THE CENTER FOR RURAL COMMUNITIES RESEARCH AND DEVELOPMENT

FINAL REPORT

BIOGAS VALUE CHAIN PHYSICAL AUDIT

(Package 24)

Submitted to:

LOW CARBON AGRICULTURE SUPPORT PROJECT

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ABBREVIATIONS

ADB	The Asian Development Bank
PMU	Project Management Unit
MARD	Ministry of Agriculture and Rural Development
BVC	Biogas Value Chain
CDM	Clean Development Mechanism
LBPs	Large Biogas Plants
LCASP	Low Carbon Agriculture Support Project
MBPs	Medium Biogas Plants
SBPs	Small Biogas Plants
DARD	Department of Agriculture and Rural Development
TOR	Terms of Reference
PC	People's Committee

ACKNOWLEDGMENTS

This Biogas value chain physical audit report (package 24) was conducted by the Center for Rural Communities Research and Development (CCRD) with participation of key experts: Dr. Pham Van Thanh, MSc Nguyen Duc Thinh, Dr. Tran Hiep, Dr. Phan Van Hoi, Dr. Nguyen Manh Khai, Dr. Luu The Anh and other experts and researchers.

On behalf of the Consultant, we would like to express our deep gratitude for the support and coordination from the Central Project Management Unit (CPMU), especially Mr. Nguyen The Hinh - Deputy Director of the Agriculture Project Management Board, Project Director of LCASP, Mr. Hoang Thai Ninh - Deputy Director of LCASP and many other officers of LCASP during the assignment implementation. We would like to express our sincere thanks to LIC Consultant and LCASP Project Management Unit in 10 project provinces of Lao Cai, Son La, Phu Tho, Bac Giang, Nam Dinh, Ha Tinh, Binh Dinh, Tien Giang, Ben Tre and Soc Trang. We would also like to thank the team of technicians, mason/biogas agencies and local authorities in surveyed areas. In particular, we would like to express our deep gratitude to households in providing information and supporting for survey activities.

We hope the results of this report will well meet objectives set out in TOR. Also we would like to receive comments from stakeholders to improve the report.

Thank you very much!

Director

Pham Van Thanh

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CHAPTER I. BACKGROUND OF BIOGAS VALUE CHAIN PHYSICAL AUDIT ACTIVITY

1. Introduction on Low Carbon Agriculture Support Project (LCASP)

The Low Carbon Agricultural Support Project (the Project) is a ADB-funded project under Loan 2968-VIE (SF) signed on 07 March 2013 between the Government of Vietnam and ADB. The total investment for LCASP is 84 million USD, of which 74 million USD as a loan from ADB, 3.7 million USD from Government of Viet Nam and 6.3 million USD from Financial Intermediaries (FIs). Expected project duration is in 6 years (6/2013 - 6/2019).

The Ministry of Agriculture and Rural Development (MARD) is the Project Executing Agency. Agriculture Project Management Board of the Ministry of Agriculture and Rural Development is the Project Investor. The Central Project Management Unit (CPMU) was established to coordinate and manage the whole project and10 Provincial Project Management Units (PPMUs) were established under the Departments of Agriculture and Rural Development (DARD) of provinces participating in the project to manage all project activities at the provincial/city level. Financial intermediaries (FIs) including Viet Nam Bank of Agricultural and Rural Development and Cooperative Bank of Viet Nam have been selected to support credit for households participating in biogas value chains in 10 project provinces.

The project is implemented with following objectives:

- *Overall objectives:*

- Build a sustainable, efficient and environment-friendly agricultural production through development and replication of studies and technology transfer models in agricultural production towards greenhouse gas emission reduction and adaptation to/mitigation of climate change, efficient use of natural resources and agriculture by-products, effective management of produce processing activities and post-harvest preservation.
- Minimize environmental pollution due to agricultural wastes through the expansion and development of biogas program from small-scale household projects to large and medium-scale projects creating clean energy sources; improve livelihoods and enhance the quality of life of rural people.

- *Specific Objectives*

- Improve the management of livestock waste, by-products in biogas production; reduce environmental pollution; contribute to the development of sustainable animal husbandry and livestock for farmers and farms; generate clean energy sources; improve livelihood and enhance the quality of life of rural people; generate revenues from CDM projects;
- Study to apply technologies in low carbon agricultural production in the field of farming, livestock and aquaculture that have been recognized in the world, in the conditions of Vietnam and selectively replicate models in order to enhance economic efficiency, adaptation to / mitigation of climate change and reduce greenhouse gas emissions.

- The Project (i) supports construction of about 36,000 small biogas plants (SBPs), 40 medium biogas plants (MBPs) and 10 large biogas plants (LBPs); (ii) empowers biogas plant operators, masons, technicians, engineers, contractors, and biogas relevant agencies to follow good biogas value chain (BVC) management practices. To support national policies, strategies and programs aimed at compliance with BP technical and environmental standards.

The Project is implemented in the 10 provinces of Bac Giang, Ben Tre, Binh Dinh, Ha Tinh, Lao Cai, Nam Dinh, Phu Tho, Soc Trang, Son La, and Tien Giang. The Project comprises 4 components: (i) Expanded use of livestock waste management infrastructure; (ii) Credit lines for biogas value chains; (iii) Enhanced CSAWMP technology transfer; and (iv) Effective project management.

2. Introduction on Package "Biogas Value Chain Physical Audit"

2.1. Package Objectives

The objective of small biogas value chain physical audit is to verify and monitor the construction status and quality of biogas plant construction, under the LCASP program. The audit aims to:

- Ascertain the adequacy of digester volume with respect to available feedstocks and livestock numbers.
- Ensure that the technical standards for the digester to be eligible for LCASP support were applied
- Assess the quality and use of environmental package as part of the construction package
- Confirm the receipt of incentive funds for the construction and installation of the digesters by the source of project funds.
- Confirm the digester is a LCASP supported digester and is not linked to other digester subsidy programs.

2.2. Detail task

The Consultant is contracted to undertake the audit using a fixed budget selection (FBS) contract through desk research and fieldwork based study, specifically as follows:

Desk study:

The team has reviewed PPMU documentation for the LCASP digesters database, as part of this review a random sample was identified for inspection, the records were extracted for the sample and financial payment records obtain form the PPMU LCASP financial accounts. The Consultant also compared the details of the selected sample with the records of the NBP and SNV digester databases to ensure no-overlaps.

The Consultant has worked with PPMUs in step by step to ensure the following contents:

(i) Obtain a complete list of LCASP supported digesters including the owners name, financial record reference, size and description of digester and the environment technology package, date of installation, name and contacts of the mason or supplier, date of construction check, name of construction inspector, the outcome of the construction inspection, description or classification of construction inspection findings, financial payment and accounting transfer date and reference.

(ii) For each PPMU, the Consultant has conducted an assessment of records for their adequacy and completeness of digester documentation - including the financial approval processing forms being Forms 1, 2, 3, and 4 for incentive approvals and the methods for building and managing the project database (form 6). In each province, the Consultant selected a random check at least 40% acceptance file that is stored at PPMU;

(iii) Check training program records to estimate and confirm the participation rate of constructed biogas household's in the training;

(iv) Identify the process and responses for problem solving and remedial actions of technicians that receive information/report from grass root level;

(v) Describe the actual procedures for the confirmation and payment of financial incentives, confirm the date of payment and the record of recipient within the PPMU financial records.

Field study:

The Consultant has undertaken field work and visited selected households, inspected digesters and interviewed the recipient of the digester. Further the Consultant also interviewed at least 60% of mason teams and composite biogas agencies to identify the number of construction inspections they have received, the number of recommended upgrades or remedial fixes, and the number of rebuild or rejections. A listing of the reasons for remedial work or rejection was developed.

The Consultant has visited, based on a random sample that is drawn for the PPMU data base, at least 500 constructed/installed biogas plants and 100 under construction/installation plants. Each digester included in the sample was visited and a site inspection and household interview completed. Where no access to a beneficiary was obtained, additional households were added by the consultant through selection of the next nearest beneficial household.

During site visits, all collected information was recorded in a field data survey form that was prepared by the consultant and shared with the CPMU for prior approval.

In addition, a coding sheet was provided that provides a listing of response categories. The collected information was filled in the quality control form right at the site.

During site visits the Consultant used the technical form to evaluate the following parameters:

(i) Interview farmer on: number and type of livestock and feedstock availability, purpose of construction biogas plant, identify what environmental package was sought and installed,

participation in user training, access to user handbook, satisfaction of household with construction quality, technical support provided by technicians, and the receipt of the incentive – amount received, time taken and confirm that the beneficiary as eligible for the payment;

(ii) Inspect the BVC installation and measure: Type and size of biogas plant, date of construction, plant code, geometric dimension, and position of digester, inlet tank, outlet location, and compensation tank and environment packages. The assessment includes and specifically reports on the provision of the environmental package, the final disposal of slurry.

(iii) Interview operator to identify operation standards and process, gas use of plant owner in term of safety and convenience;

(iv) The validity of the plan (compliance with the design of the Project; constructed by project's mason team; installed by certified biogas composite agencies; built in the year of implementation)

v) Assess if the mason team comes from another province belonged to the project, do they work according to the procedure of LCASP, if not what variations were there and why? Is there a local technician to manage the installation?

(vi) Identify what training was provided to the biogas users after construction completed. Detail, how many courses were delivered and the level of participation at each course reconcile against the number of installations? During site visits identify the number of households that receive the training and resource material, identify who provided these materials from where/whom, any reading instruction has been given to them;

(vii) During the site visits ascertain consumer's knowledge of the availability of guarantees and their use of these. Provide a cross check that the guarantee paper has been provided to the plant's owner by mason;

(viii) Identify if there have been any technical faults and how these were responded to, with the outcome of these responses categories as solved, ongoing or unresolved.

(ix) All data forms are to be integrated into a final minute that will be discussed in a closing meeting that proposes technician to follow and send the result by document to PPMU in the agreed time.

(x) Skill of plant checking (in accordance with criteria in form 3 for under-construction and acceptance check, in form 4 for checking completed construction. Ability of doing technical consultancy of technician;

(xi) Construction techniques (are the design specifications followed, follow dimension designed, the visible physical presence of the LCASP digester mark on the digester, attach plant label);

(xii) Assess and evaluate satisfaction of biogas households and carry out assessment on the operation and maintenance aspects of biogas plants, the biogas value chain and its benefits,

and the effectiveness of the environmental package in terms of operator benefits, and environmental protection;

Based on collected information at the field, the Consultant identifies areas for improvement and provides recommendations for each PPMU and CPMU to improve quality control system of LCASP. The Consultant reflects these recommendations in a consolidated format in the final report. The consultant classifies if there are common mistakes or malfunctions between the 10 different provinces for the technicians or if it is coincidental mistakes.

3. Research methodologies

To meet the required objectives and tasks of the biogas value chain physical audit, the Consultant has used following research methods, including:

(i) Desk study;

(ii) Random sampling;

(iii) Household survey using questionnaire / technical form including testing survey to draw experience before official survey;

(iv) In-depth interview;

(v) Observations and physical audit;

(vi) Data analysis using SPSS software and report writing.

a/ Desk study:

Desk study focuses on following key documents: (i) a complete list of LCASP supported digesters; (ii) technical standards and quality control regulations in the construction of LCASP supported digesters; (iii) provisions on adequacy and completeness of digester documentation, including the financial approval processing forms for LCASP supported digesters, etc. Based on the analysis of relevant documents, the consultant: (i) identify a random sample of 14,400 records that is stored at PPMU for checking in PPMU offices; (ii) identify a random sample of 500 records of constructed biogas plants and 100 records of under-construction plants for physical audit at households; (iii) check records of training courses organized for households supported by LCASP Project; (iv) define roles and responsibilities of technicians in responding and solving issues related to construction and operation of biogas digester from the grassroots; (v) review the procedures related to receipt and payment of incentive at the PPMU; etc.

Based on the number of digesters in the provinces, the Consultant has allocated 14,440 records to be checked to each province in a certain proportion. In fact, in 10 provinces, the Consultant has checked 14,485 records, 85 more than originally expected.

Table 1. The number of records checked at PPMUs

No.	Province	No. of records required in TOR	No. of records checked
1	Bac Giang	2276	2275
2	Ben Tre	1583	1582
3	Binh Dinh	2335	2335
4	Ha Tinh	1522	1507
5	Lao Cai	680	680
6	Nam Dinh	1479	1532
7	Phu Tho	2136	2136
8	Soc Trang	888	893
9	Son La	614	614
10	Tien Giang	887	931
	Total	**14,400**	**14,485**

b/ Random sampling

To ensure representativeness of physical audit activities, the Consultant selected sampling method as follows: synthesis a complete list of households with LCASP supported digesters including a list of households with constructed/installed biogas plants and a list of households with under construction/installation plants based on data provided by the provinces. The list of selected households is based on principle of randomness and ensures diversity of size, type and is consistent with ratio of CPS to KT1, KT2 of the project. Specifically, in order to ensure representativeness of sample structure according to digester volume, the Consultant chose more small digesters (less than $9m^3$) than larger ones[1]. CPS digester also accounts for about 50% of the total. Accordingly, following steps were carried out:

Step 1: Determine project areas in the provinces to select surveyed districts (select districts with large and small number of plants to compare and select districts with both constructed and under construction plants for survey). On that basis, at least 02 districts/towns/cities were selected in each province;

Step 2: Determine surveyed communes from selected districts, select at least 02 communes/wards in each district/town/city;

Step 3: Randomly identify number of households to be surveyed and substitute ones in case of inaccessibility of selected households to ensure sufficient number of surveyed households. The number of households surveyed in communes and districts is different but it

[1] At survey time, according to data provided by CPMU, ratio of digesters from $9m^3$ or less accounted for 52.6%

is ensured that the number of surveyed households in each province is not changed much compared to TOR[2].

c/ Field survey in provinces:

Testing survey: After completing the toolkit, the Consultant has conducted a testing survey in Bac Giang province to finalize it. The testing survey was conducted both at the provincial and household level. After that, the consultants proceed to revise the toolkit and seek approval from the PMU through organizing workshop to collect consultation and comments from relevant stakeholders. After approved, the Consultant conducted training for experts to prepare for the official survey in 10 provinces.

Official survey in 10 project provinces: In preparation for official survey in 10 project provinces, the Consultant has conducted training for member experts based on experience gained from the testing survey. At the same time, a detailed plan was prepared for submission to CPMU for sending to PPMUs for implementation support.

In all 10 provinces of the project, the consultant team had a first working day with the PPMU to understand the baseline information of the project implementation in the locality and the requirements of the physical audit activities. Based on that, the consultants arranged the follow-up work plan that best fit the reality of each locality, including the assignment of personnel to check the records at the PPMU and physical audit at households.

Table 2. The number of plants audited at households in 10 provinces

No.	Province	According to TOR		Field survey	
		Completed biogas plants	**Under-construction biogas plants**	**Completed biogas plants**	**Under-construction biogas plants[3]**
1	Son La	30	5	30	5
2	Lao Cai	30	5	30	6
3	Phu Tho	70	12	70	12
4	Bac Giang	80	15	82	15
5	Nam Dinh	50	8	52	6
6	Ha Tinh	60	15	62	13
7	Binh Dinh	60	13	60	13
8	Tien Giang	40	10	50	-
9	Ben Tre	50	10	38	21
10	Soc Trang	30	7	34	2

[2] Some changes in number of surveyed households compared to TORs are mainly due to lack of households with plants under construction, so the Consultant has to increase number of constructed ones in some provinces or increase number of plants under construction in other provinces.

[3] At the time of evaluation, access to under-construction plants is difficult due to the number of new digesters built in 2017 is very low compared to previous years.

No.	Province	According to TOR		Field survey	
		Completed biogas plants	Under-construction biogas plants	Completed biogas plants	Under-construction biogas plants[3]
	Total	**500**	**100**	**508**	**93**

d/ In-depth interview

In-depth interview was used to clarify, explain and supplement quantitative survey data. In-depth interviews were conducted with groups related to biogas value chain including: (i) representatives of the PPMUs; (ii) representatives of mason teams/biogas enterprises/agencies; (iii) representatives of technicians; (iv) representatives of local government; (v) community representatives.

e/ Observations and physical audit

Observations and physical audit of biogas plants is to support collection of additional information and verification of information collected in questionnaire. Accordingly, the consultants recorded the construction/operation specifications, geometric dimension, position of digester, inlet tank, outlet, compensation tank and items of environment packages etc. to determine the compliance of the plants in practice with CPMU's regulations as well as effectiveness of the biogas plant. The Consultant has combined using technical forms for independent monitoring with other approaches such as photographing in this method.

f/ Data processing and report writing

The collected data was imported and processed using SPSS software for storage and report writing. The consultant mainly uses SPSS software to process information in terms of frequency, percentage of the data to be collected, compare data between households with constructed digesters and those with under-construction ones; compare between 10 project provinces; compare between constructed and composite digesters etc. The Consultant also used SPSS software to calculate statistical indicators such as[4]: Mean, Maximun, Minimun, Mode; Median etc. to serve the assessment of the project's economic, social and environmental performance according to DMF framework and other relevant indicators.

[4] Mean (average value of a series of numbers), Maximum (the maximum value of a series of numbers), Minimun (the smallest value of a series of numbers), Mode (the value appears the most times in a series of numbers); Median (the value divides a series of numbers into two equal parts) etc.

CHAPTER II. CHAPTER II. RESULTS OF PHYSICAL AUDIT OF BIOGAS VALUE CHAIN

1. Basic information of surveyed households

- Demographic characteristics of surveyed households:

Most of the households with the size of 4 or more members have been building biogas plants under the Project, which accounts for about 75% of the total surveyed households. The size of these households is also suitable for small-scale biogas plant because the amount of gas produced can meet the demand of the household. For households that have constructed and installed biogas plants, the total number of women in surveyed households is 1,181, accounting for 50.5%. For households that are constructing biogas plants, the total number of women in these households is 218, accounting for 52.6%. In addition, the total number of children in households that have constructed biogas plants is 514, accounting for 22%. For households with biogas plants under construction, the total number of children is 99, accounting for 23.5%.

- Ethnic composition of surveyed households:

One of the priority groups of the LCASP (Low carbon agricultural support Project) project is the ethnic minority group. The survey shows that about 10% of households that benefit from the LCASP project belongs to the ethnic minority groups. According to the new regulations of the Project, the households in the priority group will receive 5 million VND / a small-scale biogas plant. Therefore, until the end of the project, the proportion of ethnic minority households under the project will likely increase, especially in Son La, Lao Cai, Phu Tho and Soc Trang.

- Household economic status:

Poor households[5] are also included in the priority group of LCASP Project. However, the percentage of poor and near-poor households benefiting from the project is still not high because this group of households often has financial difficulties in order to invest in the construction of biogas plants. For the poor households, the percentage of poor households involved in construction of biogas plants is 1.8%. However, after the Project adjusted the policy on the level of support for priority groups under the project since 10/2016, the percentage of poor households building biogas plants has increased significantly. Survey of households that are building biogas plants shows that this rate has increased to 11%. This may be due to the fact that the survey is conducted in 2017, when the provinces are mainly focusing on the construction based on the support level of 5 million per household, therefore, this percentage has increased rapidly. This can be seen as an evidence demonstrating that the decision to support 5 million VND / biogas plant for vulnerable households of the Project is

[5]The poor households that benefit from the project are households under the Decision of the Commune People's Committee

very timely and appropriate. It also shows that the demand for construction of biogas plants is not small.

Table 3. Household economic status (%)

	Households that have built biogas plants	**Households that are building biogas plants**
Poor households	1.8	11.0
Near-poor households	2.0	3.3
Normal households	79.7	75.8
Well-off households	15.8	9.9
Rich households	0.6	0

- Current scale of livestock production of surveyed households:

In terms of the current scale of livestock production, on average, households that are constructing and installing biogas plants have16 market hogs, 3 breeding pigs and 1 buffalo / cow. For households that have built biogas plants, the average number is 21 market hogs, 3 breeding pigs and 1 buffalo / cow. On average, households that are building biogas plants have a smaller livestock size because breeding facilities are unstable and not completed.

Table 4. Current number of livestock of households under the Project (animals)

No.	**Types of livestock**	**Households that are building biogas plants**	**Households that have built biogas plants**
A.	**Average number of livestock / household**		
1	Market hog	16	21
2	Breeding pig	3	3
3	Buffalo / cow	1	1
B.	**The largest number of livestock/ household**		
1	Market hog	130	500
2	Breeding pig	20	300
3	Buffalo / cow	15	20
C.	**The smallest number of livestock/ household**		
1	Market hog	1	1
2	Breeding pig	1	1
3	Buffalo / cow	1	1

The survey results indicate that the number of pigs and buffaloes/ cows in the households that have built biogas plants and households that are building biogas plants is quite similar in proportion. For pig production, the number of households with less than 7 heads accounts for the highest proportion (households that are building biogas plants accounts for 31.6% and households that have built biogas plants accounts for 32.3%). Notably, the proportion of households with more 20 pigs also accounts for an extremely high proportion (households that are building biogas plants 31.5% and households that have built biogas plants accounts for 29.3%). For buffaloes/ cows, the majority of households only raise less than 3 animals.

Table 5. Proportion of livestock by breeding scale of households (%)

Number of livestock	Households that are building biogas plants	Households that have built biogas plants
A. Market hog		
Less than 7 animals	31.6	32.3
8-9 animals	2.6	6.0
10-12 animals	15.8	12.8
13-20 animals	18.4	19.5
21-50 animals	27.6	20.2
More than 51 animals	3.9	9.1
B. Buffalo / cow		
Less than 3 animals	70.4	65.8
4-5 animals	18.5	15.8
6-7 animals	7.4	9.5
More than 8 animals	3.7	8.9

2. Communication work on biogas value chain development

2.1. People's access to information about the Project

Among the forms of communication that have been made, direct counseling is a popular communication channel because in people's opinions, this form helps them to answer almost any questions about the Project. In particular, commune officials and masons / biogas agents are the main information channels to help people learn about the project. For households that have built biogas plants, this proportion is 29.7% and 40%, respectively; for households that are building biogas plants, this proportion is 41.9% and 35.5%, respectively. For households that are building biogas plants, the percentage of commune officials providing information tends to be higher than that of the masons due to the fact that many households are receiving the support of VND 5 million per biogas plant, and commune officials manage the list of these priority households. In addition, information from neighbors also accounts for

a large proportion (26.9% and 27.2%, for households that have built biogas plants and households that are building biogas plants, respectively)

The results of household interviews reveal that the percentage of households guided to prepare a dossier for participation in the project is very high, reaching 99.2% for households that have built biogas plants and 94.6% for households that are building biogas plants, especially guided by masons / biogas agents and technicians (59.7% and 37.9% for households that have built biogas plants, respectively; 59.1% and 28.4% for households that are building biogas plants, respectively). However, by reviewing the records and interviews with commune officials and technicians, it was found that 100% of the households were instructed by the technicians and the masons to prepare a dossier for participation in the project. A small number of respondents were not instructed to prepare a dossier because they believed that the dossier was just an Application form for participation. In fact, these households are instructed by other people to fill out forms (neighbors, friends ...), after the application is approved by the PPMU (Provincial Project Management Unit), the technicians or masons will continue to instruct these households to complete the dossier in order to receive support from the Project.

2.2. Receipt and processing of information by the PPMU

The results of the examination of the records kept at the PPMU indicate that the time on the forms stipulated in Form 1 to Form 5 is within the scope of the regulations of the Project. The comparison between the start-up time and the completion time of biogas plants shows that the plants are quickly completed, usually within a week to a month, even in many provinces, the completion time of these plants can be counted by days. Once the biogas plant is completed, other related procedures such as acceptance, evaluation and transfer of assistance funds are also quickly proceeded. Overall, people are satisfied with the process of receiving and processing information that the Project has implemented.

2.3. Consultation on the selection of biogas plants for the households

The masons / biogas agents are the main providers and consultants for the households (65.1%), followed by technicians (32.7%). These are also two main groups of stakeholders involved in the entire project support process for households, therefore; the high level of consultation on the selection of biogas plants of these two groups is understandable.

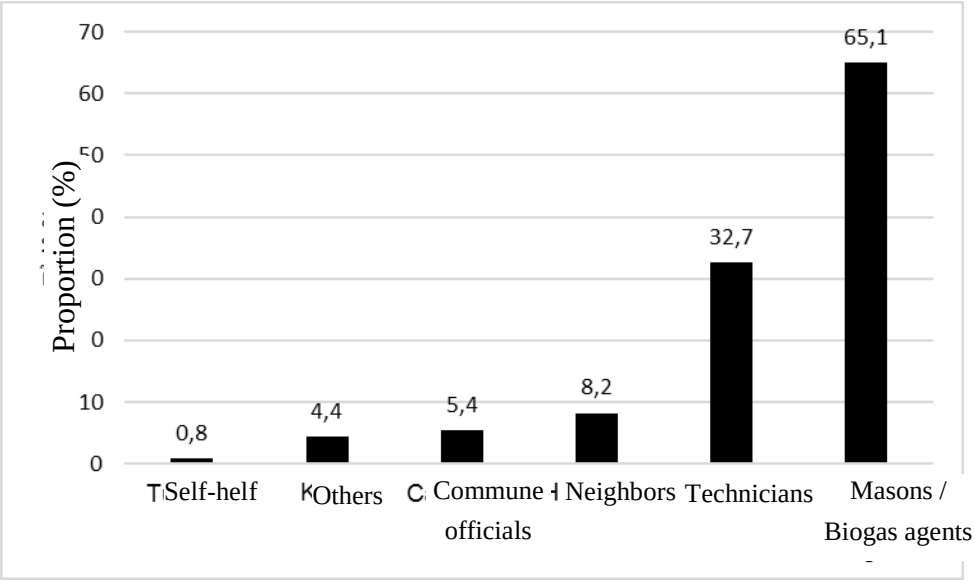

Figure 1. Individuals / organizations involved in the consultation on the construction of biogas plants for the households (%)

The results of interviews with surveyed households indicates that the selection of the volume for building biogas plant is based on 2 main factors, which are the amount of waste to be treated and the demand of gas consumption of each household. In particular, nearly 100% households including households that have built biogas plants and households that are building biogas plants select the volume of the biogas plant based on the amount of waste that needs to be treated. Only a very small number of households have responded that their selection of the volume of biogas plant is based on their construction costs or the popular volume in the neighborhood. From a theoretical point of view, people's perception of such biogas plant selections is relatively good. However, the selection of volume of biogas plants based on the demand for gas is not yet focused.

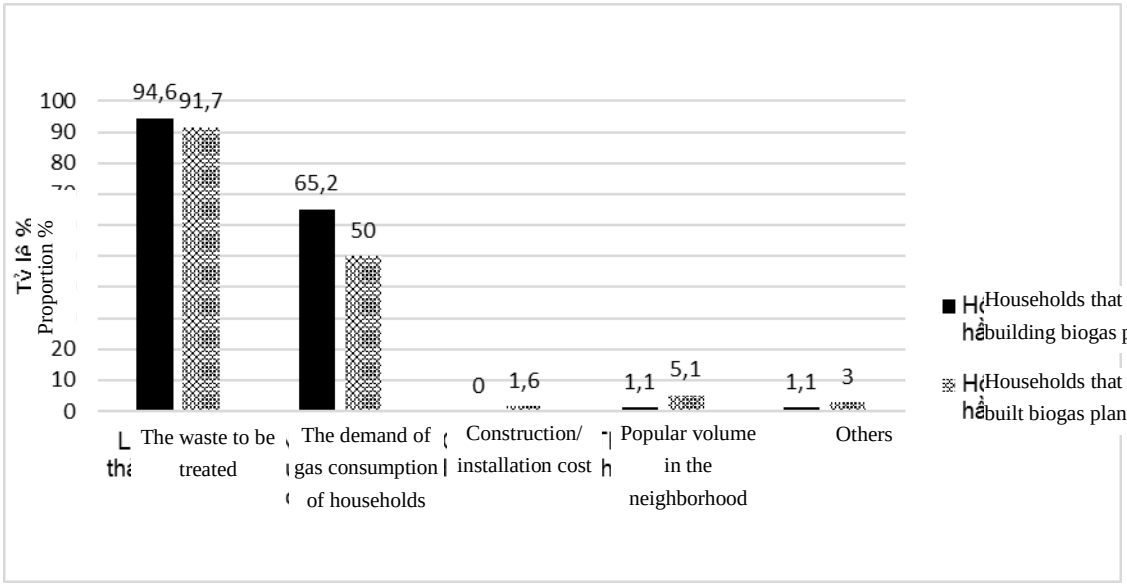

Figure 2. Factor affecting the selection of biogas plant volume (%)

Analysis of the correlation between the volume of the biogas plant and the scale of livestock production of surveyed households shows that in practice, people do not select the volume of the biogas plant based on the amount of waste to be treated. Comparison of the data of Table 5 (Proportion of livestock by breeding scale of households) and Table 7 (Volume of the biogas plant of households that have built biogas plants) shows the correlation as follows:

- 32.2% of households have less than 7 pigs, but only 9.2% of surveyed biogas plants have a volume of 7m^3 or less.

- 6.0% of households have 8-9 pigs, but up to 44.2% of surveyed biogas plants have a volume from 7.1 to 9m^3.

- 12.8% of households have 10-12 pigs, but 20.2% of surveyed biogas plants have a volume of 9,1-12m^3.

- In particular, 29.3% of households have more than 20 pigs, but only 7% of surveyed biogas plants have a volume of over 20m^3.

In fact, households do not select the volume of the biogas plant based on the amount of waste to be treated, and there will be high rates of overloaded biogas plants at certain times.

Through interviews with local government officials, technicians, masons / biogas agent and field analysis, households tend to select the volume of biogas plants based on two main factors:

i) Based on the popular volume in the neighborhood; and:

ii) Consultation of masons or biogas agents.

Project information for the people is quite adequate. However, the individuals who provide this information as well as consult households are mainly masons / biogas dealer. Information provided by project officials (technicians) and local authorities is generally limited. The fact that the majority of households are consulted by masons / biogas agents have had a great influence on the selection of which units to build / install biogas plants. This does not exclude the possibility that masons / biogas agents will not fully consult on the biogas plant, especially the selection of its volume compared to the gas demand of the households. The survey results reveal that there is a high proportion of households that determine the volume of the biogas plant based on the scale of livestock. Meanwhile, the scale of livestock is constantly changing. Therefore, this factor may be inaccurate. Consequently, this would lead to an excess of gas, causing economic waste and environmental pollution.

3. Observation and physical audit of biogas plants

3.1. General information about biogas plants

- Type of biogas plants and volume of biogas plants at surveyed households:

Among 508 surveyed gas plants, the CPS plants accounts for the highest proportion (49.6%), followed by KT1 (27.2%) and KT2 (23.2%). However, the structure of biogas plants surveyed in different provinces is not the same. In Lao Cai, Son La, Soc Trang, CTCPS has

the dominating proportion, meanwhile in Bac Giang and Tien Giang, there is a high proportion of constructed biogas plants (KT1, KT2).

Table 6. Features of biogas plants of households that have built these plants

Province	KT1	KT2	Composite
Bac Giang	71	4	7
Phu Tho	26	1	43
Lao Cai	1	0	29
Son La	2	0	28
Binh Dinh	8	24	28
Nam Dinh	4	14	34
Tien Giang	26	24	0
Soc Trang	0	4	30
Ben Tre	0	19	19
Ha Tinh	0	28	34
Total	**138**	**118**	**252**
Proportion	27.2%	23.2%	49.6%

Regarding the volume of biogas plants of surveyed households, the majority of surveyed households have biogas plants with the volume of less than $9m^3$ (53.4%), especially in provinces such as Son La and Soc Trang. More than 70% of the total number of surveyed biogas plants has a volume of $12m^3$ or less. Tien Giang, Ben Tre and Binh Dinh are the provinces with higher proportion of biogas plants with a volume of 12-20 m^3 than other provinces. For biogas plants with a volume of over 20 m^3, they are concentrated in Bac Giang (accounting for over 60% of the total surveyed biogas plants in the province).

The survey also shows that 100% of CTCPS have a volume of $12m^3$ or less. This can be explained because the volume of the CPS biogas plant is limited to less than $13m^3$. At the same time, for constructed biogas plants, the popular volume ranges from over 12 to $20m^3$, this volume accounts for over 60% of the total number of biogas plants constructed.

Table 7. Volume of the biogas plant of households that have built biogas plants (%)

Province	=<7m^3		7,1-9 m^3		9,1-12 m^3		12,1-20 m^3		>=20.1 m^3	
	CPS	KT1/2	CPS	KT1/2	CPS	KT1/2	CPS	KT1/2	CPS	KT1/2
Bac Giang	14.3	0.0	71.4	0.0	0.0	1.4	14.3	37.8	0.0	60.8
Phu Tho	0.0	0.0	33.3	10.7	64.3	60.7	2.4	28.6	0.0	0.0
Lao Cai	0.0	0.0	58.6	0.0	41.4	0.0	0.0	0.0	0.0	100.0
Son La	0.0	0.0	96.4	50.0	3.6	50.0	0.0	0.0	0.0	0.0
Binh Dinh	7.1	0.0	89.3	12.5	3.6	25.0	0.0	59.4	0.0	3.1

Province	=<7m^3		7,1-9 m^3		9,1-12 m^3		12,1-20 m^3		>=20.1 m^3	
	CPS	KT1/2	CPS	KT1/2	CPS	KT1/2	CPS	KT1/2	CPS	KT1/2
Nam Dinh	64.7	5.6	32.4	27.8	2.9	33.3	0.0	33.3	0.0	0.0
Tien Giang	0.0	0.0	0.0	0.0	0.0	28.0	0.0	64.0	0.0	8.0
	26.7	50.0	73.3	0.0	0.0	25.0	0.0	25.0	0.0	0.0
Ben Tre	0.0	5.3	100.0	21.1	0.0	15.8	0.0	57.9	0.0	0.0
Ha Tinh	17.6	3.6	76.5	35.7	5.9	46.4	0.0	14.3	0.0	0.0
Proportion by type of biogas plants	15.5	2	66.1	10.5	17.5	25	0.8	42.6	0.0	19.9
Proportion by volume	9.2		44.2		20.2		19.4		7.0	

3.2. Potential overlap with other Projects

By checking the records at the PPMU and household filed inspections, no household was supported that overlaps with other Projects. This can be asserted based on the following factors:

i) The LCASP project does not coincide with other major biogas projects in 10 provinces. This project starts at the end of other Projects. As such, overlapping is eliminated. Specifically, the LIFSAP project will be implemented in the period of 2011-2015 in Hanoi, Thai Binh, Hung Yen, Hai Duong, Hai Phong, Cao Bang, Thanh Hoa, Nghe An, Ho Chi Minh City, Long An, Dong Nai and Lam Dong. Therefore, these provinces do not overlap with the 10 provinces of the project. The QSEAP project was implemented in 16 provinces including: Bac Giang, Ben Tre, Binh Thuan, Da Nang, Ha Noi, Hai Duong, Hai Phong, Ho Chi Minh City, Lam Dong, Ninh Thuan, Phu Tho, Son La, Thai Nguyen, Tien Giang, Vinh Phuc and Yen Bai. Among these provinces, Bac Giang, Ben Tre, Phu Tho, Son La and Tien Giang have participated in the LCASP project. However, there is no possibility of overlapping support for the reasons below.

ii) The requirement to associate the biogas plant code with the encoding information about the neighborhood, type of biogas plant, size and time of completion of the biogas plant ... also helps avoid the risk of overlapping beneficiaries with other projects.

iii) Strict regulation of household information in the record keeping process of the project may help to check the duplication of the object against other projects (For example, personal information of both husband and wife - including their ID card numbers). In particular, in Form 01, the Commune People's Committee will certify the status of unregistered households or households' commitment that they have not received support from other projects and other sources of funding.

iv) The process of checking information from other major Projects on biogas also does not recognize this overlapping.

v) The physical audit at the households shows that the biogas plants of the project are all the only biogas plants at these households. Comparing documents with the actual situation of the households also show that no households receive more than one source of support.

vi) The PPMU and the Central PMU also carry out random inspections for biogas plants in the provinces under the Project. The results show that there is no duplication of the LCASP Project with other projects.

3.3. Quality inspection of construction items of biogas plants

a / Construction items

As stipulated by the LCASP Project, in order to get support from the project, when constructing a biogas plant, households will need to develop some other related items, called the environmental package, including:

(i) disinfection fountains / hand-washing faucets;

(ii) post-biogas by-product storage tanks;

(iii) waste collection systems;

(iv) gas appliances.

The results of the examination of the dossiers at the PPMU for Form 03 (inspection and acceptance minutes) of these items are also complete and adequate.

Physical audits also show that items of the environmental package are also adequately implemented. Specifically:

- *About the disinfection fountains / hand-washing faucets:* Due to the small scale of livestock production, most households opt for a faucet instead of a fountain. Particularly, in some provinces, people also make sanitizing holes with hand-washing faucets such as in Lao Cai, Phu Tho or Binh Dinh. There are also a few cases of broken faucets, or faucets having no water at physical audit in Ben Tre, Bac Giang. However, this item is basically considered complete.

Table 8. Disinfection fountains or handwashing faucets (%)

Province	No available facilities	Disinfecting fountains	Handwashing faucets	Both
Bac Giang	4.3	2.9	88.6	4.3
Phu Tho	0	0	60.3	39.7
Lao Cai	0	0	57.1	42.9
Son La	0	0	100	0
Binh Dinh	0	0	87.7	12.3
Nam Dinh	0	0	100	0
Tien Giang	0	0	100	0
Soc Trang	0	0	100	0

Province	No available facilities	Disinfecting fountains	Handwashing faucets	Both
Ben Tre	0	2.6	97.4	0
Ha Tinh	1.8	0	96.5	1.8

- *About the post-biogas by-product storage tanks*, the survey shows that 94.1% of households are using post-biogas by-product storage tanks. Generally, the by-product tank is constructed with a volume of $1m^3$ or more, which is relatively suitable for the size of small-scale biogas plants. Therefore, biogas waste is properly collected and used. However, there are a number of households that build too small by-product tanks, as a result, the role of the by-product tanks in these cases has not been really fulfilled.
- *About the waste collection system:* The physical audit shows that 100% of households have a waste collection system. However, only 79.6% of households have a complete and proper waste collection systems (including sewer / pipeline system to collect wastes from the breeding facilities to the biogas plant area, filter/ compensation tanks before releasing animal by-products into the biogas plant). More than 20% of households have incomplete waste collection systems (most of them lack filter/ compensation tanks before releasing animal by-products into the biogas plant). However, it is worth mentioning that this system has not been really effective in the context that people do not have the habit of properly loading animal by-products into the biogas plant. Most of the households still choose to load all the animal by-products (including solid and liquid by-products) into the biogas plant, with a large amount of water used to wash breeding facilities.
- *About the gas appliances:* There are 3 basic types: gas stove, lighting system and generator. However, for small-scale biogas plants, generators are not suitable. Of the 508 households surveyed, no households use generators. For lighting system using biogas fuel, due to their durability and low efficiency, some households used to have them, but at the time of survey almost households no longer use this device. For gas stoves, 100% of surveyed households have 1 to 3 or more stoves, of which the majority of households have two stoves (accounting for 54.5%).

Table 9. Gas stoves (%)

Province	One stove	Two stoves	More than two stoves
Bac Giang	36.6	59.2	4.2
Phu Tho	44.9	52.2	2.9
Lao Cai	31.0	62.1	6.9
Son La	44.8	51.7	3.4
Nam Dinh	51.9	48.1	0

Province	One stove	Two stoves	More than two stoves
Ha Tinh	35.1	64.9	0
Binh Dinh	11.7	56.7	30.0
Tien Giang	34.1	48.8	17.1
Ben Tre	63.2	28.9	7.8
Soc Trang	29.0	71.0	0
Average	**37.7**	**54.5**	**7.8**

Thus, the inspection process at households that have built biogas plants shows that the environmental items are generally adequate. Some households, due to large-scale livestock production, are not able to meet the demand, leading to the overflow of the tank. In addition, some households have temporarily stopped raising livestock so some items, especially handwashing faucets which are damaged or have no water has not been timely repaired. For gas appliances, especially gas stoves, they generally work well after many years of installation.

b / Quality of construction

In order to become masons/ a supplier for biogas plants, the enterprises / organizations and individuals concerned must comply with the strict technical regulations of the project. Prior to the LCASP project, there were also many other projects on biogas deployed, therefore there are many experienced masons / biogas agents that have been trained before. As a result, the construction and installation team of biogas plants under the project is relatively skilled, the rate of incidences in the process of construction / installation of biogas plants is very low.

Table 10. Some problems in the construction of biogas plants (%)

Province	Subsidence	Position of the components in the system is changed	Non-sealed joints (for composite tanks)	Overflowing (for composite tanks)	Others	No problems detected
Bac Giang	0.0	0.0	0.0	0.0	1.3	98.8
Phu Tho	1.4	0.0	0.0	0.0	0.0	98.6
Lao Cai	0.0	0.0	0.0	0.0	6.9	93.1
Son La	0.0	3.3	3.3	3.3	0.0	90.0
Binh Dinh	0.0	0.0	1.7	0.0	0.0	98.3
Nam Dinh	0.0	0.0	0.0	0.0	0.0	100.0
Tien Giang	0.0	0.0	0.0	0.0	0.0	100.0
Soc Trang	2.9	0.0	0.0	0.0	0.0	97.1
Ben Tre	0.0	0.0	0.0	0.0	0.0	100.0
Ha Tinh	1.6	0.0	0.0	0.0	0.0	98.4

Among the 10 provinces under the Project, Nam Dinh, Tien Giang and Ben Tre did not report any incidents during the construction / installation process. Son La has a high rate of incidences during the construction and installation (about 10%), which are mainly related to CTCPS. These incidents can be due to that fact that Son La is a remote province, which may cause incidences for transportation, so that CTCPS encountered problems during the transport process.

The percentage of households experiencing gas leakage accounts for about 2.9% of total surveyed households. Soc Trang, Tien Giang and Ha Tinh did not report any leakage of gas. In Phu Tho, the percentage of households having gas leakage problem is 8.6%. However, according to these households, they can overcome these leakage issues by themselves.

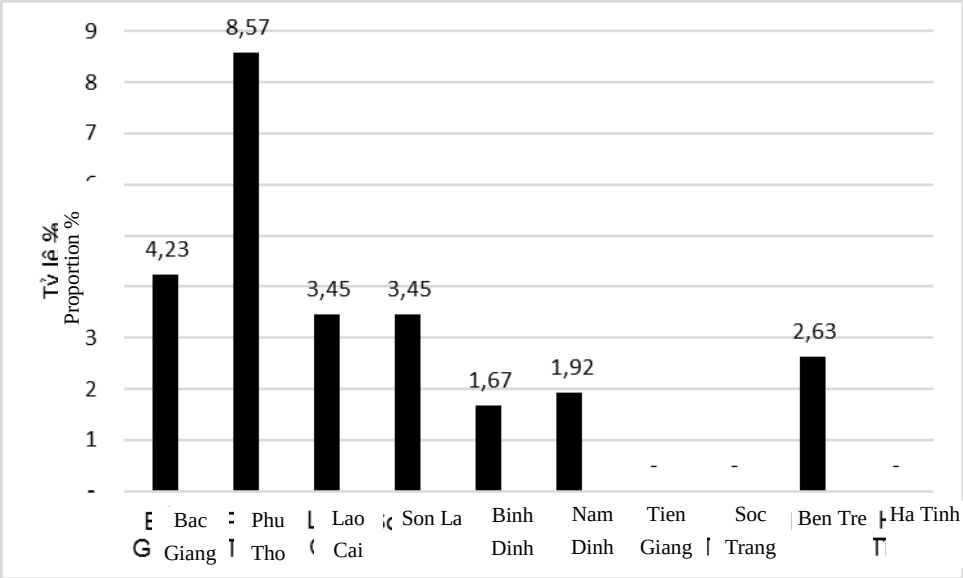

Figure 3. Gas leakage rate (%)

In general, after a period of being put into operation and use, the biogas plants have been meeting the needs of people, especially in terms of fuel. People in the provinces under the Project highly appreciate the quality of the biogas plants that have been constructed / installed by the masons and suppliers of the Project. Of which, 93.6% is rated with good quality, the rest is normal, no supplier is evaluated with poor quality. Binh Dinh, Tien Giang, Bac Giang and Ben Tre have a high rate of people appreciating the quality of masons / suppliers of the biogas plants under the Project. Meanwhile, in Phu Tho and Nam Dinh, the rating of normal quality is 18.6% and 11.6%, respectively.

4. Inspection and supervision in construction and installation of biogas plants

During the construction and installation process, monitoring activities of the Project are always carried out, especially by the technicians. The survey results show that from the period of preparation to the period of acceptance, the average times that technician visited the households is about 3.3 times. Of which, the highest number of visits/ household is10 times, the lowest number of visits/ household is 1 time and the average number is 3 times.

In addition to the supervision of technicians, the percentage of households involved in supervising the construction / installation process in the neighborhood is also very high. Many

province has 100% households involved in the supervision process. According to local people, this helps to ensure better construction / installation quality as they can both monitor and learn how to operate and deal with simple damages to biogas plants.

The fact that households participate in close monitoring of the construction / installation process also significantly reduces the incidents occurring during the construction / installation process. Survey results reveal that 98% of households did not encounter incidents during the construction / installation process.

5. Operation, maintenance and warranty of biogas plants

5.1. Participation of households in training/ coaching activities on using biogas plants

For households who have built biogas plants, the percentage of households confirming to attend training courses is almost 90%. Meanwhile, for households who are building biogas plants, the rate is also over 52%. This is because the proportion of households who are building biogas plants in the provinces under the Project is low, and raining activities are only organized after the construction of new facilities is complete.

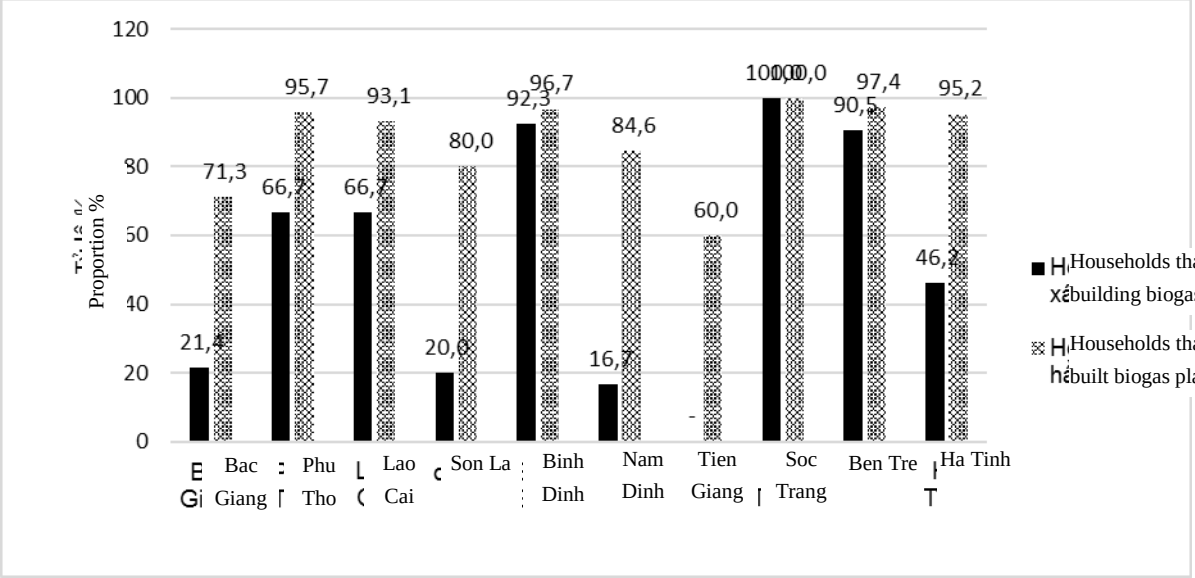

Figure 4. Attendance rate for training courses (%)

In a household, the husband is a more active participant in the training courses under the project (accounting for 58.1%). However, the rate of 33.9% of housewives participating in training activities can be considered as an initial success in gender aspects of the Project. In particular, the percentage of women participating in training courses in Ha Tinh is very high, which is up to 71.2%. The percentage of women attending training courses in Tien Giang is 54.8%, for Soc Trang and Binh Dinh, it is 47.1% and 42.4%, respectively. Lao Cai, Son La, and Nam Dinh are the provinces where the percentage of women attending training is below 20%. In addition, a small percentage of participants are children, parents, or relatives living in the households.

The PPMU have conducted full training courses for the owners of the facilities. In addition to the formal training, manual activities at the household level are also carried out. Through these activities of the technician, the masons / biogas agents, almost all members of

the households are properly trained. However, the low proportion of women attending formal training (33.9%) will have an impact on ensuring the outputs of the Project related to the component of Comprehensive management of animal waste (which requires at least 50% of women to participate in training on biogas use). In order to improve this indicator, in 2017, provinces have paid special attention to the fact that the owners of the biogas plants are mostly women. This is expected to help the Project achieve its objectives.

5.2. Operation of biogas plants

The guidance on operation of biogas plants in the households plays a very important role as it facilitates the operation of biogas plants of households more effective and practical. The percentage of households trained and conducted in the surveyed households is 97.8%, many provinces achieved 100%. In contrast to the intensive training activities, operation manual at the households is visual and familiar to the households. Furthermore, when the operation guidance is provided at the households, not only one member is instructed but all members can be participated if there is a need.

In many places, husbands go to training courses more often, but their wives are the main users of biogas plants in their families since they are main cooker. As a result, the practice guideline at the household will help the main users of biogas plants not to be unfamiliar. The rate of biogas operators are wives in 10 provinces is 48.7%, husbands is on average 36.2%, the rest is other (more than 15%). In the 10 project provinces, there are 5 provinces with more than 50% of wives as biogas operator, this is especially high in Ha Tinh, which is 77.4%. In addition, some other members living in the household are the main operators, but this is not prevalent.

Table 11. Operation ratio of biogas plants by gender (%)

rovince	Wife	Husband	Other
Bac Giang	56.2	20.5	23.3
Phu Tho	36.2	52.2	11.6
Lao Cai	24.1	51.7	24.1
Son La	58.3	20.8	20.8
Binh Dinh	36.7	63.3	0.0
Nam Dinh	38.5	32.7	28.8
Tien Giang	53.1	32.7	14.3
Soc Trang	61.8	29.4	8.8
Ben Tre	44.7	52.6	2.6
Ha Tinh	77.4	6.5	16.1
Average	**48.7**	**36.2**	**15.1**

Safety issues in the operation of biogas plants

It is assessed by local people that the operation of biogas plants is relatively simple. However, the operation of biogas plants still has to put the safety factor fist. As a result, the

project has many activities to help people safely operate the biogas plants. The survey results showed that safety issues in operation of the biogas plants have been ensured. Specifically, it can be measured via following aspects:

(i) Building/supplying equipment: Local mason teams and biogas service providers have been selected and trained thoroughly to ensure the quality of construction and installation at the best level. Also, most of the selected mason teams have had many experiences in building biogas plants through other previous projects. In addition, during construction and installation in the household, strict monitoring of the technicians and members of household is observed. The results of physical audit at the households showed that the incidence rate is very low. Even in Soc Trang and Ben Tre, no problem has been reported.

(ii) Training aspect: The compulsory requirement for receiving project support is that owner of biogas plant must attend training course of the project. Through the document examination and surveys at households, the owners are fully trained. At the same time, people also appreciate guideline manual of the project prepared by visual and easy to understand. The percentage of households keeping these documents after many years is quite high.

(iii) Operation guideline at the household: In addition to participate in formal training, households are also guided to operate the work at the households through mason teams/biogas agents and technicians from the project. People appreciate this form of guiding practice because it is visual and can guide all members of the households. Therefore, safety in operation is ensured.

(iv) Warranty and repair: warranty and maintenance activities after construction has been closely attended to by mason teams/service provider teams. Even though a small percentage of biogas plants are damaged during use, these damages are mostly minor, simple and easy to fix at a low cost and very short recovery time. Therefore, there are almost no risks and dangers with regards to the biogas plants of the project

(v) Gas leakage: Physical audit at the households showed that a few households have experienced gas leaks. However, it is reported by the local people that these leaks have been corrected immediately and there are no signs of leakage so the biogas plants are safe from fire and explosion.

5.3. Maintenance and warranty of biogas plants

The maintenance and warranty activities of biogas plant after construction has been carried out well by the mason team/biogas agents in all surveyed provinces.

- *Time of warranty:*

For composite (CPS) digester, the owner households will usually get warranty for a period of 5 years. For the constructed digester, the warranty period is not as long as the composite digester (about 1 to 3 years), but the damage encountered by constructed digester after installation is usually less than the CPS digester.

- *The damage rate after construction:*

The results of field test show that the percentage of digesters that have been damaged is 40, accounting for 8% of total surveyed digesters. Of which, approximately 27 digesters, i.e. more than two thirds of damaged digesters, are CPS digesters.

Table 12. Damage status of biogas plants

Type of work	Number of damaged works	Damage rate compared to total of same-type works (%)	Damage rate compared to total of damaged works (%)
KT1	9	6.7	22.5
KT2	4	3.4	10.0
CPS	27	10.5	65.0
Total	40	8.0	100

There are no confirmed cases of damaged digesters in Ben Tre and Soc Trang provinces. Meanwhile, in the provinces of Nam Dinh, Bac Giang, Lao Cai, Son La and Ha Tinh, the damage rate is between 11.3% and 15.4%.

Although, up to 8% of the surveyed biogas plants have been damaged, the damage recorded up to the time of the survey is mainly minor damage, easy to handle and low repair costs.

- *Overhaul and repair:*

About 25% of the damage was caused by the users trying to fix the digesters themselves which is more likely higher than the damages caused by technicians' mistakes (8.3%). However, the main repairers for this type of damage are the mason team/biogas dealer, accounting for 52.8%. The remaining (8.3%) was households that do not treated the damage and 5.5% was repaired by hiring outside workers.

- *Promptness of repairing:*

Out of 22 households reporting to the mason team/biogas dealer to repair damaged biogas plants, 13 households have to wait within 1 day, 13 have to wait from 2 to 7 days for repairing; one household has to wait for 1 month. Worse enough one household has to wait up to 12 months.

The most common time for repairing damages at the household is within one day (15 households), the fastest time is 0.5 day (07 households), one household has to repair in 3 days and only one household has to fix it up to 3 months as gas is not available[6].

- *Cost of damage repair:*

Except for warranties, the highest reparation cost for damaged households is VND 1 million (no gas), while the average cost is VND 336 thousand. In addition, most households only spend about 25 thousand VND to repair the damage.

- *The level of satisfaction in the maintenance and warranty:*

[6] Ms. Lưu Thị Dinh's household in Tu village, Tan My commune, Bac Giang city.

Overall assessment from households shows that, for post-construction/installation services, the average score (Mean) is 9.09 points. Meanwhile, the popular score (Mode) is 10 points. Specifically, in the 10 surveyed provinces, Ben Tre province has the rate of evaluating services after construction and installation from 9-10 points, occupied 100%; and then the provinces of Tien Giang, Soc Trang, and Lao Cai accounted for over 90%. On the highest score, the provinces with the lowest rates are Phu Tho and Nam Dinh, 50% and 53.2%, respectively.

6. Financial support for households building biogas plants

6.1. Financial support of the project

Compared with many other projects supporting construction of biogas plants, the support level of LCASP project is still a high level, especially for construction/installation of small biogas plant. Before 2017, for small-scale biogas plants, households will receive a subsidy of 3 million VND from the project. With this level of support, depending on the scale of biogas digester constructed in different households, it is usually accounted from 15% to 25% of the total budget for construction of biogas plants. From 2017, the support level of project increase to 5 million VND/small biogas plant applied for priority households such as poor households, ethnic minority households and households with women are the head of family, this subsidy is accounted up to 25% - 43% of total budget for construction of biogas works. This is a very good level for this group of livestock farmers, contributing to promoting and encouraging them to actively handle the livestock environment in the household and generate more income for the family.

Table 13. Average cost for construction of biogas plants and support rate of the project

Provinces	**Total budget for construction of 01 digester (average value – million VND)**	**Support rate/total budget (support level is 3 million VND)**
Bac Giang	19.37	15.49
Phu Tho	13.36	22.46
Lao Cai	16.03	18.71
Son La	15.43	19.44
Binh Dinh	14.55	20.62
Nam Dinh	11.69	25.66
Tien Giang	19.64	15.27
Soc Trang	14.96	20.05
Ben Tre	14.41	20.82
Ha Tinh	12.97	23.13

The financial support of LCASP project accounts for about 15% -25% for households receiving funding of 3 million and 25% - 43% for households receiving funding of 5 million

per small biogas plant. For the people, this is a very appropriate level of support to help them decide on construction/installation of the biogas plant. Although the project supported a relatively large amount of money to build biogas plants, the proportion of people who have to borrow additionally funding is still more than 30%. This means that, without the project support, the demand for construction/installation of digester will be reduced. The results of implementing LCASP project have proven this when the number of small-scale digesters exceed the initial target of 36,000 digesters and it is likely to reach the revised target of 65,000 digesters[7]. For the group of households who are constructing biogas digester, the survey has showed that approximately 20% of households will not build/install without a project's subsidy.

The efficiency of project financial support is also shown when the project prioritizes to provide 5 million VND/small biogas plant to disadvantaged groups (poor households, near poor households, ethnic minority households, and households that women is the head of family...). For the disadvantaged groups, the project's support with 5 million VND will give them opportunity for construction/installation of biogas plants.

The financial support of the project according to people's assessment is also very simple. According to villagers, completion of the project documentation and paperwork are quite complex with many procedures, but they always receive support from technicians, masons/biogas agents so they do not meet any difficulties. Therefore, the satisfaction level of the people for financial support of the project is very high.

Besides the advantages, during the physical audit in 10 project provinces, there are also some problems regarding the financial support. These are mainly related to households who construct medium biogas plants. The original project document regulated that, the financial support for medium biogas plant was only 10 million VND. This level of support is actually too low compared to the demand of people. Therefore, it leads to the situation that some households which should have constructed medium digester but still choose to make small digester to save money. This has led to the overload of biogas plants. In 2017, this shortcoming was solved when the support level of the project for medium digester was raised to 50 million VND/digester. However, if these decisions are made sooner, the effectiveness of project will be improved.

In addition, the results of working with PPMUs indicated that disbursement progress of the project in 2017 is too slow. This has affected too many PPMU activities, including financial support. In addition, since households will be supported to prepare paperwork, so some households also did not pay attention to receive financial support to timely pay for the mason teams/biogas agents. Some households also believe that money is transferred directly to the mason teams/biogas agents so they do not need to pay attention to this support. As a result, the awareness of some households about financial support of the project is insufficient.

[7]Including 51,000 works with 3 million VND financed and 14,000 works with 5 million VND subsidy.

The survey found that people feel very satisfied with financial support of the project, the average score in the 10 provinces is 9.09. Of which, except for Bac Giang and Phu Tho, there were satisfactory scores on financial support procedures below 9 points, the scores of remaining 8 provinces are 9 or more. These points are then accrued with the previous scores of work quality and it is shows that people are satisfied with the project's support. This is a great success of the Project even though the credit component is not as effective as expected.

6.2. Credit support

Apart from the financial support of the project, not all households have enough money to build biogas plants. Therefore, selection of loans for construction/installation of biogas plants is quite popular, with an average of 31.6% in 10 provinces, i.e. nearly one third of households using loan for construction of biogas plants. Of these, most notably in Ha Tinh, the loan ratio was up to 2/3 of the total households. In Soc Trang, the loan ratio also reached more than half of total households. Binh Dinh is the province with the lowest percentage of households using loans to build biogas plants (only 6.7%).

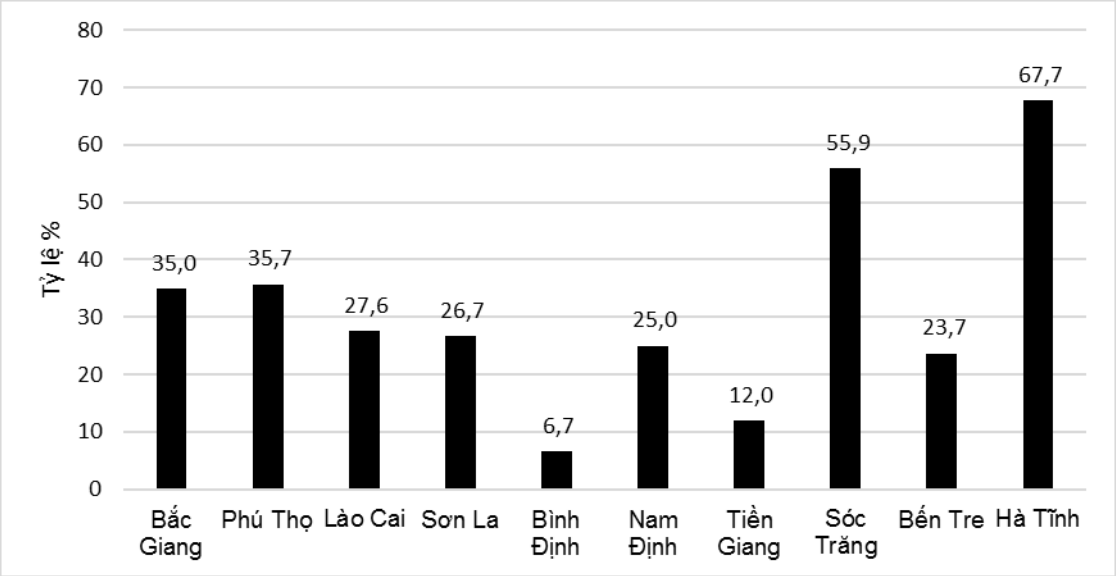

Figure 5.Loans for building digester (%)

In order to address capital constraints for households, credit component of the project was designed to assist households who have need of loans to build biogas plants through the Vietnam Bank of Agriculture and Rural Development and the Cooperative Bank with the amount of up to 100 million VND/small biogas plant and the interest rate is only 90% of the market interest rate for agricultural loans. However, this component is not as effective as expected since the people do not want to borrow if their have to mortgage. High interest rate is another important reason why the fund of credit component does not reach households who have the need. Majority of households who need to loan have to find other sources of loans, especially commercial banks that have easier lending mechanisms than the project credit (accounting for 55.6%). Others find their relatives (34.6%) and a few (6.2%) seek outside sources, especially in Tien Giang and Binh Dinh provinces.

Table 14. Other loan resources (%)

Province	Friend	Relative	Bank	Other credit
Bac Giang	25	57.1	42.9	0
Phu Tho	0	20	64	12
Lao Cai	25	0	75	0
Son La	12.5	50	37.5	0
Binh Dinh	0	25	50	25
Nam Dinh	7.7	61.5	38.5	0
Tien Giang	0	0	50	50
Soc Trang	0	0	94.7	5.3
Ben Tre	0	22.2	66.7	11.1
Ha Tinh	9.5	47.6	45.2	2.4

Not only households who have built biogas plants, the demand and determination of households who are constructing are also very high. The survey results show that 82.6% of households who are currently constructing/installing biogas plants are willing to pay for construction if they are not supported by the project. There are 4 provinces with the rate of 100%, namely Nam Dinh, Lao Cai, Soc Trang and Ben Tre. 34.6% of households are willing to borrow money for construction of biogas plants. This rate is particularly high in Bac Giang and Ha Tinh, 78.6% and 69.2% respectively. Nam Dinh and Lao Cai provinces are the lowest (16.7%).

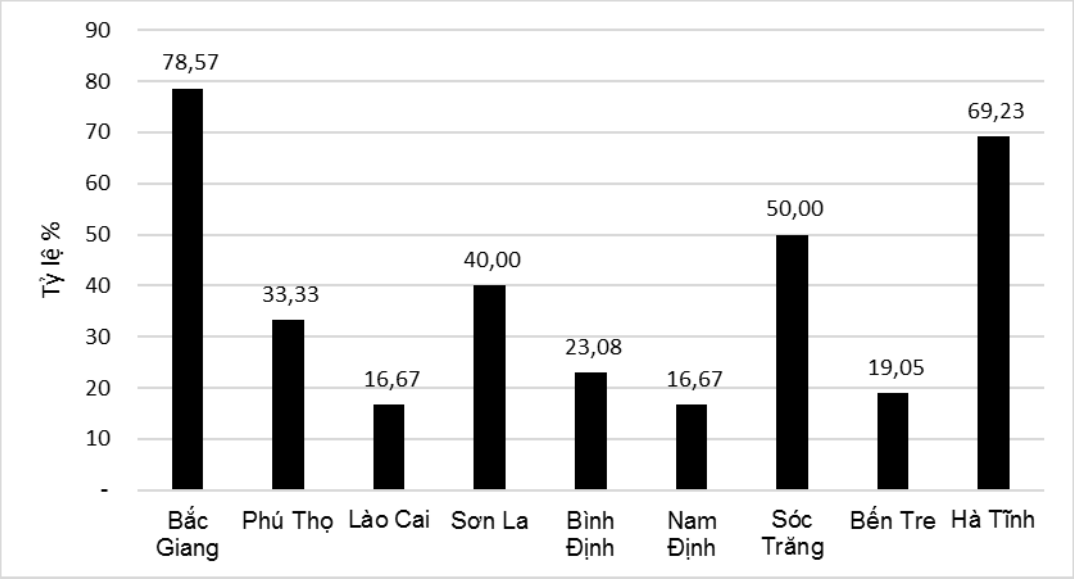

Figure 6. Proportion of willingness to borrow money for construction/installation of biogas plants of the households who are constructing the plants (%)

Similarly to the households that have been built, bank loan is the best option for the households who are constructing. This rate is highest in Lao Cai, Nam Dinh, Binh Dinh, and Soc Trang. However, for Son La province, the top choice for a loan is asking from relatives.

Table 15. Proposed capital resources for construction/installation of biogas plants in under-construction households (%)

Province	Friend	Relative	Bank	Other credit
Bac Giang	27.3	36.4	45.5	0
Phu Tho	50	25	50	0
Lao Cai	0	0	100	0
Son La	50	100	0	0
Binh Dinh	0	0	100	0
Nam Dinh	0	0	100	0
Tien Giang	0	0	100	0
Soc Trang	0	25	75	0
Ben Tre	0	33.3	55.6	11.1
Ha Tinh	27.3	36.4	45.5	0

The credit support component of the project is designed to develop infrastructure of biogas value chain. In particular, it focus on construction of waste collection systems, biogas tanks, gas-using equipment, construction items related to environmental treatment, construction items related to production of organic fertilizer, hygienic works to avoid spreading diseases to livestock. In other words, credit loans are designed to help households deal fully with animal waste in the biogas value chain. The credit component accounts for 50% of the total project fund. However, the delays in disbursement of this component had a great impact on overall implementation of the project. In 2017, the two banks mentioned above have just disbursed 28 loans, the disbursement amount was approximately 3 billion VND. The average amount was over 107 million VND/loan. Thus, the total accumulated disbursement amount to the end of 2017 is 16.5 billion VND, the average amount is about 45.5 million VND/loan.

The survey in 10 project provinces and at the households showed that there are many different reasons leading to slow disbursement of credit component:

i) *Loan conditions:* In fact, there are many items that are eligible for credit loans, but these items do not include construction or repair of livestock facilities. While this is an item that people have a very high demand. With households who have had stable livestock facilities, they want to invest in livestock (buying more seeds, raising livestock etc.) but they are not eligible for a loan. Thus, the purpose of lending and purpose of loan has many points that are not compatible with each other.

ii) *Collateral assets:* If only construction of small biogas plants, financial support of the project accounted for 15% - 40% of the construction value. So, the people only need to borrow about 8-10 million if they must use loan. This loan is low but it still requires

people to have collateral. This does not fit the reality when many households have mortgaged their assets at the Bank for the previous loans.

iii) *Borrowing Procedures:* Although the value of loan is low and small, the bank staff still has to complete the required documents. Loan applications must comply with the Bank's procedures, and it also requires a series of other documents (copies of the forms in the financial support profile). This means that the household have to mobilize funds for construction in advance, then they will complete procedures to borrow money from Bank. This clearly puts great financial pressure on households and many households are unlikely to meet the demand.

iv) In comparison with the Vietnam Bank for Social Policies (VBSP), VBARD and the Cooperative Bank do not have many advantages in disbursing small loans to households. According to regulations with loans of less than 50 million VND, VBSP can lend without collateral but only through security of Socio-Political Organizations (Farmers' Association, Women Association, Youth Union, Veterans Association...). Thus, with the involvement of VBSP, many existing bottlenecks of the credit component could be addressed and the progress of this component would be improved.

7. Document filing at the PPMUs

According to the project regulations, forms related to supporting documentation for households include:

- Form 01: Application
- Form 02: Technical and financial support contract for construction of biogas plant
- Form 03: Minutes of technical inspection and acceptance for construction of biogas plants
- Form 04: Evaluation minutes of the biogas plant in operation
- Form 05: Audit log of biogas plant

Initially, the basic information of these forms was entered and stored in Form 06 for monitoring and evaluation. After a period of time, the Central PMU has designed a software for management of biogas plants to allow data to be imported online and managed online at website http://khisinhhocvietnam.com.

The results of document examination at the PPMUs show that a set of records consists forms 01, 02, 03; 04. In addition, the dossier also contains a copy of ID card of the biogas plant's owner and a copy of training certificate. In some provinces, it also includes a quality certification of biogas plants by CPS, together with the Bank's payment slip. In general, the number of forms and arrangement of the dossiers are in line with the regulations of Central Project Management Unit. Detailed checking for each form show that the forms are fully informative. A small number of forms are missing information but it is not significant. The level of lacked information in the forms and between provinces are different.

For Form 01, based on the project regulations, the information to be checked includes: (i) information of the application; (2) confirmation by CPC; (iii) signature of the people; (iv)

household's information. The results showed that the CPC's confirmation and signature of local people was very sufficient in most provinces. While, the contents on household's information is lacked more than other sections, especially ID information of the owner's wife. This is partly because many rural women do not have ID card.

Table 16. Results of document examination - Form 01

Province	Enough information in the application	Confirmed by CPC	Full signature of local people	Adequate information on the household
Bac Giang	99.6	100	100	66.5
Phu Tho	98.3	99.9	99.9	91.2
Lao Cai	100	100	99.9	97.6
Son La	99.7	100	100	84.0
Nam Dinh	99.9	99.3	99.9	49.6
Ha Tinh	98.3	99.8	99.9	71.9
Binh Dinh	100	100	99.8	96.9
Tien Giang	100	100	100	99.7
Ben Tre	85.3	100	100	84.1
Soc Trang	85.0	100	100	84.2
Average	***97.0***	***99.9***	***99.9***	***81.2***

For Form 02 (Technical and financial assistance contract for construction of biogas plant), the information to be checked includes: (i) Information of the contract; (ii) Confirmation by the PPMU; (iii) confirmation of local people; (iv) Contractor's certification (biogas plant construction/installation). The results of document examination showed that the information provided in Form 2 is more sufficient than in Form 1. The information reached over 90%, many information reached nearly 100%. Some provinces that have high completion rate for Form 2 are Binh Dinh, Ha Tinh, and Lao Cai and Soc Trang provinces.

Table 17. Results of document examination - Form 02

Province	Enough information in the contract	Confirmed by PPMU	Confirmed by local people	Confirmed by the contractor
Bac Giang	98.4	68.6	99.9	99.9
Phu Tho	98.5	85.5	99.9	99.9
Lao Cai	100	99.3	100	99.7
Son La	84.4	100	100	100
Nam Dinh	91.6	98.5	98.5	98.4
Ha Tinh	99.8	99.9	99.9	99.7

Province	Enough information in the contract	Confirmed by PPMU	Confirmed by local people	Confirmed by the contractor
Binh Dinh	100	99.7	100	99.8
Tien Giang	99.8	99.4	99.7	100
Ben Tre	82.2	100	100	100
Soc Trang	100	100	100	100
Average	***96.0***	***92.6***	***99.8***	***99.7***

For Form 03 (checking and technical acceptance minutes of biogas plant construction), the information that need to be checked includes: (i) information on the examination report; (ii) certification by technician; (iii) confirmation by local people; (iv) confirmation of the installation group/mason team. The results of checking documents showed that this form also had a high degree of completion, especially in Lao Cai, Binh Dinh and Tien Giang provinces.

Table 18. Result of document examination - Form 03

Province	Enough information in the examination report	Confirmed by technicians	Confirmed by local people	Confirmed by installer/ builder
Bac Giang	89.0	99.9	100.0	99.5
Phu Tho	99.0	99.7	100.0	99.8
Lao Cai	100.0	100.0	100.0	100.0
Son La	72.3	68.6	72.3	68.4
Nam Dinh	74.9	98.5	98.5	98.0
Ha Tinh	97.7	99.5	99.9	98.5
Binh Dinh	100.0	100.0	100.0	99.9
Tien Giang	100.0	99.8	100.0	99.9
Ben Tre	77.6	100.0	100.0	100.0
Soc Trang	100.0	100.0	100.0	100.0
Average	***91.6***	***98.4***	***98.7***	***98.2***

For the form 04 (the minutes of the evaluation of operating biogas plants), the information needs to be checked includes: (i) information on audit log; (ii) contents on the audit log; (iii) confirmation of people and technicians. Through examining records, generally this is a form with high level of completion, in which the most outstanding examples are Lao Cai, Binh Dinh, Tien Giang and Ben Tre.

Table 19. Results of examination of records - Form 04

Province	Enough information on the audit log	Enough contents on the audit log	Enough confirmation of local people and technicians

Province	Enough information on the audit log	Enough contents on the audit log	Enough confirmation of local people and technicians
Bac Giang	86.8	99.6	99.8
Phu Tho	98.2	99.9	99.9
Lao Cai	100.0	100.0	100
Son La	93.5	93.6	93.7
Nam Dinh	96.3	96.7	96.7
Ha Tinh	99.7	99.8	99.8
Binh Dinh	100.0	100.0	100.0
Tien Giang	100.0	100.0	100.0
Ben Tre	100.0	100.0	100.0
Soc Trang	100.0	100.0	100.0
Average	***97.0***	***99.3***	***99.3***

As analyzed above, in addition to the 01-04 forms, one set of record kept at the PPMUs also includes a copy of the training certificate. According to the project regulations, to receive support from the project, it is compulsory for people to complete the training activities of the project. In general, the level of completion of training certificates in the provinces was quite high, with an average of 96.6%.

For records storage at PPMUs, the survey results show that all PPMUs kept track of records by district and by year. Depending on the number of records of each district in the year, they would be divided into different periods. All the archives will be numbered in period and year. Some provinces also make a list of basic information about the households in the archive in each period in order to make it easy to track, search and manage information.

Importing data into the form 06 and entering them online after March 2016 happened quite smoothly. Working with data entry officers of CPMUs shows that the process of importing information online at the early stage has some problems such as: (i) The movement of the fields is not yet convenient; (ii) sometimes data can not be saved after the import; (iii) unfriendly looking information interface; (iv) the export of direct reports through software is difficult, etc. However, these issues were later fixed and the information stored on the website of the project operated smoothly, then improving the efficiency of monitoring, evaluation and project supervision.

8. Demand and ability to expand biogas plants

In the context of livestock production facing many difficulties, it is possible to see that the demand for construction/installation of biogas plants in 10 provinces of the project will not be as high as in previous periods. However, the survey results show that demand for construction/installation of biogas plants in 10 provinces of the project is still relatively high. According to the assessment of the households which have built underground digester, the demand for construction/installation of digesters in the local areas is quite high, at 26.7%, low

demand is 44.8%, the remaining 28.5% is unknown. Out of the 10 provinces, Binh Dinh, Lao Cai and Phu Tho are the ones where the percentage of people who think that the great demand for construction is higher than the other provinces.

Table 20. Assessing the demand for construction of biogas digester (%)

Province	**High**	**Low**	**Unknown**
Bac Giang	11.2	50.0	38.8
Phu Tho	32.9	44.3	22.9
Lao Cai	48.3	51.7	0.0
Son La	20.0	40.0	40.0
Binh Dinh	66.7	18.3	15.0
Nam Dinh	25.0	34.6	40.4
Tien Giang	8.0	72.0	20.0
Soc Trang	5.9	58.8	35.3
Ben Tre	34.2	50.0	15.8
Ha Tinh	17.7	38.7	43.5
Average	**26.7**	**44.8**	**28.5**

From the other perspective, it can be said that the demand for construction of biogas plants is still high. For households that are building digesters, 82.6% of them said they would be willing to pay for construction/installation without the support of the project. This clearly demonstrates the need of the households for the construction/installation of biogas plant. It should be noted that out of 82.6% of households willing to pay for the digester construction, 34.6% of them are willing to borrow money to build digesters. This means that the demand for biogas is still high. However, based on the actual implementation of the LCASP, biogas plant is not the only option to treat livestock waste. There are still other forms and other technologies should be used to support biogas technology in livestock waste treatment, especially for households with large livestock quantity. In fact, the level of overloaded biogas is very clear. Therefore, in order to effectively replicate biogas plants, it is necessary to expand other models and technologies such as separators, generators, compost tanks, etc or other livestock models based on organic fertilizer.

CHAPTER III. THE IMPACTS OF SUPPORTING THE CONSTRUCTION OF BIOGAS PLANTS UNDER THE LCASP

1. Effectiveness of livestock environment treatment

- *Situation of livestock waste treatment before having biogas plants:*

Before participating in the LCASP, livestock waste was treated in household by four methods: (i) discharge to the garden/field/pond (31.1%); (ii) composting (28.2%); natural decomposition (up to 20.9%); (iv) discharge into public sewer/ponds/lakes (14.8%), the rest are some other forms.

Table 21. Methods of livestock waste treatment before having biogas plants(%)

Province	Composting	Decomposition	Discharge into the garden/field/ pond of the family	Discharge into the sewer/ lake/pond
Bac Giang	36.6	14.6	34.1	11.0
Phu Tho	35.7	22.9	40.0	14.3
Lao Cai	70.0	10.0	10.0	23.3
Son La	36.7	33.3	16.7	0.0
Binh Dinh	8.3	40.0	58.3	28.3
Nam Dinh	5.8	21.2	50.0	3.8
Tien Giang	12.0	22.0	26.0	14.0
Soc Trang	11.8	5.9	47.1	26.5
Ben Tre	5.3	13.2	21.1	18.4
Ha Tinh	59.7	25.8	8.1	8.1
Average	**28.2**	**20.9**	**31.1**	**14.8**

Physical audit in households show that they are less likely to select at the same time two or above forms of livestock waste treatment. For composting, the average rate is 94.2%. For natural decay, the average waste rate is 89.4%. For household / home waste, the average waste rate is 80.8%. The last method is discharging into ponds, sewers, the rate is 70.4%. The non-diversified livestock waste treatment habit before having biogas plants continues to affect the behavior of households, after having the biogas, there are likely no alternative treatment options other than putting down to digesters.

Table 22. An average rate of waste that is treated in each method before having biogas plants (%)

Value	Composting	Decomposition	Discharge into the garden/field/ pond of the family	Discharge into the sewer/ lake/pond
Mean	94.2	89.4	80.8	70.4
Mode	100	100	100	100
Minimum	20	20	10	10
Maximum	100	100	100	100

The common scale of livestock production of households before having biogas plants was 12 pigs (11 pigs and one sow). As such, it can be seen that the amount of daily livestock waste discharged into the environment is very large so the livestock pollution is also very serious. Therefore, the treatment of livestock environment is the option and inevitable demand of many households.

- *The situation of livestock waste treatment after having biogas plants:*

For households, there are two main purposes for selecting biogas plants: livestock waste treatment and additional fuel. In most provinces, the two purposes are almost inseparable (84.6% of surveyed households confirmed both purposes as the main purpose for the construction of biogas works). Therefore, the construction of biogas plants will not only bring income to the farmers, but also help the livestock environment treatment in the household become efficient and quick, reducing labor.

Table 23. Main purposes for digester construction (%)

Province	Waste treatment	More fuel for family use	Both of these purposes
Bac Giang	17.50	5.00	77.50
Phu Tho	2.90	5.70	91.40
Lao Cai	10.30	0	89.70
Son La	13.30	6.70	80.00
Binh Dinh	25.00	3.30	71.70
Nam Dinh	48.10	0	51.90
Tien Giang	4.00	0	96.00
Soc Trang	0	0	100.00
Ben Tre	5.30	0	94.70
Ha Tinh	4.80	1.60	93.50
Average	**13.1**	**2.2**	**84.6**

The survey shows that nearly 100% of households that built biogas digester have put livestock waste into digesters. The rate of selection of other methods is very low, especially the method that is harmful to the environment such as disposing directly to the

garden/field/pond of the family or discharging into the sewers/ponds is almost no longer. This is a very positive environmental result that the project has achieved. In addition, some households have also chosen other methods of waste treatment such as composting or natural decomposition to reduce the status of overloaded biogas plants.

Table 24. Methods of livestock waste treatment after having biogas plants (%)

Province	Put into the digester	Composting	Decomposition	Discharge into the garden/ field/ pond of the family	Discharge into the sewer/ lake/pond
Bac Giang	100	1.3	0.0	0.0	0.0
Phu Tho	98.6	14.3	0.0	0.0	0.0
Lao Cai	100	6.9	0.0	0.0	0.0
Son La	100	13.3	3.3	0.0	0.0
Binh Dinh	100	0.0	0.0	0.0	0.0
Nam Dinh	100	5.8	1.9	7.7	0.0
Tien Giang	100	12.0	22.0	0.0	0.0
Soc Trang	100	2.9	38.2	0.0	0.0
Ben Tre	100	2.6	31.6	0.0	0.0
Ha Tinh	100	8.1	3.2	0.0	0.0

According to statistical analysis, 91.2% of livestock waste is discharged into biogas digesters by households. Among them, many households discharge 100% of the waste into the biogas digesters. For households choosing the composting, the average amount of waste composted is 40.6%. On a small scale, compared to other methods of livestock waste treatment, composting is the most appropriate. This method is not only easy to implement but the cost of implementation is very low and is able to support the biogas digesters well in thoroughly processing livestock waste.

Table 25. An average rate of waste that is treated in each method after having biogas digesters (%)

Value	Put into the digester	Composting	Decomposition	Discharge into the garden/field/ pond of the family	Discharge into the sewer/ lake/pond
Mean	91.2	40.6	71.8	45.0	0
Mode	100	50	80	50.0	0
Minimum	10	10	10	30.0	0
Maximum	100	90	100	50.0	0

Therefore, after the construction of biogas plants, although some households in Nam Dinh still directly discharge waste into their own fields, none of the households directly discharge the waste into the sewers or ponds outside.

- *Effectiveness of using biogas at households:*

The majority of biogas is used by households mainly for cooking purposes, accounting for 94.6%. In many provinces, the rate is 100%, such as Son La or Soc Trang. Apart from this main purpose, biogas is also used for cooking rice bran, which is about 40.6% of households. The use of biogas for other purposes such as cooking wine, lighting, processing noodles is very low. In Ben Tre, Son La, there is a relatively large portion of biogas shared with neighbors (21.1% and 6.7% respectively)

Table 26. Purposes of biogas use of the family (%)

Province	Cooking	Cooking rice bran	Cooking wine	Running generator	Lighting	Boiling water, slaughtering livestock	Sharing for neighbors	Processing noodles, beans	Others
Bac Giang	83.8	78.8	1.3	0	1.3	0		1.3	0
Phu Tho	97.1	32.9	1.4	0	1.4	0	0	0	1.4
Lao Cai	96.6	58.6	3.4	0	0	0	0	0	0
Son La	100	20	3.3	0	3.3	0	6.7	0	0
Binh Dinh	98.3	61.7	3.3	0	0	0	0	0	0
Nam Dinh	84.6	44.2	3.8	0	7.7	3.8	0	0	5.8
Tien Giang	92	30	12	0	0	0	0	0	4
Soc Trang	100	23.5	2.9	0	0	0	2.9	0	29.4
Ben Tre	97.4	7.9	5.3	0	0	0	21.1	0	0
Ha Tinh	96.7	49.2	4.9	0	1.6	0	1.6	0	3.3
Average	**94.65**	**40.68**	**4.16**	**0**	**1.53**	**0.38**	**3.23**	**0.13**	**4.39**

Generally, the amount of biogas generated by households is sufficient, accounting for 67.6%. Meanwhile, about 20% of households assess that the gas generated is excessive and over 12.2% is by contrast. Ben Tre, Tien Giang and Son La provinces have a large amount of excess gas. Phu Tho, Bac Giang and Ha Tinh are the provinces that have many households claim that the gas produced is not enough to use. For the provinces of Phu Tho, Bac Giang and Ha Tinh, the scale of livestock production is relatively large compared to other provinces so when the livestock market fluctuates sharply, it has led to a sudden decline or even stop the production in some households. Therefore, in these provinces, the percentage of households

assessing the amount of biogas is lacking compared to the demand for use is higher than other provinces.

Table 27. Level of response of the amount of biogas in comparison with demand (%)

Province	Excess	Enough	Lack
Bac Giang	13.80	71.30	15.00
Phu Tho	11.40	60.00	28.60
Lao Cai	10.30	75.90	13.80
Son La	23.30	66.70	10.00
Binh Dinh	13.30	75.00	11.70
Nam Dinh	17.30	75.00	7.70
Tien Giang	38.00	54.00	8.00
Soc Trang	14.70	82.40	2.90
Ben Tre	47.40	42.10	10.50
Ha Tinh	11.30	74.20	14.50

The average amount of biogas used daily in Son La, Tien Giang, Ben Tre estimates about 80% of total gas. Meanwhile, in Lao Cai, Soc Trang, Phu Tho, Ha Tinh or Bac Giang, the estimated gas used is over 90%. Generally, for the 10 project provinces, the average daily biogas utilization rate accounts for 86.8% of the total gas produced. Thus, this indicator has reached and exceeded the targets set in the DMF of the project.

Table 28. Amount of gas produced daily at livestock households (%)

Provinces	Estimates of used gas/generated gas by %
Bac Giang	90.06
Phu Tho	91.01
Lao Cai	95.71
Son La	81.67
Binh Dinh	85.44
Nam Dinh	81.69
Tien Giang	77.23
Soc Trang	95.00
Ben Tre	77.57
Ha Tinh	93.16

Particularly for households with excess biogas (about 20% of the total surveyed households), the excess gas treatment methods are also quite diverse. In particular, the common option is burning out (accounting for 45.2%), while also many households opt for

sharing with their neighbors (34.4%), the option of discharging into the environment accounts for 23.2%. For households discharging waste into the environment, their estimated portion of environmental emissions is 10% of the total amount of gas produced.

Table 29. Forms of treatment when having excess gas (%)

Province	For neighbors	Burning	Discharge into the environment
Bac Giang	45.50	27.30	27.30
Phu Tho	-	37.50	62.50
Lao Cai	-	66.70	33.30
Son La	28.60	85.70	14.30
Binh Dinh	42.90	42.90	14.30
Nam Dinh	11.10	44.40	44.40
Tien Giang	57.90	36.80	5.30
Soc Trang	40.00	40.00	20.00
Ben Tre	61.10	27.80	11.10
Ha Tinh	57.10	42.90	-
Average	**34.4**	**45.2**	**23.2**

- *Reduce greenhouse gas emissions:*

The total volume of 508 digesters surveyed is 4833.8 m3. Meanwhile, until 31/12/2017, the entire LCASP project has deployed 51,210 small-scale plants, 23 medium-sized plants and 2 large-scale plants. Of which 50,078 small plants, 19 medium-sized ones and 2 large-sized ones have been accepted. The number of supported plants is 48,213 for small-sized plants, 12 for medium-sized ones and 2 for large ones. As a result, for small plants, if the average volume is 9.57 m3 per a plant, the total volume of the whole small plant is 479,340 m3 (calculated on the number of plants already accepted).

According to the results published in the **Report on Installation of biogas plants to reduce greenhouse gas emissions of the LCASP**, announced in August 2017, the GHG emission reduction of the biogas digesters built in the LCASP fluctuates from about 4.62 to 4.694 tons CO2e/digester/year, the best value is 4.62 tons CO2e per year. This means that each year the project contributes to reduce greenhouse gas emissions by 231,360.4 tons CO2. In other words, each m3 of LCASP's biogas plants reduces emissions by 0.483 tCO2/yr.

According to the research results approved by Biogas Program for the livestock industry in Vietnam, a biogas plant each year reduces 6 tons of CO2. This means that each year the project contributes to reduce greenhouse gas emissions by 300,468 tons of CO2. In other words, each m3 of LCASP's biogas plants reduces emissions by 0.627 tons CO2 per year.

Thus, with both methods, the biogas plants of the LCASP reduce GHG emissions equivalent to 0.2 tons of CO2 annually per cubic meter of biogas plants

- *The effectiveness of using waste after biogas plants:*

The waste from the biogas plant is still mainly wastewater. The slurry is only a small proportion and many households do not have it because the new biogas plant has just been put into operation.

For wastewater use after biogas plants in 10 provinces, the option for fertilizer accounts for the highest percentage (58.4%), followed by discharging into the environment (48.4%), and last one is for discharging into fish ponds.

Table 30. Waste treatment after having biogas plants (%)

Province	For Gardening	For fish	Discharge into the environment
Bac Giang	20.30	7.59	83.54
Phu Tho	88.60	-	15.71
Lao Cai	82.76	-	37.93
Son La	86.20	-	20.69
Binh Dinh	83.33	-	21.67
Nam Dinh	44.23	5.80	69.20
Tien Giang	53.10	4.08	48.98
Soc Trang	11.76	5.88	85.29
Ben Tre	52.60	13.20	44.74
Ha Tinh	61.00	1.69	55.93
Average	**58.4**	**3.8**	**48.4**

The level of diversity in the use of wastewater treatment after biogas plants is not high. Households usually only choose one method of treatment. In particular, the average rate of wastewater treatment for irrigation in gardens, fields of households is 90.9% and in many households the number is 100%. However, for the households applying the method of discharging into the environment, the rate of wastewater discharged into the environment is also 89.2%. According to local people, they do not know how to treat this wastewater properly as there are many households that are not favorable to transport to the field. Therefore, they still choose the method of discharging into the environment, despite knowing that it will lead to environmental pollution. This is still a pressing problem with no measure available that the project will have to pay more attention in the future.

Table 31. Wastewater treatment after biogas plants by methods in average (%)

Value	For Gardening	For fish	Discharge into the environment
Mean	90.9	87.8	89.2
Mode	100	100	100
Minimum	10	50	10

Maximum	100	100	100

Only about 35% of households have slurry after biogas plants. Among them, the most popular option for these households is still fertilizer (26%), followed by environment disposal (9.1%) and less than 1% for fish ponds. The provinces of Binh Dinh, Son La and Lao Cai are the areas using slurry after the digesters to make the most fertilizer. Selection of waste discharged into the environment after biogas plants in Bac Giang, Lao Cai is much higher than that in the remaining areas.

Table 32. Methods of sludge treatment after having biogas plants (%)

Province	**For Gardening**	**For fish**	**Discharge into the environment**
Bac Giang	8.80	1.20	20.00
Phu Tho	32.90	-	4.30
Lao Cai	41.40	-	20.70
Son La	44.80	-	10.30
Binh Dinh	55.00	-	-
Nam Dinh	11.50	1.90	7.70
Tien Giang	14.30	-	4.10
Soc Trang	8.80	2.90	11.80
Ben Tre	18.40	-	13.20
Ha Tinh	32.30	1.60	4.80
Average	**26.8**	**0.8**	**9.1**

Similar to wastewater after the digester, the method of treating slurry of households is usually only one way. The average treated slurry is 97.4%, which is almost absolute for households choosing this method. At the same time, for the households who choose to discharge into the environment, the average slurry ratio is 89.3%. Although the percentage of households discharging into the environment is only one third of the number of households using slurry as fertilizer, as fish feed, these figures still show the gaps that the project needs to handle after biogas digester.

Table 33. Average rate of sludge treatment in all forms (%)

Value	**For Gardening**	**For fish**	**Discharge into the environment**
Mean	97.4	100	89.3
Mode	100	100	100
Minimum	30	100	10
Maximum	100	100	100

Prior to the biogas plants, one out of ten households had their neighbors that complain about pollution, with an average of 10.6%. After having biogas plants, this figure is only 1.8%. In particular, many localities have not complained about environmental pollution caused by livestock after having biogas plants such as in Soc Trang, Tien Giang, Nam Dinh, Phu Tho or Ha Tinh. Son La has the highest rate of complaints about livestock contamination before having the biogas plants (20.7%). This rate has decreased to 6.9% for households after having biogas plants.

Table 34. Complaints about pollution caused by livestock production before and after having biogas plants (%)

Province	**Before having biogas digesters**	**After having biogas digesters**
Bac Giang	10.13	1.27
Phu Tho	5.71	-
Lao Cai	17.24	3.45
Son La	20.69	6.90
Binh Dinh	18.33	3.33
Nam Dinh	5.77	-
Tien Giang	6.12	-
Soc Trang	2.94	-
Ben Tre	10.53	2.63
Ha Tinh	8.06	-

- *Satisfaction level of people on biogas plants of the project:*

Compared to other projects, people participating in the LCASP must build an additional environmental package to receive financial support. The effect of the environmental package on households is very different, but essentially contributes to address the environmental issues in livestock production along with biogas digesters. When being compared, wastewater is cleaner than that from biogas digesters. Therefore, the overall level of satisfaction of local people on the environmental package is very high.

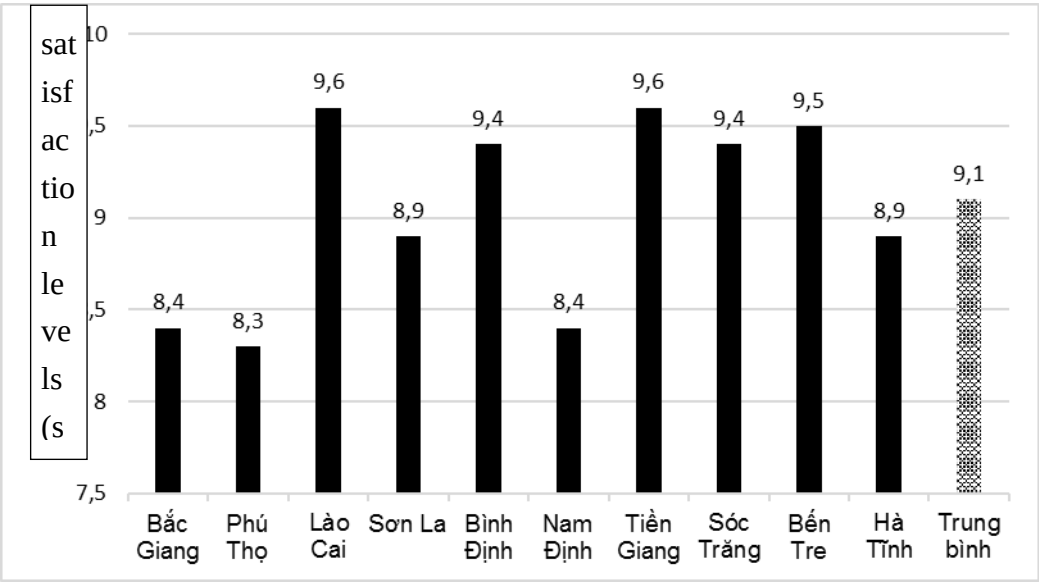

Figure 7. Satisfaction level about environmental package (on a scale of 10))

Some existing problems:

- Results of the actual inspection at the households show that there are three aspects that need to be considered when constructing biogas plants: (i) overloading capacity of biogas digesters; (ii) gas excess status and (iii) difficulties in using slurry, wastewater after biogas digesters as follows
- *Overload of capacity of biogas plants:*

In 2017, as pig prices were still low, the scale of livestock production had a tendency to decrease at households, especially small-scale producers. However, this does not mean that the livestock over-production compared to the capacity of biogas plants will not occur. According to the theory, each pig requires about 1m3 of the digester to treat livestock waste. The results of physical audit show that the average volume of biogas plants is 9.57m3. Meanwhile, the average size of porkers is 24, not including cattle. At its peak time, the average porker size is up to 39, not including cattle. Many households usually raise 2-3 pigs per 1m3. Most people consider biogas plants to be a very effective tool for livestock waste treatment. As a result, almost all of the waste is put down to the digesters with an amount of rinse water that always exceeds the recommended limit. If the rate of raising one pig is 1 m3 biogas plant, then 47.5% of households have livestock scale suitable for the scale of biogas plants. The rate of households exceeding the digester volume from 1.1 to 2 times accounts for 22.4%. The rate of households exceeding the digester volume from 2.1 times to 3 times accounts for 11.3%. The rate of households exceeding the digester volume from 3.1 times or over accounts for 18.8%. There are also differences between provinces like Ben Tre, Son La, Tien Giang and Lao Cai and the other provinces. Particularly in Bac Giang, the rate of livestock production is the highest, which is suitable for the fact that households in Bac Giang often choose digesters with large volume.

Table 35. Comparison between livestock size and digester volume

Province	Less than once	From 1.1 to 2 times	From 2.1 to 3 times	Over 3 times

Bac Giang	88.7	9.7	1.6	0.0
Phu Tho	68.3	22.2	4.8	4.8
Lao Cai	48.3	20.7	6.9	24.1
Son La	37.0	14.8	7.4	40.7
Binh Dinh	46.4	23.2	16.1	14.3
Nam Dinh	27.7	36.2	14.9	21.3
Tien Giang	21.2	27.3	15.2	36.4
Soc Trang	29.4	17.6	41.2	11.8
Ben Tre	7.1	21.4	7.1	64.3
Ha Tinh	41.5	28.3	17.0	13.2

The results of the physical audit show that up to 99% of the households put their livestock waste into the digester. In particular, 83.6% of the total livestock waste is discharged into the digester without using any method of livestock waste treatment. Only 6.3% of households have composted organic waste and treated livestock waste through biogas plants. Thus, the overload of biogas plants capacity is clearly a common phenomenon. Therefore, it is necessary to apply other technologies to support biogas plants in the treatment of livestock waste, especially at households with dozens of pigs or more.

- *Excess biogas:*

Results of the physical audit at households show that 94.6% of households use biogas for daily living, with an estimated usage of 0.3 m^3 per adolescent for daily meals[8]. Also, with the average household size of 4, each family will need at least 1,2 m^3 of biogas per day. Thus, based on surveyed households, the total volume of biogas generated per day is 1.222 m^3 (applying the formula of 0.2 m^3 generated biogas per 1 m^3 digester volume)[9]. Meanwhile, calculations of biogas usage capacity of each household, based on number of household members and daily activities, show that the total volume of biogas used per day is 714.84 m^3 (accounting for 58.5% of total generated biogas). Specifically, 12.3% of households lack access to biogas, 6.8% have 100% volume of generated and used biogas, and the remaining 80.9% have excess biogas. However, the excess levels are varied among households. Evidently, of the above 80.9%, 48.6% have excess level at 1 m3/day, 17.8% at 1 m^3 – 1.9 m^3/day and 14.6% at more than 2 m^3/day. Therefore, the number of households with excess biogas is higher than the estimates calculated by households themselves[10]. However, if the percentage of households with excess biogas of below 1 m^3 is not to be accounted, the rate of excess gas (1m3 or more) accounts for 32.4%.. Compared to estimates done by households, this calculation shows that biogas is still not used to the fullest extent as expected. This is due

[8] Nguyen The Hinh, *Research on the economic efficiency of biogas plants to explain the behavior of households in biogas investment*, Journal of Agriculture and Rural Development, No. 18, 2017, page 8
[9]Nguyen The Hinh, *Research on the economic efficiency of biogas plants to explain the behavior of households in biogas investment*, Journal of Agriculture and Rural Development, No. 18, 2017, page 8
[10]According to estimates by households, 67.6% of digesters provide enough biogas for households, about 20% excess biogas, and the rest is lacking.

to the fact that many households prefer digesters with large capacity, despite minimal biogas demand. Some households also shared with their neighbors, but this number is still insignificant.

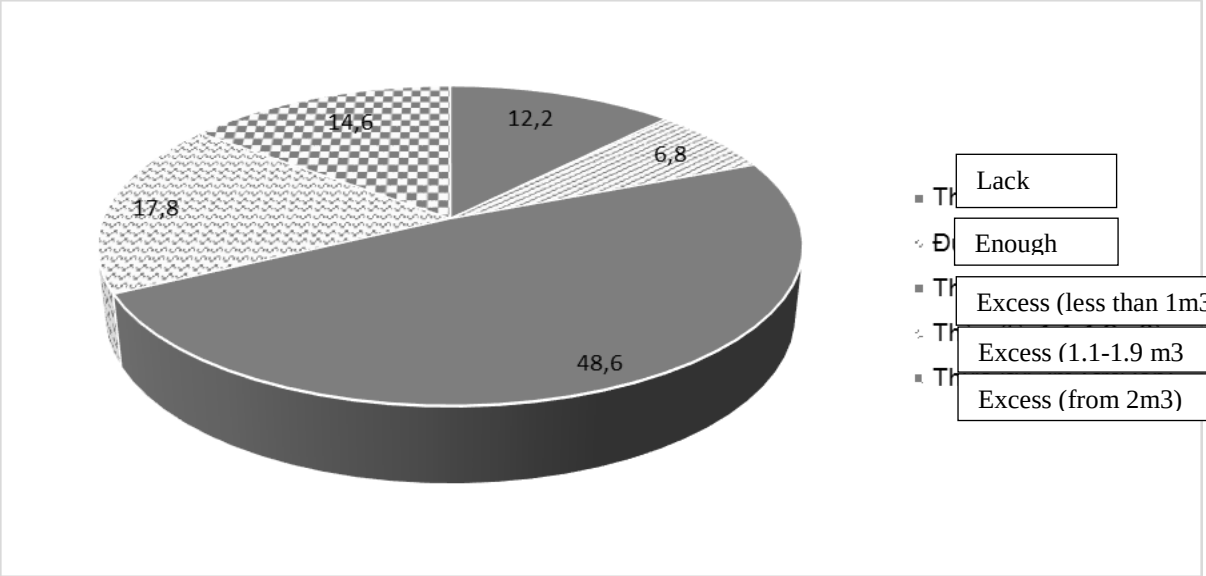

Figure 8. Gas percentage of households (%)

The above formula also demonstrates the suitability of digester volume with 9 m^3 capacity for household sizes of 4-5 individuals (smaller capacities may not be sufficient in some situations). In instances that households perform activities that consume larger volumes of biogas, they may opt the digester volume of 12 m^3 capacity and smaller variations. Choosing the right biogas plants will help prevent excess biogas and increase efficiency in biogas usage and protect the environment.

Table 36. Rate of gas used in the surveyed households according to the digester volume and number of livestock (%)

Province	**Lack**	**Enough**	**Excess (from 0.1-1m^3)**	**Excess (1.1-1.9m^3)**	**Over 2m^3**
Bac Giang	5.1	0.0	5.1	19.0	70.9
Phu Tho	8.6	4.3	52.9	31.4	2.9
Lao Cai	20.7	3.4	62.1	10.3	3.4
Son La	16.7	23.3	53.3	6.7	0.0
Binh Dinh	11.7	11.7	53.3	20.0	3.3
Nam Dinh	21.2	7.7	53.8	17.3	0.0
Tien Giang	0.0	0.0	20.0	36.0	44.0
Soc Trang	20.6	5.9	64.7	5.9	2.9
Ben Tre	5.3	5.3	57.9	13.2	18.4
Ha Tinh	12.9	6.5	62.9	17.7	0.0

- *Difficulty in using slurry and wastewater after biogas plants:*

Among the solutions for using wastewater after biogas plants, conversion into fertilizer for gardening accounts for the highest percentage, with 58.4% of households while dumping into the environment accounts for 48.3%. Of these 48.3% households, 80.4% choose to dump the entire wastewater volumes into the environment.

Similarly, 35% of total households with slurry also choose to dump into the environment (9.1%). Of these 35%, 81.8% choose to dump the entire slurry volume into the environment. It can be seen that the effectiveness of using slurry and wastewater in this phase is low. This is because the majority of farmers tend to use chemical fertilizers in agricultural production, hence slurry is still not used as a popular fertilizer source. On the other hand, some households claim that they are not thoroughly instructed on how to process and re-use slurry and wastewater for plants, so they avoid using them as fertilizers.

2. Economic effectiveness

Overall, the average cost for households to construct biogas plants is VND 15 million, including VND 3-5 million for special support for priotized households and the actual cost of VND 10-12 million for the biogas plants. Meanwhile, households can save up VND 131,000/month on fuel purchasing costs, accummulating to VND 1,580,000 annually. This means over the space of 6-7 years, fuel savings money alone can compensate for the biogas plant construction cost. For households that are already constructing biogas digesters, the average cost for fuel today is VND 207,000/month. It means instead of 6-7 years, the timeframe to compensate for construction cost is just 4 years. Another notable aspect is that neighboring households also benefit economically from biogas digesters via shared biogas. Approximately 20% of surveyed households have excess biogas and they are sharing with their neighbors. This demonstrates the expanding economical impact that biogas digesters can bring about. In theory, if each household saves up to VND 1.58 million annually, all 65,000 biogas plants of the entire LCASP can save up to VND 100 billion annually, equivalent to a large amount of or wood that will be consumed if not having biogas plants. Therefore, the government should consider expanding the scope of propaganda and providing additional support for citizens constructing biogas plants on a smaller scale in other provinces outside the project.

Table 37. Cost of fuel purchasing before and after having biogas plants of the households (%)

	Average monthly amount of fuels before having biogas digesters (VND 1,000)	**Average monthly amount of fuels after having biogas digesters (VND 1,000)**	**Reduction (times)**
Bac Giang	257.27	63.77	4.03
Phu Tho	135.06	30.43	4.44
Lao Cai	145.86	33.45	4.36
Son La	159.66	27.24	5.86

Binh Dinh	119	28.3	4.20
Nam Dinh	303	106.9	2.83
Tien Giang	145.11	30	4.84
Soc Trang	197.94	30	6.60
Ben Tre	56.84	18.4	3.09
Ha Tinh	148.55	28.63	5.19
Average	**166.829**	**35.165**	**4.74**

3. Social effectiveness

According to the the project's DMF until 2018, after the construction of biogas plants, working hours for women and children will be reduced by 1.8-2hrs/day. This target shows the role of biogas plants in resolving labor-related issues of women and children in homes. These occupations have long been considered to be women's duties, especially sanitizing farms and cooking (including meal preparation).

Table 38. Average time for barn cleaning before and after having biogas plants

Province	Average time for barn cleaning before having biogas digesters (hours/day)	Average time for barn cleaning after having biogas digesters (hours/day)	Reduction (hours)
Bac Giang	2.04	1.29	0.75
Phu Tho	1.73	0.74	0.99
Lao Cai	1.31	0.53	0.78
Son La	2.16	1.27	0.89
Binh Dinh	2.53	1.07	1.46
Nam Dinh	2.41	1.93	0.48
Tien Giang	1.7	1.38	0.32
Soc Trang	1.67	1.5	0.17
Ben Tre	1.46	0.92	0.54
Ha Tinh	1.8	1.29	0.51
Average	**1.94**	**1.2**	**0.74**

Prior to the construction of biogas plants, the average time spent for sanitizing farms of households is 1.94hrs/day. For households already constructing biogas digesters, this time length is 1.55hrs/day. After biogas plants come into effect, it is 1.2 hrs/day. Therefore, on average, biogas plants help reduce the time spent for sanitizing farms by 0.74 hours. Among the 10 project provinces, Binh Dinh province has witnessed the most dramatic reduction at

1.46 hours compared to before biogas plants. Baseline data in 2013[11] showed that the previous time length was 2.8 hours. As a result, in 2017, the time required for women to sanitize farms and feeding livestock has decreased by 1.6hrs/day.

Regarding daily preparation of meals, women needed to spend 1.54hrs/day before having biogas plants and 1.15hrs/day after having biogas digesters, saving 0.39 hrs/day. Again, Binh Dinh has witnessed the most dramatic reduction of time spent to prepare meals for women at 1.03hrs/day. Baseline data in 2013[12] showed that the previous time length was 1.54 hours. As a result, in 2017, the time required for meal preparation has decreased by 0.39 hrs/day.

Table 39. Time for meal preparation before and after having biogas plants

	Average time for meal preparation of women before having biogas digesters	**Average time for meal preparation of women after having biogas digesters**	**Reduction (hours)**
Bac Giang	1.75	1.3	0.45
Phu Tho	0.98	0.65	0.33
Lao Cai	1.41	0.83	0.58
Son La	1.9	1.64	0.26
Binh Dinh	1.85	0.82	1.03
Nam Dinh	1.71	1.68	0.03
Tien Giang	1.4	1.23	0.17
Soc Trang	1.43	1.28	0.15
Ben Tre	1.09	0.92	0.17
Ha Tinh	1.36	1.24	0.12
Average	**1.54**	**1.15**	**0.39**

For children, due to many households not having children or having children incapable of being involved in these activities, only several localities have limited recorded information regarding reduced labor time for children.

As a result, the amount of daily work for women and children decreased by 1.8-2hrs/day compared to the project's DMF, while according to Baseline Survey in 2013, this number was 1.99hrs/day. If taking the range of households surveyed in 2017 (before and after having biogas digesters), the time length is reduced by 1.07hrs/day compared to before having biogas plants.

[11]LCASP Baseline Survey Report (2016)
[12]LCASP, Baseline Survey Report (2016)

Some limitations:

- Small-scale biogas plants are the optimal option, especially for disgester volume of 9-12 m3. However, in reality, this investment, although supported by the project, is still a big investment with many farmers. The survey results show that for the households that built biogas plants, only 1.8% are poor households, 2% are near-poor households. Most of the households are middle-income households, while the remaining households are households with above average income Thus, the finance is still a major barrier to access to biogas technology from the project. Moreover, investment in biogas technology is a long-term investment and the profitability of this investment is much lower than that of other production sectors. Calculations show[13] that the return on investment (ROI) of a farrow of pigs is 25% - 35%. Some cases, this rate is up to 50% (when the pig is sold at a high price). Within one year, a household can invest 2-3 farrows of pigs. Meanwhile, although it is significant in terms of environmental treatment, the return on investment of biogas plants is low with long recovery. For plants with high ROI (about 9m3 or less) it usually takes over the space of 6-7 years to recover capital, not including the larger the volume, the lower the ROI and the longer. Therefore, many people are not interested in biogas plants because of economic issues, especially for disadvantaged groups. Therefore, despite knowing the benefits of the biogas plants, not all households have access to the project, even if the level of support has been adjusted up to VND 5 million per household for disadvantaged groups.

- Thanks to the biogas plants, the time spent for meal preparation of women and children has been significantly reduced compared to that in 2013. This reduction has been achieved the objective of the DMF. However, in comparison with the surveyed households in 2017, the reduction is not high. This is an important part because most of the surveyed households built digesters in 2016, some households built digesters in 2017. Therefore, the use of industrial gas is much more common than the time before 2013.

- Another problem is that while women reduced their time to clean the barn and prepare meals, their free time is spent mainly for other tasks. Thus, women's working time for housework did not fall sharply, only changing from one job to another job. Of course, this factor is out the impact of the project, but more or less also influenced the social efficiency of the project.

- Although the awareness of people about biogas plants has improved significantly, it is still incomplete. Local people are mainly concerned about the safe operation of biogas plants, but do not pay enough attention to the environmental efficiency of biogas plants. Therefore, when building biogas plants, people also do not evaluate the importance of the relationship between the number of livestock and the volume of the digester. As a result, the situation of livestock production exceeding the capacity of biogas plants is widespread. Even when livestock prices go down, the scale of livestock production decreases, there are still

[13] Nguyen The Hinh, *Research on the economic efficiency of biogas plants to explain the behavior of households in biogas investment*, Journal of Agriculture and Rural Development, No. 18, 2017, page 8

many livestock farms with the scale beyond the environmental treatment capacity of biogas plants. In addition, people do not pay attention to technical factors in the process of discharging into the digester. There are not many households with biogas digester applying other livestock waste treatment technologies to put down into the digester with proper amount of fertilizer. At the same time, the tendency to put down a large amount of water into biogas plants is still common. The awareness and behavior of water saving in general is still limited. As a result, waste after biogas plants cannot be standardized, and it is completely capable of causing environmental pollution. Therefore, even the households use waste after digesters for fertilizer, gardening, and fishes, the risk of pollution can still occur. At the same time, it is not mention that many households still discharge waste after biogas plants to the environment. Thus, the efficiency of environmental treatment of biogas digester has not been ensured. It can be said that most people consider biogas plants is the perfect solution, the only solution to treat livestock waste. As a result, many households have not complied with the technical regulations in digester operation, especially in the environmental aspect.

CHAPTER IV. CONCLUSIONS AND RECOMMENDATIONS

1. Conclusions

The outcome of the physical audit in 10 project provinces, including 14,485 records of PPMUs and 601 biogas plants of households, shows that the implementation of the LCASP has achieved significant results, meeting the project objectives.

1.1. Evaluation according to the specific objectives of the package:

- ***Regarding the digester volume with respect to available feedstocks and livestock numbers***: The perception of local people about the selection of the digester volume with respect to available feedstocks and livestock numbers is relatively good (94.6% households built biogas plants said that the selection of the digester volume was based on the amount of waste to be treated. However, in practice, assurance of digester volume with respect to available livestock numbers has not paid attention properly, because the livestock numbers have depended mainly on market prices. (According to the correlation between digester volume and livestock numbers, only 47.5% of surveyed households have the scale of livestock that is appropriate with the volume of biogas plants, and the remaining households have the scale of livestock that is excess the capacity of biogas plants)
- ***Regarding ensure that the technical standards for the digester to be eligible for LCASP support were applied :*** Through the physical audit and stakeholder interviews show that biogas plants under the project are eligible to receive support from the project. Specifically: i) Mason teams are selected by the project and trained to build biogas plants; Composite tank supplier are licensed by the project; ii) The process of construction and installation is monitored by local people and technicians; 100% of the biogas plants are certified by local people and technicians to be qualified for construction and putting into operation; iii) There are very few incidents, damages during construction and operation. These damages and incidents are small, it is easy to handle these issues with low cost.
- ***Regarding the quality and use of environmental package***: There are four items related to the project's environmental package: (i) Disinfection Tanks/faucets; (ii) sludge tanks after biogas; (iii) waste collection system and (iv) gas appliances. According to the physical audit, the household built all four items as prescribed. In particular, 100% of the plants has disinfection tanks and faucets at the time of construction. Until now, the rate of disinfection tanks/faucets used is over 99%. At the same time, 100% of plants have sludge tanks, of which 94.1% are using sludge tanks; 100% of plants have waste

collection system (79.6% have full collection system: sewer/pipe, compensation/filtration tank); 100% of plants have gas appliances (gas stoves). These plants are still in use, of good quality, meeting the requirements of the project.

- ***Regarding the receipt of incentive funds for the construction and installation of the digesters by the source of project funds***: The financial support for the construction and installation of biogas plants from the source of project funds is sufficient and timely. Records about financial support of the PPMUs are in line with the format promulgated by the CPMU. The records are complete and valid. At households, 100% of households received full support from the project. The majority of local people are very satisfied with the financial support of the project with an average score of 9.09 points.
- ***Regarding confirm the digester is a LCASP supported digester and is not linked to other digester subsidy programs:*** The results of the examination of records at the PPMUs and at household show that the digester is a LCASP supported digester and is not linked to other digester subsidy programs. During the LCASP implementation, a small number of biogas projects were implemented and LCASP's regulations about the duplication prevention were very strict. Specifically, 10 provinces of the LIFSAP are not 10 provinces of the LCASP. The QSEAP has been implemented in 16 provinces, including 05 provinces of the LCASP - Bac Giang, Ben Tre, Phu Tho, Son La and Tien Giang provinces. However, there is no possibility of duplication in these five provinces because: (i) all records and documents of the LCASP have been fully and properly completed, especially information of both spouses of supported households; (ii) all records and documents are full of stamps, signatures, specific time of related parties such as People's Committees of communes and wards; PPMUs, technicians, mason teams/biogas enterprises/agencies, local people; (iii) all plants of LCASP are coded; (iv) The PPMU and the CPMU have re-examined the probability of duplication.

1.2. Other detailed evaluations

During the physical audit, the consulting unit also reviewed and assessed comprehensively all other relevant activities related to the management, archives and finalization of the records at the PPMUs and inspected directly at households.

- ***For management and archives of the records at PPMUs:***

➢ The results at the PPMUs show that the records are valid. Forms stipulated by the project are included in the records of the provinces, including form 01, form 02, form 03, form 04. In addition, there is also a copy of the owner's ID, copy of training certificate. The Bank's payment order is also included in some provinces.

- Records are archived by location (by district) and by time. This makes searching, management easy and convenient. Some provinces also make lists of records in each folder so it is easy to control. The specific information for each form is also highly complete in most provinces. The information of records is not complete in some provinces but basically this information is not mandatory information (according to the M&E form of the project). Generally, the records in 10 project provinces meet the requirements.
- At the same time, the project data has been managed online at the website: khisinhhocvietnam.com so it is easy to check and search in all 10 project provinces. Importing and managing online data have also been handled timely after the malfunction, meeting the requirements set out.

- ***For construction of biogas plants:***

- *Implementation process:* The project is fully implemented and professional. The project information is diverse and complete so people can learn about the project. The implementation process is tight but did not make it difficult for local people because of the active support from the mason teams/biogas agencies and the technicians. The mason teams/biogas agencies plays an important role in the construction consultancy and support for the completion of the project's records. Local people are also involved in supervising the construction/installation process with high rate, many provinces reach 100%.
- *Quality of construction/installation:* People highly appreciate the quality of biogas plants (93.6% - good quality). 2.9% of the plants encountered problems during construction/installation but all have been handled in time. The percentage of households that have been leaked gas is also low and all have been handled in time. The percentage of households that encountered the incidents and problems during operation is very small. In particular, the majority of the incidents and problems are small and are handled in time with low cost.
- *Operation:* 100% of households are instructed to operate biogass plants; At the same time, the percentage of households participating in the training is nearly 100%. Operational manuals of the project are well understood and appreciated by local people. The physical audit shows that the plants are operating safely and the number of incidents and problems is small. With nearly 40% of women attending formal training, the project will certainly need to make efforts to reach the target of 50% of women attending formal training activities.
- *Financial support:* 100% of the financial support of the project was spent for the right objects and 100% of the households received the full amount of support from the project. The financial support of the project accounts for 15% -40% of the value of biogas plants of the household. This is a large level of support in comparison with previous projects and is an important basis for many people to access biogas

technology, especially poor households and ethnic minority households. Local people highly appreciate the support of technicians, masons, and biogas agencies in finalizing the project's financial procedures with an average score of 9.09 points.

- *Environmental, economic and social effectiveness of the project:* Compared to the time before the implementation of the project in 2013, the indicators achieved by the project are relatively good. Livestock waste that discharges into the water source after the biogas plant has reduced by more than 50%. The rate of waste after biogas digester is converted to organic fertilizer, reaching more than 70%, the daily work of women and children has decreased by 1.99h per day. According to the household‘s calculation, the total amount of gas used has accounted for 86.8% of the total gas produced. According to the consultant's calculation, the total amount of gas used is lower than the calculated level of the household as the capacity of many household is beyond the capacity of the biogas plant. However, the biogas consumption is basically high. If the scale of the livestock production is well matched to the capacity of the biogas plants, the amount of gas consumed will meet basically the objective of the DMF. The physical audit also shows that the household can save about an average amount of VND 1,580 thousand per year for fuel purchasing thanks to biogas plants. It means that over the space of 6-7 years, the amount of money saved from fuel purchasing will be equal to the amount invested in biogas plants.
- *Some limitations:* In addition to the results obtained, the physical audit in 10 project provinces also shows some limitations such as: awareness of people about biogas plant is not enough; The application of other methods of livestock waste treatment such as composting tanks is not common in households after the construction of biogas plants. Overloaded biogas plants are also occurring in some households due to the market changes. the rate of wastewater use after biogas is not common; demand for credit loans of local people is quite high but this demand has not been met in time; disbursement process is slow in some localities, etc.

Therefore, in the context of the project coming to an end, apart from the efforts of the CPMU and the PPMUs, other stakeholders including government at all levels, mason teams/biogas agencies, households, etc should support actively. It should prioritize the development and replication of other technologies related to livestock waste treatment to support for biogas technology. It must be confirmed that biogas technology is not an universal key for livestock waste treatment. This requires a change in the perceptions and actions of stakeholders with regard to effectively and safely treat livestock waste.

2. Recommendations

- It is necessary to promote and diversify communication activities, technical guidance and counseling to raise awareness and access to the project information. The forms of propaganda should be diversified, focusing on information such as: (i) how to determine the

digester volume that is suitable for household use; (ii) Which types of the digester with the highest profit; (iii) how to discharge livestock waste properly into the digester; (iv) how to clean the barn that helps them save water; (v) Harmful effects of overloaded biogas plants; (vi) other models/technologies for comprehensive treatment of livestock waste can be applied at the household scale, etc. When the scale of livestock production is beyond the capacity of biogas plants, additional measures to treat livestock waste should be applied such as using wastewater after biogas plants as organic fertilizer and irrigation water for trees/plants, or using part of fertilizer as organic fertilizer to avoid overloaded biogas plants.

- Regarding the training on the operation of biogas plants, the project should increase the proportion of women trained through the promotion of women participation as the owner of the plant. Training methods for local people should be paid attention. Additional methods can be applied to mobilize people's participation or training at biogas plants can be organized to increase the practicality of training activities.

- The role of local authorities, mass organizations for coordinating communication, raising awareness about the project should be paid attention. If the role of local authorities and mass organizations is well promoted, the implementation of the project will be more effective, especially for disadvantaged groups.

- The PPMUs should review the mason teams/biogas agencies to evaluate the mason teams/biogas agencies, thereby providing management, technical assistance, capacity building about counseling skills, organizational skills for these agents in order to increase the effectiveness of counseling and support to local people. Increasing competition among mason teams aims to increase the selection of people for the construction/installation of biogas plants. For biogas plants built/installed for disadvantaged groups, the project should encourage the mason teams/biogas agencies to reduce costs for these households.

- The project should continue to promote support activities for the construction of small biogas plants (with the volume of $9m^3$-$12m^3$). This is the most appropriate digester type in terms of economic value, capital recovery, gas provision for the family use. For households that built large digesters but only use for their housheols, it is advised to build/install additional equipment to use biogas and waste from the biogas plant or run generators, or share biogas with neighbors.

- The project should quickly implement demonstration models to help validate and evaluate the effectiveness of other biogas technologies in livestock waste treatment such as fertilizer presses, generators, composting, production associated with livestock waste, etc. On that basis, early replication of the model and policy recommendations will develop and replicate these models in practice. These models will help households maximize the use of livestock waste before and after having biogas plants.

- The CPMU should develop a mechanism of cooperation with the Bank for Social Policies to facilitate access to capital from the credit component of the project.

- The CPMU should direct the PPMUs to review and evaluate the project outcome to propose solutions that aims to maintain and replicate the implementation models of the project after ending the project because of the great demand for construction of biogas plants in the 10 provinces. After ending the project, 10 project provinces can still support the construction of biogas plants in accordance with Decision No. 50/2014/QD-TTg dated September 4, 2014 of the Prime Minister on policies to support the raising of the efficiency of farm households in the 2015-2020 period.

- With the positive results of the project and the great demand for construction of the biogas plant, the project needs to strengthen the propaganda on the effectiveness of the project and expand its operation to other provinces in the country.

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ANNEXES

Annex 1: Survey toolkit

QUESTIONAIRE FOR HOUSEHOLDS THAT ALREADY BUILT BIOGAS PLANTS

PART 1. GENERAL INFORMATION

C1. Full name:……... Village……Commune……District……..Province…….
C2. Date of Birth: ……
C3. Gender: 1. Male 2. Female
C4. Marital status? 0. Single 3. Divorced 1. Married 4. Widowed 2. Separated
C5. Ethnicity: 1. Kinh 2. Others (specific):…… ***Ethnicity of wife/husband??*** 1. Kinh 3. Others (specific):…… 2. Single/Separated/Divorced/Widowed
C6. At the time of constructing the biogas plant, What kind of your family did you have (according to the CPC list)? 1. Poor household 4. Good household 2. Near poor household 5. Rich household 3. Average household
C7. Number of family members today? (only people who are living people in households) 1. Total number of people: ..... .In particular: - Number of men: .... people - Number of women: ..... people - Number of children (under 16 years): .... people
C8. Number of animals before building the biogas plant? 1. Pig: ..... head, including sow: ..... .head 3. Others (specific) .... .head 2. Cow/buffalo ....head
C9. Number of animals at the highest point since building the biogas plant? 1. Pig: ..... head, including sow: ..... .head 3. Others (specific) .... .head 2. Cow/buffalo ....head
C10. Number of animals at present? 1. Pig: ..... head, including sow: ..... .head 3. Others (specific) .... .head 2. Cow/buffalo ....head

PART 2. BIOGAS PLANT CONSTRUCTION

C11. When did you know about this program?

1. On day/month/year
2. Do not remember

C12. He/she knows information about this program from whom?

1. Commune officials
2. Agricultural extension staff
3. Neighbors
4. Mass media
5. Mason/Biogas agency
6. Others (specific) ....

C13. Time to sign the application for construction/installation?

On day/month/year

C14. Are you guided on how to prepare an application?

1. Yes 2. No

If yes, who is the instructor?

1. Technician
2. Mason team
3. Neighbors
4. Others (specific)……

C15. Starting time of works?

On day/month/year

C16. Completion time of works?

On day/month/year

C17. Type of biogas?

1. KT1
2. KT2
3. Composite: (provided by……..)
4. Others (specific)……

C18. Volume of biogas plant?

……..m^3

C19. Pursuant to choose the volume of biogas plant?

1. The amount of waste to be treated
2. Biogas demand of household
3. Construction/installation costs
4. Volume which is common in the locality
5. Others (specific) ....

C20. The main purpose for building plant?

1. Waste treatment
2. More fuel
3. Others (specific) .....

C21. Who is the consultant for building plant?

1. Technician
2. Enterprise/mason team
3. Local authorities

4. Neighbors, relatives 5. Option 6. Others (specific)……..
C22. From the time of preparation until the biogas plant is accepted, How often did the technician go to your family? 1. …….times 2. Don't remember
C23. Is the family provided technical drawings before the construction works? 1. Yes 2. No
C24. Did the family monitor construction/installation works? 1. Yes 2. No

PART 3. QUALITY OF BIOGAS PLANTS AND SUPPORT OF THE PROJECT

C25. During the construction/installation, are there any incidents? 1. Subsidence 2. Change the location into part in the system 3. Collapse/leaking joints (for composite tanks) 4. Submerged/floating tank (composite) 5. Others (specific) ....
C26. General assessment of the quality of construction/installation of the service provider (mason/composite tank supplier)? 1. Good 2. Normal 3. Not Good
C27. Is the plant damaged? 1. Yes (What items damaged)……. 2. No **(MOVE TO C32)**
C28. Who is the repairer? 1. Mason/enterprise 2. Technician 3. Self-repairing 4. Others…….
C29. From the plant is damaged, How long does it take to repair? . …… day
C30. How long does the repair last?? . …… day
C31. How much does the repair cost?? 1. ……Thousand dong (specific: Reason for no warranty ……..……) 2. Free
C32. Levels of satisfaction about services after construction/installation? (scoring 1-5 from unsatisfied to very satisfied) …….point
C33. Total cost of construction (million dong) …….million dong. ***In particular, the actual amount received from the LCASP project:*** ……million dong
C34. Did the family have to borrow money to build the biogas plant? 1. Yes 2. No

If Yes, is this amount borrowed from?

1. From friends
2. From relatives
3. From the bank
4. From other credit sources (specific) ....

C35. Procedures for receiving financial support?

1. Simple 2. Complex 3. Others (specific)……..

C36. Satisfaction levels about support procedures (scoring 1-5 from unsatisfied to very satisfied)

…….point

PART 4. EFFICIENCY OF BIOGAS PLANTS

C37. Before having biogas plants, How is livestock waste of the family collected and treated?

1. Composting (estimate ….%)
2. Decomposition (estimate …….%)
3. Discharge into the garden/field/ pond of the family (estimate ….%)
4. Discharge into the sewer/lake (estimate ….%)
5. Others (specific) .....

C38. When having biogas plants, How is livestock waste of the family collected and treated?

1. Biogas: Rate%: ....
2. Organic compost: Rate%: ....
3. Dry: Rate%: ....
4. Discharge into the environment around the farm: Rate%: ....
5. Discharge into surface water: Rate%: ....

C39. Are you guided how to operate?

1. Yes 2. No

C40. Who is the instructor?

1. Technician
2. Mason/Biogas agency
3. Others (specific) .....

C41. Are you attended the LCASP training courses?

1. Yes
2. No

……..times

1st Average time: ..... day

1st training time: ....Date ..... month ..... 201 ...

2nd average times: ..... day

2nd training time: ..... date .... month ..... 201 ...

C42. Are the materials provided and are you guided how to read?

1. Yes 2. No

C43. Are Documents easy to understand and easy to apply?

1. Yes 2. No

C44. Did you still keep documents?

1. Yes 2. No

C45. Who participated in the LCASP training?

1. Wife 2. Husband 3. Others (specific)……..

C46. Who is the main operator?

1. Wife 2. Husband 3. Others (specific)……..

C47. What are the main gas appliances of the family?

1. Gas stove (number ....., capacity……)
2. Lamp (number ....., capacity……)
3. Generator (number ....., capacity……)
4. Others .....

   Name: (number ....., capacity……)

C48. Did your family use gas for?

1. For family members
2. For cooking rice bran (number of animals used to cook bran: ....head)
3. For cooking wine (liter/day: ..... liter)
4. For running generator
5. For lighting
6. For boiling water, slaughtering livestock (liter / day: ..... liter)
7. Sharing for neighbors (..... people)
8. Processing noodles, beans (kg/day …..)\
9. Others (specific)……

C49. Is the amount of gas generated?

1. Excess 2. Enough 3. Not Enough

C50. Estimate the amount of gas used each day (cooking, lighting ...)

……% total amount of gas

C51. FOR HOUSEHOLDS HAVE EXCESS GAS, How is excess gas used?

1. For neighbors
2. Burning
3. Discharge into the environment (.....% of total gas)
4. Others (specific) .....

C52. Before building the biogas plant, How long does the family take to clean the livestock pens everyday?

……hour/day

C53. After building the biogas plant, How long does the family take to clean the livestock pens everyday?

……hour/day

C54. Before building the biogas plant, How long do women and children spend on food preparation and cooking for their family everyday (collecting firewood, fuel for cooking)?

1. Women:……hour/day
2. Children:……hour/day

C55. After building the biogas plant, How long do women and children spend on food preparation and cooking for their family everyday (collecting firewood, fuel for cooking)?

1. Women:……hour/day
2. Children:……hour/day

What do they do in their free time?

1. Women:……..
2. Children:……..

C56. How much money does the family spend on buying fuel each month before and after the construction?

1. Before the construction ..... thousand VND / month
2. After the construction ..... thousand VND / month

C57. How is Wastewater of the biogas plant used?

1. For Gardening, estimated .....%
2. For fish, estimated .....%
3. Discharge into the environment: Estimated .....%
4. Others (specific) .....%

C58. How is slurry used?

1. For Gardening, estimated .....%
2. For fish, estimated .....%
3. Discharge into the environment: Estimated .....%
4. Others (specific) .....%

C59. Did Neighbors have any complaints about the livestock of your family?

1. Before the construction
2. After the construction

Why (specific)?.....

C60. Level of satisfaction about the environmental package (scoring from 1 - 5 from unsatisfied to very satisfied)

.....point

C61. Demand for building biogas plants in the locality in the future?

1. High
2. Low
3. Unknown

THANK YOU!

QUESTIONNAIRE FOR HOUSEHOLDS THAT ARE BUILDING BIOGAS PLANTS

PART 1. GENERAL INFORMATION

C1. Full name:……...

Village……Commune……District……..Province…….

C2. Date of Birth: ……

C3. Gender: 1. Male 2. Female

C4. Marital status?

0. Single 3. Divorced

1. Married 4. Widowed

2. Separated

C5. Ethnicity:

1. Kinh 2. Others (specific):……

Ethnicity of wife/husband??

1. Kinh 3. Others (specific):……

2. Single/Separated/Divorced/Widowed

C6. At the time of constructing the biogas plant, What kind of your family do you have (according to the CPC list in 2016)?

1. 1. Poor household 4. Good household

2. Near poor household 5. Rich household

3. Average household

C7. The number of family members today? (only people who are living people in households)

1. Total number of people: ..... .In particular:

- Number of men: .... people
- Number of women: ..... people
- Number of children (under 16 years): .... people

C8. Number of animals before building the biogas plant?

1. Pig: ..... head, including sow: ..... .head 3. Others (specific) .... .head

2. Cow/buffalo ....head

C9. At present, How to treat livestock waste?

1. Composting (about…… %)
2. Decomposition (about ….%)
3. Discharge the garden/field/ pond of the family (about…… %)
4. Discharge into the sewer/lake/pond (about…… %)
5. Others (specific) ....

C10. Is the current environment of the family polluted?

1. Air pollution
2. Water pollution
3. No pollution

PART 2. BIOGAS PLANT CONSTRUCTION
C11. When did you know about this program? 1. On day/month/year 2. Do not remember
C12. He/she knows information about this program from whom? 1. Commune officials 2. Agricultural extension staff 3. Neighbors 4. Mass media 5. Mason/Biogas Team 6. Others (specific) ....
C13. Time to sign the application for construction/installation works? On day/month/year
C14. Are you guided on how to prepare an application? 1. Yes 2. No If yes, who is the instructor? 1. Technician 2. Mason team 3. Neighbors 4. Others (specific)……
C15. Starting time of works? On day/month/year
C16. Why did the family chose to sign the construction/installation contract with mason team/enterprise? 1. From neighbors 2. From friends 3. From technicians 4. From mason team 5. From Enterprise 6. From the mass media 7. Others (specific) .....
C17. Are you attended the LCASP training courses? 1. Yes 2. No ……..times 1st Average time: ..... day 1st training time: ....Date ..... month ..... 201 ... 2nd average times: ..... day 2nd training time: ..... date .... month ..... 201 ...
C18. Pursuant to choose the volume of plant? 1. Amount of waste to be treated 2. Household gas demand

3. Construction/installation costs
4. Common volume in locality
5. Others (specific) ....

C19. Purpose of construction?

1. Waste treatment
2. More fuel
3. Others (specific) .....

C20. Is the family provided technical drawings before the construction works?

1. Yes 2. No

C21. Did the family supervise the construction/installation?

1. Yes 2. No

PART 3. PROPOSED USE OF THE BIOGAS PLANT

C22. Did your family plan to use gas for?

1) For family members
2) For cooking rice bran (number of animals used to cook bran: ....head)
3) For cooking wine (liter/day: ..... liter)
4) For running generator
5) For lighting
6) For boiling water, slaughtering livestock (liter / day: ..... liter)
7) Sharing for neighbors (..... people)
8) Processing noodles, beans (kg/day …..)
9) Others

C23. How long does the family take to clean the livestock pens everyday?

……..hour/day

C24. How long do women and children spend on food preparation and cooking for their family everyday (collecting firewood, fuel for cooking)?

1. Women:……hour/day 2. Children:……hour/day

C25. How much money does the family spend on buying fuel each month (gas, firewood, coal)?

…… VND thousand/month

C26. How do you plan to use wastewater after biogas?

1. Irrigation
2. For fishs
3. Discharge waste into the sewer
4. Discharge waste into the canal
5. Others (specific)……

C27. If the family is not supported by the project, Will the family build the biogas plant?

1. Yes
2. No

C28. Did the family have to borrow money to build the biogas plant? 1. Yes 2. No If Yes, is it borrowed from? 1. From friends 2. From relatives 3. From the bank 4. From other credit sources (specific) ....
C29. Did neighbors complain about the livestock waste of the family? **1.** Yes 2. No
C30. Is the family reminded about environmental pollution caused by the waste of their own livestock? 1. No 2. Yes If yes, who is the reminder? (specific)……
C31. Is the family punished for environmental pollution due to livestock waste? 1. No 2. Yes If yes, what is the form? Punished by? (specific)……

THANK YOU!

CHECKLIST FOR HOUSEHOLDS THAT ALREADY BUILT

Items	Answer	How to test
1. Code of works	*LCASP……..*	Capture the code of each work, compare with the record
2. Location	1. House surroundings 2. Others (specific)……	Actual observation
3. Size of works	……m3	Measure the height of discharge (Hxa) of the works .... cm
4. Design compliance	1. Disinfection Tank or faucets 2. Slurry Tank 3. Waste collection system 4. Gas appliances	Investigator's assessment about sufficiency of all project items. Compare with the record
5. Solid Waste Collection	Investigator's assessment about waste collection system: 1. Is solid waste collected? a/ Yes b/ No 2. Is there solid waste storage? a/ Yes b/ No 3. What is solid waste used for? a/ Decomposition b/ Apply directly to plants c/ Others (specific)	Observation and evaluation
6. Liquid Waste Collection	1. Is all liquid waste released into the biogas plant? a / All b / A part ***(Move to 2)*** 2. What is liquid waste used for if it is not released into the biogas plant? a / For fishes b / Discharge directly to the field c / Others (specific)	Observation and evaluation
7. By-product tank	Size: length ... ..m, width ..... m, depth ....m 1. Is it divided? a / Yes b / No 2. Is there a cover? a / Yes b / No	- Using a ruler - Observation and evaluation

Items	Answer	How to test
8. Bio-Slurry of the by-product tank	a / Gardening b / For fishes c / Discharge into the environment d/ Others (specific)……	Observation and evaluation
9. Waste water after the by-product tank	a / Irrigation b / For fishes c / Discharge waste into the sewer d / Discharge waste into the canal e / Others (specific)……	Observation and evaluation
10. Disinfection Tank or faucets	1. Disinfection Tank 2. Faucets	Check faucets/Tank are used or not
11. Color of waste water	1. Yellow 2. Light Black 3. Dark Black 4. Fizzy 5. Others (specific)…….	Observation and evaluation
12. Neighbor's response about waste of the works	1. Good 2. Not Good 3. Others……..	Direct observation or ask neighbors
13. Equipment for the use of gas	1) Kitchen (number .....) 2) Lamp (Number .....) 3) Generator (capacity .....) 4) Others	It is important to observe and check the gas appliances based on the documentation
14. Purpose of using gas.	1. For cooking in daily life 2. For cooking rice bran 3. For cooking wine 4. For running generator 5. For lighting 6. For boiling water, slaughtering livestock	Direct observation

Items	Answer	How to test
	7. Sharing for neighbors 8. Processing noodles, beans 9. Others (specific)…….	
15. Gas leak	1. Yes 2. No 3. Leak position (specific)…….	Observation and feeling
16. Safety valve	1. Yes 2. No	Direct observation
17. In livestock pens	1. Investigator's assessment about livestock pens a / Clean b / Relatively clean c / Dirty. 2. How does the smell in livestock pens? a / No odor b / Less smells c / Much smells 3. Flies and other insects in livestock pens a / Many b / Few c / No	Observation and feeling
18. Around livestock pens	1. Investigator's assessment about livestock pens a / Clean b / Relatively clean c / Dirty. 2. How does the smell in livestock pens? a / No odor b / Less smells c / Much smells 3. Flies and other insects in livestock pens a / Many b / Few c / No	Observation and feeling

THANK YOU!

CHECKLIST FOR HOUSEHOLDS THAT ARE BUILDING BIOGAS PLANTS

Items	Answer	How to test
1. Location of works	1. House surrounding 2. Others (specific)……	Direct observation
2. Ground	1. Hard 2. Soft	Use a shovel for digging
3. Size of works	……m3	Measure the digester's diameter and calculate the volume
4. Size of Pit	Diameter: ... ... m Depth of the pit: ... m	Using a ruler
5. Type of works	1. KT1 2. KT2 3. Composite	Direct observation
6. Check the record	1. Three-party contract 2. Technical drawings	Review the record of the owner of construction
7. Waste treatment?	1. Composting 2. Decomposition 3. Discharge the garden/field/ pond of the family 4. Discharge sewer 5. Discharge the lake 6. Others (specific)	Direct observation
8. Observe livestock pens	1. Investigator's assessment about livestock pens a / Clean b / Relatively clean c / Dirty. 2. How does the smell in livestock pens? a / No odor b / Less smells c / Much smells 3. Flies and other insects in livestock pens a / Many b / Few c / No	Observation and feeling
9. Observe livestock areas	1. Investigator's assessment about livestock pens a / Clean b / Relatively clean c / Dirty. 2. How does the smell in livestock pens? a / No odor b / Less smells c / Much smells	Observation and feeling

Items	Answer	How to test
	3. Flies and other insects in livestock pens a / Many b / Few c / No	
10. Neighbor's response about waste of the works.	1. Good 2. Not Good 3. Others……..	Direct observation or ask neighbors

THANK YOU!