (b) for degraded forests with an estimated 50 ton biomass/hectare. The figure is developed by dividing the amount of saved wood by the amount of biomass per hectare.

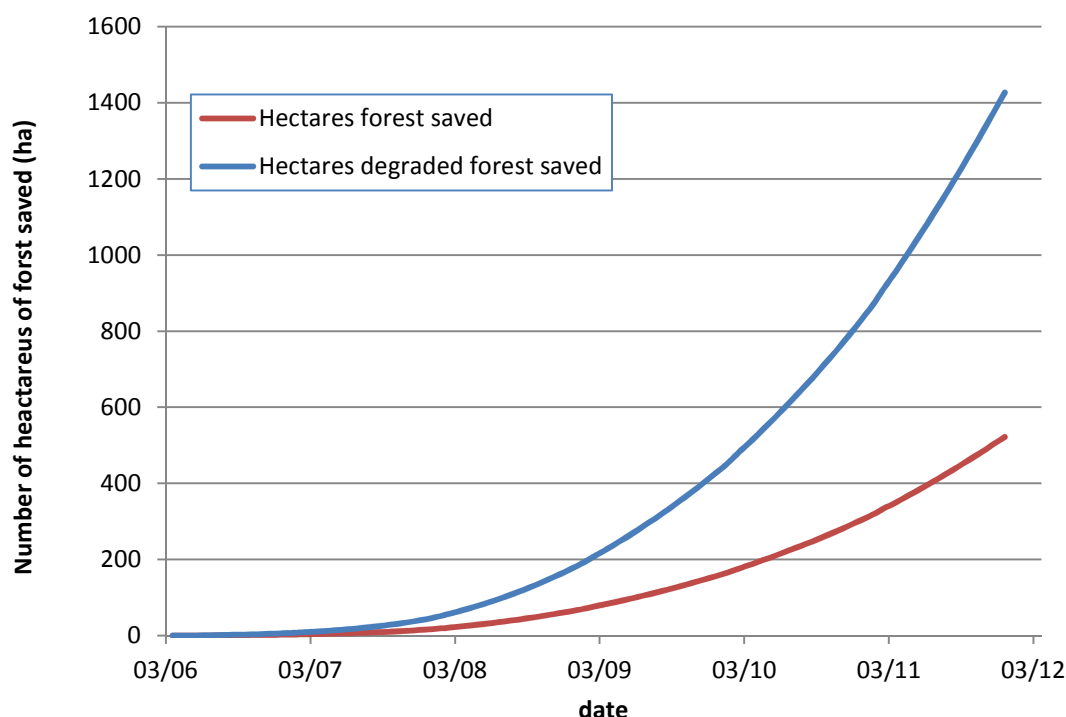


Figure 5: Cumulative avoided deforestation attributed to the VGS project activities

The NBP project results in saving of 522 to 1427 hectares, 522 in the case intact forests are saved that contain the average weighted biomass in Cambodia and 1427 for degraded forests with only 50 ton biomass per hectare. This is a considerable saving and in other words, 522 to 1427 hectares of habitat for flora and fauna were saved from deforestation by the activities of NBP.

ID 5: Quality of Employment and ID 8: Quantitative employment and income generation

The chosen parameter for ID 5 is:

Number of trained masons and supervisors (quality inspectors of biodigesters) and number of companies working of marketing, construction and after sale services

The chosen parameter for ID 8 is:

¹⁴ Calculated weighted average biomass growing stock of the VGS project area forests, see PDD page 77

(1) Number of masons and (2) supervisors trained, (3) number of companies working on marketing, construction and after-sales services

Table 24: VGS project performance on ID 5 and ID 8

Cumulative number as of	Masons	Supervisor	Biogas Construction Companies
Baseline	0	0	0
1-1-2009	325	51	0
GSPR*	338	54	0
1-1-2010	357	59	21
MRI	450	65	21
MRII	574	93	43
Target	> 600 combined		>30

* Number of supervisors as of July 2009 is **54** but reported as **44** in GSPR v7.

The target that NBP has set is achieved with MPII. NBP has both trained more masons and supervisors and more Biogas Construction Companies (BCC) started operation than the target set.

ID 6: Livelihood of the poor

The chosen parameter 1 for ID 6 is:

Increase in access to basic sanitation by the installation of a toilet to the biodigester

Chosen parameter 2 for ID6 is:

Reliance on biogas as lighting fuel

Chosen parameter 3 for ID6 is:

Reliance on biogas as cooking fuel

The results of the 3 parameters are shown in the next table

The performance on these indicators is obtained from the MPII survey.

Table 25: VGS project performance on ID 6: Livelihood of the poor expressed

Moment of recording	Parameter 1: <i>Toilet ownership</i>	Parameter 2: <i>Reliance on biogas as lighting fuel</i>	Parameter 3: <i>Reliance on biogas as cooking fuel</i>
	% of all users		
Situation before having a biogas plant (baseline)	28.8%*	0%	0%
1-1-2009	64.7%	N/A*	N/A*
GSPR**	74%	92%	100%
1-1-2010	61.6%	N/A*	N/A*
MRI	73%	71%	100%
MRII	79%	90%	100%
Future target	50% of household have a toilet connected to biodigester	Biogas is used for lighting for all the biodigester households, unless an energy source is available higher up the energy ladder	100% usage of biogas as main cooking fuel

* Not included in the survey of that year or no survey was executed at that date

** 31-08-2010

Parameter 1: The numbers of households that have access to basic sanitation is steadily increasing, from 28.8% in the baseline to 79% in MRII. The number of households that have their toilet connected to the biogas plant is depicted in table 21. Around 11.4% have their toilet connected to the biogas at this MP II.

Parameter 2: The proportion of household that use biogas for lighting is also increasing, with almost 89% of the households using biogas of that purpose.

Parameter 3: The main use of biogas is cooking. This is the main motivation of households to install a biogas plant and the statistics clearly evidence this by showing that at all measurement moment the use of biogas for cooking is 100%.

ID 7: Access to affordable and clean energy services

The chosen parameter for ID7 is:

Reduction in cooking and lighting fuel expenditure compared to the baseline

Performance on ID7 is calculated by subtracting the fuel expenditures in the project from the baseline fuel expenditures that were obtained from the CDM baseline survey, see the next table:

Table 26: VGS project performance on ID 7: Reduction in cooking and lighting fuel expenditures

Moment of recording	Average Cooking and lighting fuel expenditures	Household fuel expenditure savings compared to the baseline
	US\$/month/hh	US\$/month/hh
Baseline	\$8.66	\$0.00
GSPR	\$0.63	\$8.03
MRI	\$1.08	\$7.57
MRII	\$0.75	\$7.91
Future target	Significant reduction in expenditure on cooking	

Households save around \$7.91 per month on the reduced reliance on biomass and kerosene. This is a substantial saving, amounting to almost \$94.93/year. Therefore, the procurement of a biodigester will not only provide access to a clean energy source, but also to energy source that saves expenditures on energy. These savings will reduce the pressure on the household income and opens opportunities for other activities, i.e. schooling.

ID 9: Balance of payments and investments

The chosen parameter for ID 10 is:

Net cash inflow: sum of cash inflows – cash outflows. Cash inflow is VER income, foreign direct investment; the cash outflow is the expenditure on materials and equipment not available in Cambodia.

The performance on this indicator is obtained from the NBP accountant and financial reports.

Table 27: VGS project performance on ID 10: Balance of payment and investments

Applicable to period:	Net Cash inflow
Baseline	\$0
MPI	\$2,123,508
MPII	\$1,826,430
Future target	Not available

The NBP program results in a significant net inflow during the monitoring period II to Cambodia. The main outflow was the result of the purchase of appliances and the high costs for validation and verification by the DOE SQS and TÜV Rheinland.

ID 10: Technology transfer and technological self-reliance

The chosen parameter for ID 11 is:

Number of biodigesters built

The performance on this indicator is sourced from the NBP user database. The total number of biodigester built is described in detail in chapter 1.5. In total 14,144 units have been built between 13-06-2006 and 31-12-2011 (see table 5 for annual figures). The next table shows the number of biogas plants built by period.

Table 28: Number of units built by period

Total, at the end of:	Number of units commissioned	Cumulative
Registration	4,822	4,822
MPI	3,579	8,571
MPII	5,573	14,144

5. STAKEHOLDER FEEDBACK

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

These opportunities to provide feedback are, inter alia:

1. Email addresses of the NBP staff can be found on the NBP website (<http://www.nbp.org.kh/page.php?id=13>). This allows stakeholders to direct their email to specific persons;
2. Phone numbers of PBPO staff can be found on the same webpage;
3. Comment form on the website (<http://www.nbp.org.kh/comments.php>)
4. NBP and PBPO phone numbers are given in the user manuals and leaflets

The following comments were received by the programme director: The programme director has received many emails but none of them were comments.

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

6. DATA QUALITY CONTROL AND ASSURANCE

NBP implements an elaborate QC/QA mechanism on the construction of the biodigester. This process is described into detail in PDD section B.7.2. In addition to this, the emission reductions and the impact on sustainable development are monitored at least biennially using survey methods. The DOE plays an important role to verify the quality of these monitoring activities as a third party independent verifier.

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

The emission reduction is based on field questionnaires administered to a sample of users, the quality assurance lies in the design of the questionnaires, their reliable administration and calculations based on the data analysis. It is therefore of high importance that the questionnaires are administered by specially trained personnel with extensive experience. Quality Assurance of this process is carried out by NBP Cambodia in collaboration with the SNV biogas advisor.

- **Quality assurance of questionnaire design**

The main tool to capture information required for this report is the household survey questionnaire. The household survey is executed by Rogier van Mansvelt, independent consultant. He has been selected based on an open tender process which he won based on his experiences and qualities. The household questionnaire is drafted by the selected consultant based on the requirements that NBP put down in the Terms of Reference (ToR). This draft is subsequently discussed and reviewed by NBP staff, their technical advisor of SNV and the independently contracted CDM specialist.

The questionnaire used is a slightly modified version of the survey form used for MPI. Using a tested questionnaire assures quality as the survey has proven to yield reliable and unbiased information during MPI. The MRI survey form was developed according to the next steps:

1. Field testing with surveyors;
2. Improvement of the survey based on the review and feedback from the field;
3. Implementation of the survey for MRI;

- **Quality assurance on data collection activities**

The surveyors are selected based on relevant education level, field experience. Five out of the eight selected surveyors were also involved in the survey for MPI and therefore it was ensured that they had relevant experience. The other 3 were recruited, trained and coupled with an experienced surveyor during the survey (surveying is done in teams of 2 and it was ensured that at least one experienced surveyor from MPI was present in each time).

All surveyors have received a two day train on 4 and 5 January 2012. A training report is included in Annex III. The interviews were carried out from January 7 to 17 January 2012. The 150 farmers in 12 districts to be visited were divided between 4 groups of interviewers. On average each group was able to interview around 4 to 5 households with biodigesters per day.

Quantitative data was obtained using a calibrated weighting scale, the calibration procedure and testing is included in annex IV.

The survey forms were checked before the data entry started. Some important data was double checked, such as the amount of firewood still used, number of livestock and working biogas lamps. The data was entered by an experienced person who was also involved in the data entry during MRI. Data was entered into SPSS (data analysis programme) and exported to excel.

- **QC/QA on monitoring report**

The monitoring report is developed by an independent consultant with relevant experience of CDM and carbon monitoring of domestic biogas projects, his name is Eric Buysman. The consultant is selected in a tender process, and selected based on a quality cost basis. The selected consultant has considerable experience as the consultant also developed MRI and is the lead consultant for a sister VGS project in Viet Nam, Biogas Program for Animal Husbandry Sector of Viet Nam. The monitoring report is checked before release by NBP staff and their SNV advisor. Comments on the report were received on the 16th of February, and based on the comments improved. Final guarantee about compliance with the used Methodology and PDD is provided by the DOE and the GS.

- **Quality Control by DOE**

The Quality control is to be performed by a DOE on at least a biennial basis. They will visit a select group of households which is part of the project sample group. They must at least fulfil the same knowledge requirements as the survey team. At the household they will assess the reliability of the questionnaire by checking the figures provided by the respondents. If deviations occur, the value will be adjusted accordingly.

ANNEX 1: CONTACT DETAILS OF THE PROJECT PARTICIPANTS

Organisation:	National Biodigester Programme
Street/P.O.Box:	PO Box 2590
Building:	-
City:	Phnom Penh
State/Region:	-
Postfix/ZIP:	-
Country:	Cambodia
Telephone:	+85523992609
FAX:	+85523992604
E-Mail:	admin@nbp.org.kh
URL:	www.nbp.org.kh
Represented by:	Mrs. Lam Saoleng
Title:	Programme Coordinator
Salutation:	Mrs.
Last Name:	Lam
Middle Name:	-
First Name:	Saoleng
Department:	-
Mobile:	+85517961056
Direct FAX:	-
Direct tel:	-
Personal E-Mail:	saoleng@nbp.org.kh

Organisation:	SNV-Netherlands Development Organisation, Cambodia
Street/P.O.Box:	#184, street 217, PO Box 2597
Building:	Premier Office Center (POC)
City:	Phnom Penh
State/Region:	Phnom Penh
Postfix/ZIP:	
Country:	Cambodia
Telephone:	+ 855 23 994 562
FAX:	+ 855 23 994 563
E-Mail:	cambodia@snvworld.org
URL:	www.snvworld.org
Represented by:	Wilbert Schouten
Title:	Country Director
Salutation:	Mr.
Last Name:	Schouten
Middle Name:	
First Name:	Wilbert
Department:	
Mobile:	+ 855 92 945089
Direct FAX:	+855 23 994563
Direct tel:	+855 23 994562
Personal E-Mail:	wschouten@snvworld.org

ANNEX II: TRAINING REPORT

Report training days 4 & 5 January 2012

4 January (13.30 -17.00)

At the start of the training Rogier (van Mansvelt) gave a general introduction about the Biodigester User Survey. He introduced the survey coordinator (Patrick Kooijman) and his role. Also the interviewers who had not joined the BUS last year introduced themselves. Rogier emphasized on the importance for each team to bring the 2 kilo standardized weigh stone with them into the field to measure the accuracy of their scale on a daily basis.

Rogier furthermore showed and explained the biodigester to the new surveyors who were unfamiliar with the model. After the introduction at the scale model the group visited the demo model biodigester at the entrance of the MAFF office.

The rest of the afternoon team leader Phanny (Sras Phanny) took over and started to discuss the questions one by one in the BUS questionnaire. Sophorn Ngy assisted Phanny to edit the questions where needed. In some cases extra communication was needed to have a clear interpretation of the translated (from English to Khmer) questions. Phanny's explanation clarified the purpose of the question in case of misunderstanding the meaning. At 17.00 we almost discussed half the questions and stopped for the day.

5 January (08.00 – 17.00)

Most of the next morning was used to finish the remainder of the questions to be discussed. In between Jan Lam stepped in to give the teams a word of advice. He emphasized on the importance of the BUS and the impact the results have on NBP's policy.

After the lunch break the researchers were informed about the guidelines (which they received on paper) and instructions they have to follow up while doing the field research. The paper also informed the students about their payment. Later on I handed out \$150 to each team member as advance for their costs.

Phanny showed the list of 150 addresses and the teams discussed how to split this up in for equal selections for the teams. See picture below which teams were formed and their target area(s).

All teams were provided with a bag full of materials from NBP. From clipboards, pens, NBP brochures, t-shirts and cap. The final version of the questionnaire was copied and handed out Friday (6th) afternoon to the teams.



Team 1

Keo Udom & Chariya
KP Cham



Team 2

La Piseth & Heng Sok Nang
Kampot, KP Speu, KP Chnnang



Team 3

Sras Phanny & Meng Ny
Kampot (Chhuk & Chumkiri)



Team 4

Vorleak & Pahna
Takeo, Prey Veng & Kandal

Patrick Kooijman

ANNEX III: CARBON MOTORING SURVEY SAMPLING

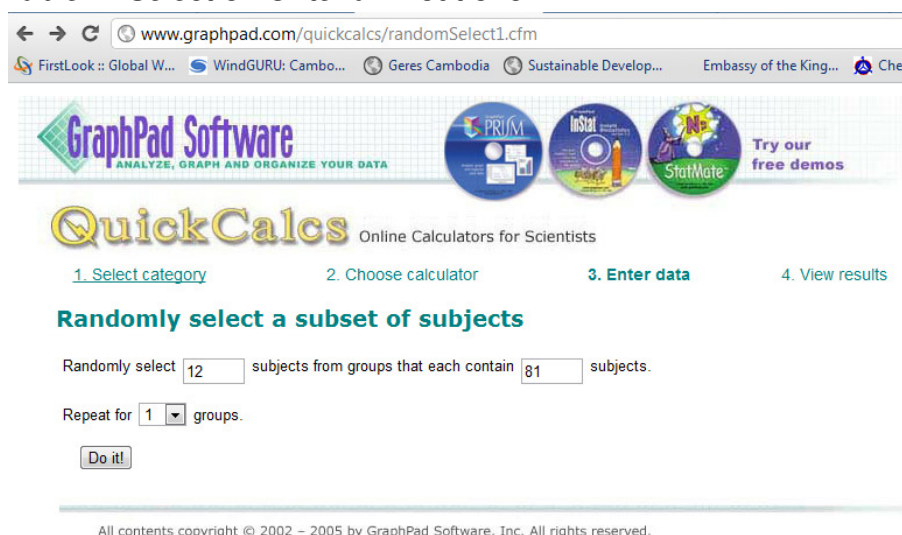
SAMPLING OF 12 DISTRICTS OUT OF A TOTAL OF 81 DISTRICT IN 8 PROVINCES

Sampling Date 2011, December 13th.

Sampling: Selection of 12 Districts out of 81 Districts

The Districts are ordered by province and the districts per province on alphabetical order with a total of 81 Districts. The sampling will result in a random number that will relate to 12 out of the 81 Districts (Table A). The result is shown in Table A. In the second step all the households in the 12 Districts are selected from the NBP database and out of these 1681 household a total of 150 households are selected to be interviewed, see table B. The list with households is included in the VGS database.

Table A: Selection Criteria 12 out of 81



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1. Select category 2. Choose calculator 3. Enter data 4. View results

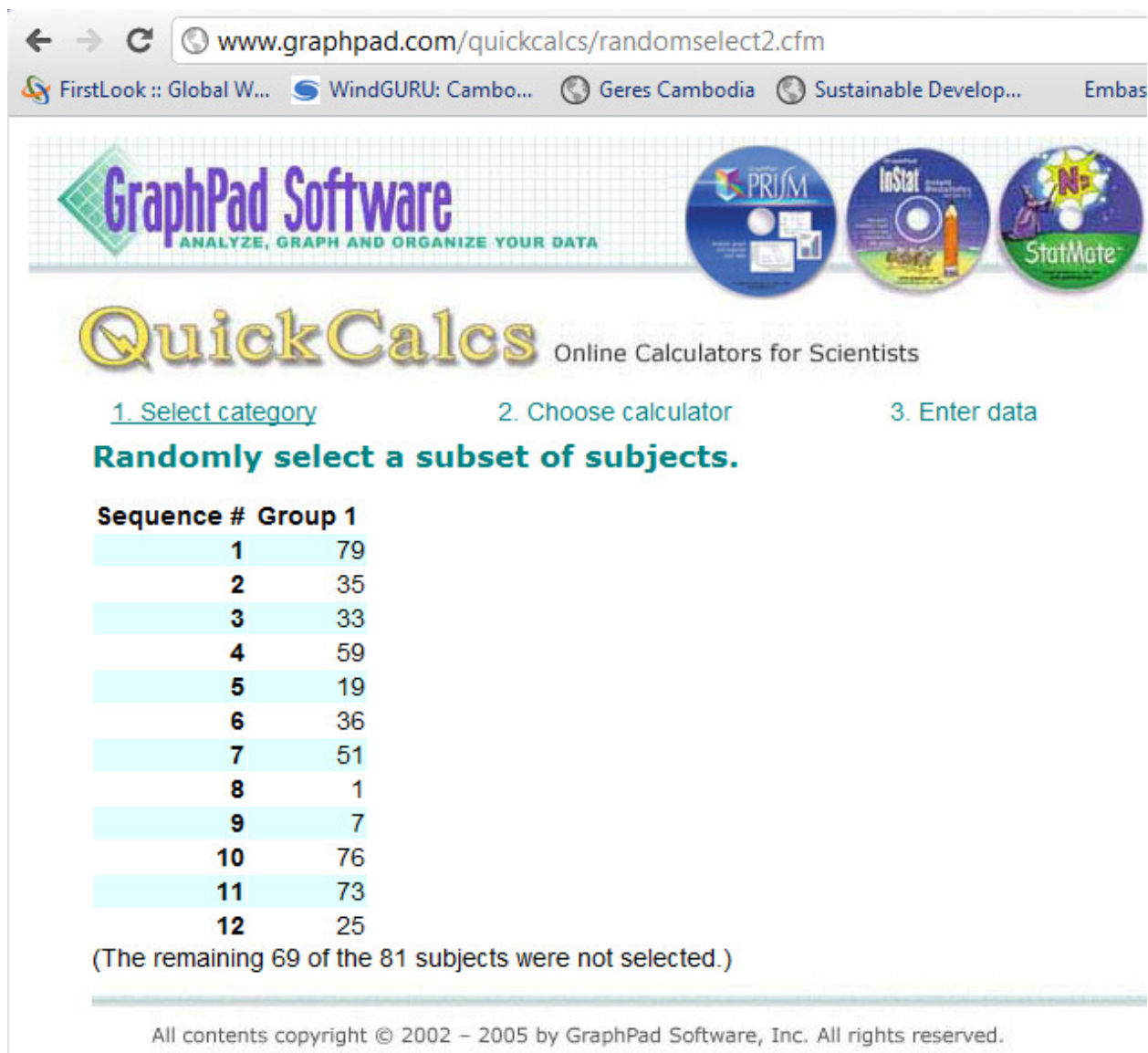
Randomly select a subset of subjects

Randomly select subjects from groups that each contain subjects.

Repeat for groups.

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Results: Group number refers to selected District out of the list.



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1. [Select category](#) 2. [Choose calculator](#) 3. [Enter data](#)

Randomly select a subset of subjects.

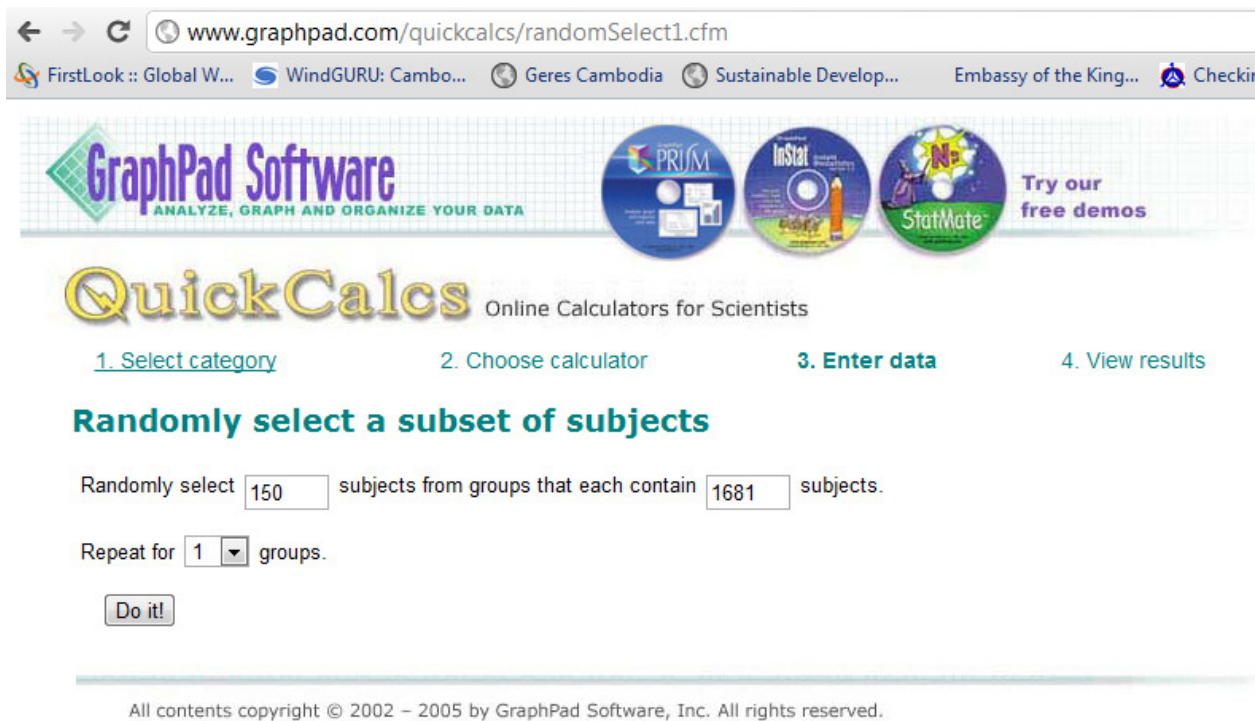
Sequence #	Group 1
1	79
2	35
3	33
4	59
5	19
6	36
7	51
8	1
9	7
10	76
11	73
12	25

(The remaining 69 of the 81 subjects were not selected.)

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In these 12 Districts a total of 1681 biodigester are registered in the NBP database. A random sample of 150 is taken from this 1681. The result is shown in the following screen shots.

Table B: Selection of 150 households from 1681



← → ↻ www.graphpad.com/quickcalcs/randomSelect1.cfm

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Randomly select a subset of subjects

Randomly select subjects from groups that each contain subjects.

Repeat for groups.

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Randomly select a subset of subjects.

Randomly select a subset of subjects.

Sequence #	Group 1				
1	881	22	1148	47	539
2	1053	23	1050	48	1128
3	963	24	409	49	1247
4	521	25	1606	50	763
5	1316	26	1627	51	977
6	1549	27	1532	52	182
7	889	28	529	53	155
8	903	29	1210	54	920
9	1142	30	833	55	1598
10	579	31	969	56	577
11	667	32	62	57	1021
12	465	33	723	58	964
13	924	34	1436	59	583
14	1232	35	1552	60	560
15	263	36	314	61	1291
16	223	37	823	62	888
17	1516	38	1019	63	740
18	1496	39	835	64	1085
19	49	40	721	65	1659
20	1607	41	176	66	1370
21	631	42	292	67	1586
		43	1597	68	1478
		44	908	69	222
		45	1368	70	388
		46	904	71	220

72	1323	97	826		
73	866	98	640	122	370
74	1068	99	124	123	202
75	361	100	161	124	896
76	1035	101	749	125	430
77	96	102	302	126	1561
78	349	103	347	127	506
79	231	104	246	128	657
80	420	105	564	129	1676
81	1093	106	338	130	1162
82	580	107	852	131	1177
83	1402	108	1390	132	348
84	1057	109	1603	133	1456
85	979	110	450	134	251
86	1307	111	694	135	594
87	1680	112	1359	136	188
88	764	113	1657	137	1158
89	1062	114	1562	138	1043
90	86	115	1524	139	454
91	315	116	565	140	1352
92	478	117	1185	141	1654
93	747	118	1642	142	941
94	1165	119	574	143	1430
95	542	120	364	144	475
96	804	121	1106	145	47
				146	1134
147	383				
148	1219				
149	793				
150	1507				

(The remaining 1531 of the 1681 subjects were not selected.)

ANNEX IV: WEIGHT SCALE AND CALIBRATION

Calibration procedure

1. Calibrated and certified weight stones were developed by DTW (see hereunder the details);
2. The newton scales were checked with the weight stones to ensure that the scales were reliable before the start of the survey;
3. In total 4 interview teams of two interviewers undertook the 150 interviews, each team was in possession of 2 scales and one calibrated weight stone;
4. The survey team was instructed to check each morning if the scale was still providing reliable and unbiased weights using the calibrated weight;
5. On January 18th the scales, after the teams returned from the field the scale were again tested with the weight stones produced by DTW. All the scales measured reliably.

Procedure calibration of scales

The Expert Organization DTW has calibrated the 9 scales provided by NBP on December 27th 2011. DTW has also produced 6 weight stones calibrated with their own official weight stone of 2 kg and precision electronic balance. Picture 1 shows the official weight stone on the precision scale.

Figure 6: Official weights stone on precision scale

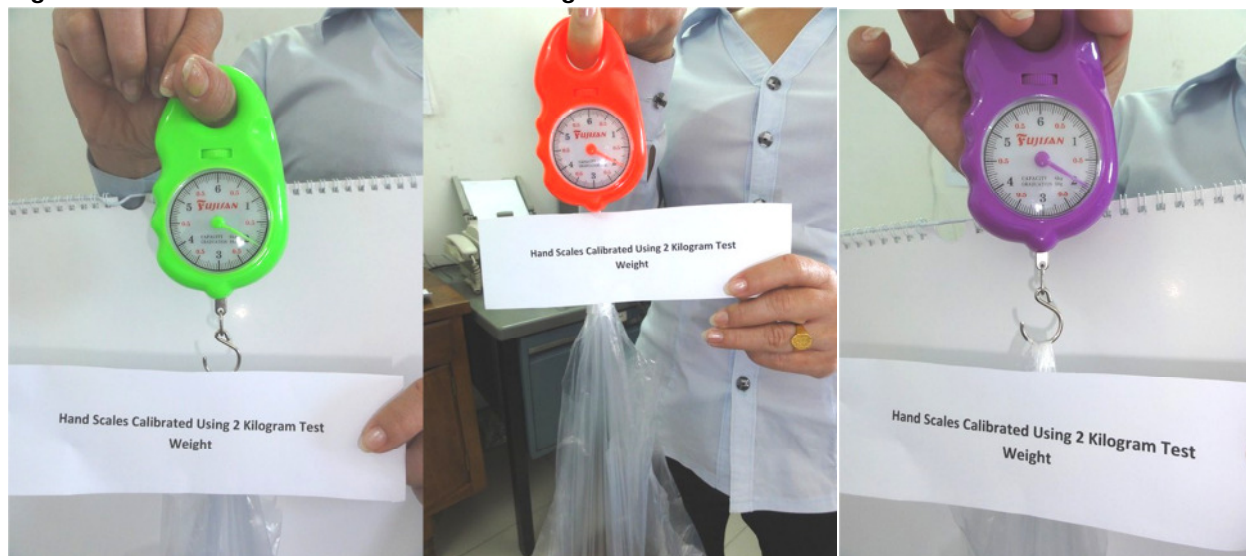


Nine scales were purchased and calibrated with the official weight stone at DTW, see Figure 2 and 3.

Figure 7: 9 scales of 0-6 kg.



Figure 8: Calibration of 9 scales at DTW with weight stone.



The production report of the weight stones is depicted hereunder.

Official report by DTW producing 6 weight stones of 2 kg.



Unit: 001, Street 220
Sangkat: Chaktomuk,
Khan: Sen Sok
Phnom Penh
Cambodia

Phone: +855 (0) 23 969 761
Fax: +855 (0) 23 969 762
Email: dtw@dtw.org.kh
Web: www.dtw.org.kh

2 Kilogram Test Weights Supplied by Development Technology Workshop

Statement of Conformity:

The six weights were machined from black mild steel bar 80mm diameter and individually calibrated on a new Electronic Balance (OHAUS NC Series Model A12).

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

Listed below are the six weights numbered and stamped with their individual weight:

- 1 – 2.0082KG
- 2 – 2.0088KG
- 3 – 2.0092KG
- 4 – 2.0008KG
- 5 – 2.0007KG
- 6 – 2.0058KG

Harold S. Pearson.

Development Technology Workshop
DTW General Manager.

Phnom Penh – Cambodia

December 28th 2011

DTW is a charity undertaking product design and development with technology transfer for developing countries.
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