



Monitoring report form (Version 03.2)

MONITORING REPORT

Title of the project activity	Hubei Eco-Farming Biogas Project Phase I
Reference number of the project activity	2221
Version number of the monitoring report	01
Completion date of the monitoring report	08/11/2013
Registration date of the project activity	19/02/2009
Monitoring period number and duration of this monitoring period	Monitoring period number : 4 rd monitoring period Duration of this monitoring period: 01/01/2012 - 31/12/2012 (Including both days)
Project participant(s)	<ol style="list-style-type: none"> 1. P.R.China: Hubei Qingjiang Zhongye Company Ltd. 2. The State of the Netherlands, Acting through Netherlands' Ministry of Infrastructure and the Environment (IenM) The International Bank for Reconstruction and Development (IBRD) as trustee of Community Development Carbon Fund 3. Japan: Daiwa Securities Capital Markets Co. Ltd.; FUJIFILM Corporation; Idemitsu Kosan Co., Ltd.; JX Nippon Oil & Energy Corporation; The Okinawa Electric Power Corporation, Incorporated 4. Belgium: Kingdom of Belgium - Walloon Region: Walloon Air and Climate Agency; 5. Bruxelles Environnement – IBGECanada: Government of Canada - Ministry of Foreign Affairs and International Trade 6. Denmark: Aalborg Portland A/S; Danish Ministry of Climate and Energy/Danish Energy Agency; DONG Naturgas A/S; Mærsk Olie og Gas AS; Nordjysk Elhandel A/S

	<p>7. Italy: Government of Italy - Ministry for the Environment, Land and Sea</p> <p>8. Luxembourg: Government of Luxembourg - Ministry of Sustainable Development and Infrastructure - Department of Environment</p> <p>9. Norway: Stratkraft Carbon Invest AS; Statoil ASA</p> <p>10. Spain: Endesa Generación S.A.; Kingdom of Spain - Ministry of Environment and Rural and Marine Affairs & Ministry of Economy and Finance; EDP-Energias de Portugal, S.A.; Gas Natural SDG, S.A.; Hidroeléctrica del Cantábrico, S.A.</p> <p>11. Sweden: Göteborg Energi AB</p> <p>12. Switzerland: Schweizerische Rückversicherungsgesellschafts AG (Swiss RE)</p> <p>13. Germany: BASF SE; KfW</p> <p>14. Austria: Kommunalkredit Public Consulting GmbH</p> <p>15. Finland: Rautaruukki Metals Oy</p>
Host Party(ies)	P.R.China
Sectoral scope(s) and applied methodology(ies)	<p>Sectoral scopes: 1-Energy industries (renewables-/non-renewable sources); 15- Agriculture</p> <p>Applied methodology(ies): Version 12 of AMS-I.C: "Thermal energy for the user with or without electricity" Version 01 of AMS-III.R: "Methane recovery in agricultural activities at household/small farm level"</p>
Estimated amount of GHG emission reductions or net anthropogenic GHG removals by sinks for this monitoring period in the registered PDD	58,444 tCO ₂ e
Actual GHG emission reductions or net anthropogenic GHG removals by sinks achieved in this monitoring period	55,106 tCO ₂ e

Actual GHG emission reductions or net anthropogenic GHG removals by sinks achieved during the period up to 31 December 2012(if applicable)	55,106 tCO ₂ e
Actual GHG emission reductions or net anthropogenic GHG removals by sinks achieved during the period from 1 January 2013 onwards (if applicable).	0 tCO ₂ e

SECTION A. Description of project activity

A.1. Purpose and general description of project activity

1. Purpose of the project activity and the measures taken to reduce greenhouse gas emissions

Hubei Eco-Farming Biogas Project Phase I located in Enshi Prefecture, a mountainous poor area of Hubei Province. The purpose of this project is to demonstrate innovative technical approaches and a credible carbon trade process for a household-based Clean Development Mechanism (CDM) biogas digester program.

The project activity is a bundle of 33,000 household-level activities, which recover methane from biogas digesters with pig manure as fermentation material and utilize the generated biogas to displace fossil fuel for cooking and heating. In addition, the recovery and utilization of biogas from digested slurry in a biogas digester reduced CH₄ emission from the manure that would otherwise have been stored in a deep pit.

2. Brief description of the installed technology and equipment

The technology employed by the project activity includes installing “one biogas digester with 3 supplementary renovations” for 33,000 households in Enshi Prefecture, Hubei Province. More specifically, the project installed 10082 biogas digesters with reactor size of 8 m³; 14181 biogas digesters with reactor size of 10 m³; 4167 biogas digesters with reactor size of 12 m³; and 4,570 biogas digesters with reactor size of 15 m³.

3. Relevant dates for the project activity (e.g. construction, commissioning, continued operation periods, etc.)

The project installed 33,000 household biogas digesters during 2007 and 2008, and the installation completed before July 2008. Biogas digesters were commissioned after construction and initial check. All biogas digesters began to generate biogas for daily cooking and heating water before September, 2008. The certified emission reduction (CERs) for first monitoring (19/02/2009 – 31/08/2009) were issued in 11/05/2011. The certified emission reduction (CERs) for second monitoring period (01/09/2009 – 31/12/2010) were issued in 08/03/2013. The certified emission reduction (CERs) for third monitoring period (01/01/2011 – 31/12/2011) were issued in 22/08/2013.

4. Total emission reductions achieved in this monitoring period.

This monitoring report is for the fourth monitoring period, which is from and including 01/01/2012 to 31/12/2012. Total emission reductions achieved in this monitoring period are 55,106 tCO₂e.

A.2. Location of project activity

The location of the project is in eight counties including Enshi, Lichuan, Jianshi, Badong, Xuan'en, Xianfeng, Laifeng and Hefeng of Enshi Prefecture, a mountainous poor area of Hubei Province. The location of the activities is shown in Table A2.

Table A2: Location of project counties

County/City	County/City capital Latitude	County/City capital Longitude	County/City longitude scope	County/City latitude scope
Enshi	+109.4750	+30.2703	+30.0667 - +30.6500	+109.0667 - +109.9667
Jianshi	+109.7222	+30.6033	+30.1000 - +30.9000	+109.5333 - +110.2000
Badong	+110.3450	+31.0439	+30.2167 - +31.4667	+110.0667 - +110.5333
Lichuan	+108.9317	+30.2981	+29.7000 - +30.6500	+108.3500 - +109.3000
Xuan'en	+109.4797	+29.9933	+29.5500 - +30.2000	+109.1833 - +109.9167
Xianfeng	+109.1519	+29.6964	+29.3167 - +30.0500	+108.6333 - +109.3333

Laifeng	+109.4028	+29.5097	+29.1000 - +29.6667	+109.0000 - +109.4500
Hefeng	+110.0156	+29.8878	+29.6333 - +30.2333	+109.7500 - +110.6333

A.3. Parties and project participant(s)

Party involved ((host) indicates a host Party)	Private and/or public entity(ies) project participants (as applicable)	Indicate if the Party involved wishes to be considered as project participant (Yes/No)
P.R.China	Hubei Qingjiang Zhongye Company Ltd.	No
Netherlands	The International Bank for Reconstruction and Development (IBRD) as trustee of Community Development Carbon Fund Netherlands' Ministry of Infrastructure and the Environment (IenM)	Yes
Japan	Daiwa Securities Capital Markets Co. Ltd.; FUJIFILM Corporation; Idemitsu Kosan Co., Ltd.; JX Nippon Oil & Energy Corporation; The Okinawa Electric Power Corporation, Incorporated	No
Belgium	Kingdom of Belgium - Walloon Region: Walloon Air and Climate Agency; Bruxelles Environnement – IBGE Walloon Region Ministry of the Environment	Yes
Canada	Ministry of Foreign Affairs and International Trade	Yes
Denmark	Aalborg Portland A/S; Danish Ministry of Climate and Energy/Danish Energy Agency; Dong Naturgas A/S; Maersk Olie og Gas AS; Nordjysk Elhandel A/S	Yes
Italy	Ministry for the Environment, Land and Sea	Yes
Luxembourg	Ministry of Sustainable Development and Infrastructure - Department of Environment	Yes
Norway	Stratkraft Carbon Invest AS; Statoil ASA	No

Spain	Endesa Generación S.A.; Kindom of Spain - Ministry of Environment and Rural and Marine Affairs & Ministry of Economy and Finance; EDP-Energias de Portugal, S.A.; Gas Natural SDG, S.A.; Hidroeléctrica del Cantábrico, S.A.	Yes
Sweden	Göteborg Energi AB	No
Switzerland	Schweizerische Rückversicherungsgesellschafts AG (Swiss RE)	No
Germany	BASF SE; KfW	No
Austria	Kommunalkredit Public Consulting GmbH	No
Finland	Ruukki Metals Oy	No

A.4. Reference of applied methodology

Approved methodologies Version 12 of AMS-I.C titled “Thermal energy for the user with or without electricity” and Version 01 of AMS-III.R titled “Methane recovery in agricultural activities at household/small farm level” were applied. These baseline methodologies can be downloaded from the Executive Board (EB) website: <http://cdm.unfccc.int/methodologies/PAMethodologies/approved.html>.

A.5. Crediting period of project activity

The choice of the crediting period is fixed crediting period. The starting date is 19/02/2009. The length of the crediting period is 10 years.

SECTION B. Implementation of project activity

B.1. Description of implemented registered project activity

The installation completed before July 2008. To ensure quality of installed biogas digesters up to the standards and its sustainable operation, all digesters were constructed by certified technicians according to the technical design as described in PDD. Township biogas Project Management Group made initial check, in which the biogas digester construction, biogas stove, biogas tube and the operation of each digester were checked for each individual household digester. An ID card for each participating household with all relevant information was established. Based on the initial check, the county Project Management Office (PMO) checked the operation status for all the project digesters and submitted the assessment reports as well as the ID cards data base to Prefecture PMO. Biogas digesters were commissioned after construction and initial check. All biogas digesters began to generate biogas for daily cooking and heating water before September, 2008. Table B1 summarized the constructed biogas digesters with different volume in different county in the CDM project.

Table B1: Summary of constructed biogas digesters with different volume in different counties in the CDM project

County /City	No. of biogas digesters with different digester volume				Total no. of biogas installed 2007-2008 in each county	Construction date	starting date of operation	Data sources
	8m ³	10m ³	12m ³	15m ³				
Enshi	1,918	2,412			4330	April, 2007 to May, 2008	June, 2007 to June, 2008	Name list of Enshi CDM

Jianshi	540	4,030			4570	May, 2007 to Aug., 2008	June, 2007 to Aug., 2008	project, provided by Enshi Prefecture PMO on 6, May 2013.
Badong	1,581	2,989			4570	Aug., 2007 to April, 2008	Sept., 2007 to May, 2008	
Lichuan	3,043	2,917			5960	May, 2007 to April, 2008	June, 2007 to May, 2008	
Xuan'en		1,833	1,167		3000	June, 2007 to July, 2008	July, 2007 to Aug., 2008	
Xianfeng				4,570	4570	June, 2007 to Aug., 2008	June, 2007 to Sept., 2008	
Laifeng	3,000				3000	June, 2007 to March, 2008	July, 2007 to April, 2008	
Hefeng			3,000		3000	May, 2007 to May, 2008	June, 2007 to June, 2008	
Total	10,082	14,181	4,167	4,570	33000			

To ensure the effective operation of biogas digesters established under the project, a four-tier technical supporting service system has been established. At prefecture level, biogas association and consulting agency was established by Enshi Autonomous Prefecture. Rural energy service center was established at county level. Township government established rural energy service branch; and village community set rural biogas service network. The four-tier service system was proven to work well in delivering timely and adequate services to farmers and monitoring the biogas digester operation. The reasons are as follow: First, the system could provide extensive network services since each level of the service system has been equipped with communication equipment, such as computer, internet and telephone, as well as the professional staff. The assigned engineers could provide the technical services according to farmers' needs. Second, the system could provide quick services in short notice. For instance, the requested biogas digester maintenance services could be provided within 2 days no matter how far the household is located. Third, the system would provide timely training services. The prefecture and county PMOs as well as township service branches have TVs, videos, and training materials, as well as technical staff. They could teach farmers biogas digester operation and maintenance related knowledge. Finally each village level service network stocks with special parts and fittings for biogas digester maintenance. One village service network is able to reach around 300 households. Farmers could easily purchase the needed parts and fittings and receive technical assistance. Besides the four-tier service system, the project also distributes Biogas Digester Operation Manual and relevant wall-hanging posters to farmers, which could remind the farmer of safety measures of operating biogas system, ensuring continuous effective operation of household biogas digesters in the crediting period.

During this monitoring period, there were not any events or situations that occurred which may impact the applicability of the methodology. There were 456 biogas digesters not operating due to temporary employment in urban area, digester breakdown etc.

B.2. Post registration changes

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

NA.

B.2.2. Corrections

NA.

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

NA .

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

NA.

B.2.5. Changes to start date of crediting period

NA.

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

NA.

SECTION C. Description of monitoring system**1. Monitoring methodology applied**

The monitoring methodology of version 12 of AMS I.C “Thermal energy for the user with or without electricity” and the monitoring methodology of version 1 of AMS III.R “Methane recovery in agricultural activities at household/small farm level” were applied.

Because an expected annual emission reduction is less than 5 tonnes of CO₂ a year per system (biogas digester), option (c) of version 12 of AMS I.C with version 1 of AMS III.R is applied. In the case of Hubei Biogas Project, the bundled project activity involves installation of 33,000 household biogas digesters, of the same type of technology across eight counties. Therefore, an identical monitoring plan with defined sampling requirements is applicable for this project. The sampling methodology was applied according to the monitoring requirements of the version 12 of AMS I.C, and version 1 of AMS III.R. The implementation of sampling plan was described in section D.3.

2. Data collection procedure**1) Recording the number of operating biogas digesters**

After the project start, project coordinator monitored the number of operational biogas installation and operation, and established a database containing all relative identification information of each household, such as name, address, date on installation and operation of biogas digester. In the same time, the quality of the biogas digester installed under the project would also be checked according to the project technical design. The readout records of the number of operating biogas digesters and list of biogas stove delivered by county energy bureau will be recorded for DOE review.

During this monitoring period, each month, the village service staff checked the operation of all the project digesters and recorded the numbers of not operating digesters. Technicians of township service station accompanied by village technicians visited all the households one time to check whether biogas digesters operating or not. It was conducted during 10 Dec., 2012 to 30, Dec., 2012¹. If the biogas digester was not operating, the project technical support panel would investigate the reasons. For the biogas digesters which were not operating, if it was not caused by total discharge of biogas residue², these biogas digesters were assumed to be not operating.

2) Estimation of annual operational hours of biogas digesters

Operational hours of biogas digesters was estimated based on the length of the period that the biogas digesters are not operating while they are discharged annually and restart. The length of the period that the biogas digesters are not operating will be collected by surveying a sample of 2,750 household participants. This sample size will ensure a precision at 95% confidence intervals (T-values). The files containing the estimation of annual operational hours of biogas digesters will be recorded for DOE review.

3) Swine population

Pig numbers which manure treated in biogas digester for the 2,750 randomly sampled households in each county were recorded monthly and reported to Enshi Energy Bureau. The average values of monitored data in each month were used as swine stock during monitoring period. Record pig number from 2,750 household participants. The sample size of 2,750 household ensures a precision needed to give a precision

¹ Notification for the investigation of operational biogas digesters during the fourth monitoring period. It was issued by Enshi PMO 5 Dec., 2012.

² Residue discharge means to remove the biogas residue from the digester. The digester will stop producing biogas.

at 95% confidence intervals (T-values).

4) Amount of pig manure VS generated and fed into the biogas digester

Amount of pig manure VS generated in individual household were calculated as the product of swine population of individual household multiplied by IPCC default VS values. All the manure generated was fed into biogas digesters directly. Therefore the amount of pig manure VS fed into the biogas digesters is same to what the pig manure VS generated.

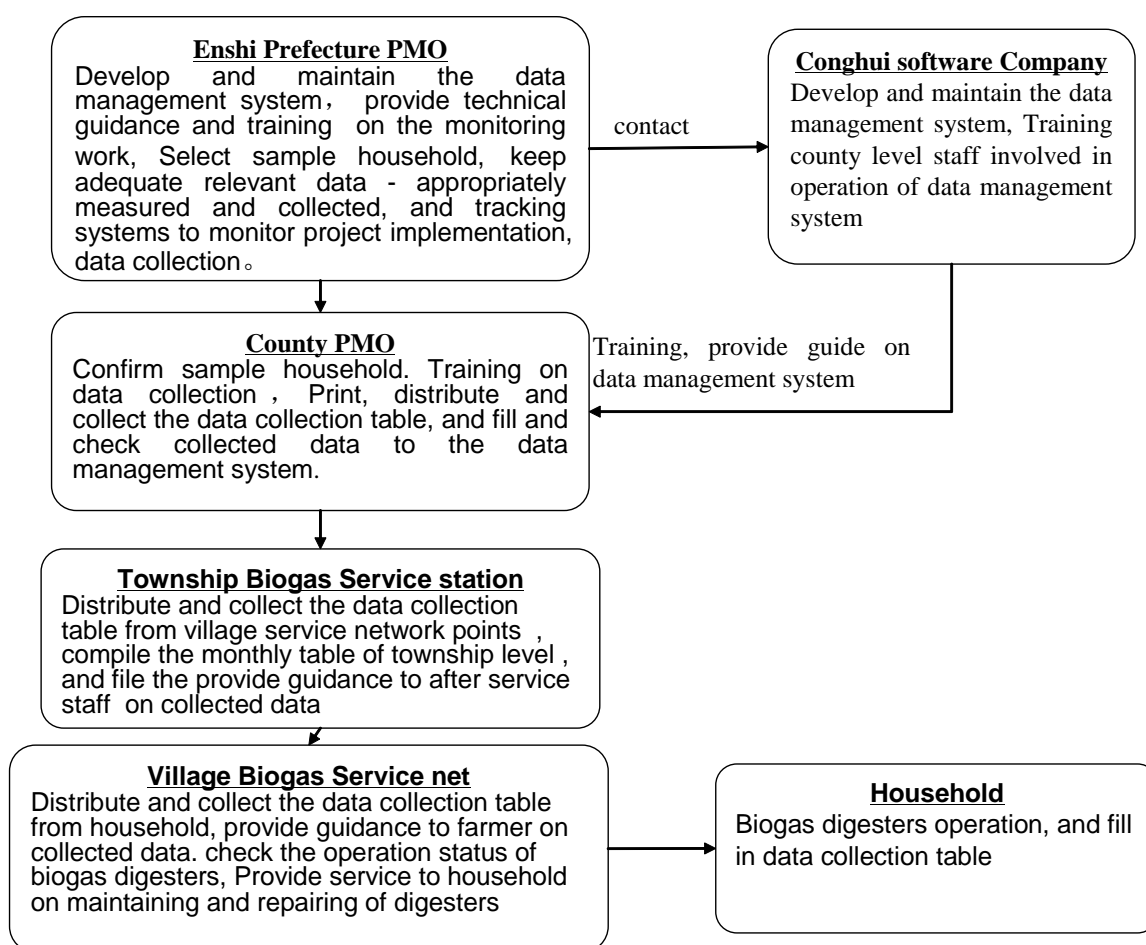
5) Application of biogas residue

The destination of biogas residue for the 2,750 randomly sampled households were recorded and reported to Enshi Energy Bureau.

6) Temperature

Annual average temperature data were brought from monitored by Enshi Meteorological Station.

2. Monitoring management and organizational structure



3. Quality control

(1) The quality control of biogas digesters installation process:

All biogas digesters were installed by certified technicians and required to pass the assessment of county level PMO. All biogas stoves were distributed to households after the equipment suppliers were selected through a public bidding process organized by the government.

(2) The quality control of monitoring data collection:

To ensure reliable field measurements and data collection quality, the following procedures were applied:

- Standard Monitoring Procedures and tables for field data collection were developed and adhered to throughout the monitoring period. According to the monitoring plan in PDD, Enshi Prefecture PMO calculated the sample size (see table D9) for each county based on the distribution of digester numbers and volume size, and then randomly selected the monitoring household as sample from the database which including the 33,000 household information. Enshi Prefecture PMO then informed county PMOs the selected monitoring households through Enshi energy documents No. ([2011]11)³, and provided standard data collection tables to the county PMO⁴.
- To improve the quality of data collection, training courses on field data collection and how to use software program for data analysis was organized in 19/12/2011⁵, more than 40 data collection staffs from county level and township level attended the training course. The training was carried out for village service staffs after the county-level course was completed⁶. Training courses ensured that each on-site staff fully understands and masters the whole monitoring procedure, as well as data collection process.
- To clearly define the responsibility of monitoring members at different levels, i.e. prefecture, county, township and village, through formal documents. New staffs have received adequate training. The training courses include project introduction, monitoring plan, monitoring process, and information on new staff responsibility.
- The village service staffs checked the digester operational status and examined whether data were properly filled in by the households for all project digesters in each month during the monitoring period⁷. The staffs of township biogas service station compiled the monthly table based on the data monitored by households⁸, and township level staff visited the monitoring household each month to check the data collected⁸. County PMO staffs collected the compiled the monthly table and then filed into the database. During data input process, one staff typed in the data in the system and another staff was required to cross check the input data to ensure data accuracy and consistency⁸. Enshi Energy Bureau, as project coordinator kept the monitoring data and records. Data was archived electronically at the end of each month. The electronic files were stored in hard disk and cd-rom. In addition, at the end of the monitoring period, a hard copy print-out of compiled results and relevant evidence was archived. Paper documents such as maps, diagrams, and environmental impact assessments were collected and documented in PMOs and Project Entity. All data records will be kept for a period of 2 years beyond the end of the crediting period.

SECTION D. Data and parameters

D.1. Data and parameters fixed ex ante or at renewal of crediting period

Data / Parameter:	MS_{ij}
Unit:	dimensionless
Description:	Fraction of manure handled in manure management system j in the baseline, in County i
Source of data:	Project proponents
Value(s) applied:	1.0

³ Notification of household list for the fourth monitoring period, provided by Enshi PMO, issued on 16 Dec., 2011.

⁴ Please see the document "Monitoring Manual" provided by Enshi Prefecture PMO, issued on 10 July, 2009.

⁵ Please see the documents "Notification of Prefectural Training Course on Household CDM Project" which was issued by Enshi Prefecture PMO on 16, Dec., 2011.

⁶ Evidence on training courses was provided by each county. Please see the documents "Evidence of training courses for the county and township levels" which was provided by Enshi Prefecture PMO on 6, May 2012.

⁷ Please see the document "Monitoring plan for Enshi Eco-farming household CDM project" which was provided by Enshi Prefecture PMO on 6, May 2012.

⁸ Please see the evidence documents contained in zipped file "Spot check on monitored monthly data" which provided by Enshi Prefecture PMO on 6, May 2012.

Purpose of data:	Data on Fraction of manure handled in system j in the baseline are used for baseline emission calculations.
Additional comment:	

Data / Parameter:	LF_{AD}
Unit:	%
Description:	Methane leakage from Anaerobic digester
Source of data:	2006 IPCC Guidelines
Value(s) applied:	10%
Purpose of data:	Methane leakage from anaerobic digester was applied in project emission calculation
Additional comment:	

Data / Parameter:	VS
Unit:	kg dry matter/animal/day
Description:	Volatile solid excretion
Source of data:	2006 IPCC Guidelines
Value(s) applied:	0.3
Purpose of data:	VS data was applied both in baseline and project emission calculation
Additional comment:	

Data / Parameter:	Bo
Unit:	m ³ CH ₄ /kg-dm VS
Description:	Maximum methane production
Source of data:	IPCC 2006 Guidelines
Value(s) applied:	0.29
Purpose of data:	Bo data was applied both in baseline and project emission calculation
Additional comment:	

Data / Parameter:	GWP_{CH_4}
Unit:	tCO ₂ e/tCH ₄
Description:	Global warming potential for CH ₄
Source of data:	IPCC
Value(s) applied:	21
Purpose of data:	GWP_{CH_4} of 21 was applied both in baseline and project emission calculation
Additional comment:	

Data / Parameter:	D_{CH_4}
Unit:	kg/m ³
Description:	Conversion factor of 1 m ³ CH ₄ to kilograms CH ₄
Source of data:	2006 IPCC Guidelines
Value(s) applied:	0.67
Purpose of data:	D_{CH_4} of 0.67 kg/ m ³ was applied both in baseline and project emission calculation
Additional comment:	

Data / Parameter:	$BG_{coal,i,k}$
Unit:	Kg/household/year
Description:	Average annual coal consumption for household before installation of biogas digesters with volume k, in country i.

Source of data:	Sample survey
Value(s) applied:	See Table B5 of registered PDD
Purpose of data:	Data of $BG_{coal,i,k}$ was applied in baseline emission calculation
Additional comment:	Data was collected as parts of baseline sample survey, sample size was 2,485 households with biogas digesters, 2,485 household is accounted about 7.5 percent of total number of project household.

Data / Parameter:	$PG_{coal,i,k}$
Unit:	Kg/household/year
Description:	Average annual coal consumption for household after installation of biogas digesters with volume k, in country i.
Source of data:	Sample survey
Value(s) applied:	See Table B7 of registered PDD
Purpose of data:	The data of $PG_{coal,i,k}$ was applied in project emission calculation
Additional comment:	Data was collected as parts of baseline sample survey, sample size was 2,485 households with biogas digesters, 2,485 household is accounted about 7.5 percent of total number of project household.

Data / Parameter:	NCV
Unit:	kJ/kg
Description:	Default net calorific values of cooking coal
Source of data:	Published data by NDRC of P.R.China (www.ccchina.gov.cn)
Value(s) applied:	20908
Purpose of data:	The data was applied both in baseline and project emission calculation
Additional comment:	

Data / Parameter:	Carbon EF
Unit:	tC/TJ
Description:	Carbon emission factor per unit of energy of coal that would have been used in the baseline in (tC/ TJ)
Source of data:	Published data by NDRC of P.R.China (www.ccchina.gov.cn)
Value(s) applied:	25.8
Purpose of data:	The data was applied both in baseline and project emission calculation
Additional comment:	

Data / Parameter:	Fraction oxidized
Unit:	
Description:	Fraction oxidized
Source of data:	Published data by NDRC of P.R.China (www.ccchina.gov.cn)
Value(s) applied:	1.00
Purpose of data:	The data was applied both in baseline and project emission calculation
Additional comment:	

Data / Parameter:	$EF_{Rawcoal}$
Unit:	t CO ₂ /t coal
Description:	Emission factor of raw coal
Source of data:	Calculated according to AMS I.C. The emission factor for raw coal (Carbon EF) is 25.8 tC/TJ. Net Calorific Value (NCV) of raw coal is 20908 kJ/kg. Fraction oxidized is 1. $EF_{Rawcoal} = \text{Carbon EF} \times \text{NCV} \times \text{Fraction oxidized} = 25.8 \times 20908 \times 1 \times 44/12/10^6 = 1.98 \text{ t CO}_2/\text{t coal}$.
Value(s) applied:	1.98

Purpose of data:	The data of $EF_{Rawcoal}$ was applied in project emission calculation
Additional comment:	
D.2. Data and parameters monitored	
Data / Parameter:	$ND_{i,k}$
Unit:	Number
Description:	Total number of operational biogas digester with volume k, in county i, during the monitoring period
Measured /Calculated /Default:	Calculated based on survey
Source of data:	Project proponents
Value(s) of monitored parameter:	See table D2 below
Monitoring equipment	NA
Measuring/ Reading/ Recording frequency:	Annually
Calculation method (if applicable):	In this monitoring period, number of operating biogas digesters with different volume in each county was calculated based on the difference between the total number of constructed biogas digesters within different volume and the number of biogas digesters that are not functional due to reasons other than biogas residue discharge.
QA/QC procedures applied:	<p>After the start of the project, project coordinator monitored the number of operational biogas installation and established a database containing all relative identification information of each household, such as name, address, date on installation and operation of biogas digester. In the same time, the quality of the biogas digester installed under the project was checked according to the project technical design. The readout records of the number of operating biogas digesters and list of biogas stove delivered by county energy bureau was recorded for DOE review.</p> <p>Each month, the village service staff checked the operation of all the project digesters and recorded the numbers of not operating digesters. Technicians of township service station accompanied by village technicians visited all the households one time to check whether biogas digesters operating or not. It was conducted during 10 Dec., 2012 to 30, Dec., 2012⁹. If the biogas digester was not operating, the project technical support panel would investigate the reasons. For the biogas digesters which were not operating, if it was not caused by total discharge of biogas residue⁹, these biogas digesters were assumed to be not operating.</p>
Purpose of data	The data was used for baseline, project emission calculations
Additional comment:	-
Data / Parameter:	$H_{i,k}$
Unit:	Hour
Description:	Operational hours of biogas digesters with different volume k, in County i during the monitoring period

⁹ Residue discharge means to remove the biogas residue from the digester. The digester will stop producing biogas.

Measured /Calculated /Default:	Calculated based on survey
Source of data:	Calculated Project proponents
Value(s) of monitored parameter:	See Table D4
Monitoring equipment	NA
Measuring/ Reading/ Recording frequency:	Annually
Calculation method (if applicable):	It was calculated based on survey. The average operational hours for biogas digesters with different volume in each county equate to total hours of the fourth monitoring period (365 days*24hours) minus the average hours that are not functional (Table D3*24 hours)of each biogas digester with different volume in that county due to residue discharge or other temporary repairing.
QA/QC procedures applied:	<p>Operational hours of biogas digesters was estimated based on the length of the period that the biogas digesters are not operating while biogas residue was discharged or other maintenance and repairing happens. The length of the period that the biogas digesters were not operating was collected by surveying 2,750 household participants. The sample size of household number will ensure a precision needed to give a precision at 95 % confidence intervals (T-values).</p> <p>A three-tier approach is applied to determine the length of non-operational period.</p> <p>First, the trained village service staff checked the digesters on site and examined whether operational status is properly recorded by households on monthly basis. During monthly site check, staff cross-checked the non-operational hours filed in the monthly form. In addition, they verified the digester status by turning on biogas stove. If there is no flare when lighting, it means no biogas flowing and the digester is not operating, and the non-operational hours will be recorded as the whole month if it is inconsistent with the recorded data. On second level, staff of township service station compiled the monthly table based on the recorded household data and visited the sampled household each month to check the filed data.</p> <p>Third, county PMO staff spot-checked sampled households during this monitoring period.</p>
Purpose of data	The data was used for baseline, project emission calculations
Additional comment:	

Data / Parameter:	T_i
Unit:	°C
Description:	Annual Average ambient temperature in county i weather station nearby project site
Measured /Calculated /Default:	Measured
Source of data:	County weather stations
Value(s) of monitored parameter:	See Table D5
Monitoring equipment	Mercury thermometer
Measuring/ Reading/ Recording frequency:	Monthly

Calculation method (if applicable):	Average the monthly mean temperature and get the average temperature during the fourth monitoring period.
QA/QC procedures applied:	Purchase from County meteorology stations. Archive electronically during project plus 5 years
Purpose of data	The data was used for baseline, project emission calculations
Additional comment:	
Data / Parameter:	$LN_{i,k}$
Data unit:	Number
Description:	Average swine stock population in household with biogas digester volume k, in County i.
Measured /Calculated /Default:	Calculated based on recorded data
Source of data:	Project proponents
Value(s) of monitored parameter:	See Table D6
Monitoring equipment (type, accuracy class, serial number, calibration frequency, date of last calibration, validity)	NA
Measuring/ Reading/ Recording frequency:	Monthly
Calculation method (if applicable):	Average swine population were calculated based on monthly monitored swine population of each county by volume biogas digester during the monitoring period.
QA/QC procedures applied:	Pig numbers of a number of 2,750 sampled project households across all eight county were recorded monthly. The average values of monitored data in each month were used as swine stock during monitoring period.. The sample size of 2,750 household ensures a precision needed to give a precision at 95% confidence intervals (T-values).
Additional comment:	
Data / Parameter:	$VS_{y,i,k}$
Unit:	kg dry matter/household/year
Description:	Annual pig manure VS generated and fed into biogas digesters with volume k. in county i. on a dry matter weight basis, in year y in project case.
Measured /Calculated /Default:	Calculated
Source of data:	Project proponents
Value(s) of monitored parameter:	See Table D7
Monitoring equipment	NA
Measuring/ Reading/ Recording frequency:	Monthly
Calculation method (if applicable):	According to description on “ amount of pig manure VS generated and fed into the biogas digesters “ in page 43 of registered PDD monitoring plan, “all manure generated will be fed into biogas digester directly, therefore the amount of pig manure VS fed into biogas digester is same

	to what the manure generated". Therefore, Annual pig manure VS generated and fed into biogas digesters in individual household was calculated as product of swine population ($LN_{i,k}$) in individual household in project case in table D6 times IPCC default VS values of 0.3 kg dry matter/animal/day, then times 365.
QA/QC procedures applied:	
Purpose of data	The data was used for baseline, project emission calculations
Additional comment:	

Data / Parameter:	Sludge
Unit:	---
Description:	Destination of biogas sludge application
Measured /Calculated /Default:	NA
Source of data:	Household
Value(s) of monitored parameter:	See Table D8
Monitoring equipment	NA
Measuring/ Reading/ Recording frequency:	Every application
Calculation method (if applicable):	NA
QA/QC procedures applied:	The destination of biogas residue in the sampled households was recorded monthly. All sludge from biogas digesters was applied to the arable land with aerobically conditions at appropriate time, thus no methane emission is generated from land application and the sludge nutrient was fully utilized. The biogas digesters would restart after all sludge was applied to land.
Purpose of data	The data was used for baseline, project emission calculations
Additional comment:	

Table D1: Number of not operating biogas digesters with different volume in different county during the fourth monitoring period.

	8 m ³	10 m ³	12 m ³	15 m ³	Total	Data Sources
Enshi	0	0			0	Survey result on operating of biogas digester, provided by Ehshi PMO on 6, May 2013.
Jianshi	0	0			0	Survey result on operating of biogas digester, provided by Ehshi PMO on 6, May 2013.
Badong	2	9			11	Survey result on operating of biogas digester, provided by Ehshi PMO on 6, May 2013.
Lichuan	19	16			35	Survey result on operating of biogas digester, provided by Ehshi PMO on 6, May 2013.
Xuan'en		43	27		70	Survey result on operating of biogas digester, provided by Ehshi PMO on 6, May 2013.
Xianfeng				288	288	Survey result on operating of biogas digester, provided by Ehshi PMO on 6, May 2013.
Laifeng	44				44	Survey result on operating of biogas digester, provided by Ehshi PMO on 6, May 2013.
Hefeng			8		8	Survey result on operating of biogas digester, provided by Ehshi PMO on 6, May 2013.
Total	65	68	35	288	456	

Table D2: Number of operating biogas digesters with different volume in different county during the fourth monitoring period*

County/City	No. of operating biogas digesters with different volume					Date sources
	8 m ³	10 m ³	12 m ³	15 m ³	Total	
Enshi	1918	2412				Survey result on operating of biogas digester, provided by Ehshi PMO on 6, May 2013.
Jianshi	540	4,030				Survey result on operating of biogas digester, provided by Ehshi PMO on 6, May 2013.
Badong	1,579	2,980				Survey result on operating of biogas digester, provided by Ehshi PMO on 6, May 2013.
Lichuan	3,024	2,901				Survey result on operating of biogas digester, provided by Ehshi PMO on 6, May 2013.
Xuan'en		1,790	1,140			Survey result on operating of biogas digester, provided by Ehshi PMO on 6, May 2013.
Xianfeng				4,282		Survey result on operating of biogas digester, provided by Ehshi PMO on 6, May 2013.
Laifeng	2956					Survey result on operating of biogas digester, provided by Ehshi PMO on 6, May 2013.
Hefeng			2992			Survey result on operating of biogas digester, provided by Ehshi PMO on 6, May 2013.
Total	10017	14113	4132	4282	32544	

* In this monitoring period, number of operating biogas digesters with different volume in each county was calculated based on the difference between the total number of constructed biogas digesters within different volume and the number of biogas digesters that are not functional due to reasons other than biogas residue discharge (Table B1-Table D1).

Table D3: Non-operational days during the fourth monitoring period of operational biogas digesters*

County name	8 m ³ (days)	10 m ³ (days)	12 m ³ (days)	15 m ³ (days)	Data Source
Enshi	0.54	0.92			Survey result on operating of biogas digester, provided by Ehshi PMO on 6, May 2013.
Jianshi	0.26	0.39			Survey result on operating of biogas digester, provided by Ehshi PMO on 6, May 2013.
Badong	0.15	0.23			Survey result on operating of biogas digester, provided by Ehshi PMO on 6, May 2013.
Lichuan	0.16	0.17			Survey result on operating of biogas digester, provided by Ehshi PMO on 6, May 2013.
Xuan'en		1.40	1.66		Survey result on operating of biogas digester, provided by Ehshi PMO on 6, May 2013.
Xianfeng				0.39	Survey result on operating of biogas digester, provided by Ehshi PMO on 6, May 2013.
Laifeng	0				Survey result on operating of biogas digester, provided by Ehshi PMO on 6, May 2013.
Hefeng			0.21		Survey result on operating of biogas digester, provided by Ehshi PMO on 6, May 2013.

* The non-operational days for biogas digesters with different volume in each county equate to total non-operational days, due to residue discharge or other temporary repair, of all the monitored biogas digesters under each volume divided by the total number of monitored and operational biogas digester with the same volume.

Table D4: Operational hours during the fourth monitoring period*

County name	8 m ³ (Hour)	10 m ³ (Hour)	12 m ³ (Hour)	15 m ³ (Hour)
-------------	----------------------------	-----------------------------	-----------------------------	-----------------------------

Enshi	8747.04	8737.92		
Jianshi	8753.76	8750.64		
Badong	8756.4	8754.48		
Lichuan	8755.92	8755.92		
Xuan'en		8726.4	8720.16	
Xianfeng				8750.64
Laifeng	8738.88			
Hefeng			8754.96	

* The operational hours for biogas digesters with different volume in each county equate to total hours of the fourth monitoring period (365 days*24hours) minus the average hours that are not functional (Table D3*24 hours) of each biogas digester with different volume in that county due to residue discharge or other temporary repair.

Table D5: Average temperature in different counties during the fourth monitoring period

County	Enshi	Jianshi	Badong	Lichuan	Xuan'en	Xianfeng	Laifeng	Hefeng
(°C)	16.0	15.2	16.7	12.6	15.3	13.5	15.3	15.1
Data sources on Monthly average temperature of each county/city								
Organization of the evidence provision	Meteoro-logical Station of Enshi	Meteoro-logical Station of Jianshi	Meteoro-logical Station of Badong	Meteoro-logical Station of Lichuan	Meteoro-logical Station of Xuan'en	Meteoro-logical Station of Xianfeng	Meteoro-logical Station of Laifeng	Meteoro-logical Station of Hefeng
Date of the provision	20/02/2013	30/01/2013	21/02/2013	23/02/2013	20/01/2013	10/01/2013	20/01/2013	17/01/2013

Table D6: Average annual swine stock during the fourth monitoring period

County name	8 m ³ (Head)	10 m ³ (Head)	12 m ³ (Head)	15 m ³ (Head)	Data Source
Enshi	4.18	4.07			Survey result on operating of biogas digester, provided by Ehshi PMO on 6, May 2013.
Jianshi	3.7	4.69			Survey result on operating of biogas digester, provided by Ehshi PMO on 6, May 2013.
Badong	4.51	4.48			Survey result on operating of biogas digester, provided by Ehshi PMO on 6, May 2013.
Lichuan	4.1	4.08			Survey result on operating of biogas digester, provided by Ehshi PMO on 6, May 2013.
Xuan'en		4.14	4.13		Survey result on operating of biogas digester, provided by Ehshi PMO on 6, May 2013.
Xianfeng				3.78	Survey result on operating of biogas digester, provided by Ehshi PMO on 6, May 2013.
Laifeng	4.76				Survey result on operating of biogas digester, provided by Ehshi PMO on 6, May 2013.
Hefeng			4.05		Survey result on operating of biogas digester, provided by Ehshi PMO on 6, May 2013.

Table D7: Annual pig manure VS generated and fed into biogas digesters in individual household in project case*

County name	8 m ³ kg dry matter/day/head	10 m ³ kg dry matter/day/head	12 m ³ kg dry matter/day/head	15 m ³ kg dry matter/day/head
Enshi	457.71	445.665		
Jianshi	405.15	513.555		
Badong	493.845	490.56		
Lichuan	448.95	446.76		
Xuan'en		453.33	452.235	
Xianfeng				413.91
Laifeng	521.22			
Hefeng			443.475	

* Annual pig manure VS generated and fed into biogas digesters in individual household is

calculated as the average annual swine stock during the fourth monitoring period (in Table D6) times 0.3 , which is the IPCC VS defaults value provided by 2006 IPCC guideline, , then time 365 days/year..

Table D8: Average application number and its destination of sludge during the fourth monitoring period

County name	Dry land (time)				Vegetable field (time)				Paddy field (time)				Data Source
	8 m ³	10 m ³	12 m ³	15 m ³	8 m ³	10 m ³	12 m ³	15 m ³	8 m ³	10 m ³	12 m ³	15 m ³	
Enshi	5.4	5.4			6.4	6.1			0	0			Survey result on operating of biogas digester, provided by Ehshi PMO on 6, May 2013.
Jianshi	12.2	6.7			0.0	5.4			0	0			Survey result on operating of biogas digester, provided by Ehshi PMO on 6, May 2013.
Badong	4.5	4.6			6.0	6.3			0	0			Survey result on operating of biogas digester, provided by Ehshi PMO on 6, May 2013.
Lichuan	6.9	6.7			9.0	8.2			0	0			Survey result on operating of biogas digester, provided by Ehshi PMO on 6, May 2013.
Xuan'en		3.7	4.0			4.7	4.7			0	0		Survey result on operating of biogas digester, provided by Ehshi PMO on 6, May 2013.
Xianfeng				5.4				3.9				0	Survey result on operating of biogas digester, provided by Ehshi PMO on 6, May 2013.
Laifeng	4.7				7.1				0				Survey result on operating of biogas digester, provided by Ehshi PMO on 6, May 2013.
Hefeng			4.8				5.1				0		Survey result on operating of biogas digester, provided by Ehshi PMO on 6, May 2013.

D.3. Implementation of sampling plan

(a) Description of implemented sampling design;

As per the registered PDD, the total sampled householders for the 3rd monitoring period is 2750. The sampling method for annual household monitoring includes following steps:

Step 1: Select 2750 participant households randomly in the database of 33,000 participant households. The number of sampling households needed for monitoring was first calculated proportionally as per total number of biogas digesters in each volume size category. 841 households with 8m³, 1182 households with 10m³, 347 households with 12m³, 380 households with 15m³, respectively, were required for monitoring across 8 counties.

Step 2: According to required numbers of households with different volumes in each county, the database system automatically selected households with different volume for each county on a random basis and the coordination entity will distribute the sample name lists to local energy offices in each county. The distribution of the total number of 2750 sampled households is listed in table D9.

Table D9: Sampling number of households with different biogas digester volume in each county

County/City	No. of households monitored with different digesters' volume				No. of biogas digesters monitored in each county	Data sources
	8 m ³	10 m ³	12 m ³	15 m ³		
Enshi	160	200			360	Notification of name list of monitored household during fourth monitoring period, provided by Enshi Prefectural PMO. The document was issued on 16 Dec. 2011.
Jianshi	46	334			380	
Badong	130	250			380	
Lichuan	255	245			500	

Xuan'en		153	97		250	
Xianfeng				380	380	
Laifeng	250				250	
Hefeng			250		250	
Total					2750	

(b) Data collection and record of sampled households

Step 1: After the randomly selection of monitoring household for this monitoring period (in Dec., 2011, the monitoring form was distributed to each of the sampled households, no later than 10 Jan., 2012. The households record the swine population on 15th of every month, residue land application on the day of residue application occurrence, beginning and restart date of biogas digester if maintenance and residue removal occurrence, and the duration of un-operation of the biogas digester.

Step 2: The technician in township visits each of the monitoring household at the end of each month further check the consistence of records filled by the households;

Step 3: The technician in the county will select 1-2 villages and 10-15 household to check the monitored results. Country PMO staff filed all the recorded into the database. The electronic spread sheets of each county was provided to DOE for review;

(c) Analysis of the collected data

After the analysis of the monitored data, the sample size of household number can meet the precision requirement at 95% confidence intervals. It is in line with the procedure in "Standard for sampling and surveys for CDM project activities and programme of activities "(version 03.0). The electronic spread sheets of the analysis were provided to DOE.

(d) Demonstration on whether the required confidence/precision has been met:

According to the analysis of monitored data, precisions for monitored parameters for different BD volume in all counties were higher than 95%, met the requirement of "Standard for sampling and surveys for CDM project activities and programme of activities "(version 03.0) (see table D10).

Table D10: Precision for monitored parameters under confidence level of 95%

Location	Volume of BD	Precision of operational days	Precision of swine population											
			Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Enshi	8m3	96.9%	96.4%	96.4%	96.3%	96.5%	96.7%	96.7%	96.4%	96.4%	96.3%	96.5%	96.3%	96.6%
	10m3	97.8%	97.0%	97.1%	96.9%	96.8%	96.6%	96.6%	96.6%	96.9%	96.9%	97.1%	96.8%	96.7%
Jianshi	8m3	100.0%	96.8%	96.8%	95.9%	95.5%	95.3%	96.0%	96.0%	96.0%	96.0%	98.5%	98.5%	98.5%
	10m3	95.7%	98.1%	98.1%	98.1%	98.0%	98.0%	98.0%	97.9%	97.8%	97.8%	97.6%	97.5%	97.8%
Badong	8m3	97.4%	97.3%	97.7%	96.4%	96.8%	96.8%	97.2%	97.2%	97.2%	96.0%	96.1%	96.6%	95.2%
	10m3	95.5%	98.2%	98.2%	97.3%	97.6%	97.6%	97.8%	97.6%	97.6%	97.1%	97.2%	97.7%	97.8%
Lichuan	8m3	96.5%	96.9%	97.2%	97.3%	97.2%	97.1%	97.4%	97.3%	97.5%	97.3%	97.2%	97.3%	97.0%
	10m3	95.4%	96.7%	97.0%	97.2%	97.3%	97.2%	97.4%	97.6%	97.3%	97.2%	97.4%	97.4%	96.8%
Xuan'en	10m3	97.5%	96.6%	96.2%	96.4%	96.2%	95.9%	96.0%	96.1%	96.2%	95.9%	95.9%	96.5%	96.3%
	12m3	97.6%	95.6%	95.1%	96.0%	95.8%	96.0%	95.8%	96.0%	96.0%	95.1%	95.5%	96.2%	95.8%
Xianfeng	15m3	97.5%	98.1%	98.2%	98.2%	98.1%	98.1%	98.2%	98.2%	98.3%	98.3%	98.3%	98.1%	98.2%
Laifeng	8m3	95.2%	96.8%	96.8%	96.7%	96.8%	96.9%	96.9%	96.7%	96.8%	97.2%	97.0%	97.4%	97.3%
Hefeng	12m3	97.0%	97.0%	97.0%	97.0%	97.0%	97.0%	97.0%	97.1%	97.0%	97.0%	97.1%	97.0%	97.0%

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

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

The calculation spread sheet on baseline emission are included in excel file named as “Hubei Household biogas CDM-ER calculation-fourth monitoring period”. Baseline emissions are estimated as follows:

1. Methane emission factor

Methane emission factor for deep pit manure management system is calculated according to IPCC Tier 2 approach (formula (1)). Default 2006 IPCC values for Bo and VS were applied because there are no national specific values.

$$EF_i = (VS \times 365) \times [Bo \times 0.67 \times \sum_j \frac{MCF_{ij}}{100} \times MS_{ij}] \quad (1)$$

Where,

EF_i	Methane emission factor for deep pit manure management system in base line condition in county i , kg CH ₄ /year/head
365	Number of days in one year, days/year
0.67	Conversion factor of 1 m ³ CH ₄ to kilograms CH ₄ , kg/m ³
VS	Volatile solid excretion per day per animal on a dry matter basis for a defined swine population. kg-dm/head/day
Bo	Maximum methane producing capacity for manure produced by swine , m ³ CH ₄ /kg-dm VS
MCF_{ij}	Methane conversion factor for manure management system j, in county i. %
MS_{ij}	Fraction of swine manure handled using manure management system j, in county i., dimensionless.

According to the average temperature during the monitoring period, the MCF_{ij} for each county is listed in table E1.

Table E1: MCF_{ij} and EF_i in each county according to 2006 IPCC Guidelines

County	Enshi	Jianshi	Badong	Lichuan	Xuan'en	Xianfeng	Laifeng	Hefeng
Average T (°C)	16.0	15.2	16.7	12.6	15.3	13.5	15.3	15.1
$MCF_{ij}/100$	0.29	0.27	0.29	0.2	0.27	0.22	0.27	0.27
EF_i (kg CH ₄ /year/head)	6.170	5.744	6.170	4.255	5.744	4.681	5.744	5.744

2. Emission factor of coal combustion

According to the baseline methodology for small-scale CDM project activity categories I.C titled “Thermal energy for the user with or without electricity” for renewable energy technologies that displace technologies using fossil fuels, the simplified baseline is the fuel consumption of the technologies that would have been used in the absence of the project activity times an emission coefficient for the displaced fossil fuel. In this project, national specific emission factor provided by National Development and Reform Committee (NDRC) will be adopted (www.ccchina.gov.cn). The emission factor for raw coal is

25.8 tC/TJ. Net Calorific Value (kJ/kg) of raw coal is 20908 kJ/kg. Fraction oxidized is 1.
 $EF_{\text{Rawcoal}} = 25.8 \times 20908 \times 1 \times 44/12/10^6 = 1.98 \text{ t CO}_2/\text{t coal}$.

Table E2: IPCC default values and other reference values used in the calculation of emission factors

Parameters	Data variable	Data source	unit	Value
VS	Volatile solid excretion per day per animal on a dry matter basis for a defined swine population.	Table 10A-7 and 10A-8, chapter 10, volume 4, IPCC 2006 Guidelines	kg-dm/head/day	0.3
Bo	Maximum methane producing capacity for manure produced by swine	2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 4, and Chapter 10	$\text{m}^3 \text{CH}_4 \text{ kg}^{-1}$ of VS excreted	0.29
$MCF_{ij}/100$	Methane conversion factor for manure management system j, in county i. in this project, baseline manure management is deep pit manure management system	IPCC 2006 Guidelines Table 10A-7, chapter 10, volume 4, according to the average T in each county	Fraction	Table E1 above
MS_{ij}	Fraction of swine manure handled using manure management system j, in county i. In this project, 100 percent of manure is stored in deep pit	Project participants	Dimensionless	1.0
NCV	Default net calorific values of cooking coal	Published data by NDRC of P.R.China (www.ccchina.gov.cn)	kJ/kg	20908
Carbon EF	Carbon emission factor per unit of energy of coal that would have been used in the baseline	Published data by NDRC of P.R. China (www.ccchina.gov.cn)	tC/ TJ	25.8

3. Baseline emission

1) CH_4 emission from manure management per household

$$BE_{\text{CH}_4, i, k} = GWP_{\text{CH}_4} \times \frac{1}{1000} \times LN_{i, k} \times EF_i \quad (2)$$

Where,

$BE_{\text{CH}_4, i, k}$	CH_4 emission from manure management per household, t CO_2 e/household/year
GWP_{CH_4}	Global warming potential for CH_4 , t CO_2 e/t CH_4
$LN_{i, k}$	Average swine stock population in household with biogas digester volume k, in County i, number
EF_i	Methane emission factor for deep pit manure management system in base line condition in county i, kg CH_4 /year/head

Table E3: Baseline CH_4 emission during the fourth monitoring period (t CO_2 e/household/year)

County	Enshi	Jianshi	Badong	Lichuan	Xuanen	Xianfeng	Laifeng	Hefeng
8 m^3	0.54	0.45	0.58	0.37			0.57	
10 m^3	0.53	0.57	0.58	0.36	0.50			
12 m^3					0.50			0.49

15 m ³						0.37		
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Note: the calculation does not deduct the baseline CH₄ emissions during the un-operational days.

2) CO₂ emission from coal consumption

$$BE_{CO_2,i,k} = BG_{Coal,i,k} \times EF_{Rawcoal} \quad (3)$$

Where,

$BE_{CO_2,i,k}$ CO₂ emission from coal consumption per household in baseline condition, t CO₂ e/household/year

$BG_{Coal,i,k}$ Average annual coal consumption for household before the installation of digester with volume k, in county i, tcoal/household/year

$EF_{Rawcoal}$ Emission factor of raw coal, t CO₂/t coal

Table E4: Baseline CO₂ emission from coal burning during the fourth monitoring period (tCO₂ e/household/year)

County	Enshi	Jianshi	Badong	Lichuan	Xuanen	Xianfeng	Laifeng	Hefeng
8 m ³	2.80	2.89	2.75	2.88			2.57	
10 m ³	2.86	2.97	2.65	2.95	2.88			
12 m ³					2.98			3.32
15 m ³						3.15		

Note: the calculation does not deduct the baseline CO₂ emissions from coal burning during the un-operational days.

3) Baseline GHG emission calculation per household

$$BE_{y,i,k} = BE_{CH_4,i,k} + BE_{CO_2,i,k} \quad (4)$$

Where,

$BE_{y,i,k}$ Baseline GHG emission per household, t CO₂ e/household/year

$BE_{CH_4,i,k}$ CH₄ emission from manure management per household, t CO₂ e/household/year

$BE_{CO_2,i,k}$ CO₂ emission from coal consumption per household, t CO₂ e/household/year

Table E5: Total GHG emission under baseline activity during the fourth monitoring period (tCO₂ e/household/year)

County	Enshi	Jianshi	Badong	Lichuan	Xuanen	Xianfeng	Laifeng	Hefeng
8 m ³	3.35	3.34	3.33	3.24			3.14	
10 m ³	3.38	3.53	3.23	3.32	3.38			
12 m ³					3.48			3.81
15 m ³						3.52		

Note: Table E5= Table E3 +Table E4

4) Total baseline GHG emission during monitoring period

$$BE_y = \sum_i \left(\sum_{k=1} (ND_{i,k} * BE_{y,i,k}) \right) \quad (5)$$

Where,

BE_y Total baseline GHG emission during monitoring period, t CO₂ e/year

$ND_{i,k}$ Total number of operational biogas digester with volume k, in county i, number

$BE_{y,i,k}$ Baseline GHG emission per household, t CO₂ e/household/year

Table E6: Total baseline emission during the fourth monitoring period (t CO₂ e/year)

County	Enshi	Jianshi	Badong	Lichuan	Xuanen	Xianfeng	Laifeng	Hefeng	Total
8 m ³	6416	1802	5259	9808			9283		32568
10 m ³	8159	14233	9619	9628	6058				47696
12 m ³					3963			11385	15348
15 m ³						15063			15063
Total	14575	16035	14878	19435	10021	15063	9283	11385	110675

Note: the calculation does not deduct the baseline emissions during the un-operational days.

Considering there were some biogas digesters did not work in some time due to the biogas residual removal during the monitoring period, the actual baseline emissions is adjusted for the un-operational days, that is, deduct the emission during the un-operational days.

$$BE_{actualy} = BE_y * H_{i,k} \div 8760 = \sum_i \left(\sum_{k=1} (ND_{i,k} * BE_{y,i,k} * H_{i,k} \div 8760) \right) \quad (6)$$

Where,

$BE_{actualy}$ Actual baseline emission during monitoring period, t CO₂ e

$H_{i,k}$ Operational hours of biogas digesters with different volume k, in County i during the monitoring period, hour

8760 Total hours in the third crediting period (=365 days*24 hours/day), hours

Table E7: Actual total baseline emission during the fourth monitoring period(t CO₂ e)

County	Enshi	Jianshi	Badong	Lichuan	Xuanen	Xianfeng	Laifeng	Hefeng	Total
8 m ³	6406	1800	5256	9803			9260		32525
10 m ³	8138	14218	9612	9623	6034				47625
12 m ³					3944			11378	15322

15 m ³						15047			15047
Total	14544	16018	14868	19426	9978	15047	9260	11378	110519

Table E8: Parameters, value and data source for calculating baseline GHG emissions

Parameters	Data variable	Data source	unit	Value
GWP_{CH_4}	Global warming potential for CH ₄	IPCC	tCO ₂ e/tCH ₄	21
$LN_{i,k}$	Average swine stock population in household with biogas digester volume k, in County i.	Survey	Number	see table D6 above
EF_i	CH ₄ emission factor for deep pit swine manure management in county i	Calculated using equation (1)	kg CH ₄ /swine/year	see Table E1 above
$BG_{Coal,i,k}$	Average annual coal consumption for household before the installation of digester with volume k, in county i, t coal of each household	Baseline survey	tcoal/household/year	see PDD
$EF_{Rawcoal}$	Emission factor of raw coal	INDRC	t CO ₂ /t coal	1.98
$ND_{i,k}$	Total number of operational biogas digester with volume k, in county i, during the monitoring period	Monitoring results	Number	See table D2 above
$H_{i,k}$	Operational hours of biogas digesters with different volume k, in County i during the monitoring period	Monitoring results	hour	see table D4 above

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

The calculation of project emissions is included in excel file named as Hubei Household biogas CDM-ER calculation - fourth monitoring period.

Project emissions are calculated as follows:

1) CH₄ emission from physical leakages of anaerobic digesters

According to AMS III.R and the registered PDD, annual leakage emission from anaerobic digester in county i, volume k, is calculated using equation (6):

$$PE_{ly} = LF_{AD} \left[GWP_{CH_4} \times D_{CH_4} \times B_o \times VS_{y,i,k} \right] / 1000 \quad (7)$$

Where,

PE_{ly}	Project emissions from physical leakages in the biogas digesters with volume k, per household, in county I, in year y, t CO ₂ e/household/year
LF_{AD}	0.10
GWP_{CH_4}	Global Warming Potential of CH ₄ , 21 tCO ₂ e/tCH ₄
B_o	Maximum methane producing potential of the swine manure treated in the biogas digesters
D_{CH_4}	Conversion factor of m ³ CH ₄ to kilograms CH ₄ , 0.67 kg/m ³
$VS_{y,i,k}$	Annual amount of volatile solid treated in /fed into the biogas digesters with volume k, in county i, on a dry matter weight basis, in year y, kg dry matter/household/year As description on “ amount of pig manure VS generated and fed into the biogas digesters “ in page 43 of registered PDD monitoring plan, “all manure generated will be fed into biogas

digester directly, therefore the amount of pig manure VS fed into biogas digester is same to what the manure generated”.

$$VS_{y,i,k} = 365 \times LN_{i,k} \times VS \quad (8)$$

Where,

$LN_{i,k}$ Average swine stock population in household with biogas digester volume k, in County i, number
 365 Number of days in one year, day/year
 VS Volatile solid excretion per day per animal on a dry matter basis for a defined swine population. kg-dm/head/day

Table E9: CH₄ emission from leakage under project activity during the fourth monitoring period (t CO₂ e/household/year)

County	Enshi	Jianshi	Badong	Lichuan	Xuanen	Xianfeng	Laifeng	Hefeng
8 m ³	0.19	0.17	0.20	0.18			0.21	
10 m ³	0.18	0.21	0.20	0.18	0.18			
12 m ³					0.18			0.18
15 m ³						0.17		

Note: the calculation does not deduct the CH₄ emission of physical leakage during the un-operational days.

2) Project CO₂ emission from coal combustion

$$PE_{CO_2,i,k} = PG_{Coal,i,k} \times EF_{Rawcoal} \quad (9)$$

Where,

$PE_{CO_2,i,k}$ CO₂ emission from coal consumption per household in project condition, t CO₂ e/household/year
 $PG_{Coal,i,k}$ Average annual coal consumption for household after the installation of digester with volume k, in county i, t coal/household/year
 $EF_{Rawcoal}$ Emission factor of raw coal, t CO₂/t coal

Table E10: CO₂ emission from coal burning under project activity during the fourth monitoring period (t CO₂ e/household/year)

County	Enshi	Jianshi	Badong	Lichuan	Xuanen	Xianfeng	Laifeng	Hefeng
8 m ³	1.60	1.64	1.44	1.67			1.21	
10 m ³	1.41	1.55	1.22	1.53	1.52			
12 m ³					1.47			1.83
15 m ³						1.61		

Note: the calculation does not deduct the CO₂ emissions from coal burning during the un-operational days.

3) Project GHG emission calculation

$$PE_{y,i,k} = PE_{CO_2,i,k} + PE_{ly} \quad (10)$$

Where,

$PE_{y,i,k}$ Project GHG emission per household, t CO₂ e/household/year

PE_{ly} Project emissions from physical leakages in the biogas digesters per household in year y, t CO₂e/household/year

$PE_{CO_2,i,k}$ CO₂ emission from coal consumption per household in project condition, t CO₂ e/household/year

Table E11: Project emission from under project activities during the fourth monitoring period (t CO₂ e/household/year)

County	Enshi	Jianshi	Badong	Lichuan	Xuanen	Xianfeng	Laifeng	Hefeng
8 m ³	1.79	1.80	1.64	1.85			1.42	
10 m ³	1.59	1.76	1.42	1.71	1.71			
12 m ³					1.65			2.01
15 m ³						1.77		

Note: Table E11= Table E9 +Table E10

4) Total project GHG emission

$$PE_y = \sum_i \left(\sum_{k=1} (ND_{i,k} * PE_{y,i,k}) \right) \quad (11)$$

Where,

PE_y Total project GHG emission during monitoring period, t CO₂ e/year

$ND_{i,k}$ Total number of operational biogas digester with volume k, in county i, number

$PE_{y,i,k}$ Project GHG emission calculation per household, t CO₂ e/household/year

Table E12: Total emission under project activity during the fourth monitoring period(t CO₂ e)

County	Enshi	Jianshi	Badong	Lichuan	Xuanen	Xianfeng	Laifeng	Hefeng	Total
8 m ³	3430	973	2594	5601			4199		16799
10 m ³	3829	7108	4219	4957	3060				23175
12 m ³					1881			6027	7908
15 m ³						7599			7599
Total	7260	8082	6814	10559	4941	7599	4199	6027	55480

Note: the calculation does not deduct the project emissions during the un-operational days.

Considering there were some biogas digesters did not work due to the biogas residual removal during the monitoring period, the actual project emissions is adjusted for the un-operational days, that is, deduct the

project emission during the un-operational days.

$$PE_{actualY} = PE_Y * H_{i,k} \div 8760 = \sum_i (\sum_{k=1} (ND_{i,k} * PE_{y,i,k} * H_{i,k} \div 8760)) \quad (12)$$

Where,

$PE_{actualY}$ Actual project emission during the monitor period , t CO₂ e

$H_{i,k}$ Operational hours of biogas digesters with different volume k, in County i during the monitoring period, hour

8760 Total hours in the third crediting period (=365 days*24 hours/day), hours

Table E13: Actual total emission under project activity during the fourth monitoring period(t CO₂ e)

County	Enshi	Jianshi	Badong	Lichuan	Xuanen	Xianfeng	Laifeng	Hefeng	Total
8 m ³	3426	973	2594	5599			4189		16781
10 m ³	3820	7101	4217	4956	3049				23143
12 m ³					1873			6024	7897
15 m ³						7592			7592
Total	7246	8074	6811	10555	4922	7592	4189	6024	55413

Table E14: Parameters, value and data source for calculating GHG emissions under project activity

Parameters	Data variable	Data source	unit	Value
LF_{AD}	Methane leakages from Anaerobic digesters	Table 10A-8 of 2006 IPCC Guidelines Volume 4, and Chapter 10.	%	10
D_{CH_4}	Conversion factor of m ³ CH ₄ to kilograms CH ₄	2006 IPCC guideline, See Volume 4, Chapter 10, Page 10.42	kg/m ³	0.67
Bo	Maximum methane producing capacity for manure produced by swine	2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 4, and Chapter 10	m ³ CH ₄ kg ⁻¹ of VS excreted	0.29
VS	Volatile solid excretion per day per animal on a dry matter basis for a defined swine population.	Table 10A-7 and 10A-8, chapter 10, volume 4, IPCC 2006 Guidelines	kg-dm/head/day	0.3
$PG_{coal,i,k}$	Average annual coal consumption of the household after installation of digester with volume k, in county i	Baseline survey	t coal of each household	See PDD
$EF_{Rawcoal}$	Emission factor of raw coal	Calculated according to AMS I.C.	t CO ₂ /t coal	1.98
$ND_{i,k}$	Numbers of operational digesters with volume k, in county i	Monitoring results	numbers	see table D2 above

$H_{i,k}$	Operational hours during the monitoring period with different volume k, in County i	Monitoring results	hour	see table D4 above
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E.3. Calculation of leakage

According to version 12 of AMS I.C and version 1 of AMS III.R, neither methane recovery and equipment used in the project activity is transferred from another activity, nor the existing equipment is transferred to another activity. Therefore, leakage emissions are not considered in the project activity.

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

Total project GHG emission reduction

$$ER_{actualy} = BE_{Actualy} - PE_{actualy} - Leakage \quad (13)$$

ER_y	Total project emission reduction during the monitor period , t CO ₂ e
$BE_{actualy}$	Actual baseline emission during the monitor period , t CO ₂ e
$PE_{actualy}$	Actual project emission during the monitor period , t CO ₂ e
Leakage	leakage emissions, in this project , leakage = 0

Table E 15. Summary of emission reductions during the monitoring period

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

Item	Baseline emissions or baseline net GHG removals by sinks (tCO ₂ e)	Project emissions or actual net GHG removals by sinks (tCO ₂ e)	Leakage (tCO ₂ e)	Emission reductions or net anthropogenic GHG removals by sinks (tCO ₂ e)
Total	110,519	55,413	0	55,106

estimates in registered PDD

Item	Values estimated in ex-ante calculation of registered PDD	Actual values achieved during this monitoring period
Emission reductions or GHG removals by sinks (t CO₂e)	58,444	55,106

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

According to the registered PDD, the expected emission reduction of the project was estimated to be 58,444 tCO₂e per year. During the monitoring period (01/01/2012-31/12/2012), the measured annual emission reduction was 55,106 tCO₂e which is 5.7% lower than the ex-ante calculated result. The main reason for this lower measured emission reduction is that some biogas digesters were not operational and swine population in Xuan'en and Xianfeng counties were less than expected.

E.7. Actual emission reductions or net anthropogenic GHG removals by sinks during the first commitment period and the period from 1 January 2013 onwards

	Item	Actual values achieved up to 31 December 2012	Actual values achieved from 1 January 2013 onwards	
	Emission reductions or GHG removals by sinks (t CO₂e)	55,106	-	

The duration of this monitoring period is from 01/01/2012 - 31/12/2012 (including the last day of this period) which does not cross end of 2012. Therefore, all emission reductions for this period belong in the first column.

Document information

Version	Date	Description
03.2	5 November 2013	Editorial revision to correct table in page 1.
03.1	2 January 2013	Editorial revision to correct table in section E.5.
03.0	3 December 2012	Revision required to introduce a provision on reporting actual emission reductions or net anthropogenic GHG removals by sinks for the period up to 31 December 2012 and the period from 1 January 2013 onwards (EB70, Annex 11).
02.0	13 March 2012	Revision required to ensure consistency with the "Guidelines for completing the monitoring report form" (EB 66, Annex 20).
01	28 May 2010	EB 54, Annex 34. Initial adoption.
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