Sustainable Energy Development Consultancy Joint Stock Company

FINAL REPORT

Evaluation Study for Household Biogas Plant Models

April 2010

Acronyms and Abbreviations

BOD_5	Biochemical Oxygen Demand
BPD	Biogas Project Division
BTNMT	Ministry of Enviroment and Resource
CBE	Chief Biogas Engineer
COD	Chemical Oxygen Demand
CTA	Chief Technical Advisor
Consultant	Sustainable Energy Development Consultancy Company
DLP	Department of Livestock Production, under MARD
IRR	Internal Rates of Return
MARD	Ministry of Agriculture and Rural Development
MONRE	Ministry of Resources and Environment
NPV	Net Present Value
NTR	National Technical Regulation
ODA	Overseas Development Assistance
O&M	Operation and maintainance
PBPD	Provincial Biogas Project Office
PC	Project Coordinator
QC	Quality Control
QCVN	National Technical Regulation
SEDCC	Sustainable Energy Development Consultancy Company
SNV	Netherlands Development Organization
TCVN	Vietnam Standard
ToR	Terms of Reference

GENERAL INFORMATION

1. Research title: Evaluation Study for Household Biogas Plant Model
2. Donor: Biogas Project for the Animal Husbandry Sector in Vietnam 2007-2011
3. Implementer: SEDCC
4. Duration: From 15th October to 31st December, 2009
5. Research Team leader: Mrs. Tran Hai Anh

Table of content

ANNEXES

Annex 1: Guidelines of Feeding-in material, operation and maintenance.

Annex 2: Detail construction cost

Annex 3: Calculation of Financial indexes

Annex 7: QCVN 08 – 2008 BTNMT National technical regulation on surface water quality

Annex 8: Analyze result

Annex 9: Record Sheet for gas yield

Acknowledgements

This report was written during the Inception Phase of the Evaluation Study for Household Biogas Plant Models, under the contract between BPD and SEDCC signed on 12 October 2009. The sole purpose of the report is to provide an overall working plan of SEDCC to fulfill its obligation under the said contract as well as method and methodology and expected output of the assignment.

I especially appreciate the encouragement given by BPD's management staffs and BPD's technical officers for valuable supports and encouragement.

My sincerely thanks go to PBPD Hanoi and PBPD Tien Giang for their great cooperation.

Consultant Team Leader
Tran Hai Anh

PART I: BACK GROUND

The Project "Biogas Program for the Animal Husbandry Sector in Vietnam" (hereafter called "the Project") has been started 6 years ago. The project received ODA from the Netherlands government and implemented by DLP. To date, the project has been deployed in 35 provinces. Under the project, more than 75,000 household biogas plants have been constructed. The project target is constructing 165,000 household biogas plants by 2012.

To date, KT1 and KT2 models have officially used whole the Project with technical drawing in the North and in the South respectively. In order to meet the target of 165,000 biogas plant by 2012, the Project is seeking suitable biogas plant models, different from KT1 and KT2, for widely use within the Project. The new models are expected not only to help reduce investment but also facilitate the construction procedure. In addition, households will have more chances to select the biogas model, which is best use for them.

SEDCC (hereafter called the Consultant) has signed a contract with BPD to carry out ''Evaluation Study for Household Biogas Plant Models'' (hereafter called the Study). The purposes of the study include:

- Evaluate three different household biogas design models in Vietnam, namely: KT31, Composite and nylon bag (based on ToR);
- Compare three preceding biogas models with KT1 and KT 2;
- Construct demonstration of researched models
- Recommend for further use of pilot models

The study was carried out in Soc Son, Hanoi (representative for the North) and My Tho, Tien Giang (representative for the South). The reason for selecting Soc Son includes: Soc Son has huge potential for develop biogas in the coming time. At present, composite model has been used widely in Soc Son. Additionally, geological and hydrological condition of Soc Son is typical for Northern part of Vietnam. Further, Soc Son's mason has good experience of constructing biogas plant.

My Tho (Tien Giang) is selected as representative for the South. The reason for selecting My Tho includes: My Tho's social and natural condition is typical for the South. My Tho's potential for biogas development is huge. My Tho ground is week with high ground water table, which is suitable for composite model. My Tho's mason has vast experience of constructing KT2, nylon bag.

The study was done within 2.5 months, from 15th October to 31 December 2009.

The draft final report is the Consultant's products within this period. The report includes:

- Summary the work done by the consultant;
- Analyze the pilot models;
- Conclusion and recommendation.

PART II: DESCRIPTION OF PROJECT SITES

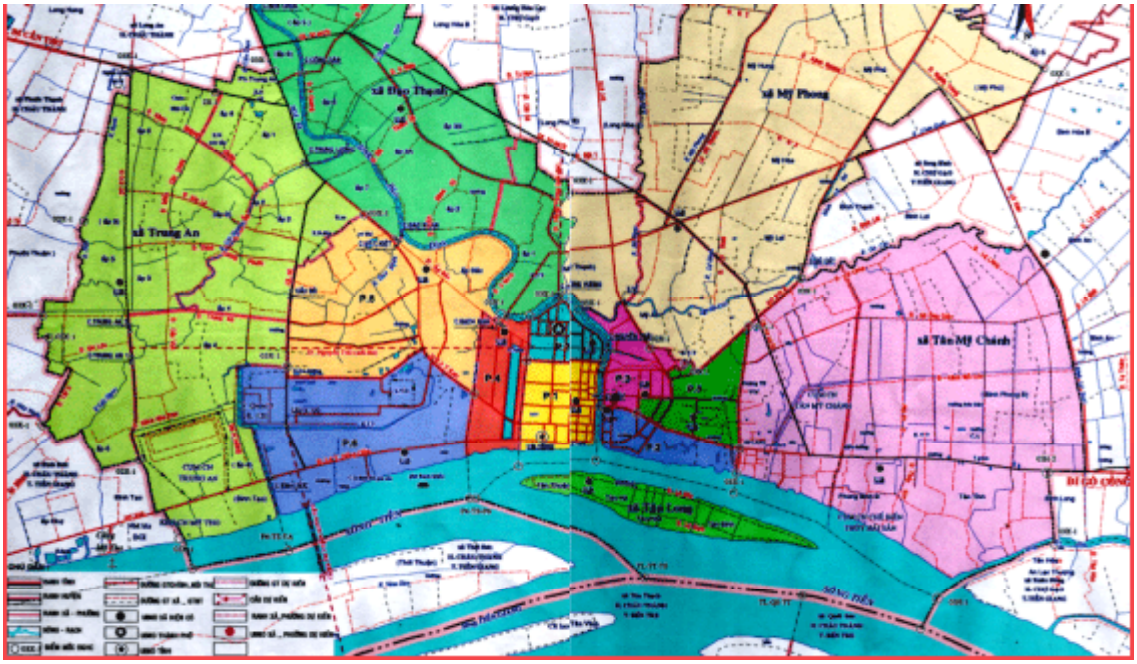
II.1 MY THO (TIEN GIANG)

Geographic location

My Tho city is classified as urban type II, it is the chief town of Tien Giang province. My Tho locates on North banks, downstream of Tien river. It borders with Cho Gao district in the East and North, with Chau Thanh district in the West, with Tien River and Ben Tre province in the South, natural area is 49.98 km2, 9.17km2 in which is the urban area.

Thanks to its favorable location in regard of navigation and road access system, nearby Ho Chi Minh city and to be the gate connecting Western provinces, My Tho naturally becomes the provincial chief town and political, economic, cultural, technical and scientific center of the province playing an important role in pushing up the development in various zones of province and the whole region.

Figure II-1: Map of My Tho city



Climate setting

Air temperature:

- Mean annual temperature 27.9 ^{0}C
- Average maximum 29.5 ^{0}5 C (April)
- Average minimum 26^0 (October)
- Absolute maximum 38.9 ^{0}C (May/1930)
- Absolute minimum 14.9 ^{0}C (January/1963)

Air humidity:

- Mean annual humidity 79.2%
- Average humidity in rainy season 88.4%
- Average humidity in dry season 70%

Rainfall

- Maximum recorded rainfall 398.6mm (July/1997)
- Mean annual rainfall 1500mm
- Wettest year 1922mm (1982)
- Driest year 867mm (1957)

Evaporation:

- Maximum 4.5mm/day (February)
- Minimum 2.4mm/day (October)

Wind:

- The South-East monsoon predominates between January and April, velocity 2-5m/s;
- The South and South West monsoon predominates between May and September, velocity 1-5m/s;
- The West monsoon predominates in August, velocity 5-6m/s.

Economy

My Tho is the main economic zone of the province whose economy is structured by 36.9% from industry and construction; 47.5% from commercial and service, 15.6% from agriculture and aqua-cultivation. The average GDP from 1995 so far is higher than 10%, the value created by industry and construction in the zone up to 2006 was a bout 1,000 billion Vietnam Dong, contributing 150 billion VND to the budget and some of 110 billion VND has been invested on construction.

Population

The number of permanent and temporary residence in My Tho city is about 215,000 people living in 15 administrative units (including 11 wards and 04 communes). The population structure is described in table hereunder.

Table II-1. Forecast on size of population and labor force in My Tho city up to the year 2020

No	Index	Unit	2010 forecasted	2020 forecasted
1	Population	preson	250.000	316.000
	- Non agriculture	preson	198.000	258.000
	- Agriculture	preson	52.000	58.000
2	Average popoluation growth	%	4,30	3,20
	- Natural	%	1,20	1,20
	- Mechanical	%	3,10	2,0
3	Total household	household	58.857	83.833
	- Non agriculture	household (Person/household)	44.000 (4,5ng/hộ)	64.500 (4ng/hộ)
	- Agriculture	Household (person/household)	14.857 (3,5per./hh)	19.333 (3per./hh)
6	Total population in working age	Person/ % of population	165.400 (66,16%)	195.446 (61,85%)

Geology:

Me Kong delta in general and My Tho city in particular was founded geologically by a depression of Kainozoic rock foundation, which was filled by Kainozoic sedimentations. These Kainozoic sedimentations were filled little by little via a number of marine-transgression and degression. The thickness of these sedimentations is huge, which increases gradually from both wings to the center of Mekong delta, which is deepest location. The deepest location is bordered by Tien Giang and Hau Giang rivers.

According to geological investigation under 60.02 programs, geological strata of My Tho, from oldest to youngest as follows:

- Mesozoic: (mz) Juraic – Creta (j-k): siltstone, sandstone, metamorphic stone, sandstone, and effusive stone.

- Kainozoic (kz). Neocene (N). Nioxene (N1): find to coarse grained sand, greenish – grey, blackish- grey quartz pebble, lens of greenish- grey, whitish – grey clay which are covered by a spotted siltstone.
- Pliocene (N2): fine to coarse grained sand mixed with greenish – grey, blackish-grey quartz pebble and brown coal and fossils of tree and lens of greenish- grey, whitish – grey clay, which are covered b a brown, yellow, spotted green carbonate siltstone and clay.
- Quarternary
    - Pleistocene (QI-Qm): silt, stand, clay, mud, etc.
    - Holocene (QIV): the whole province is coverd by Holocene formation, which consists of silt, sand, clay, fine sand.
    - Mixed river-marine sedimentation: its exposures account for 90% of the whole province, which mainly includes siltstone, sandstone, brownish grey, yellowish grey clay and spotted brown, yellow, grey fined grained sand.
    - River-swamp: blackish grey, whitish grey mud and clay mixed with brown coal and botanic fossils, which concentrated in Dong Thap Muoi depression locating in north-western north part of the province.
    - Alluvium sedimentation: narrow exposures along rivers and canals which are expanded presently. Main components are black, brownish-grey sand, clay, silt mixed with botanic matters.

Ground water table of My Tho is close to the ground surface, which is effected by surface water coming from river, lake, pond, canal, etc. The underground water formation for living purpose is located deeper, at 13-18 m, which is over-exploited.

Household biogas plants, with depth of excavation pit is about 10 m, are mostly lying within Quaternary sedimentations, which are described above.

Feedstock potential

My Tho city is classified as urban type II, feedstock development concentrated in surbub commune according to direction biological safety and enviromental protection. Almost feedstock of My Tho is household farm from 10 to 100 animals and farm over animals. Poultry feedstock was developed in the ways of commercial egg-produce chicken, from 3,000 to 15,000 animals/farm.

Based on statistics data of Department of Agriculture and Rural Development of Tien Giang, up to now, My Tho has:

- 18,131 pigs,
- 138,747 poultries,
- 2,747 cows;
- 1,259 goats;

Feestock waste treatment issue was interested by appropriate authorities in supporting construction biogas plants, compost…but, at present, feedstock waste treatment for environmental protection was not meet market development speed.

Trend for feedstock in coming time is developing feedstock in the way of semi-industry and industry, set up chicken, pig and cow feedstock farms and quickly develop milk cow feedstock equipment. Estimation feedstock potential of My Tho will be increased from 3-5% in 2010-2015.

II.2 SOC SON (HA NOI)

Geographic location

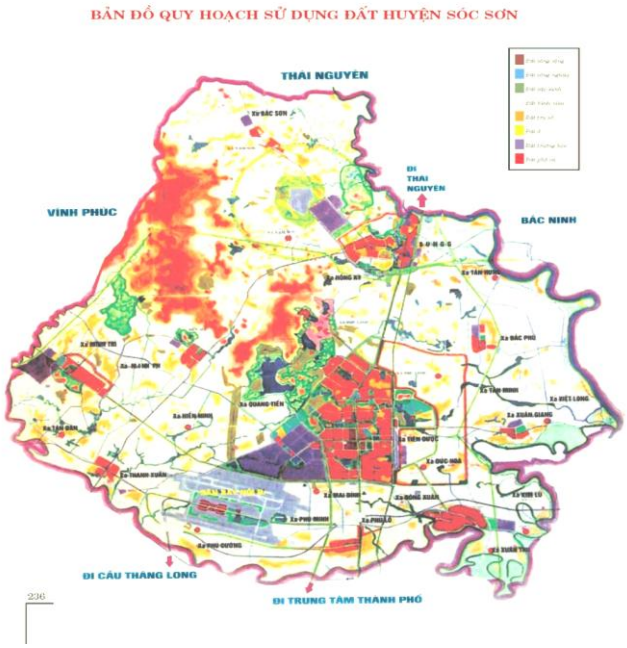
Soc Son is a suburb district locating North of Hanoi capital with Soc Son is chief town, some of 35km from Hanoi following National Road 3A Hanoi – Thai Nguyen. The Soc Son district is 306.51km2 large, to be the largest among other suburb districts of Hanoi.

Soc Son district borders with Pho Yen district of Thai Nguyen province in the North, with Yen Phong district of Bac Ninh province in North-East, with Me Linh and Dong Anh districts in North-West and South respectively.

Soc Son district is set up by the mergence between Da Phuc and Kim Anh districts of Vinh Phuc province. Ever from December 29th 1978 it is a part of Hanoi capital.

Natural area of Soc Son is 306.51 km2 with 25 administrative units of commune level: Hanh Xuan, Minh Phu, Quang Tien, Phu Minh, Phu Lo, Nam Son, Hong Ky, Tan Hung, Viet Long, Duc Hoa, Kim Lu, Tan Minh, Tan Dan, Minh Tri, Hien Ninh, Phu Cuong, Mai Dinh, Dong Xuan, Bac Son, Trung Gia, Bac Phu, Xuan Giang, Xuan Thu, Phu Linh and Tien Duoc.

Figure II- 2: Map of Soc Son district



Climate setting

The climate in Soc Son is characterized by humid tropical monsoon, summer is hot and lots of rain, winter is cold and less rain. Locating within tropical area, all the year around Soc Son is available with plenty radiation and high temperature.

Temperature:

- Mean annual temperature 23.6 ^{0}C
- Absolute maximum recorded 42.8 ^{0} C (May/1926)
- Absolute minimum recorded 2.7^{0}C ^{0}C (January/1955)

Air humidity: mean annual 79 %

Rainfall: average is 1 682 mm

Hanoi weather is characterized with all four seasons: spring, summer, autumn and winter. Circulation between seasons has helped the weather in Hanoi area more colorful and specialized.

- From May to August is summer time when weather is hot and sometimes with heavy rain.
- From September to November is autumn time when weather is dry, the sky is blue and high, cool wind, golden sunlight.

- From November to January next year is winter time when weather is cold and dry.
- From February to April is spring time when air humidity is high therefore vegetation is well growing.

Details on hydrological-meteorological conditions of Soc Son area are listed in Table 1.

Table II-2: Hydrological-Meteorological Conditions

Month	Average Sunlight (hours)	Temperature				Relative humidity		Average Precipitation (mm)	Wet Days (+0.25 mm)
		Average		Record					
		Min	Max	Min	Max	am	pm		
Jan	1	13	20	6	33	78	68	18	7
Feb	1	14	21	6	34	82	70	28	13
March	1	17	23	12	37	83	76	38	15
April	2	20	28	10	39	83	75	81	14
May	4	23	32	16	43	77	69	196	15
June	5	26	33	21	40	78	71	239	14
July	5	26	33	22	40	79	72	323	15
Aug	4	26	32	21	38	82	75	343	16
Sept	4	24	31	17	37	79	73	254	14
Oct	4	22	29	14	36	75	69	99	9
Nov	3	18	26	7	36	74	68	43	7
Dec	2	15	22	7	37	75	67	20	7

Economy

In recent years, Soc Son economy is continuously growing as the higher this year than the previous. The economic structure of the district is moving toward industry 44.5%, services 34.4%, and agriculture 21.1%. Investment attraction in the area is sharply increasing, in 2003 it was 141 enterprises but it is more than 327 enterprises in the year 2009, including 34 joint venture enterprises and companies with 100% foreign investment capital.

Hanoi city has made the Plan 61 available with concrete policies and specialized structures applying to Soc Son. Particularly, in priority programs such as assigning Soc Son the implementation of 33 projects in many sectors. So far the district has completed 9 projects, including 2 planning projects and 7 projects of investment. In addition to those has been completed according to Plan 61, Soc Son district is now going on with the implementation of many other projects relating to the planning. In the same time the district authority is going on with investment on infrastructures of Mai Dinh small and medium industrial zone.

Population

Presently, Soc Son is place for 254,000 people living on, in which the non-agriculture population takes 9.1%. It is forecasted that up to 2020 there will be 387,880 people living there in Soc Son with 56% among which is taken by urban population. The population density at present is 829 people/km^2

Geology[1]

Red river delta in general and Soc Son, Hanoi, in particular were founded since Early Pleistoxen (Q11), via a number of marine-transgressions and degressions and strong uplift process, which consists of Kainozoic sedimentation (Neocene in lower part and Quaternary in upper part).

Quaternary sedimentations include the followings:

[1] According to Nguyen Thi Ha, ĐCTV-ĐCCT General Confederation, Cau Giay, Hanoi.

- Le Chi formation (Q11 lc): widely distributed in Han Noi depression, at 65-90 m depth. Main components are gray pebble, gravel, sand originating from river or mixed marine-river. Its average thickness is 10-20 m.
- Hanoi formation (Q12-3 hn): distributed widely but covered by other formation. Only small exposures are seen in the edges.
- Vinh Phuc formation (Q13 vp): alluvium sedimentation (aQ13b vp) is seen at 15-30m depth. The lower parts are medium-coarse grained sand mixed with pebble and gravel. The lower parts are whitest – grey clay mixed with sand and silt. The upper parts are whitest grey weathered sand, silt, clay in 5-38 m deep. These sedimentations have very good water-containing capacity;
- River – lake-swamp sedimentation (alb Q13b vp) distributes in small area in Soc Son and Yen Phong. These sedimentations have low water-containing capacity.
- Hai Hung formation (Q21-2 hh): distributes at 5-25 m deep that consists of alluvium (aQ21-2 hh): main components sand, silt.
- Alluvium –marine sedimentation (lbQ21-2 hh): main components are brown coal mixed with black, grey silt, clay mixed with botanic organic matter.
- Marine-swamp sedimentation (mb Q21-2hh): main components are silt, clay, sand mixed with botanic matters and thin lens of brown coal.
- Marine sedimentation (m Q21-2hh): main components are grey, whitest grey, clay, silt, and sand 2-20 m thick.

There are two aquifers in Hanoi namely: porous Holocene (Qh) aquifer and porous pressure Pleistocene aquifer. Both aquifers are tens to hundred meters deep.

Household biogas plants, with depth of excavation pit is about 10 m, are mostly lying within Quaternary sedimentations, which are described above.

Feedstock potential

Feedstock potential of Son Son was quickly increased from the year 2005 to year 2008. In 2009, the number of cattle and poultry had a little varies in comparision with year 2008. This data is showed in table II -3

Table II-3: Number of cattle and poultry in Soc Son from 2003 to 2009

Unit: animal

Kind of animal	2005	2006	2007	2008	2009
Buffalo	5,213	5,378	5,472	5,621	5,665
Cow	22,510	23,755	26,369	26,632	27,782
Pig	102,350	110,767	119,628	121,324	121,350
Poultry	908,230	911,352	915,170	974,660	974,816

In 2010, estimation buffalo, pig and poultry will be increased 3%,4%,7% respectively. At present, Soc Son is focusing on feedstock development for each commune as followings:

- Egg-laying hen in Tan Hung and Phu Lo commune;
- Commercial chicken in Bac Son, Nam Son, Minh Phu and Minh Tri commune;
- Cow in Tan Minh, Bac Son, Minh Tri and Minh Phu commune;
- Milk cow in Tan Dan and Nam Son commune;
- Pig in Xuan Giang, Xuan Thu, Dong Xuan and Bac Phu comnune.

PART III: RESEARCH PRINCIPLE AND METHODOLOGY

III.1 RESEARCH PRINCIPLE

- A biogas plant in this context is household scale, not industrial scale. On the other words, the selected household in this research will have animal husbandry at household scale. According to information given in the website of the project, household scale means each household has in average 2 buffalos/cows or 5-6 pigs with 50 kg/each. Biogas yielded from the biogas plant will be used for domestic uses such as cooking, lighting, etc. Large scale and industrial scale biogas plants, therefore, will be out of question. With reference to information given in the website of the project, the Consultant recommends to select 10 m^3 - biogas plant for this research for evaluation on construction cost, labor days, financial criteria, operation and maintenance, gas production and yield. Gas yield is defined as the gas amount generated by a biogas plant per one cubic meter of digestion per day (Vd).
- The comparisons among four preceding models will base on technical drawings, document/video clips to guide construction and operation/maintenance and on the reality of demonstration construction.
- Biogas appliances as biogas stove and lamp will not be included in the final assessment because there are not significant differences among those.

III.2 DESK STUDY

- Gathering related document and information: design drawings, documents relating to 2 models KT1 and KT2 from BPD.
- Gathering document relating to composite model, nylon bag and KT31.
- Gathering training documents, leaflet, poster, CD movies showing how to construct, operate and use biogas slurry from BDP and suppliers;
- Gathering standards on construction serving the analysis and re-evaluation in office table.
- Preparing list of questionnaires, setting up criteria on selecting household, criteria on selecting building masons, criteria on evaluation, assessment and classification.
- Study legal national standard and national technical regulation to refer during analyze and comparison: National Standard on Surface water quality (TCVN 5942-1995), National Technical Regulation on Surface water quality (QCVN 08 – 2008/BTNMT), Sectoral Standard on Domestic biogas plant (10TCN 97:102-2006 – MARD). We suggest to use National Technical Regulation on Surface Water Quality QCVN 08- 2008 BTNMT (NTR) to replace National Standard for Industrial waste water – discharge standards TCVN 5945-2005 (NS) for two reasons i) NTR is obligatory to apply while NS is not and ii) so far no NTR for animal waste water has been issued, NTR for industrial waste water and NTR for domestic waste water are not compatible[2].

[2] National Technical Regulation on industrial waste water quality is applied for any organization or individual who discharge industrial waste water into receiving water source.
National Technical Regulation on domestic waste water quality is applied for public facilitation, military garrison, service falicitation, apartment block or residential area, establishment who discharge domestic waste water into environment.

III.3 CONSTRUCTION PILOT MODEL

- There are 04 households in Soc Son and other 04 households in Tien Giang have been selected for building the pilot models.
- A mason team in Soc Son and another in Tien Giang have been selected to construct the pilot model.
- Technical staff from Thanh Loc Composite Trading Joint Stock Company has been invited to supply technical training and supervising over the building masons at the site.
- Technical staff from Biogas Technology Center has been invited to supply technical training and supervising over the building masons at the site.
- 04 pilot models have been constructed in Soc Son and 04 pilot models have been constructed in My Tho. The consultant is directly involved in supervision during construction and installation process.
- The consultant did monitoring and inspection and instructed households how to feed-in material, how to do operation and maintenance; the consultant directly measured gas and took samples.

III.4 METHOD FOR MEASURING GAS YIELD AND TAKING SAMPLE

- To compare gas yield of four models, each plant is fed with the same material – pig dung – with the amount of 10kg per day per one cubic meter for the North and 12kg per day per one cubic meter for the South. Dilution ratio is 1 kg of animal waste and 1 litter water. Sectoral standard TCN 10TCN 97:102 – 2006 was refered in the comparison.
- To evaluate the environmental effect of the four models, samples of fresh animal waste, feeding substance (animal waste and water) and bioslurry are taken to analyze 3 parameters of BOD_5, COD and coliform. As in the South, mixing tanks were not constructed; inlet samples (dung samples) were taken in pigsties. In the North, inlet samples (feeding substance sample) were taken in the mixing tanks (where pig dung is mixed well with water with the dillution ratio of 1:1). All outlet samples (slurry samples) were taken in compensation tanks. Time for taking samples in the South and the North is 30 days and 55 days after put biogas plant into normal operation respectively.

III.3.1 Measuring gas yield

- Gas meter was used for gas measurment. Gas meters were installed at the end of gas pipeline after pressure gauge and before cookstove to measure gas generated for 24 hours (1 day) during continually 10 days. Before installing gas meters, gas in the biogas plants was used up or let out until pressure in the plant is balance with the air pressure (i.e. pressure gauge at 0 level). Number in gas meter's screen was written down in the Record Sheet.
- Time for measurement: After the biogas plants went in normal operation 30 days for the North and 20 days for the South respectively.
- Method of measurement: The gas was measured at fixed time of the day during continually 10 days. Before reading and writing down number in the gas meter's screen, gas was used up (by cooking) or let out until until pressure in the plant is balance with the air pressure (i.e. pressure gauge at 0 level). The gas output was recorded in the Record Sheet. Gas consumption was calculated by the gas value got at the measurement minus the value got at the previous measurement.

III.3.2 Taking sample and analyze

III.3.2.1 Taking sample: There are two kinds of samples need to be taken i) animal waste (animal dung and urine) and ii) outlet water (slurry). Samples are kept in Lavi bottles then brought to laboratory for analyze within 24 hours after being taken.

a. Taking animal waste sample: In the South, samples of fresh pig dung were taken at household by mixing well urine and dung left from previous night until morning when samples are taken. Probably, an amount of urine will go already to the digester.

Depending on the volume of dung, take 30 separate small samples at different places (vertically and horizontally) of the pile. Mixing well 30 small samples, then take one sample <1cm of 500 g at the cross of diagonal.

In the North, inlet samples were taken in mixing tank thus animal waste (dung and urine) were mixed well with water. The solution was taken at different places of the tank like wall, in the middle, conners etc. From the taken solution take one sample for analyze.

b. Take outlet sample (slurry sample): Take slurry sample in the compensation tank. Taking sample device: a plastic dipper of 1500ml will be used. A proper handle may be used in order to take sample at a deep place. To take a representative sample, slurry should be taken at different places of the tank including wall, in the middle, angles... Taken samples are mixed well. Take one sample from mixed solution for analysis of environmental and hygiene criteria. Lavi bottles will be used for storing liquid samples. Samples will be brought to laboratory within 24 hours after being taken.

II.3.2.2 Analyze sample:

Samples taken in Tien Giang are analyzed in laboratory of Centre of Analytical Services under Department of Science and Technology of HCM city. In Hanoi, samples are analyzed at Laboratory of Centre for Analyze and Environment under Biology, Physical and Chemical Association of Vietnam.

III.5 INTERVIEWING STAKEHOLDER

- The consultant has interviewed related parties to have background for analysis and evaluation on studied models. The interview has been performed to:
- Number of household with existing biogas: 44
- Number of household selected for pilot model: 08
- Provincial, district technician: 06
- Mason: 06
- Provincial management officers: 04
- BPD officer: 02

Data of interview is presented in the annex 4: Interview Result

PART IV: JUSTIFICATION FOR SELECTING OF PILOT MODELS

As per requirements in the Terms of Reference (ToR), the four following designs are selected for the Study:

- KT 31,
- Composite,
- Nylon bag, and,
- KT1/KT2 (as control)

In our opinion, the main reasons for the selection as mentioned below:

- General reason: The selected biogas plants have to satisfy at least one of the requirements i) simple technology but effective (in terms of generating gas, easy installation and simple operation) ii) cheap price. Besides, to serve for study, the more plenty of supporting document and material such as design and manual the favorable. Therefore, composite plant is selected due to its simple but effective technology while nylon bag is selected thank to its cheap price. Vacvina model was not selected because its weaknesses like non-material saving, les durable structure, low safety as gas is store in nylon bag nor low gas pressure etc. Design of Can Tho University is origin of KT2 thus has similar weaknesses and strong points like KT2. Design of Thu Duc University (known as horizontally precasted tub by Minh Tuan) was not selected as complicated technology (require precasting concrete) and high cost. In addition, In the annex 5 we also describe strong points and weaknesses of some biogas designs that have been deployed in Vietnam.
- KT31 is selected as the author - also the author of KT1 and KT2 - designed KT31 after a period of time working for BPD as CBE. KT31 was designed to repair the weakness of KT1 and KT2 (manually construct and not-familiar construction methods) while keep the strong points (gas section is high quality thank to be produced in factory, complex structure as all parts are put in one block) of these models. This model has been applied in many places like Dan Phuong (old Ha Tay province) at both levels of household and farm-scale.
- The composite is originated from China and is producing in mass number by some companies in Vietnam. It has been used quite popular in the North and Central of Vietnam. Advantages of the biogas composite is high durability, quite long lifetime (according to manufacturer, lifetime of this is 20 years). Construction and installation of composite is considered as simple, fast and no need training for mason, it is suitable in areas where underground water table is high. The disadvantages of this model come from its high cost and unfavorable in transporting. This model has been selected as pilot plant for the purpose of evaluating all of advantages and disadvantages as well as recommendation on using possibility in concrete conditions. Particularly, the composite biogas has been evaluated as having potentiality in My Tho district of Tien Giang province since the construction of KT1 and KT2 in this area is now heading with difficulties due to high underground water table. Besides, the composite can be excavated out and moved to other location, so it is suitable in areas in trend of urbanization.
- The nylon bag does not have advantages as the KT31 or composite due to its short lifetime (some of 3-4 years), easily exposing to damages due to environment or animal bite. However, its advantages come from low cost and initial cost of investment is not so remarkable, the material is available in the area and fast construction. Presently the nylon bag has been used popularly in the

Southern region of Vietnam. The nylon bag is selected to evaluate all of its advantages and disadvantages and to recommend its using possibility in each conditions, particularly in areas where are affected by urbanization and the local resident has no intention of long husbandry.

- Besides, in ToR of this research, three mention-aboved biogas models was comparision with KT1 and KT2 which have been applying in Project.

PART V: INTRODUCTION OF SELECTED DESIGNS

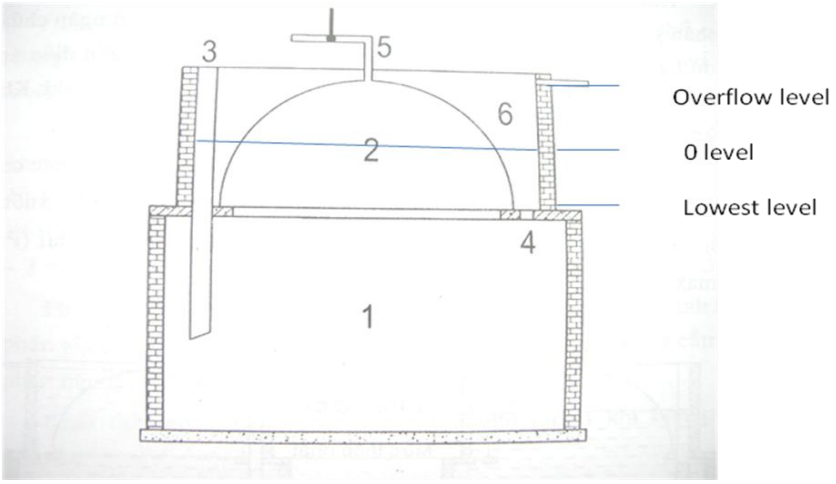
V.1 KT31 Model

KT31 is model that studied and developed by the Biogas Technology Centre (BTC). Basically, it has 3 main parts: digester, gas storage and compensation tank. The three parts are designed in one block and buried underground. However, the upper part of compensation tank is open to the air.

6 parts of KT31 are as follows:

- Digester tank (1) is built by brick in the shape of cylinder. Bottom of plant is concreted or built by brick. Main construction materials are refined brick (solid or empty), mortar and concrete with steel rod.
- A gas storage tank (2) is made of composite and sticks with the digester by bolt and special rock powder.
- Inlet pipe (3): PVC pipe with diameter of more than 100mm is used.
- Outlet pipe (4): is the way-out of bio-slurry
- Gas pipe (5)
- Compensation tank (6): is the place where store digested material when gas is generated then creating gas pressure.

Figure V-1 Diagram of KT31



Working principle:

Feeding material is fed through inlet until reaching 0 level. At this moment, the gas pressure in gas section is 0 (P=0). Gas is stored in gas section then push digestion solution to the compensation tank while pushing generated gas to gas pipe and pipeline to the place of gas utilization. When gas is used for cooking and lighting, gas pressure in gas section gets down making digestion solution come back to the digester from compensation tank. When gas is used up, gas pressure in gas section is 0. The biogas plant comes back to starting state.

During the operation of fixed dome biogas plant, its surface is up and down. The surface of the digestion solution narrows when up and expand when down. This moving help reduce the forming of scum. Additionally, proper dillution ratio and regularly stir help reduce the forming of scum.

Advantage:

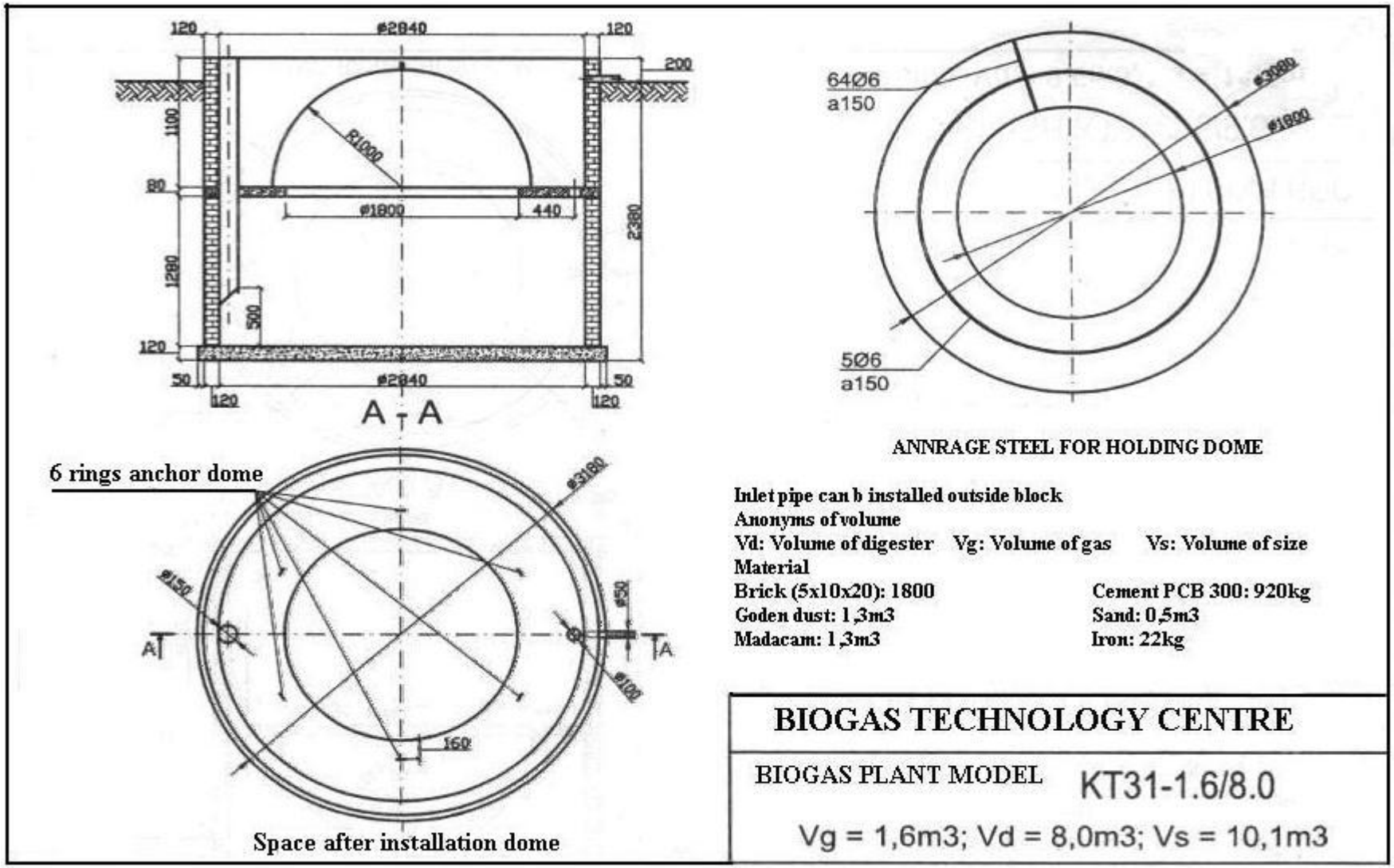
- Construction location is saved;

- Due to high durability of material, the plant has long life if the operation and maintenance is strictly followed;
- Easy operation.

Disadvantage:

- Gas dome is made of composite that not available in many localities in Vietnam
- Construction execution is complicated as a concrete plate has to be precasted to separate digester tank and gas storage tank;.
- Difficult transportation;
- Plant wall has to be thicker thus need more construction material than that of KT1/KT2, resulting in higher investment cost;
- Mason should be trained for construction of plant wall.
- As soil can not be filled in on the surface of plant, this surface cannot be used for other purpose(s).

Figure V-2: Design of KT 31 – 10.1 m^3



V.2 Composite model

Composite plant is originated from China. At present, this model has been manufactured and developed by a number of companies in Vietnam like Vietnam Veterinary Development Joint Stock Company (Hanoi), Thanh Loc Composite Company Ltd (Thai Binh province), Hung Viet composite company Ltd (Thai Binh province), Quang Huy composite company Ltd (Ha Noi). Material – which 100% imported - used for composite model is synthetic material of fiberglass, carbon fiber and polyester.

Composite model has 3 main tanks are digestion tank, gas storage tank and compensation tank. Like KT31, three parts are designed in one block and buried underground.

Composite model has 6 following parts:

- Digester, Vd= 7 m^3
- Gas storage, Vg=1.5 m^3
- Gas pipe
- Inlet for feeding material (with the dimension of 800mm)
- Overflow outlet (with the dimension of 900mm)

Working principle:

Feeding material is fed through inlet until reaching the point of 60 cm length of the inlet pipe and outlet (overflow) pipe. At this moment, the gas pressure in the digester is 0 (P=0). After feeding, inlet is close. Generated gas is stored in the upper part of the digester, and then is pushed through gas pipe that located in the middle point of the upper dome. Digestion fluid is pushed through the outlet pipe. When gas is used up, gas pressure in gas section is 0. The biogas plant comes back to starting state.

During the operation of fixed dome biogas plant, its surface is up and down. The surface of the digestion solution narrows when up and expand when down. This moving help reduce the forming of scum. Additionally, proper dilution ratio and regularly stir help reduce the forming of scum.

Advantage:

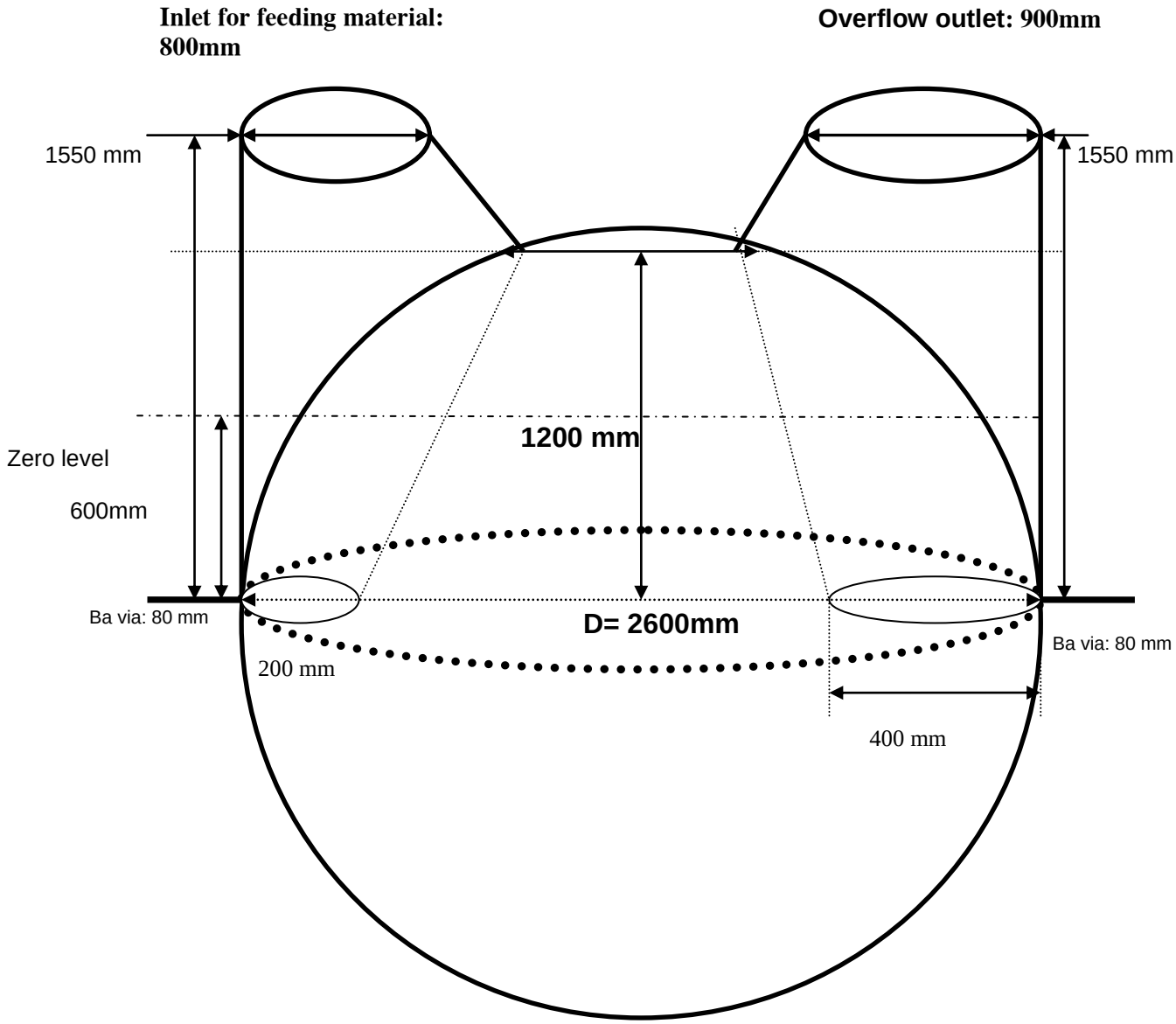
- Gas-tight and water-tight;
- Save on construction site;
- Save time for installation; do not need trained mason because composite installation was implemented by technician of suppliers/manufacturers;
- Suitable to week soil and high water table soil;
- Can be move to another location when necessary;
- Simple operation and maintenance;
- Odorless if good operation.

Disadvantage:

- High cost investment;
- As too cumbersome then difficult transportation;
- No much choices for users as few sizes of 4.8m^3, 6.9m^3, 8.8m^3 and 10 m^3;
- Not yet quality control process applied for composite model;
- When gas is used up completely, digestion solution in digester can go to the gas pipe, causing stuck in the gas pipe;

- Generated gas can go in to the air through inlet pipe and outlet pipe because the diameters of these pipe are too big;
- Unavailability in many localities in Vietnam.

Figure V-3: Diagram of Composite model



V.3 Nylon bag digester

Nylon bag digester is manufactured and delivered by Thu Duc University of Agriculture and Forestry. Material of nylon bag digester is PVC which commonly sold in many localities. This model has digestion tank and gas storage but no compensation tank. Gas pressure is created by put a heavy thing on digester or tighten gas nylon bag with an elastic band.

In terms of design, nylon bas has the following parts:

- Digester is made of 3 nylon layers. This 3-layer-bag then put in prepared hole/drain and covered with bamboo screens. The hole/drain may be constructed by brick or concreted. Vd = 8m^3, Vg = 2 m^3;
- Inlet pipe: Porcelain pipe or PVC pipe can be used;
- Outlet pipe: Porcelain pipe or PVC pipe can be used;
- Gas bag – made of one-nylon-layer - is hung on the roof of animal stable;
- Gas pipe;
- Safety valve;
- In some cases, a deposit sediment tank and slurry pit can be constructed.

Working principle:

Feeding material is stored in sand-deposit tank before fed into main digester through inlet pipe. Generated gas goes through pipeline then stored in nylon bag. After fully feeding, the digestion fluid goes automatically to slurry pit through outlet pipe. Gas pressures of the main digester are created by putting a heavy thing on the digester or fasten the digester with an elastic band.

The formation of scum can be reduced by shaking the digester manually. In addition, proper dilution ratio or regularly stir also prevents the formation of scum.

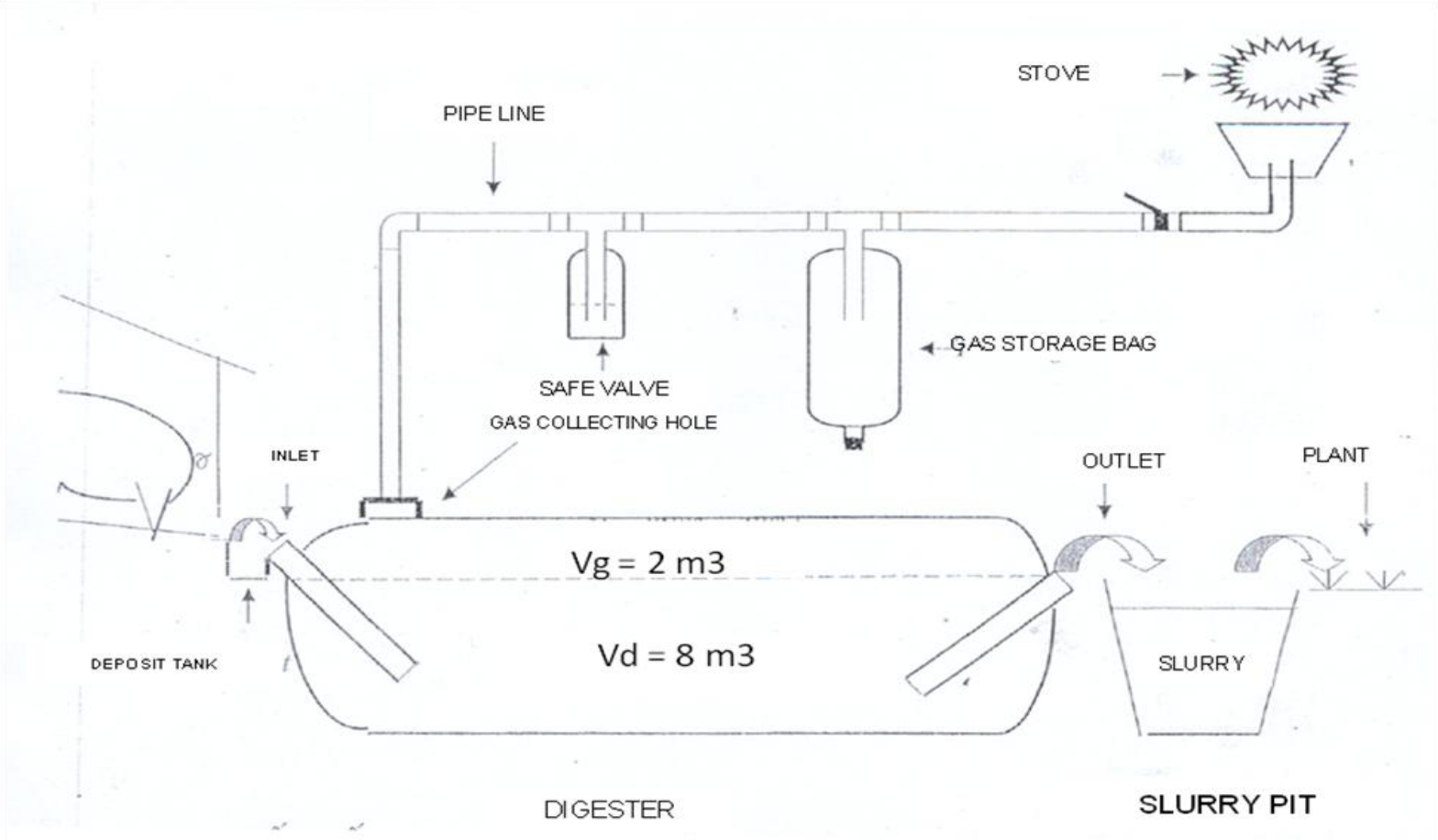
Advantage:

- Low cost investment;
- Nylon material is available every locality;
- Simple and quick installation;
- Suitable to low income households and/or households do not intend to develop their animal production;

Disadvantage:

- Require large space;
- Digester is not durable and easy to be bite by mice or cricket;
- Difficult to move out scum and sediment;
- Low gas pressure thus low utilization efficiency;
- Bad in keeping temperature thus bad operating in winter;
- Low safety to user as gas bag is easy to be damaged;
- Difficult to set up quality control procedure.

Figure V-4: Design of nylon bag digester



V.4 KT1 and KT2

KT1 and KT2 is the two model designs which developed based on sectoral standard 10TCN 492:499-2002 and 10TCN 97:102-2006 issued by MARD. The two models are introduced and developed in the Project. KT1 (figure V-5) is applied for low level water table while KT2 (figure V-6) is applied for high level water table.

The models have 6 main parts of mixing tank, digester (KT1: Vd=8m^3, Vg=1,4m^3, KT2: Vd=6m^3, Vg=2,4m^3), compensation tank, inlet, and outlet and gas pipe. Wall of digester and compensation tank is constructed by brick. Digester has dome-shape. Bottom is concreted or constructed with brick. Mixing tank has rectangle shape. This tank is not compulsory as depending on construction site. Compensation tank can be constructed or dome-shape or rectangle shape. All three tanks are connected together by inlet and outlet pipes. Gas pipe is installed in the middle of digester's cover or the highest position of digester's neck.

Working principle:

Feeding material is fed through inlet until reaching 0 level. At this moment, the gas pressure in gas section is 0 (P=0). Generated gas presses on the surface of digestion fluid then pushes a partly fluid to the compensation tank through outlet pipe while pushing generated gas to gas pipe and pipeline to the place of gas utilization. The level of fluid in the compensation tank increases then reaching the overflow level then goes to slurry pit or sewage canal through overflow pipe. When gas is used for cooking and lighting, gas pressure in gas section gets down making digestion solution come back to the digester from compensation tank. When gas is used up, gas pressure in gas section is 0. The biogas plant comes back to starting state.

During the operation of fixed dome biogas plant, its surface is up and down. The surface of the digestion solution narrows when up and expand when down. This moving help reduce the forming of scum. Additionally, proper dilution ratio and regularly stir help reduce the forming of scum.

Advantage:

- Construction material is available in most of rural areas of Vietnam;
- Thank to the dome-shaped of wall, digester resist to compress force and save on construction material;
- As constructed by good quality of materials, digester has long lifetime if good operation;
- As constructed underground, land can be used for the construction of animal shed;
- Easy operation, safety for user;
- Due to these models developed and deployed under Project, masons have been familiar with designs. Quality Control procedures has been developed and applied through out the Project;
- Due to gas-tightness and water-tightness, the models met the environmental requirements: no bad odor, clean bio-slurry if good construction and operation.

Disadvantage:

- Require rather spacious construction site;
- Mason need to be trained;
- Difficult to detect damage or repair damage;
- KT1 is not suitable to week soil or high level water table soil.

Figure V-5: KT1 - 10.5 m^3

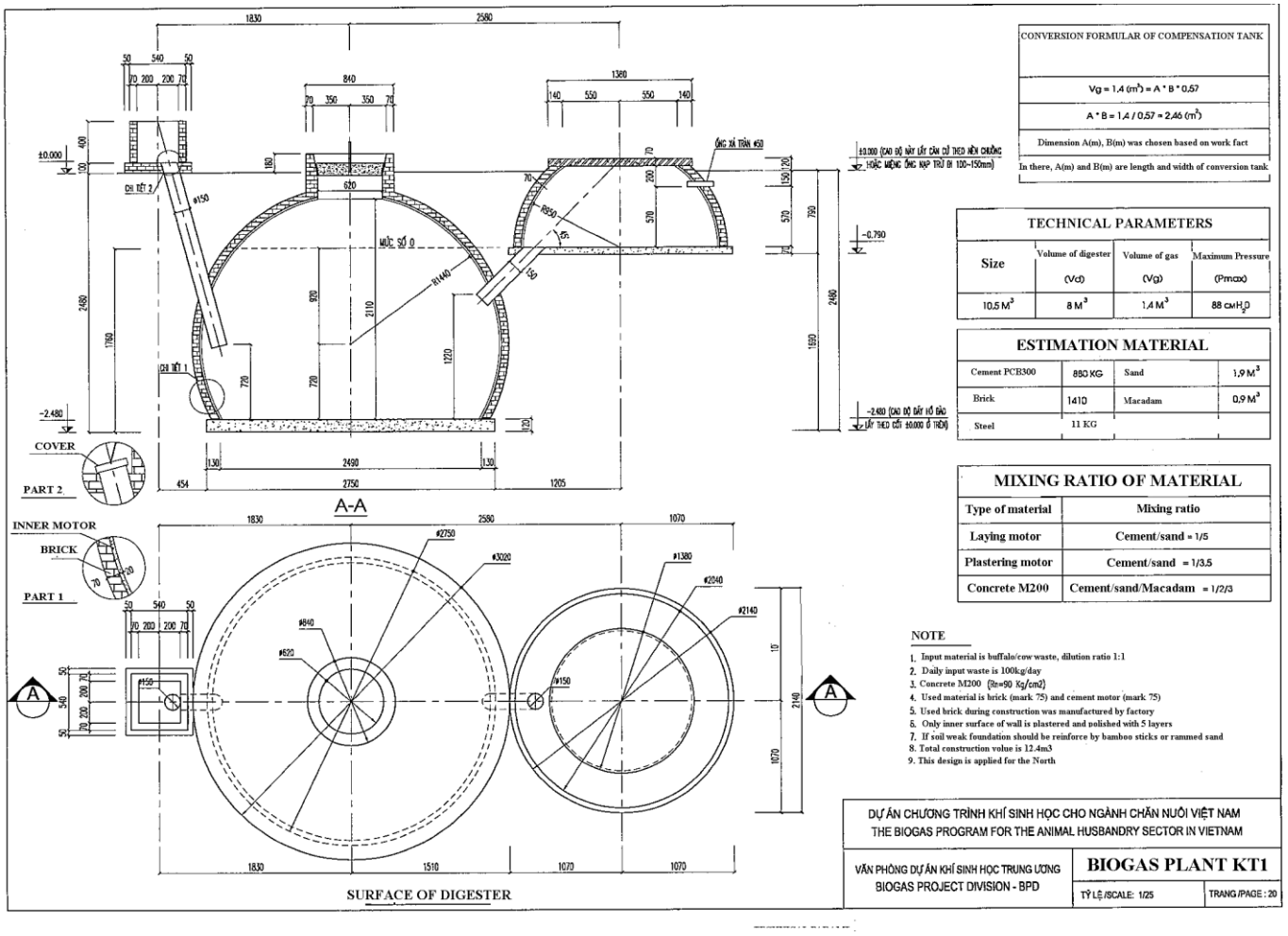
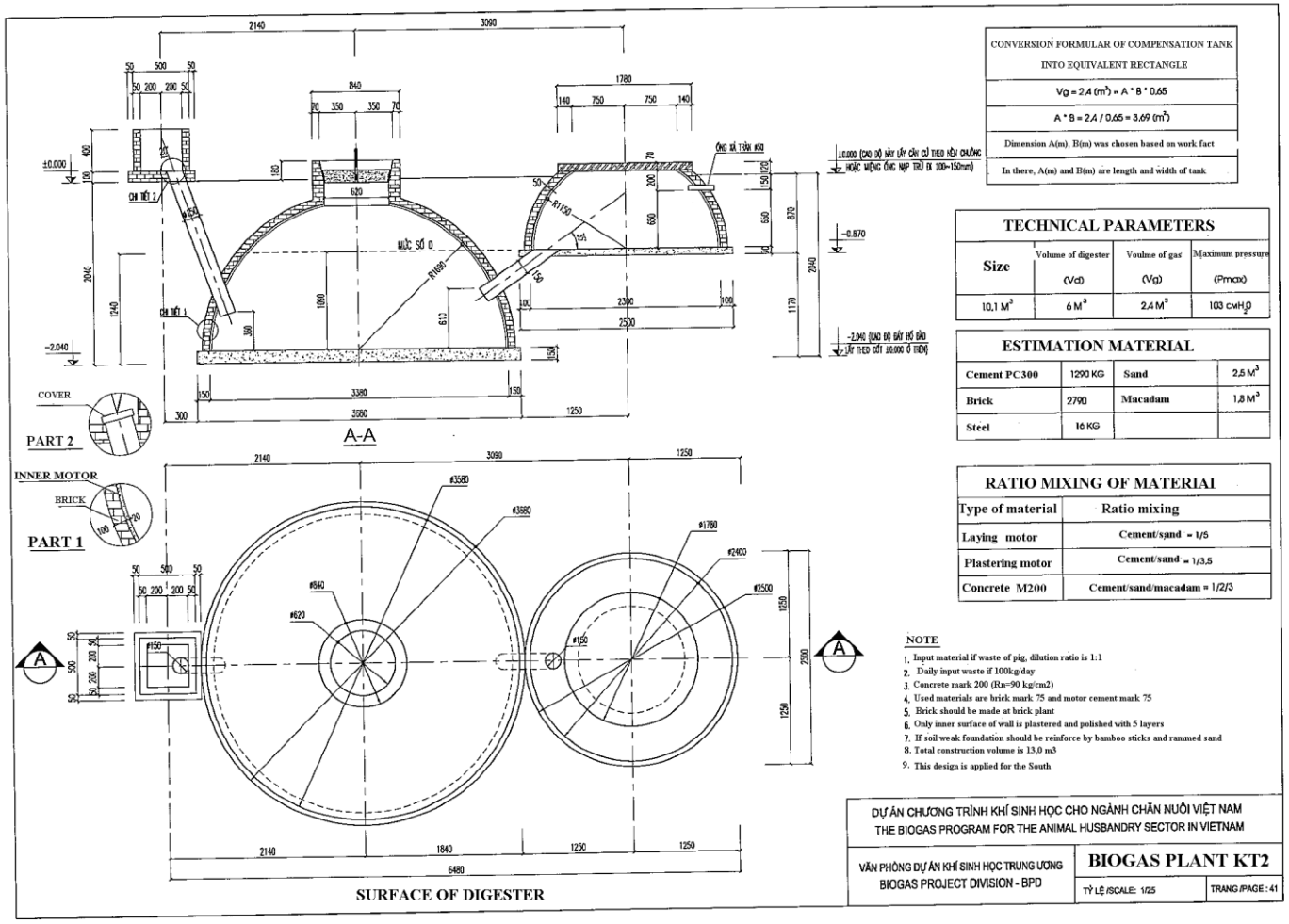


Figure V-6: KT2 – 10,1m^3



PART VI: CONSTRUCTION OF DEMONSTRATION PILOTS

As mentioned already in previous parts, all demonstration pilots are constructed in two localities which represent the North (Soc Son, Ha Noi) and the South (My Tho, Tien Giang). At each province, the Consultant constructed 4 kinds of models: KT1 in the North and KT2 in the South, KT31, and composite and nylon bag. In order to provide a fair comparison, models with the appropriately same size (about 10 cubic meters) are used. Specific in the North does not KT1 with capacity of 10 cubic meters using pig waste, therefore we chosen KT1 with caoacity of 10.5m^3 using buffalo/cow wastes for evaluation and monitoring.

The construction of models strictly followed guidance of providers or designers. The construction was carried out by trained masons of Project with the assistance of technicians of providers and enjoyed the close observation of specialists from Consultancy group. Detail construction of demonstration pilots were attached in annex 6.

Table VI-1 presents households selected for demonstration pilots in Hanoi (Bac Phu commune, Soc Son district) and Tien Giang (hamlet 5, Dao Thanh commune, My Tho city).

Table VI-1: Households selected for demonstration pilots

Locality	KT31	Composite	KT1/KT2	Nylon digester
Hanoi	Tran Van Lap	Hoang Van Khang	Tran Van Thanh	Nguyen Thi Duong
Tien Giang	Ngo Quoc Thanh	Pham Tuan Kiet	Ngo Thi Dieu	Nguyen Thi Thom

VI.1 Construction of KT31

Within this study, KT31 is constructed at household of farmer Ngo Quoc Thanh at hamlet 5, Dao Thanh commune, My Tho city, Tien Giang province and household of farmer Tran Van Lap at Bac Phu commune, Hanoi. 10.1 m^3 size is selected.

At Tien Giang, biogas plant was constructed from 26th to 29th October 2009.

At Hanoi, biogas plant was constructed from 4th to 8th November 2009.

Construction steps are summarized as follows:

- Select construction site;
- Define main parameter (diameter of digester);
- Soil excavation: A hole with outside diameter of bottom of 360 cm and 249 cm depth was excavated. In Tien Giang, the hole was digged with the slopping of 1:1.5 as water table is high.
- Concrete digester's bottom: Concrete of 200# with stone 1*2 of 12cm thick. After defining centre point and radius of the bottom, frame of concrete should be made.
- Construction of digester's wall: Wall of KT31 has cylinder shape. Wall reaches 12cm thick after plastering in case of Northern brick is used and about 10 cm thick in case Southern brick is used.
- Install inlet pipe
- Concrete plate separating digestion section and compensation section.
- Plastering
- Fill in

- Installation of composite dome: The composite dome is a hemisphere with diameter of 180cm and made of composite material. On the brim of composite dome, 10 small holes were made to install 10 bolts.
- Install pipeline, valve, gas meter and biogas appliances; test water-tight and gas-tight.

Figure VI-1 construction of digester's wall of KT31

(left for Hanoi and right for Tien Giang)

Figure VI-2: Concrete to separate digester and compensation section in Tien Giang

Figure VI-3: Concrete to separate digester and compensation section in Hanoi

Figure VI-4: Installation of composite domes

(the right for Hanoi and the left for Tien Giang)


Total time for both construction and installation of KT31 was 10 labor days and the same for the North and the South. As it was the first time this kind of model was constructed by masons. When masons are trained and be familiar, labor days may cut down.

Figure VI-2: Man-day for construction and installation of KT31 model*

Northern - KT31					
	Manday	**Unit**	**Quantity**	**Unit cost (VND)**	**Amount (VND)**
1	Excavation	m3	19.1	40,000	764,000
2	Concrete foundation	manday	1.0	200,000	200,000
3	Construct wall	manday	2.0	200,000	400,000
4	Concrete plate	manday	4.0	200,000	800,000
5	Assemble composite gas dome	manday	2.0	200,000	400,000
6	Install gas pipeline, stove, lamp	manday	1.0	200,000	200,000
	Sub-total		10.0		**2,764,000**
	Transportation				**600,000**
	Total				**3,364,000**
Southern - KT 31					
1	Excavation	m3	21.1	50,000	1,053,500
2	Concrete foundation	manday	1.0	250,000	250,000
3	Construct wall	manday	2.0	250,000	500,000
4	Concrete plate	manday	4.0	250,000	1,000,000
5	Assemble composite gas dome	manday	2.0	250,000	500,000
6	Install gas pipeline, stove, lamp	manday	1.0	250,000	250,000
	Sub-total		10		**3,553,500**
	Transportation				**1,100,000**
	Total				**4,653,500**

*: *As evaluation was based on execute the work time and construction cost so we paid money for mason based on labor Day.*

During the construction and installation of KT31 model in Tien Giang, the following difficulties were recorded:

- Due to high water level table, construction had to be carried out right after digging hole. To deal with high water level table, a water pump was used to pump out water;
- Concreting 4 plates was conducted at the same time of construction of wall, resulting in time consuming as at least 24 hours after concreting, the plates can be moved.
- The moving of 4 plates needs 8 persons. Thus in Hanoi, the plate was directly concreted on the wall.

Conclusion:

- Time for construction of KT31 was longer than expected
- Masons from Tien Giang had opinions that separate plates should be made of composite to save time for construction and installation of digester.

VI.2 Construction of composite model

Composite digesters used in the Study were bought from Thanh Loc composite Company. The digester was manufactured at the factory and has two hemispheres. These two hemispheres were connected and installed at site before putting down to the prepared hole. The connection and installation of digester was done by masons with conduction and assistance of the technician from Thanh Loc Company. This process was strictly follow instruction and technical requirements of producer. The two composite digesters were installed in both Tien Giang and Hanoi. In Tien Giang, the composite digester was installed at household of Mr. Pham Tuan Kiet at hamlet 5, Dao Thanh commune, My Tho city. In Hanoi, it was installed at household of Mr. Hoang Van Khang at Bac Phu commune, Soc Son district.

The digester was installed in Tien Giang from 26th to 29th October 2009.

The digester was installed in Hanoi from 4th to 8th November 2009.

Installation steps are summarized:

- Select site for digester
- Define main parameter (diameter of hole)
- Excavation: For selected sized of 10 cubic meters, the outer diameter of digester is 260cm. In Hanoi, a hole with diameter of bottom of 270cm and 260 cm deep was digged vertically. In Tien Giang, hole was digged with slopping of 1:1.5 due to high lever water table. The hole has parameter of 290cm * 260cm.
- Connect all parts of composite digester:
    - Connect ears: locate ear by marking on digester where to connect ears. Use prepare connection glue on brims of ear and digester then press glue on the surface of digester where connect ears. Mason goes inside digester and presses well all bolts and connect all bolts.
    - Drill a hole for gas pipe: use driller 10 to make a hole at the middle of upper digester wall. A drilled hole should have an inner diameter of 21mm. Press connection glue (like washer) and screw inner 21 mm and screw outer 21mm together. Press well connection glue surrounding both inner screw and outer screw.
- Low composite digester into digged hole and fix by rod.
- Install inlet and outlet pipes: PVC pipes of 110 mm were put on the ears of composite digester. Bricks were constructed to enclose the ears. Two concrete plates were put on the mouth of inlet and outlet to prevent rain water getting into digester.
- Install gas pipeline, gas meter and gas appliances; test water-tightness and gas-tightness.

Total time need for installation of composite model is 3.5 days in the North and 4 days in the South. The installation was done by Project masons under close observation of the technician from Thanh Loc Company Ltd,.

Figure VI-5: Connect parts of composite digester




Figure VI-6. Lowing composite digester


Table VI-3: Man-day for construction of composite model

Northern - Composite					
	Manday	**Unit**	**Quantity**	**Unit cost (VND)**	**Amount (VND)**
1	Excavation	m3	14.9	40,000	595,156
2	Assemble composite digester	manday	2.5	200,000	500,000
3	Fill in	manday	0.5	200,000	100,000
4	Install gas pipeline, stove, lamp	manday	0.5	200,000	100,000
	Sub-total		3.5		**1,295,156**
	Transportation				**600,000**
	Total				**1,895,156**
Southern - Composite					
1	Excavation	m3	17.2	50,000	743,945
2	Assemble composite digester	manday	2.0	250,000	500,000
3	Fill in	manday	1.0	250,000	250,000
4	Install gas pipeline, stove, lamp	manday	1.0	250,000	250,000
	Sub-total		4		**1,743,945**
	Transportation				**1,100,000**
	Total				**2,843,945**

During the installation of composite in Tien Giang, the following difficulties were recorded:

- Due to high water table the composite digester floated after soil filling, thus the installation was repeated. To deal with this difficulty, a hole for collect stagnant water should be digged and a water pump is necessary to pump out water before installation of digester. Soil should be compressed. Sand bags may be used to put on. After that, water can be pumped into the digester to test water-tightness and gas-tightness.
- In Hanoi, during the lowing of digester, the digester was collapsed as the ligament lines were not equally tight. This is the lesson learned for the next installation.

Conclusion:

- The installation of composite is rather quick and easy. Masons do not need training.

VI.3 Installation of nylon bag digester

In Tien Giang, nylon bag digester was installed at household of Ms. Nguyen Thi Thom at hamlet 5, Dao Thanh commune, My Tho city. In Hanoi, it was installed at household of Ms. Nguyen Thi Duong at Bac Phu commune, Soc Son district.

The installation in Tien Giang was conducted from 26th to 29th October 2009

The installation in Hanoi was conducted from 4th to 8th November 2009

In the comparison with the two above models, nylon bag digester needs a rather simple installation. 3 nylon layers were used to made digester. Then it put in a hole which already prepared. The installation was finished with the cover of some bamboo screens. The installation includes following steps:

- Select site for installation of nylon bag digester
- Define main parameters
- Soil excavation: for the size of 10 cubic meters, the hole of 1,2m * 1,2m * 10m was digged in Hanoi. Hole's edge was digged vertically and no landslide was recorded during excavation. In Tien Giang, the hole of 11 m x 1.4m x 1.2m was digged with the slopping of 1:1.5 as high water table.
- Three nylon layers were put together.
- Make leaking hole.
    - A leaking gas kit include of inner teeth, outer teeth and one round plate.
    - Create a hold in the middle of nylon bag with scissors. This hold suit completely with outer teeth of the kit. Screw two plates tightly.
- Installation of inlet and outlet pipes:
    - PVC or glazed-terra cotta pipes can be used
    - Insert pipe into nylon bag. Make many nylon folds around pipe the tie tightly with elastic band.

Figure VI-7 Diagram of nylon bag digester

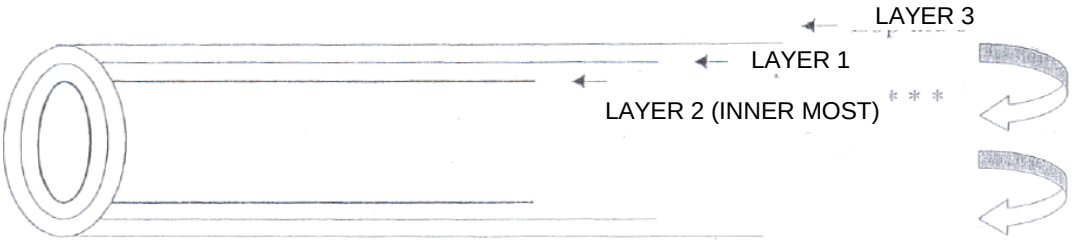


Figure VI-8: Slip nylon bag

-

Figure VI-9: Installation of inlet and outlet pipes

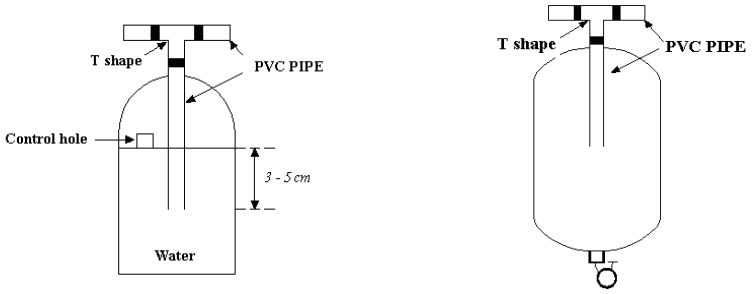

- Put nylon bag digester into the hole:
    - Check hole to remove all sharp or pointed things.
    - Fix two ends of nylon bag with two crossed tree branches. Pipes were installed to the position of 35-40cm from the bottom of the hole.
    - Pumping and correct the nylon bag to make sure no fold in the bag.

Figure VI-10: Putting nylon bag digester into hole


- Installation of gas bag:
    - A T-shaped was made of PVC with outer diameter of 21mm. The long pipe is 30cm and two shorter pipes are 5cm length.
    - Two nylon layers of 5m were slipped into each other.
    - Manipulation was as per below diagram. A PVC pipe was put into the nylon bag then fixed tightly to the bag. The other end of bag was tied tightly.
    - The bag was hung vertically or horizontally at ventilating place, avoid direct sunny ray or pointed things.
    - When using gas, a heavy thing can be hung under the bag or tie the bag with an elastic band to create pressure for the bag.
- Installation of gas pipeline, safety valve, gas appliances

- Fill in with soil, put a heavy thing on nylon digester then cover digester with bamboo screens.

Figure VI-11: Diagram of safety valve and gas bag



Safety valve Bag gas

Manipulation should be very careful so as not to damage the bag or create gas leakage at holing-place on the digester.

Total time needed for installation of nylon bag digester was 2,5days for the North and 2 days for the South. Project masons installed the two digesters under observation of the Consultant.

Table VI-4: Man-day for installation of nylon bag digester

Northern - Nylon bag model					
	Manday	**Unit**	**Quantity**	**Unit cost (VND)**	**Amount (VND)**
1	Excavation	m3	14	40,000	576,000
2	Install gas pipeline, stove, lamp	manday	2.5	200,000	500,000
	Sub-total		2.5		1,076,000
	Transportation				**0**
	Total				**1,076,000**
Southern - Nylon bag model					
1	Excavation	m3	18	50,000	720,000
2	Install gas pipeline, stove, lamp	manday	2	250,000	500,000
	Sub-total		2		1,220,000
	Transportation				**0**
	Total				**1,220,000**

The installation of nylon bag digester was rather quick and easy. Masons do not need training.

VI.4 Construction of KT1 and KT2

Within this study, KT2 model is constructed at household of farmer Ngo Thi Thom at hamlet 5, Dao Thanh commune, My Tho city, Tien Giang province. KT1 was constructed at household of farmer Tran Van Thanh at Bac Phu commune, Hanoi. 10-10.5 m^3 size is selected.

In Tien Giang, the biogas plant (KT2) was constructed from 26th to 29th October 2009.

In Hanoi, the biogas plant (KT1) was constructed from 4th to 8th November 2009.

Construction steps are summarized as follows:

- Select construction site
- Define main parameter (diameter of digester)

- Soil excavation: For selected sizes, a hole with dimension of 3m x 2.6m was digged for KT1 and a hole with dimension of 3mx2.9m was digged for KT2.
- Concrete digester's bottom: Concrete of 200# with stone 1*2 of 12cm thick. After defining centre point and radius of the bottom, frame of concrete should be made.

Figure VI-12: Some pictures of construction of KT1 (excavation, construction of wall, plastering)

- Construction of digester's wall: Wall was constructed in dome-shape. Bricks were laid horizontally, having 12cm thick after plastering and 10cm when Northern brick and Southern brick are used respectively. Bricks should be solid and not crack, having #75 compress resist intensity.
- Installation of inlet and outlet pipes
- Installation of pipeline, valve, gas meter and biogas appliances; test water-tight and gas-tight.

Figure VI-13: Some pictures of construction of KT2 (excavation, construction of wall, plastering)

Total days necessary for construction of KT1 was 8.5 days and for KT2 was 9.2 days. As masons are familiar with KT1 and KT2 so the construction was quick and favorable.

Table VI-5: Man-day for construction of KT1 and KT2

Northern (KT1) -					
	Manday	**Unit**	**Quantity**	**Unit cost (VND)**	**Amount (VND)**
1	Excavation	m3	22	40,000	889,060
2	Concrete foundation	manday	1	200,000	200,000
3	Construct wall	manday	6.5	200,000	1,300,000
4	Install gas pipeline, stove, lamp	manday	1	200,000	200,000
	Sub-total		8.50		2,589,060
	Transportation				**0**
	Total				**2,589,060**
Southern (KT2)					
1	Excavation	m3	25	50,000	1,253,684
2	Concrete foundation	manday	1.0	250,000	250,000
3	Construct wall	manday	7.2	250,000	1,800,000
4	Install gas pipeline, stove, lamp	manday	1.0	250,000	250,000
	Sub-total		9.2		3,553,684
	Transportation				**0**
	Total				**3,553,684**

PART VII: COMPARISION AND EVALUATION

VII.1 Principles of comparison

Principles of comparison and evaluation as well as the maximum scores for each criterion have been described in inception report. However, in the final report, similar issues have been grouped by the Consultant to avoid giving score many times for the same issue. Maximum score for each comparison criteria will be also grouped in corresponding groups. These principles have relatively nature and can refer for applying each specific model in difference regions.

Criteria of evaluation and the applicable score after adjustment are listed in following table:

Table VII-1: Evaluation criteria

Criteria	Maximum score
1. Construction material	**10**
1.1 availability	5
1.2 Durability	5
2. Construction	**20**
2.1 Excavation	5
2.2 How easy to construct (need training for mason?)	5
2.3 Construction time	5
2.4 Special methodology for construction	5
3. O &M	**30**
3. 1 Easy to break down by outside issues*	6
3.2 Gas yield and stable gas generation	6
3.3 Safety for end user	6
3.4 Maintenance (remove scum, mix)	6
3.5 Easy to detect fault and easy to repair	6
4. Cost effectiveness	**30**
4.1 Total investment cost	10
4.2 Annual average investment cost	10
4.3 Financial index	10
5. Sanitation and environment	**10**
5.1 Bad smell	4
4.2 BOD_5, COD, Coliform	6
Total	**100**

**: Easy to break down by outside issues as flood, earthquake, fire or being bite by animal or sharp things*

Based upon total score of researched biogas models to rank in groups of A, B, C as below definition:

Group A: Total score > 75 and each criterio is more than 50% score – Model is highly recommended to widely apply and deploy.
Group B: Total score is 50-75 scores – Model is recommended to apply with certain conditions.
Group C: Total score <50 scores – Model is not recommended.

VII.2 Evaluation on material

VII.2.1 General description on construction material

KT31

- Brick: at least of grade 75. Brick shall be evenly burned and evenly in size. The inflation brick, half baked brick and uneven size brick shall not be used. The surface of brick shall be cleaned and free from soil, sand or moss contamination.
- Sand: clean sand, content of contamination shall not more than 5%;
- Cement: Portland cement with grade at least PCB30.
- Gravel, pebble will be necessary aggregates for concrete mixing. Such material shall have clean surface, free from soil or organic matters.
- Concrete mixture: to be mixed properly by designed mixture proportions, under plastic state, not yet setting.
- Steel: using steel Φ6
- Gas pipes: free from cracks, no leakage, the inlet pipe and outlet pipe shall have diameter of at least 150mm.
- The composite arch is manufactured by fiberglass, carbon-fiber associated by polyester and no contamination filler, acid proof, anti-ultraviolet rays.
- Gas collecting pipe;
- Biogas stove and lamp.

Composite

- The composite arch is manufactured by fiberglass, carbon-fiber associated by polyester and no contamination filler, acid proof, anti-ultraviolet rays. The composite arch is manufactured by Thanh Loc Ltd., which has been verified its quality by the General Department on Measurement and Quality in document number 09/0349/TN3-CS dated 15/04/2009 on failure durability, bending durability and breaking durability.
- Resin, rock flour, bolt,
- Gas collecting pipe.
- Biogas stove and lamp.

Nylon bag

- The nylon bag will have 3 layers to enhance durability of the bag and plant lifetime.
- Inlet and outlet pipes.
- Gas collecting pipe.
- Gas holder.
- Biogas stove and lamp.

To enhance the lifetime of nylon bag biogas, the bag layers shall be inserted into each other to prevent the case of bag broken.

KT1 and KT2

The KT1 and KT2 are constructed by conventional material. To ensure quality, the material used shall be selected ensuring following standards and requirements:

- Brick: at least of grade 75. Brick shall be evenly burned and evenly in size. The inflation brick, half baked brick and uneven size brick shall not be used. The surface of brick shall be cleaned and free from soil, sand or moss contamination.
- Sand: clean sand, content of contamination shall not more than 5%;
- Cement: Portland cement with grade at least PCB30.
- Gravel, pebble will be necessary aggregates for concrete mixing. Such material shall have clean surface, free from soil or organic matters.
- Concrete mixture: to be mixed properly by designed mixture proportions, under plastic state, not yet setting.
- Steel: using steel Φ6

- Gas pipes: free from cracks, no leakage, the inlet pipe and outlet pipe shall have diameter of at least 150mm.
- Flour to seal the pipe preventing gas leakage
- Clay used to seal the mouth of digester;
- Gas collecting pipe.
- Biogas stove and lamp.

Evaluation and comparison on construction material of pilot plants will be done taking into consideration the following factors:

- Availability of material in local
- Required quantity, cost and cost of transportation
- Durability of material

VII.2.2 Availability of material

Material used in constructing biogas model types KT1, KT2 and the digester of KT31 is available in any location within Vietnam. Except the case of no-hollow brick which is not always available in any location, therefore in locations where no-hollow brick are not available, the mason is acceptable for using hollow brick (diameter not more than 2cm) in construction. In the case of using hollow brick the mason shall construct wall of digester with thickness 12cm. Clay is not always available in any location, therefore to ensure that the mouth of digester is completely sealed, the mason is requested to used clay to seal the digester's mouth. In some areas/locations where clay is not available, masons normally store clay transported from other location (as the case of Tien Giang)

The composite digester and arch of KT31 model, according to investigation of the study team, presently in the market there are some companies able to manufacture. Within frame work of this study, products of Thanh Loc Ltd., whose head office is at Thai Binh province, are used. Thanh Loc Ltd. has developed its grade I agency system all over some provinces in the Northern region such as Hanoi, Phu Tho, Bac Ninh, Bac Giang. In addition, for order of more than 15 digesters, Thanh Loc Ltd., will provide transportation and installation in any location all over the country (such as in Binh Thuan and Ninh Thuan).

The nylon bag used in biogas is available in most of locality.

According to the classifying criteria listed in table VII-1, the maximum score for available of construction material in local is 5. The material having distance of transportation less than 50km will be considered as available. Material to be transported longer than 50km and cost of transportation having to be paid shall be considered as non-available. Longer transporting distance will be less score then the shorter distance. To favorable the evaluation of construction material in regard to its availability, the KT31 arch is estimated with ratio of 40% total score (2 scores). The composite part of composite type will be estimated with ratio of 80% total score (4 scores). In other models, score will be evenly divided for each type of material.

By this principle, detail scores on available in each pilot model are listed in tables below:

Table VII-2 Availability of material for KT31

Northern Part - KT31			Total Score	Southern part - KT31		Total Score
No	**Material**	**Availability**	**(maximum 05)**	**Material**	**Availability**	**(maximum 05)**
1	Brick	yes	0.33	Brick	Yes	0.33
2	Cement	yes	0.33	Cement	Yes	0.33
3	Sand	yes	0.33	Sand	Yes	0.33
4	Pebble, gravel	yes	0.33	Pebble, gravel	Yes	0.33
5	Steel	yes	0.33	Steel	Yes	0.33
6	Pipe	yes	0.33	Pipe	Yes	0.33
7	Composite arch	Transportation Distance 100 km	1.00	Composite arch	Transportation Distance 2,000 km	0.00
8	Gas collecting pipe	Yes	0.33	Gas collecting pipe	Yes	0.33
9	Stove	Yes	0.33	Stove	Yes	0.33
10	Light	Yes	0.33	Light	Yes	0.33
	Total		4.00	Total		3.00

Table: VII-3 Availability of material for composite

Northen Part - Composite			Total Score	Southern Part - Composite		Total Score
No	**Material**	**Availability**	**(maximum 05)**	**Material**	**Availability**	**(maximum 05)**
1	Composite	Transportation distance 100 km	2.00	Composite	Transportation distance 2,000	0.00
2	Stove	yes	0.50	Stove	yes	0.50
3	Light	yes	0.50	Light	yes	0.50
	Total	yes	3.00	Total	yes	1.00

Table: VII-4 Availability of material for nylon bag

Northen Part- Nylon bag			Total Score	Southern Part - Composite		Total Score
No	**Material**	**Availability**	**(maximum 05)**	**Material**	**Availability**	**(maximum 05)**
1	Nylong bag(10m x 1	yes	0.83	Nylong bag(10m x	yes	0.83
2	Nylong bag (5m x 1	yes	0.83	Nylong bag (5m x	yes	0.83
3	Pipe	yes	0.83	Pipe	yes	0.83
4	Gas collecting pipe	yes	0.83	Gas collecting pip	yes	0.83
5	Stove	yes	0.83	Stove	yes	0.83
6	Light	yes	0.83	Light	yes	0.83
	Total		5.00			5.00

Table: VII-5 Availability of material for KT1 and KT2

Northen Part (KT1) -			Total Score	Southern Part (KT2)		Total Score
No	**Material**	**Availability**	**(maximum 05)**	**Material**	**Availability**	**(maximum 05)**
1	Brick	yes	0.45	Brick	yes	0.45
2	Cement	yes	0.45	Cement	yes	0.45
3	Sand	yes	0.45	Sand	yes	0.45
4	Peble, gravel	yes	0.45	Peble, gravel	yes	0.45
5	Steel	yes	0.45	Steel	yes	0.45
6	Pipe	yes	0.45	Pipe	yes	0.45
7	comosite arch	yes	0.45	comosite arch	yes	0.45
8	Anti-leakage powde	yes	0.45	Anti-leakage powd	yes	0.45
9	Stove	yes	0.45	Stove	yes	0.45
10	Light	yes	0.45	Light	yes	0.45
11	Clay	yes	0.45	Clay	Not available, bring from other province	0.00
	Total		5.00			4.55

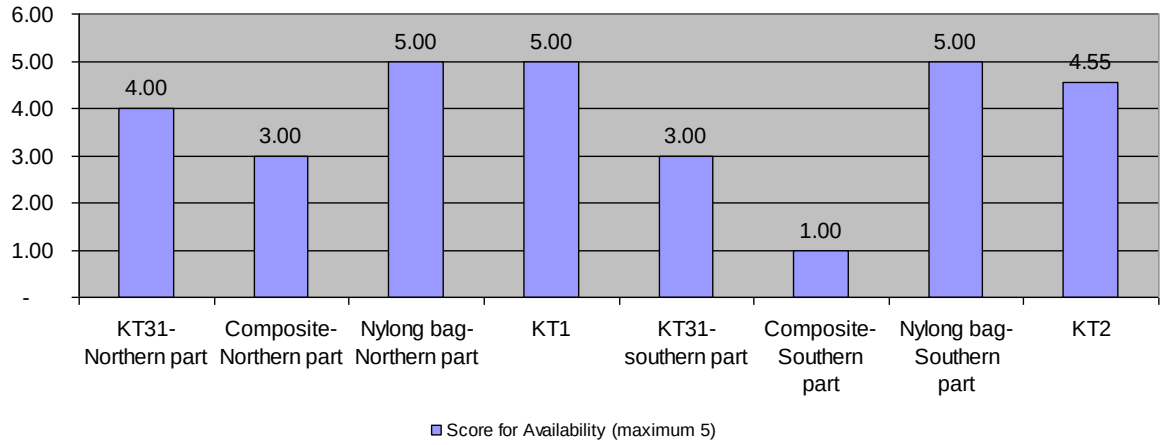
Summary on comparison on availability of material, see tables herein:

Table VII-6: Comparison and evaluation on availability of material for 4 models in two regions

The North		
No.	**Pilot model**	**Score for Availability (maximum 5)**
1	KT31	4.00
2	Composite	3.00
3	Nylon bag	5.00
4	KT1	5.00
The south		
1	KT31	3.00
2	Composite	1.00
3	Nylon bag	5.00
4	KT2	4.55

It can be said that the nylon bag and KT1/KT2 have maximum score, minimum score is composite type. Details on comparison on available are descried and showed in figure hereunder.

Figure VII-I: Comparison on availability of material for 4 studied models



VII.2.3 Evaluation on material durability

Durability of material is evaluated considering following parameters:

- Compressive strength
- Bending strength

Since durability of material in two regions will be the same therefore the regional factor will be ignored.

The bending and tensile strength of KT1, KT2 are taken according to Vietnamese Standard TCVN 1450:1986. Bending and tensile strength of nylon bag is taken from references supplied by Thu Duc Forestry-Agriculture University. Bending and tensile strengths of composites model is taken from data provided by supplier. To simplify for comparison purpose, the compressive and bending strengths of KT31 is estimated as adding average between KT1 and KT2 and composite because there are two reasons:

- Both KT31 and KT1/KT2 have:
    - Concrete digester's bottom was poured by concrete of 200# with stone 1*2 of 12cm thick;
    - Wall was constructed in dome-shape. Wall reaches 12cm thick and has compress resist intensity of #75 upward.

- Arch of both KT31 and composite are manufactured by fiberglass, carbon-fiber associated by polyester and no contamination filler, acid proof, anti-ultraviolet rays.

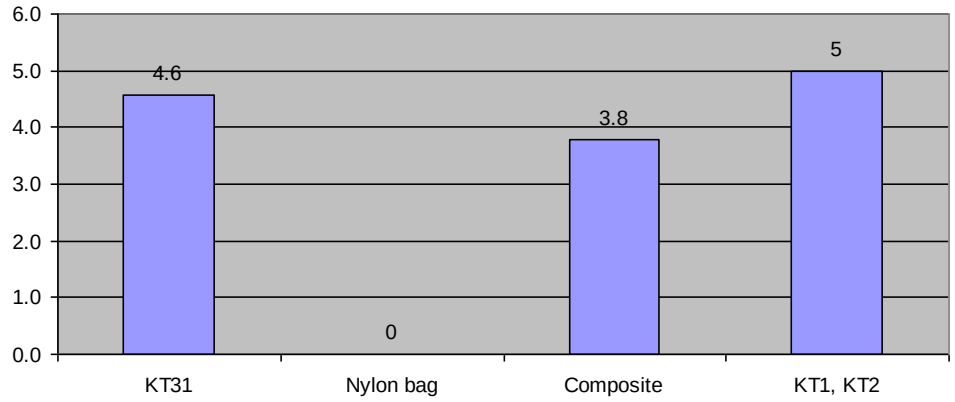
Plant having maximum strength will be paid with maximum score (5 score). Plant having minimum strength will be paid with minimum score (0 score). Scores of other works are divided by weighted average.

Table VII-7: Evaluation of material durability

Pilot model	Compresion strength (kg/cm2)	Bending Strenght (kg/cm2)	Maximum score (maximum 5)
KT31	75-45	16-19.2	4.6
Composite[3]	45	19.2	3.8
Nylon bag[4]	5.2	4.3	0
KT1, KT2[5]	75	16	5

So, KT1 and KT2 have the best durability. Nylon bag has lowest durability. See figure below for comparison on durability of material.

Figure VII-2: Comparison on material durability between 4 models



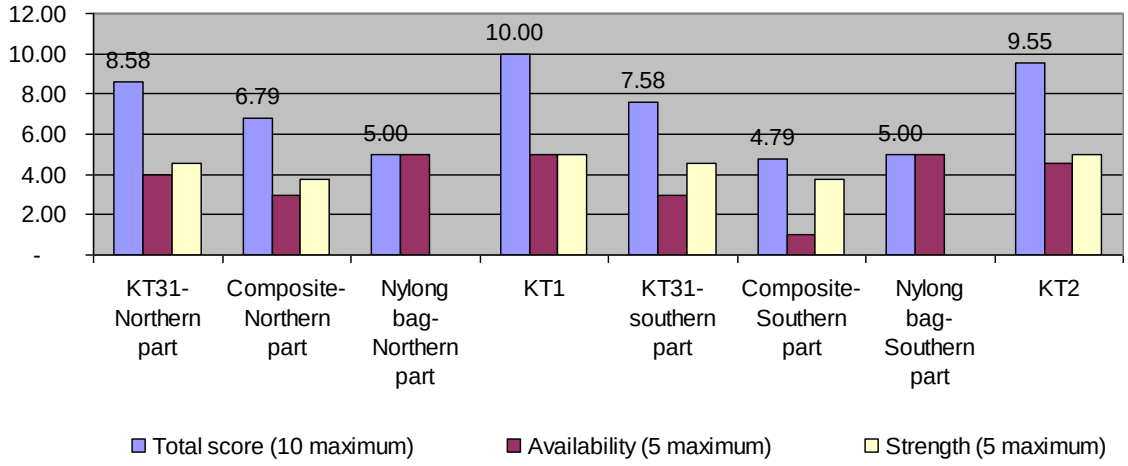
Summary on evaluation on material are listed and described in table herein:

Table VII-8: Evaluation of construction material

The North				
No.	**Pilot model**	**Total score (10 maximum)**	**Availability (5 maximum)**	**Strength (5 maximum)**
1	KT31	8.58	4.00	4.58
2	Composite	6.79	3.00	3.79
3	Nylon bag	5.00	5.00	0.00
4	KT1	10.00	5.00	5.00
The south				
1	KT31	7.58	3.00	4.58
2	Composite	4.79	1.00	3.79
3	Nylon bag	5.00	5.00	0.00
4	KT2	9.55	4.55	5.00

Figure VII-3: Evaluation of construction material

[3] Data is taken from Thanh Loc Company and evaluated by Directorate for Standard and Quality
[4] Data is taken from Thu Duc Forestry-Agriculture University
[5] Based on TCVN 1450:1986



VII.3 Evaluation of construction

Details on construction process will be described in *Part VI: Description on construction process*. To evaluate the construction process, four below factors have been considered:

- Soil excavation: the volume of soil to be excavated will be used as comparative criteria. Work having largest volume of excavation will be paid with 0 score, work having minimum volume of excavation will be paid with 5 scores. Scores of other works will be estimated by average weighted.
- Simplicity in construction, showing by the requirement on training of masons. Model required training for mason will be paid with 0 score. Models required no training for mason and the mason can read the guidance and construct themselves without any training will be paid with 5 scores. Plant required no training but requiring support from technical staff for the firs time of construction will be paid with 3 scores.
- Number of working day to build the plant. Plant having the least number of working days will be paid with 5 scores. Plant having maximum number of working day will be 0 score. Other plant will be estimated by average weighted.
- Special construction method: during building process, there are two construction methods to be applied which are base strengthening and underground dewatering. Maximum score of construction method will be 5 scores. If the plant requires foundation strengthening, it will be deducted 2 scores. Plant requires underground dewatering, will be deducted 3 scores. Plant requires both of the said methods is only 0 score.

VII.3.1 Soil excavation

Among pilot plants, KT1 and KT2 require largest volume of soil excavation. In the North, the nylon bag requires the least volume of excavation. In the South, the composite required the least excavation. Score on volume of excavation will be estimated basing on the mentioned principles and listed in following table.

Table VII-9: Evaluation and comparison on quantity of soil excavation

The North				The South	
No.	**Model**	**Excavation work (m3)**	**Score (5 maximum)**	**Excavation work (m3)**	**Score (5 maximum)**
1	KT31	19.1	2.0	21.1	2.5
2	Composite	14.9	4.7	17.2	5.0
3	Nylon bag	14.4	5.0	18.5	4.2
4	KT1-KT2	22.2	0.0	25.1	0.0

VII.3.2 Simplicity in construction

In regard to the construction, among 4 models taking into consideration and evaluation, the nylon bag is the most simply requiring no complicated building technique and no training to mason therefore being paid with maximum score: 5 scores. The KT1 and KT2 require complicated building technique and the building mason is required with training therefore having 0 score. The Composite and KT31 require no training to building mason but necessary with supports from technical staff for the first time of construction. Both types have 3 score. Scores on simplicity in construction are listed in following table:

Table VII-10: Evaluation and comparison on simplicity in construction

No.	Model	Score of how easy to build the model (5 maximum)
1	KT31	3.0
2	Composite	3.0
3	Nylon bag	5.0
4	KT1-KT2	0.0

VII.3.3 Construction time

About construction time, in both Regions, the KT31 requires longest time of construction because it needs time for placing panels, and therefore being paid with 0 score. The nylon bag requires shortest time of construction and therefore having maximum score. Scores of plants in regard of construction time are listed in table below.

Table VII-11: Evaluation and comparison on construction time

		The North		The South	
No.	Model	Man-day for construction and installation	Score (5 maxium)	Man-day for construction and installation	Score (5 maxium)
1	KT31	10.0	0.0	10.0	0.0
2	Composite	3.5	4.3	3.5	4.1
3	Nylon bag	2.5	5.0	2.0	5.0
4	KT1	8.5	1.0	9.2	0.5

VII.3.4 Special methods during construction

In Northern region, both KT1 and KT31 require base strengthening during construction process if they are built in weak soil foundation. The nylon bag and composite in general require no foundation strengthening. Since the underground water table in Hanoi area is located deeply, all of four types require no underground dewatering.

In Southern region, four models require underground dewatering during construction period. Besides, the KT2 and KT31 require base strengthening.

Scores on construction method are listed in table hereunder:

Table VII.12: Evaluation and comparison on construction method

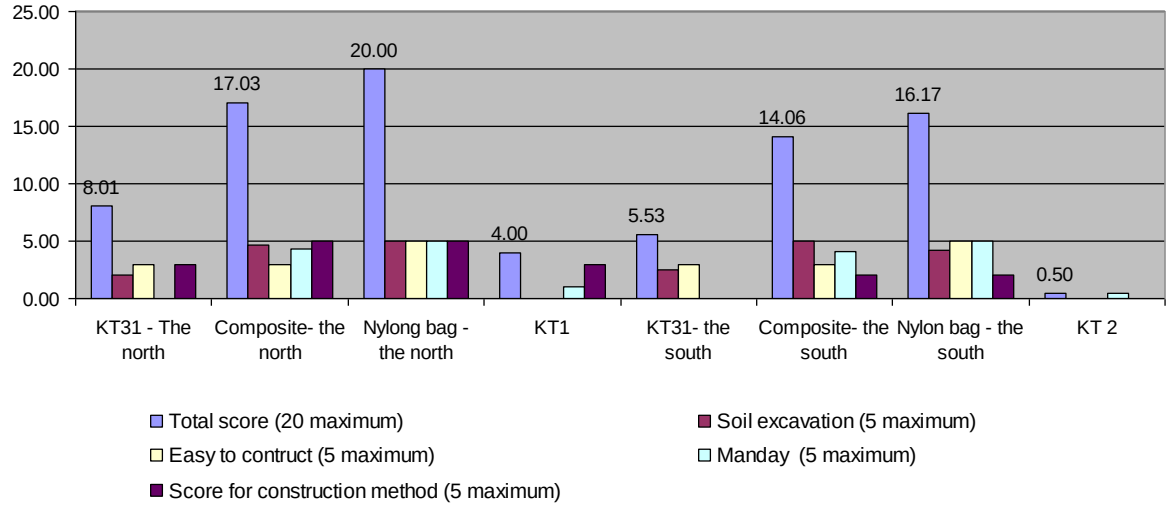
	The North		The South	
No.	Model	Score for special construction method (5 maximum)	Model	Score for special construction method (5 maximum)
1	KT31	3	KT31	0.00
2	Composite	5	Composite	2.00
3	Nylon bag	5	Nylon bag	2.00
4	KT1	3	KT 2	0.00

In summary of construction evaluation, the nylon bag is the easiest in construction and therefore having maximum score. KT1 and KT2 are those most difficult in construction and having minimum score. See details in table below:

Table VII-13: Summary and comparison on construction

The North						
No.	**Mô hình**	**Total score (20 maximum)**	**Soil excavation (5 maximum)**	**Easy to contruct (5 maximum)**	**Manday (5 maximum)**	**Score for construction method (5 maximum)**
1	KT31	8.01	2.01	3.00	0.00	3.00
2	Composite	17.03	4.69	3.00	4.33	5.00
3	Nylon bag	20.00	5.00	5.00	5.00	5.00
4	KT1	4.00	0.00	0.00	1.00	3.00
The South						
1	KT31	5.53	2.53	3.00	0.00	0.00
2	Composite	14.06	5.00	3.00	4.06	2.00
3	Nylon bag	16.17	4.17	5.00	5.00	2.00
4	KT 2	0.50	0.00	0.00	0.50	0.00

Figure VII-4: Summary and comparison on construction



VII.4. Evaluation of operation and maintenance

To evaluate the maintenance process, following factors have been taken into consideration:

- Possibility for breaking down by outside factors as flood, earthquake, fire or being bite by animal or sharp things;
- Gas creation efficiency and possibility of maintaining stable gas quality;
- Safety for user;
- Easiness for O&M;
- Possibility of detecting damages and repairing in case of damages.

VII.4.1 Possibility for breaking down by outside factors

This is a qualitative factor basing on the information gained by interviewing households who have used similar plant as well as on experiences of the Consultant. Safety of the building structure is evaluated in normal running condition. If the plant is exposed on

ground instead of underground it is more easily exposing to failure than the underground one. Maximum score of this factor will be 6. Safety to the plant in two regions will be the same.

Among pilot models, the nylon bag is more easily exposed with failure since it is not under-grounded, easily to be broken or damages if being bite by animal or sharp things. It is therefore paid with 0 score. Three other types, due to underground located, the potentiality of broken by outside factor will be less, therefore paid with 6 score.

Table VII-14: Comparison on safety of structure during operation

No.	Model	Safety of Structure (6 maximum)
The North		
1	KT31	6.00
2	Composite	6.00
3	Nylon bag	0.00
4	KT1	6.00
The South		
1	KT31	6.00
2	Composite	6.00
3	Nylon bag	0.00
4	KT2	6.00

VII.4.2 Evaluation on gas yield and stable gas generation

Total score for this criterion is 6. Factor to be evaluated is the productivity of gas creation and the ability in maintaining stable gas generation. The Consultant has performed gas measurement in each plant. Results gained from gas measurement are listed in table VII-16. The gas productivity and ability of maintaining stable gas amount are evaluated by two ways:

- Gas yield: By using the data gained from gas measurement for continually 10 days. Gas yield is calculated by dividing the average amount of gas per day by total digestion volume. Plant with the highest gas yield gets maximum score of 4; plant with lowest gas yield get 0. Other plants will be estimated by average weighted. Sectoral standard 10 TCN 97 – 2006, item 7.2 is referred.

- Stable gas generation: By interviewing the household to find out whether the gas is enough for using or no. This is the qualitative data. Plant with enough gas get 1 score; plant with deficient gas get 0 score. Be awear that all households only use gas for cooking and the demand for cooking time is different, the result is relative.

Table VII-15: Gas yield and stable gas generation

No.	Model	Gas amount (m^3/day)	Gas yield (m^3/m^3 of digestion/day)	Stable gas generation
The North				
1	KT31	2.80	0.35	Yes
2	Composite	2.24	0.32	Yes
3	Nylon bag	1.20	0.15	Yes
4	KT1	3.78	0.47	Yes
Miền Nam				
1	KT31	2.96	0.37	Yes
2	Composite	1.96	0.28	Yes

3	Nylon bag	1.76	0.22	Yes
4	KT2	3.12	0.52	Yes

Sectorial Standard stipulates the biogas plant has average gas yield of 0.25m^3/m^3 of digestion volume/day. Table VII-16 shows that KT31, composite and KT1/KT2 all have gas yield over Sectorial Standard. Nylon bag has the lowest gas yield due to bad temparate maintain. Especially, during the cold season, the feeding material has lower gas output.

From the questionaires, all models have ”yes” answer for the ”sufficient?” question so they all get maximum score of 2.

Evaluation on gas yield and ability of stable gas generation are in Table VII-16.

Table VII-16: Evaluation on gas yield and stable gas generation

No.	Model	Gas yield (maximum 4 score)	Stable gas generation (maximum 2 score)	Total (6 score)
The North				
1	KT31	2.5	2.0	4.5
2	Composite	2.1	2.0	4.1
3	Nylon bag	0.0	2.0	2.0
4	KT1	4.0	2.0	6.0
The South				
1	KT31	2.0	2.0	4.0
2	Composite	0.8	2.0	2.8
3	Nylon bag	0.0	2.0	2.0
4	KT2	4.0	2.0	6.0

VII.4.3 Evaluation on safety to user

Safety to user will be also a qualitative factor basing on interviewing households who have used similar plants and the experiences of Consultant as well. Safety for user will be evaluated in the conditions that the user follow all requirements of operation and maintenances but safety problems may be happened due to force major factors. Maximum score to this factor is 6. Safety to user in two regions will be the same.

The nylon bag is the one exposing with possibility of fire or gas leakage since the gas holder is hanging on top of piggery. Therefore the nylon bag is paid with 0 score. Other plants are located underground and if the user follows properly the guidance it will generally occur no failure.

Table VII-17: Evaluation on safety to user

No.	Model	Safety of Structure (6 maximum)
The North		
1	KT31	6.00
2	Composite	6.00
3	Nylon bag	0.00
4	KT1-KT2	6.00
The South		
1	KT31	6.00
2	Composite	6.00
3	Nylon bag	0.00
4	KT1-KT2	6.00

VII-4.4 Evaluation of easiness on O&M

Easiness during O&M will comprise of:

- Easiness for user (3 scores)
- Easiness in maintenance (3 scores)

Easiness for user will be a qualitative factor, basing on data and information gained during interviewing households and basing on experiences of Consultant. In the case of nylon bag, due to small pressure, the user sometimes has to adjust the elastic band binding the gas holder or putting heavy things on the digester. For other models, thanks to the existing of compensation tank the pressure is high making it favorable to the user. So the nylon bag is paid with 0 score on the convenience in using, other plants are 3 scores.

Maintenance of the biogas is mainly taking scum. If scum is easily taking out, the plants will be given with maximum score of 3, otherwise it is given with 0 score. Composite biogas is cleaned from scum by means of inlet and outlet which have large dimension (taking directly by pumping), which is favorable, to be given with 3 scores. The KT31 is cleaned from scum by means of taking out composite arch cover; the KT1 and KT2 are cleaned by taking scum through cover of digester. Thanks to large dimension of inlet, outlet of composite (1800mm) and the man-hole of KT31 the scum is taking out fast and shorter than that required by KT1 and KT2 whose digesters have smaller man-hole(620mm) causing unfavorable condition, therefore the KT31 is given with 2 scores, the KT1/KT2 are given with 1 score. In the case of nylon bag, the scum is taken by cleaning digester (replacing all digested solution), taking out the inlet pipe and outlet, and then taking out all of the scum. When the scum is taken out already, the user shall install all again from beginning. This plant is taking time and not so favorable to the user therefore given with 0 score.

Total score of o & M is available in table herein:

Table VII-18 Comparison of easiness for O&M

The North				
No.	**Model**	**Easiness for operation (3 maximum)**	**Easiness for mainternance (3 maximum)**	**Total (6 maximum)**
1	KT31	3.00	2.00	5.00
2	Composite	3.00	3.00	6.00
3	Nylon bag	0.00	0.00	0.00
4	KT1-KT2	3.00	1.00	4.00
The South				
1	KT31	3.00	2.00	5.00
2	Composite	3.00	3.00	6.00
3	Nylon bag	0.00	0.00	0.00
4	KT1-KT2	3.00	1.00	4.00

VII-4.5 Evaluation on easiness to detect failure and to repair

Failure was devided into 2 parts, each part had 3 scores:

- Failure of biogas means mainly from gas leakage by unprejudiced factors. The nylon bag is easily for failure detection and repairing (new replacement) therefore being given with 3 scores. Other plants located underground therefore being hard to detect the gas or water leakage and hard to mend. Other models therefore are given with 0 scores.
- Failure of pipeline and spare parts. We assume that biogas pipeline was installed in the air and used same spare parts, hence possibility of detecting damages and repairing all pipeline and spare parts are same. It is therefore paid with 3 scores.

Table VII-19 Comparison on ability of failure detection and repairing

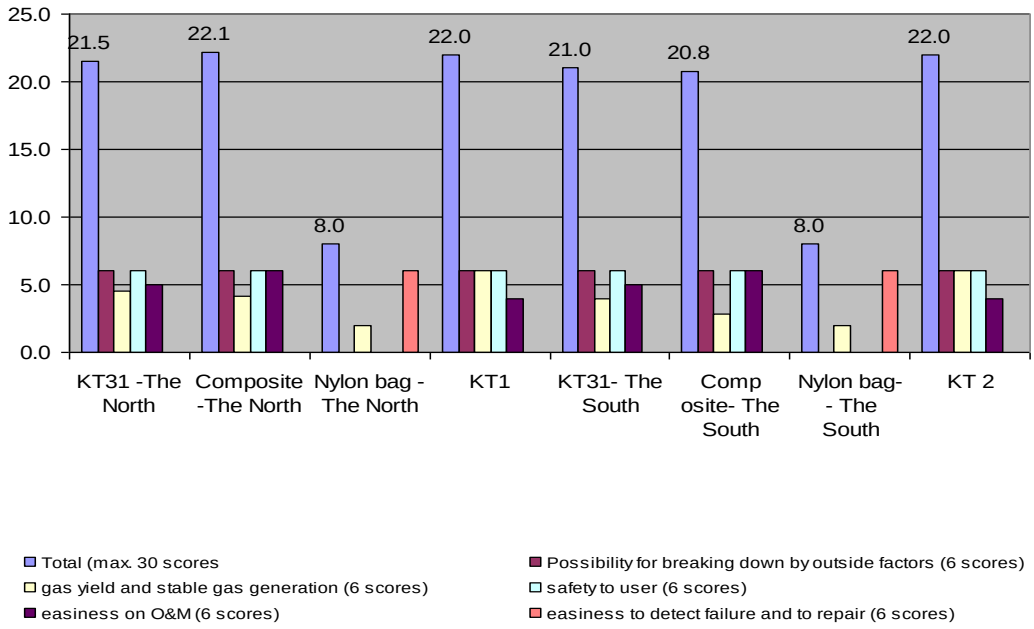
The North				
No.	**Model**	**Failure of pipeline and spare parts (max. 3 scores)**	**Failure by unprejudiced factors in**	**Total (max. 6 scores)**
1	KT31	3.00	0.00	3.00
2	Composite	3.00	0.00	3.00
3	Nylon bag	3.00	3.00	6.00
4	KT1	3.00	0.00	3.00
The South				
1	KT31	3.00	0.00	3.00
2	Composite	3.00	0.00	3.00
3	Nylon bag	3.00	3.00	6.00
4	KT2	3.00	0.00	3.00

Total score from evaluating easiness of running, maintenance of pilot plants are listed in table below:

Table VII-20 Total score from evaluating the operation and maintenance

No.	Model	Total (max. 30 scores	Possibility for breaking down by outside factors (6 scores)	gas yield and stable gas generation (6 scores)	safety to user (6 scores)	easiness on O&M (6 scores)	easiness to detect failure and to repair (6 scores)
The North							
1	KT31	21.5	6.0	4.5	6.0	5.0	0.0
2	Composite	22.1	6.0	4.1	6.0	6.0	0.0
3	Nylon bag	8.0	0.0	2.0	0.0	0.0	6.0
4	KT1	22.0	6.0	6.0	6.0	4.0	0.0
The South							
1	KT31	21.0	6.0	4.0	6.0	5.0	0.0
2	Composite	20.8	6.0	2.8	6.0	6.0	0.0
3	Nylon bag	8.0	0.0	2.0	0.0	0.0	6.0
4	KT2	22.0	6.0	6.0	6.0	4.0	0.0

Figure VII-5 Comparison and evaluation on operation and maintenance



VII.5 Evaluation of cost

VII.5.1 Principles

Total score for the cost evaluation will be 30 scores. The evaluation of cost of 4 biogas types is performed by calculating and comparing following factors:

- Total investment capital (maximum to be 10 scores)
- Average annual investment cost (maximum to be 10 scores)
- Financial indicators: payback period, NPV, and IRR (maximum to be 10 scores)

VII.5.2 Evaluation on total investment cost

Total investment cost of biogas comprise of:

- Cost of material, including stove and light

- Cost of labor
- Cost of transportation (if any)

Total cost of all biogas types are summarized basing on data recorded by Consultant at the site during construction process. Cost of material will be taken from the cost being paid actually to the supplier. Cost of transportation will be estimated in case of material to be transported from distance longer than 50km and in fact the transportation cost is required. Among pilot biogas types to be constructed, only composite and KT31 (with arch of gas holder is made of composite) are required paying transportation cost. Cost of labor is estimated using number of working and cost in fact paying to the building team. The total cost is in table herein:

Table VII-21: Construction cost of pilot biogas

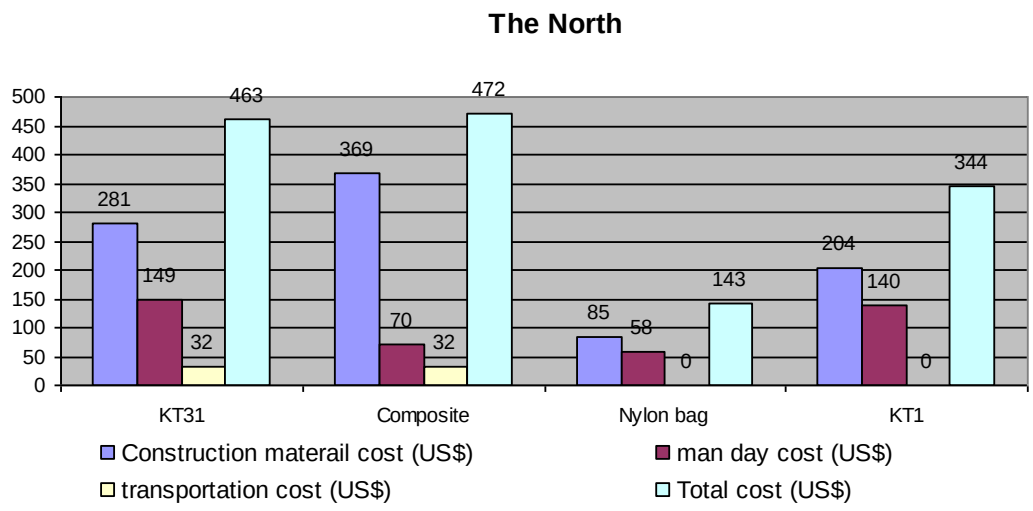
Exchange rate: 1US$=18 500 VND

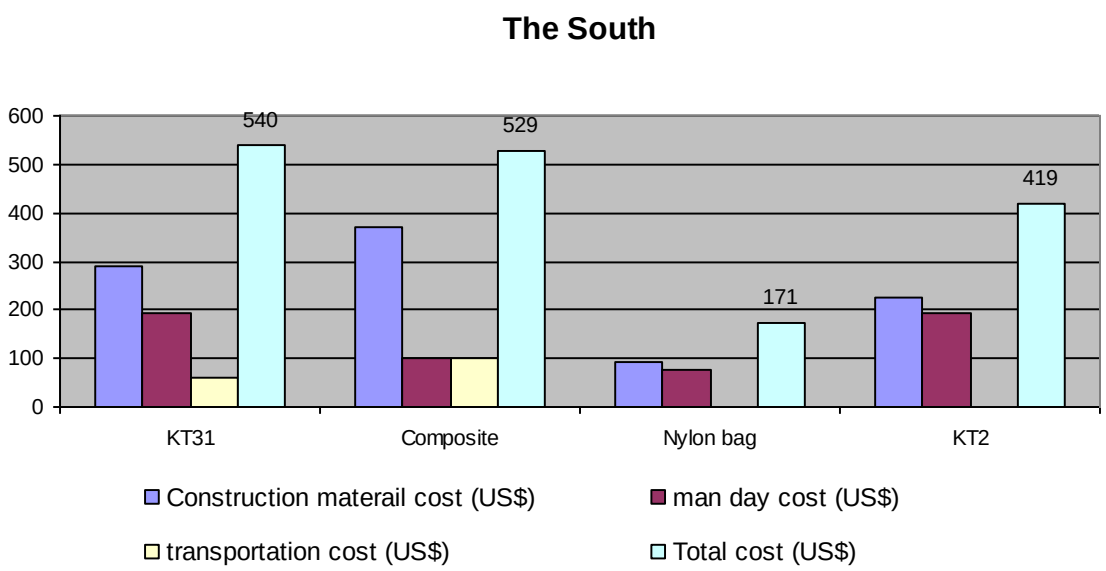
The north					
No.	**Model**	**Construction material cost (VND)**	**Man day cost (VND)**	**Transportation cost (VND)**	**Total investment cost' (VND)**
1	KT31	5,195,000	2,763,020	600,000	8,558,020
2	Composite	6,830,000	1,295,156	600,000	8,725,156
3	Nylon bag	1,565,000	1,076,000	0	2,641,000
4	KT1	3,782,500	2,589,060	0	6,371,560
The south					
1	KT31	5,343,000	3,553,500	1,100,000	9,996,500
2	Composite	6,830,000	1,858,000	1,858,000	9,788,000
3	Nylon bag	1,745,000	1,424,000	0	3,169,000
4	KT2	4,192,000	3,553,684	0	7,745,684
The north					
No.	**Model**	**Construction materail cost (US$)**	**man day cost (US$)**	**transportation cost (US$)**	**Total cost (US$)**
1	KT31	281	149	32	463
2	Composite	369	70	32	472
3	Nylon bag	85	58	0	143
4	KT1	204	140	0	344
The south					
1	KT31	289	192	59	540
2	Composite	369	100	100	529
3	Nylon bag	94	77	0	171
4	KT2	227	192	0	419

Among all of studied biogas plants, total initial investment cost of nylon bag is the cheapest and total initial investment cost of KT31 and composite are the highest. Cost is shown in following chart.

Figure VII-6: Comparison on investment cost

Unit: US$/year





Maximum score of initial investment cost will be 10 scores, those having cheapest investment cost will be given with maximum scores, those require highest cost will be 0 score. Score for other biogas will be divided by average weighted.

Detail on scores for evaluation on initial investment cost is listed in table beneath:

Table VII-22 Comparison and evaluation on total investment capital

The North			
No.	**Model**	**Total investment cost (US$)**	**Score (10 maximum)**
1	KT31	463	0.26
2	Composite	471	0.00
3	Nylon bag	143	10.00
4	KT1	344	3.86
The South			
1	KT31	540	0.00
2	Composite	529	0.32
3	Nylon bag	171	10.00
4	KT2	419	3.30

VII.5.3 Evaluation on average annual investment cost

The average annual investment cost will be estimated in average by using total investment cost divides the lifetime. According to the information from suppliers, average lifetime of composite biogas is 20 years, of KT31 biogas is 20 years. Average lifetime of nylon bag, as according to experience in using in Tien Giang, is 3 years. Average lifetime of KT1 and KT2 according to standard 10TCN 97÷ 102-2006 is 20 years.

Average annual investment cost for various types of biogas are in table VII-23.

Results gained from calculation show that the average annual investment cost of nylon bag biogas in both regions are the most expensive. In the North, KT1 biogas is the cheapest while in the South the cheapest is KT2 (though the composite biogas has been estimated with transportation cost from the North and the South). Details on comparing average annual investment cost are shown in Figure VII-7.

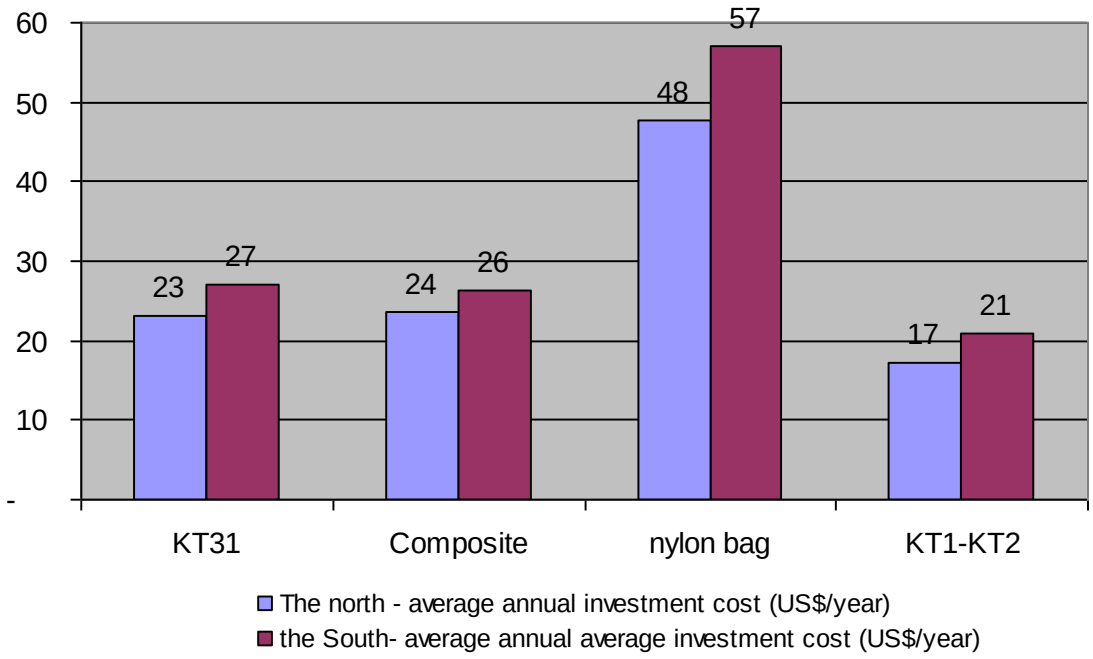
Table VII-23: Average annual investment cost of pilot biogas

Exchange rate: 1 US$=18 500 VND

The North				
No.	**Model**	**Total investment cost (VND)**	**Life time**	**Annual average investment cost (VND/year)**
1	KT31	8,558,020	20	427,901
2	Composite	8,725,156	20	436,258
3	Nylon bag	2,641,000	3	880,333
4	KT1	6,371,560	20	318,578
The South				
1	KT31	9,996,500	20	499,825
2	Composite	9,788,000	20	489,400
3	Nylon bag	3,169,000	3	1,056,333
4	KT2	7,745,684	20	387,284
The North				
No.	**Model**	**Total investment cost (VND)**	**Life time**	**Annual average investment cost**
1	KT31	463	20	23
2	Composite	471	20	24
3	Nylon bag	143	3	48
4	KT1	344	20	17
The South				
1	KT31	540	20	27
2	Composite	529	20	26
3	Nylon bag	171	3	57
4	KT2	419	20	21

Figure VII-7 Comparison of average annual investment cost

Unit: US$/year



The average annual investment cost will be given as maximum with 10 scores, those having the least cost will be give with maximum score, those having highest cost will be 0. Scores of other biogas types will be divided by average weighted.

Table VII-24: Comparison and evaluation on annual average investment cost

The North			
No.	**Model**	**Annual average investment cost (US$/year)**	**Score (10 maximum)**
1	KT31	23	8.05
2	Composite	24	7.91
3	Nylon bag	48	0.00
4	KT1	17	10.00
The South			
1	KT31	27	8.32
2	Composite	26	8.48
3	Nylon bag	57	0.00
4	KT2	21	10.00

VII.5.4 Evaluation on financial indicator (payback period, NPV, IRR)

Substitute energy

To calculate financial indexes, the Consultant has investigated cost of energy spent by each household before using biogas. In the North, the most popular energy type is "coal honeycomb" whose cost is 1,750 VND/piece (0.5kg). In the South the most popular replaced energy type is kerosene and LPG. In both regions local resident are using firewood and agricultural by-product as fuel. Firewood and agricultural by-product are produced by the people themselves therefore requiring no cost for buying. Details on energy cost of household are in table VII-24.

Estimating payback period e, NPV and IRR

Assumptions:

- Discounted rate: 10%
- Forecasting escalation in prices of substitute energy:: 2% /year
- Lifetime of KT31, KT1, KT2, composite is 20 years and of nylon bag is 3 years;
- Though the using of biogas create lots of benefits such as increasing production and quality of crops since it uses slurry, selling CER, saving time of cooking and time of finding firewood, protecting health, improving environment, etc… within the framework of this study, only benefit from substitute of energy for cooking and lighting (20W light) will be taken into consideration.
- Since this study has been done in a short time therefore the replacement and repairing cost are not yet evaluated. Therefore in financial calculation, such costs are assumed as 0.

Details on results gained from calculation are available in attached Annex 3. Summary on results see table VII-25 next pages.

Table VII-25: Cost of energy spent by household before using biogas

Unit: VND

The North KT31 - Substitute Energy per month					The South KT31 - Substitute Energy per month				
	Unit	Quantity	Unit rate	Amount (VND)		Unit	Quantity	Unit rate	Amount (VND)
LPG	kg	0	23,300	0	LPG	kg	0	23,300	0
Be-net coal	kg	45	3,500	157,500	Be-net coal	kg	0	3,500	0
Fuel Wood and agriculture residu	kg	20	0	0	Fuel Wood and agriculture res	kg	60	0	0
Karosen	kg	0	15,200	0	Karosen	kg	10	15,200	152,000
Electricty	kWh	7.2	1,000	7,200	Electricty	kWh	7.2	1,000	7,200
Total				**164,700**	Total				**159,200**
The South - composite - Substitute energy per month					**The North - composite - Substitute energy per month**				
	Unit	Quantity	Unit rate	Amount (VND)		Unit	Quantity	Unit rate	Amount (VND)
LPG	kg	0	23,300	0	LPG	kg	6	23,300	139,800
Be-net coal	kg	40	3,500	140,000	Be-net coal	kg	0	3,500	0
Fuel Wood and agriculture residu	kg	50	0	0	Fuel Wood and agriculture res	kg	70	0	0
Karosen	kg	0	15,200	0	Karosen	kg	0	15,200	0
Electricty	kWh	7.2	1,000	7,200	Electricty	kWh	7.2	1,000	7,200
Total				**147,200**	Total				**147,000**
The North KT2 - Substitute Energy per month					**The North KT1 - Substitute Energy per month**				
	Unit	Quantity	Unit rate	Amount (VND)		Unit	Quantity	Unit rate	Amount (VND)
LPG	kg	0	23,300	0	LPG	kg	0	23,300	0
Be-net coal	kg	43	3,500	150,500	Be-net coal	kg	0	3,500	0
Fuel Wood and agriculture residu	kg	70	0	0	Fuel Wood and agriculture res	kg	60	0	0
Karosen	kg	0	15,200	0	Karosen	kg	9	15,200	136,800
Electricty	kWh	7.2	1,000	7,200	Electricty	kWh	7.2	1,000	7,200
Total				**157,700**	Total				**144,000**
The North - nylon bag - Substitute Energy per month					**The South- nylon bag - Substitute Energy per month**				
	Unit	Quantity	Unit rate	Amount (VND)		Đơn vị tính	Số lượng	Đơn giá	Thành tiền (VND)
LPG	kg	0	23,300	0	LPG	kg	7	23,300	163,100
Be-net coal	kg	40	3,500	140,000	Be-net coal	kg	0	3,500	0
Fuel Wood and agriculture residu	kg	50	0	0	Fuel Wood and agriculture res	kg	50	0	0
Karosen	kg	0	15,200	0	Karosen	kg	0	15,200	0
Electricty	kWh	7.2	1,000	7,200	Electricty	kWh	7.2	1,000	7,200
Total				**147,200**	Total				**170,300**

Table VII-26: Payback period, IRR and NPV of pilot biogas

The North				
No.	**Model**	**Payback period (year)**	**NPV (US$)**	**IRR (%)**
1	KT31	4.3	3,648	32%
2	Composite	5.5	2,769	26%
3	Nylon bag	1.5	111	139%
4	KT1	3.5	4,332	45%
The South				
1	KT31	4.1	2,733	24%
2	Composite	5.5	2,271	22%
3	Nylon bag	1.4	113	114%
4	KT2	4.3	3,068	30%

Reimbursement of nylon bag in both regions is the shortest: 1.5 year in the North and 1.4 years in the South. Internal Rate of Return of nylon bag is the highest.

Figure VII-8: Payback period of pilot biogas

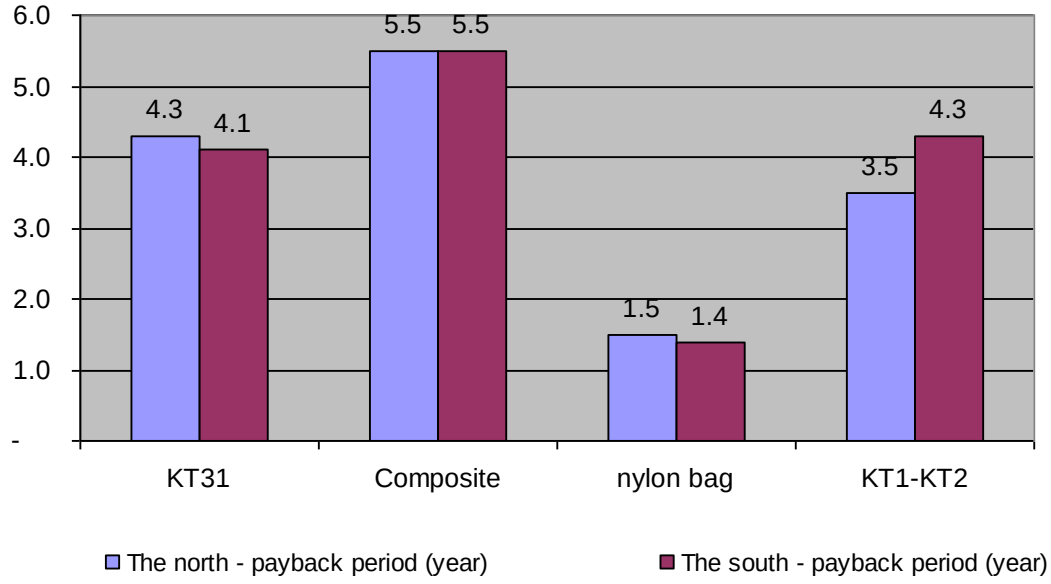
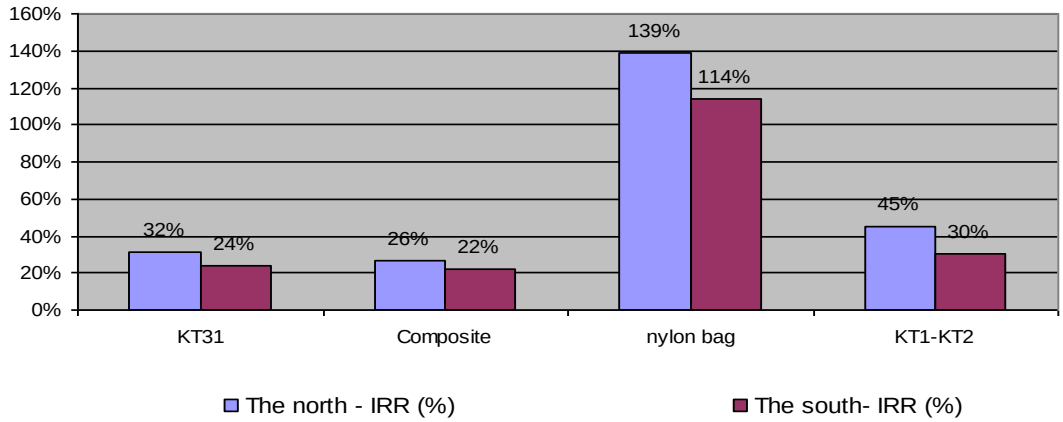
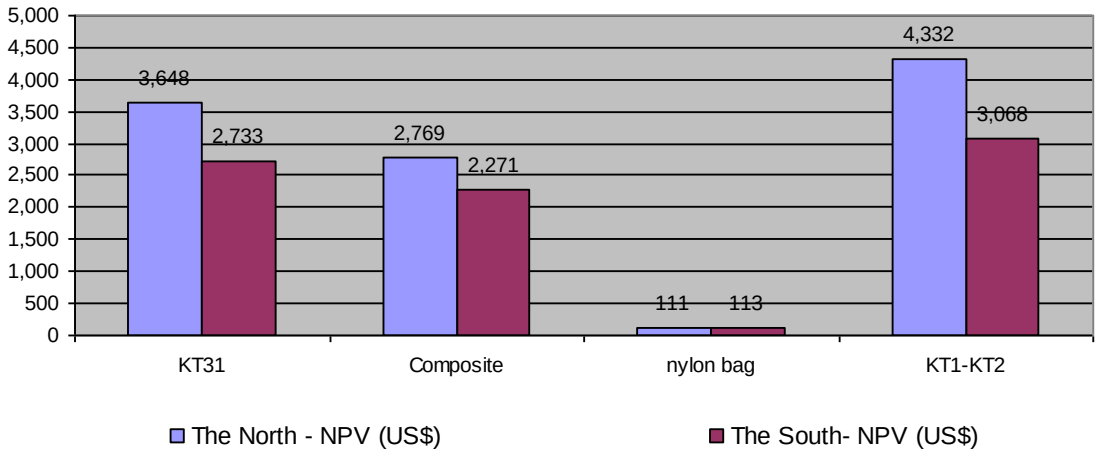


Figure VII-9: Comparison on Internal Rate of Return



NPV of the four pilot model is plus. In regard on long-term investment, all of the four biogas types are profitable to the investor. Details on comparing NPV of 4 pilot biogas models having long lifetime are shown in figure herein.

Figure VII-10: Comparing NPV



Evaluation on financial indicators

Financial indicators (payback period, NPV, IRR): maximum to be 10 scores.

- Payback period: maximum will be 3.33 score. Those having shortest payback period will be given with maximum score. Those having longest payback period will be given with minimum score. Score of other biogas types will be divided by average weighted.
- NPV: maximum to be 3.33 score. Those having highest NPV will be given with maximum score. Those having lowest NPV will be given with minimum score. Score of other biogas types will be divided by average weighted.
- IRR: maximum to be 3.33 score. Those having highest IRR will be given with maximum score. Those having lowest IRR will be given with minimum score. Score of other biogas types will be divided by average weighted.

Using the mentioned above method, scores of each biogas have been calculated and listed in following table:

Table VII-27: Comparison and evaluation according to financial indicators

No.	Model	Payback period (3.33	NPV (3.33 maximum)	IRR (3.33 maximum)	Total (10 maximum)
The North					
1	KT31	1.00	2.79	0.16	3.95
2	Composite	0.00	2.10	0.00	2.10
3	Nylon bag	3.33	0.00	3.33	6.66
4	KT1	1.67	3.33	0.55	5.54
The South					
1	KT31	1.14	2.95	0.07	4.16
2	Composite	0.00	2.43	0.00	2.43
3	Nylon bag	3.33	0.00	3.33	6.66
4	KT2	0.97	3.33	0.29	4.59

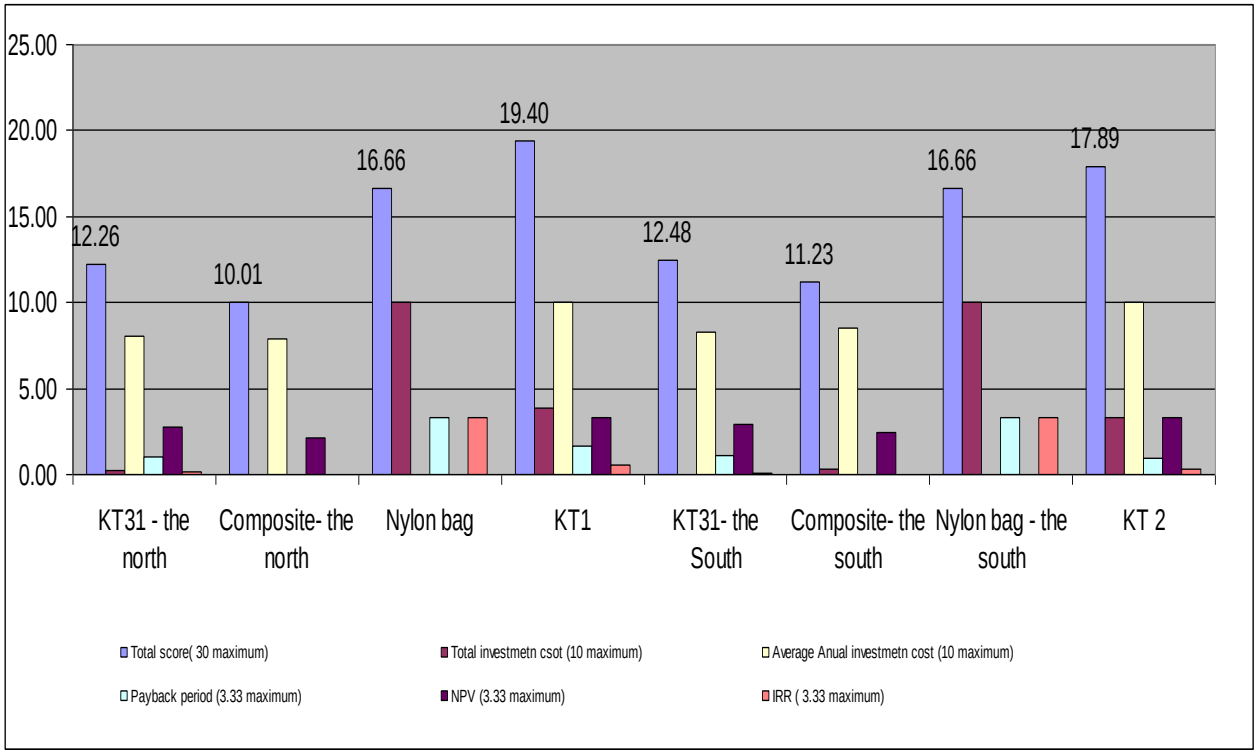
VII.5.5 Total evaluation on cost

Basing on scores calculated above, evaluation on cost is summarized and described in table hereunder:

Table VII-28: Total evaluation on cost

No.	Model	Total score(30 maximum)	Total investmetn csot (10	Average Anual investmetn cost (10	Payback period (3.33	NPV (3.33 maximum)	IRR (3.33 maximum)
The North							
1	KT31	**12.26**	0.26	8.05	1.00	2.79	0.16
2	Composite	**10.01**	0.00	7.91	0.00	2.10	0.00
3	Nylon bag	**16.66**	10.00	0.00	3.33	0.00	3.33
4	KT1	**19.40**	3.86	10.00	1.67	3.33	0.55
The South							
1	KT31	**12.48**	0.00	8.32	1.14	2.95	0.07
2	Composite	**11.23**	0.32	8.48	0.00	2.43	0.00
3	Nylon bag	**16.66**	10.00	0.00	3.33	0.00	3.33
4	KT2	**17.89**	3.30	10.00	0.97	3.33	0.29

Figure VII-11 Total evaluation on cost



VII.6 Evaluation on environment and sanitary

VII.6.1 Evaluation principle

The evaluation on environmental hygiene is done basing on:

- Bad smell (4 score)
- 03 indicators on industrial wasted water – BOD_5, COD[6], coliforms that stipulated in the National Technical Regulation for Surface water quality (6 scores).

The bad smell factor is evaluated by interviewing household. Information gained from interviewing household has proved that no biogas creates bad smell so all of them will be given with maximum score of 4.

03 environment indicators: The decrease rate (%) will be counted for inlet data and outlet data. For each indicator, biogas plant with the highest decrease rate get maximum score

[6] *BOD_5: **Biochemical Oxygen Demand**: The amount of dissolved oxygen consumed in five days by bacteria that perform biologicaldegradation of organic matter.*
*COD: **Chemical Oxygen Demand** is used as a measure of oxygen requirement of a sample that is susceptible to oxidation by strong chemical oxidant.*

of 2 while the biogas plant with the lowest decrease rate get 0 score. Score of other biogas plants will be divided by average weighted.

The analyze results are compared with those in TCN 97-2006 for Household biogas plant – Part 1: General requirements and and National Technical Regulation on Surface water quality QCVN 08-2008/BTNMT on surface water quality, stipulating for the limitation of water source for B2 for analysis.

VII.6.2 Analyze result

Total 96 samples have been taken including 48 samples of fresh pig dung taken at pigsty, and 48 samples of outlet water (slurry) taken at the compensation tanks. Samples were taken in the early morning to get rid of oxidization and stored in clean plastic bottles (Lavi bottle) and brought to the Lab for analyze within the same day of taking sample. Samples for analyze coliform had to be frozen during transportation. The analyze result is presented in the below table VII-29:

Table VII – 29: Analyze samples of animal waste, substance and slurry

The North						
Model	**Parameter**	**Unit**	**Inlet**	**Outlet**	**Reduction**	**%**
KT31	BOD	mg/l	35,421	130	35,291	99.63
	COD	mg/l	82,400	235	82,165	99.71
	Coliform	MPN/100ml	680,000,000	630,000	679,370,000	99.91
Composite	BOD	mg/l	33,290.00	195.00	33,095.00	99.41
	COD	mg/l	91,854.00	325.00	91,529.00	99.65
	Coliform	MPN/100ml	46,000,000.00	810,000.00	45,190,000.00	98.24
Nylon bag	BOD	mg/l	6,450	193	6,257	97.01
	COD	mg/l	66,046	333	65,713	99.50
	Coliform	MPN/100ml	4,500,000	790,000	3,710,000	82.44
KT1	BOD	mg/l	24,359	156	24,203	99.36
	COD	mg/l	78,420	264	78,156	99.66
	Coliform	MPN/100ml	32,000,000	56,000	31,944,000	99.83
The South						
KT31	BOD	mg/l	39,983	141	39,842	99.65
	COD	mg/l	97,110	878	96,232	99.10
	Coliform	MPN/100ml	700,000,000	400,000	699,600,000	99.94
Composite	BOD	mg/l	39,383	107	39,276	99.73
	COD	mg/l	99,450	234	99,216	99.76
	Coliform	MPN/100ml	46,000,000	28,000	45,972,000	99.94
Nylon bag	BOD	mg/l	13,183	6,453	6,730	51.05

	COD	mg/l	77,220	6,160	71,060	92.02
	Coliform	MPN/100ml	48,000,000	7,500,000	40,500,000	84.38
KT31	BOD	mg/l	28,683	1,108	27,575	96.14
	COD	mg/l	85,410	10,121	75,289	88.15
	Coliform	MPN/100ml	40,000,000	280,000	39,720,000	99.30

Table VII – 30: TCN 97-2006 and QCVN 08/2008/BTNMT on surface water quality

	BOD_5 (mg/l)	COD (mg/l)	Coliform (MPN/100ml)
TCN 97-2006	Organic amount decrease at least 50% in comparison of feeding material		Not over 10^6
QCVN*	25	50	10^4

** Nation Technical Regulation on surface water quality, stipulating for the limitation of water source for B2.*

Table VII – 29 shows that the amount of organic matter before and after biogas treatment in biogas plants experiences clear difference. BOD_5 reducing to over 97% (in the North), and from 51% (nylon bag in the South) to 99.73% (composite in the South); COD decrease over 99% in the North, from 88% (KT2) to 99.76% (composite in the South). Coliform concentration is decreased from 82.44%%(nylon bag in the North) to 92.9%(KT31 in the North) and from 84.38% (nylon bag in the South) to 99.94% (both KT31 and composite in the South).

Refer to Sectoral Standard in table VII-30, all models are meet environmental hygiene standard as organic substance content reduced significantly (more than 50%). Coliform concentration also meets standard but at difference levels. In the North, KT1 has the lowest coliform concentration. In the South, composite has the lowest coliform concentration.

Refer to the National Technical Regulation for surface water quality, the analyze results are over the limitation that stipulated for these indicators but at different levels. For BOD_5, the analyze results over 5,2 time (KT31 in the North) to 7.8 times (Composite in the North); 4.28 times (composite in the South) to 258 times (nylon bag in the South); for COD: the analyze results are over 4.7 time (KT31 in the North) to 6.7 times (nylon bag in the North); 4.7 times (composite in the South) to 123 time (nylon bag in the South). For coliform: over 5.6 times (KT1) to 81 times (composite in the Northe); over 2.8 time (composite in the South) to 750 time (nylon bag in the South). From these results, it is necessary to provide next treatment for slurry to improve its quality before discharge into the natural water system.

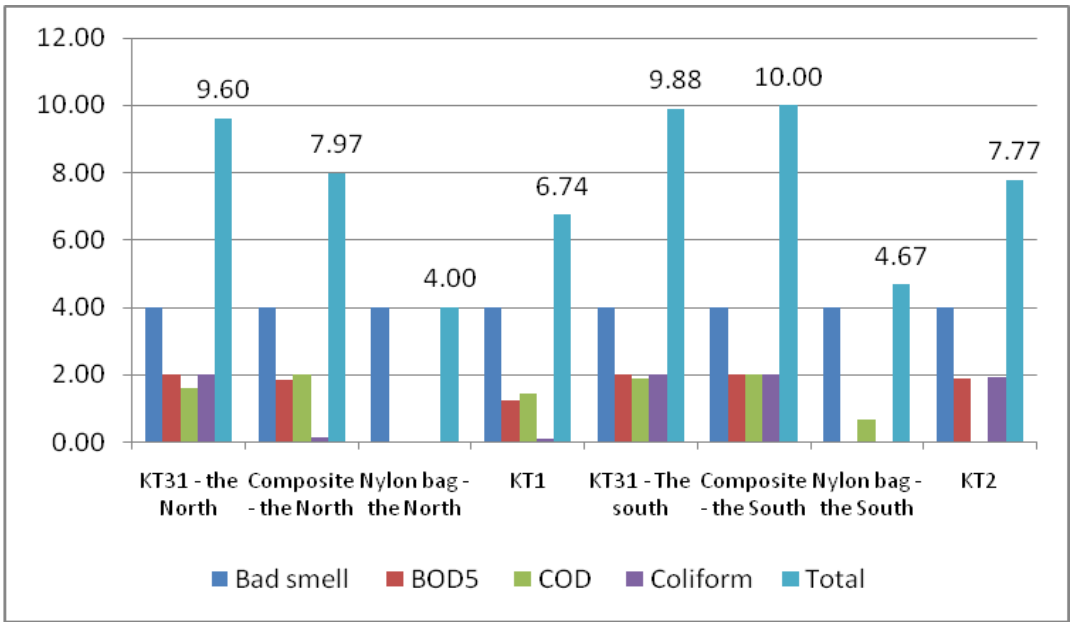
Total score for the evaluation on hygiene and environment is presented in the table VII-31 herein:

Table VII-31 Evaluation on hygiene and environment

Model	Bad smell (maximum 4 score)	BOD5 (maximum 2 score)	COD (maximum 2 score)	Coliform (maximum 2 score)	Total (10 score)
The North					

KT31	4.00	2.00	1.60	2.00	9.60
Composite	4.00	1.85	2.00	0.12	7.97
Nylon bag	4.00	0.00	0.00	0.00	4.00
KT1	4.00	1.24	1.42	0.08	6.74
Miền Nam					
KT31	4.00	2.00	1.88	2.00	9.88
Composite	4.00	2.00	2.00	2.00	10.00
Nylon bag	4.00	0.00	0.67	0.00	4.67
KT2	4.00	1.85	0.00	1.92	7.77

Figure VII-12: Evaluation on hygiene and environment



VII.7 Total evaluation and comparison

Table VII-32 shows evaluation and comparison between pilot biogas plants. Based on result evaluation, both in the North and in the South, 4 household biogas models were ranked B. However, each household biogas model have strong points and weeks points, hence the Consultant proposes the applied acondition for each specific household biogas model in the table VII-33.

Table VII-32 Total evaluation and comparison

The North								
No.	**Models**	**Construction material (max. 10 scores)**	**Construction work (max. 20 scores)**	**O&M (max. 30 scores)**	**Cost (max. 30 scores)**	**Enviromental (max. 10 scores)**	**Total (100 scores)**	**Rank**
1	KT31	8.58	8.01	21.50	12.26	9.27	59.62	B
2	Composite	6.79	17.03	22.13	10.01	7.97	63.93	B
3	Nylon bag	5.00	20.00	8.00	16.66	4.00	53.66	B
4	KT1	10.00	4.00	22.00	19.40	6.28	61.68	B
The South								
1	KT31	7.58	5.53	21.00	12.48	9.98	56.57	B
2	Composite	4.79	14.06	20.80	11.23	10.00	60.88	B
3	Nylon bag	5.00	16.17	8.00	16.66	4.00	49.83	B
4	KT2	9.55	0.50	22.00	17.89	9.45	59.39	B

Figure VII-13 : Total evaluation and comparison

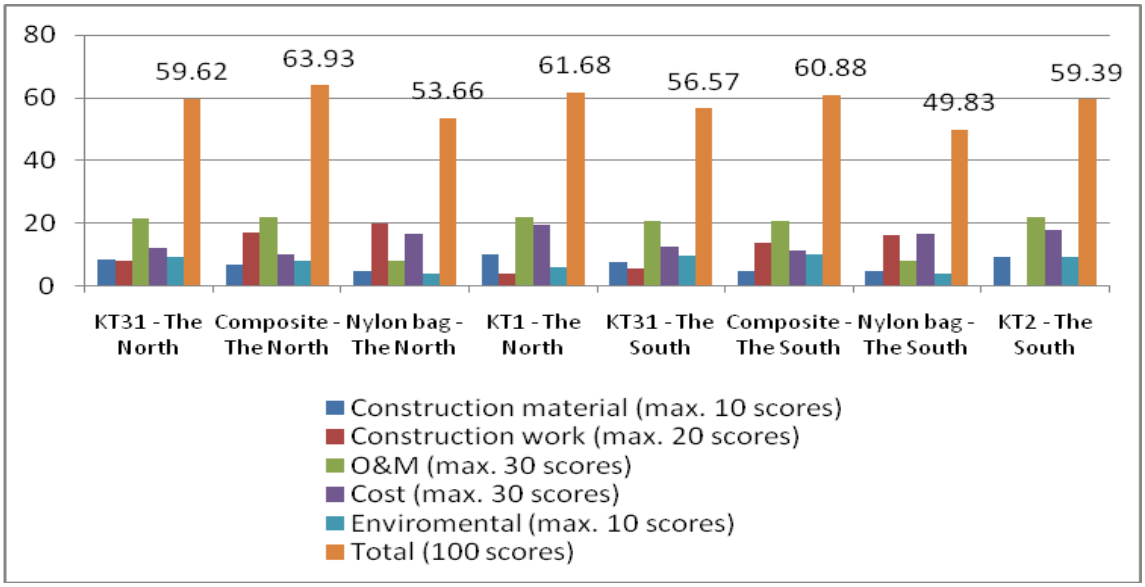


Table VII-33: Summary on advantages/disadvantages and applied condition of each household biogas model

Model	Advantages	Disadvantages	Applied condition
KT31	- Good duration of structure, long lifetime	- High cost - Need transport from other place - Not available everywhere - Complicated maintainance - High ability to have gas leakage in the connection gas hoder and digester - Need training mason - Need foundation reinforcement, if soil is weak	- To use in the places having no trained mason for KT1/KT2; -To use in household have narrow area
Composite	- Easy to construct and install - Easy for O&M - Less ability of gas leakage - Durable, long lifetime - Can be removed to other place	- High cost - Need transported from other place - Low availability - Few size for selection	- To use in places with high ground water table; - To use in the places having mo trained mason for KT1 and KT2 - To use in the place having no material for KT1 and KT2 - To use in the place farmers having no long term plan for animal husbandry
Nylon bag	- Easy to construct, no need trained mason - Low initial investment cost - High availability of construction material	- Not easy for O&M - Not durable, easy to be brroken by external factor. Easy to have fire-accident because the gas holder is hanged under roof - Low lifetime	To use in the place without trained masons who know how to built KT1/KT2; - To use in the place the construction material for KT1 and KT2 is not available; - To use in the place farmers having not long term plan for animal husbandry because of low investment cost and short lifetime; - To use by poor who has not ability to pay for such high investment cost of KT1 and KT2.
KT1-KT2	- Average investment cost - Durable, safe for end user - Construction material available everywhere	- Complicated maintenance - Need training for mason - If ground is week, the foundation has to reinforced	- Using in the places having trained mason - Using in the place with long term plan for animal husbandry

Part VIII: CONCLUSION AND RECOMMENDATIONS

VIII.1 Conclusion

Four household biogas model have from 50 to 75 scores and rank B type – household biogas model will be applied in specific condition. In other hand, each household biogas model have strong points and weak points as below:

1. Composite: It is easy in installation, no training will be required to building plants, easiness in maintenance, it is less ability to have gas leakage and water leakage, the gas productivity is high, durability of structure is good and long life-time. This type of biogas can be excavated out and replace to other location. However, the composite biogas is also existed with disadvantages such as high cost, and not available in all location, it is also required transportation, and not available in many dimension for option.

1. KT1/KT2: It is the availability of construction material in all locations, easy to operate, safe for user, long life-time and good environment treatment though complication in construction, high cost and the mason is required with training, In the South, KT2 is ranked as the second because even having similar advantages like KT1 but very difficult to construct, especially at the areas with high water table like provinces in the Western South region. The advantages of the two models are the availability of construction material in all localities, easy to operate, safe for users, long lifetime and not so high initial investment. Disadvantages of these models are complexity in construction; the mason is required with training. In addition, it is very difficult to construct KT1 and KT2 in the weak soil areas.

3. KT31: In terms of environment effect, this model has good result. Especially in the South, the rates of decrease of environment parameters are over 99%. However, for biogas plant have big size composit so it is lead to difficult in transportation.

4. Nylon bag: Advantages of this biogas is cheap and low initial investment cost, payback period is short, easy to install, material required for this biogas is available locally. But its disadvantages is that the nylon bag not so durable, easily exposing to failure during operation, the maintenance of this nylon bag biogas is not so favorable either.

VIII.2 Recommendation

Considering the mentioned above evaluation, the followings below are comments from the Consultant:

1. Keeping the using of KT1 and KT2 in provinces where trained building masons are available and where the geological conditions are favorable (no requirement on base strengthening) and where the underground water table is not so high located.

2. Considering the using of composite biogas and KT31 in provinces which are newly joining into the project where skilled building masons are not available, weak soil foundation and underground water table is high. However if the composite biogas can be more popular, the composite biogas manufacturers shall produce the composite biogas with mass quantity and making more sizes for the people to choose. Regulations, rules of quality control ever from production process to the step of construction, installation, operation and maintenance shall be prepared and made available.

3. The nylon bag biogas shall be considered for using in both new and old provinces of the Project. The nylon bag biogas is really suitable with poor family who can not afford to invest in the KT1, KT2 or composite biogas. Besides, the nylon bag biogas is also suitable in suburban areas where urbanization process is taken place sharply and where the local resident has no intention of long-term husbandry. To make it more popular in using nylon bag biogas, the regulations, rules of quality control ever from production process to the step of construction, installation, operation and maintenance shall be prepared and made available.

4. After biogas treatment, it is necessary to have next treatment for slurry (like using slurry pit, compost process, anaerobic treatment…) so that the waste water can meet the requirement before discharge into natural water system.
5. It is necessary to develop and stimulate National Technical Regulation on animal waste water.
6. It is necessary to carry out further study on other biogas models that have many advantages to introduce under the Project.

REFERENCES

1. Anonymous, Biogas User's Guide, August 2005.
2. Amrit B. Karkt, Biogas – As renewable Source of Energy in Nepal Theory and Developmet, 2005.
3. Bajgain, S., Shakya, I., The Nepal Biogas Support Program: A Successful Model of Public Private Partnership for Rural Household Energy Supply.2005.
4. BRTC, The Biogas Technology in China.
5. Biogas Project Division, Technican Manual on Biogas Technology, 2008
6. Nguyen Quang Khai, Biogas Technology KT31, Technology and Science Publicshing House, 2009
7. Nguyen Quang Khai, Biogas Technology KT1 and KT2, Technology and Science Publicshing House, 2009
8. SNV Cambodia, Evaluation Study for Biogas Plant Designs, 2005.
9. Energy Research Centre, Report on "Science workshop between Vietnam and China on exploitation and using biogas" October, 2006
10. Uri Marchaim, Biogas proceses for sustainable development, 1992.
11. Energy Institute, Refernece Document on Biogas Technology, 1994
12. Pham Van Thanh, Vacvina Model, 2008

Websites:

13. http://www.biogas.vn.

PDF files:

14. http://unfccc.int/resource/docs/convkp/kpeng.pdf (accessed October 24th 2006).
15. http://www.itcltd.com/docs/sl-bw.pdf (accessed August 12th 2006).

Annexes

Annex 1: Guidelines of feeding-in material, operation and maintenance

Preparation of feed-in material

- Feed in material: manures of pig (dung and urine)
- Requirement for feed-in material are following:
    - No contaminations such as brick, rock, pebble, saw mill, etc.
    - No toxic such as antiseptic material, soap, detergent or manures of animal having anti-biotic medicine;
- Feed in material will be collected and humidified maximum 10 days in advance.
- Volume of feed –in material should be at least equal to 50% of designed volume. For example: 10 m3 digester need 3 m3 feed-in material.

Dilution and mixing of feed in material

- Dilution ratio is 1-2 liter of water per 1 kg manure;
- Dilution water is fresh water which is not too acid or too alkali;
- Quantity of dilution water will take into account amount of water available inside digester (if any).

First time feed-in

Feed – in material, dilution ratio and feed-in method for each type of biogas plants are followings:

Table 3: Feed in requirement for each models

KT1, KT2	KT31	Composite	Nylon bag
Feed in via inlet, outlet and man-hole.	Feed in via inlet, outlet and man-hole.	Open main lock to feed in material.	Total manure and washing water will be feed in the nylon bag.
If feed-in is done during closing of a main cap, gas valve should be opened.	If feed-in is done during closing of a main cap, gas valve should be opened.		Quantity of feed –in material is quantified according to the length of digester.
First time feed-in should be done within one day only	First time feed-in should be done within one day only	First time feed-in should be done within one day only	If using disintegrated manure (black compost) to feed –in, retaining time will reduced.
Manure amount for 1 m3 of digester is 300-500 kg with dilution ratio is 1:2	Manure amount for 1 m3 of digester is 300-500 kg with dilution ratio is 1:2	Manure amount for 1 m3 of digester is 500-700 kg with dilution ratio is 1: 1.5)	Manure amount for 1 m3 of digester is 300-400 kg with dilution ratio is 1:3
After feed-in, close a cap and close gas valve in order to create anaerobic environment.	After feed-in, close a cap and close gas valve in order to create anaerobic environment.	After feed-in, close gas valve in order to create anaerobic environment.	After feed-in, close gas valve in order to create anaerobic environment.

Utilization of gas

- Gas yielded in the first during is not able to burned and has to discharge completely;
- Connect stove with gas pipe to check whether gas can be burned;
- When the stove is burned, gas can be utilized. The fist gas collection can be used up after accumulate the second batch so that quality of gas will be improved faster;
- Especially for nylon bag, heavy items should be removed or put in a gas-containing bag correspondingly in order to control pressure during cooking process.

Daily operation of biogas plant

- 10-15 days after feed in, it is necessary to carry out second feed in batch.
- Requirement of feed-in material as same as above.
- Daily additional feed-in as follows:
    - Hanoi: 10 kg feed-in material/day/m3 of digester;
    - Tien Giang: 12 kg feed-in material /day/m3 of digester;
- Feed-in material need to be mixed with water at input-tank before feeding in to the digester.
- Daily mixing inside digester is requested. There are two ways to mix:
    - Option 1: using a stick to put in inlet and put-in and pull-out many times;
    - Option 2: using dilution at output to put-in input (for KT1 and KT 2);

Each day, household should stir about 2-3 times per day, last 10-15 minutes each.

Follow up operation of biogas plant

If the biogas plant is operated well, gas productivity should be stable. If gas productivity is reduced suddenly, something wrong with operation or leakage should be detected in order to repair timely.

Annex 2: Detail Construction Cost

Exchange rate: 1US$=18,500 VND

Northen Part - KT31							Southern Part - KT 31						
No	**Material**	**Unit**	**Quantity**	**Unit cost (VND)**	**Amount (VND)**	**Amount (US$)**	**No**	**Material**	**Unit**	**Quantity**	**Unit cost (VND)**	**Amount (VND)**	**Amount (US$)**
1	Brick	Nos	2,000	900	1,800,000	97	1	Brick	Nos	3,000	500	1,500,000	81
2	Cement	kg	1,000	1,000	1,000,000	54	2	Cement	kg	900	1,220	1,098,000	59
3	Sand	m3	2	100,000	200,000	11	3	Sand	m3	3	80,000	200,000	11
4	Peble, gravel	m3	1	200,000	200,000	11	4	Peble, gravel	m3	2	250,000	375,000	20
5	Steel	kg	20	12,500	250,000	14	5	Steel	kg	22	12,500	275,000	15
6	Pipe	m	3	60,000	150,000	8	6	Pipe	m	3	100,000	300,000	16
7	comosite arch	nos	1	1,350,000	1,350,000	73	7	comosite arch	nos	1	1,350,000	1,350,000	73
8	Gas collecting pipe	Nos	1	15,000	15,000	1	8	Gas collecting pip	Nos	1	15,000	15,000	1
9	Stove	Nos	1	170,000	170,000	9	9	Stove	Nos	1	170,000	170,000	9
10	Light	Nos	1	60,000	60,000	3	10	Light	Nos	1	60,000	60,000	3
	Subtotal				**5,195,000**	**281**		**Subtotal**				**5,343,000**	**289**
	Manday	**Unit**	**Quantity**	**Unit cost (VND)**	**Amount (VND)**	**Amount (US$)**		**Manday**	**Unit**	**Quantity**	**Unit cost (VND)**	**Amount (VND)**	**Amount (US$)**
1	Excavation	m3	19.1	40,000	763,020	41	1	Excavation	m3	21.1	50,000	1,053,500	57
2	Foundation	ngày công	1.0	200,000	200,000	11	2	Foundation	ngày công	1.0	250,000	250,000	14
3	surrounding wall	ngày công	2.0	200,000	400,000	22	3	surrounding wall	ngày công	2.0	250,000	500,000	27
4	Casting concrete plate	ngày công	4.0	200,000	800,000	43	4	Casting concrete pl	ngày công	4.0	250,000	1,000,000	54
5	Installing gas holder	ngày công	2.0	200,000	400,000	22	5	Installing gas holde	ngày công	2.0	250,000	500,000	27
6	Installing pipe, stove, light	ngày công	1.0	200,000	200,000	11	6	Installing pipe, stov	ngày công	1.0	250,000	250,000	14
	Subtotal		10.0		**2,763,020**	**149**		**Subtotal**		10		**3,553,500**	**192**
	Transport				600,000	32		**Transport**				**1,100,000**	**59**
	Total				**8,558,020**	**463**		**Total**				**9,996,500**	**540**

Northen Part - Composite							Southern Part - Composite						
No	**Material**	**Unit**	**Quantity**	**Unit cost (VND)**	**Amount (VND)**	**Amount (US$)**	**No**	**Material**	**Unit**	**Quantity**	**Unit cost (VND)**	**Amount (VND)**	**Amount (US$)**
1	Composite	nos	1	6,600,000	6,600,000	357	1	Composite	nos	1	6,600,000	6,600,000	357
2	Stove	nos	1	170,000	170,000	9	2	Stove	nos	1	170,000	170,000	9
3	Light	nos	1	60,000	60,000	3	3	Light	nos	1	60,000	60,000	3
	Subtotal				**6,830,000**	**369**						**6,830,000**	**369**
	Manday	**Unit**	**Quantity**	**Unit cost (VND)**	**Amount (VND)**	**Amount (US$)**	**0**	**Manday**	**Unit**	**Quantity**	**Unit cost (VND)**	**Amount (VND)**	**Amount (US$)**
1	Excavation	m3	15	40,000	596,156	32	1	Excavation	m3	17	50,000	858,000	46
2	Installation of composite part	man day	3	200,000	500,000	27	2	Installation of composite part	man day	2.0	250,000	500,000	27
3	Fill up	man day	0.5	200,000	100,000	5	3	Fill up	man day	1	250,000	250,000	14
6	Installing pipe, stove, light	man day	1	200,000	100,000	5	6	Installing pipe, stove, light	man day	1	250,000	250,000	14
	Subtotal				**1,296,156**	**70**		**Subtotal**				**1,858,000**	**100**
	Transport							**Transport**				1,100,000	**59**
					600,000								
	Total				**8,726,156**	**439**		**Total**				**9,788,000**	**529**

Northen Part- Nylon bag							Southern Part - nylon bag						
No	**Material**	**Unit**	**Quantity**	**Unit cost (VND)**	**Amount (VND)**	**Amount (US$)**	**No**	**Material**	**Unit**	**Quantity**	**Unit cost (VND)**	**Amount (VND)**	**Amount (US$)**
1	Nylong bag(10m x 1,2m)	cái	2	420,000	840,000	45	1	Túi (10m x 1,2m)	cái	2	420,000	840,000	45
2	Nylong bag (5m x 1m)	cái	1	360,000	360,000	19	2	Túi (5m x 1m)	cái	1	360,000	360,000	19
3	Piep	m	2	60,000	120,000	6	3	Đường ống	m	3	100,000	300,000	16
4	Gas collecting pipe	cái	1	15,000	15,000	1	4	Ống thu khí	cái	1	15,000	15,000	1
5	Stove	cái	1	170,000	170,000	9	5	Bếp	cái	1	170,000	170,000	9
6	Light	cái	1	60,000	60,000	3	6	Đèn	cái	1	60,000	60,000	3
	Subtotal				**1,565,000**	**85**		**Phụ Tổng**				**1,745,000**	**94**
	Manday	**Unit**	**Quantity**	**Unit cost (VND)**	**Amount (VND)**	**Amount (US$)**		**Manday**	**Unit**	**Quantity**	**Unit cost (VND)**	**Amount (VND)**	**Amount (US$)**
1	Excavation	m3	14	40,000	576,000	31	1	Excavation	m3	18.5	50,000	924,000	50
2	Installing pipe, stove, light	ngày công	2.5	200,000	500,000	27	2	Installing pipe, stove, light	ngày công	2	250,000	500,000	27
	Subtotal				1,076,000	58		**Subtotal**				1,424,000	77
	Transport							**Transport**					
	Total				**2,641,000**			**Total**				**3,169,000**	**171**

Northen Part (KT1) -							Southern Part (KT2)						
No	**Material**	**Unit**	**Quantity**	**Unit cost (VND)**	**Amount (VND)**	**Amount (US$)**	**No**	**Material**	**Unit**	**Quantity**	**Unit cost (VND)**	**Amount (VND)**	**Amount (US$)**
1	Brick	Nos	2,000	900	1,800,000	97	1	Brick	viên	3,200	500	1,600,000	86
2	Cement	kg	1,000	1,000	1,000,000	54	2	Cement	kg	1,000	1,220	1,220,000	66
3	Sand	m3	2	100,000	200,000	11	3	Sand	m3	3	80,000	200,000	11
4	Peble, gravel	m3	1	200,000	100,000	5	4	Peble, gravel	m3	2	250,000	425,000	23
5	Steel	kg	15	12,500	187,500	10	5	Steel	kg	10	12,500	125,000	7
6	Pipe	m	3	60,000	150,000	8	6	Pipe	m	3	100,000	300,000	16
7	Gas collecting pipe	Nos	1	15,000	15,000	1	7	Gas collecting pipe	cái	1	15,000	15,000	1
8	Anti-leakage powder	kg	1	100,000	100,000	5	8	Anti-leakage powder	kg	1	110,000	77,000	4
9	Stove	Nos	1	170,000	170,000	9	9	Stove	cái	1	170,000	170,000	9
10	Light	Nos	1	60,000	60,000	3	10	Light	cái	1	60,000	60,000	3
	Subtotal				**3,782,500**	**204**		**Subtotal**				**4,192,000**	**227**
	Manday	**Unit**	**Quantity**	**Unit cost (VND)**	**Amount (VND)**	**Amount (US$)**		**Manday**	**Unit**	**Quantity**	**Unit cost (VND)**	**Amount (VND)**	**Amount (US$)**
1	Excavation	m3	22	40,000	889,060	48	1	Excavation	m3	25	50,000	1,253,684	68
2	Foundation	manday	1	200,000	200,000	11	2	Foundation	manday	1	250,000	250,000	14
3	surrounding wall	manday	6.5	200,000	1,300,000	70	3	surrounding wall	manday	7	250,000	1,800,000	97
6	Installing pipe, stove, light	manday	1	200,000	200,000	11	6	Installing pipe, stove, light	manday	1	250,000	250,000	14
	Subtotal				**2,589,060**	**140**		**Subtotal**				**3,553,684**	**192**
	Transport							**Transport**					
	Total				**6,371,560**	**344**		**Total**				**7,745,684**	**419**

Annex 3: Calculation of Financial Indexes

Forecasted escalation rate of fuel	2%
Discount rate	10%

KT31 - Northern part

	Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Total investment capital	US$	-463																			
Benefit of substitute of energy	US$	107	109	111	113	116	118	120	123	125	128	130	133	135	138	141	144	147	150	153	156
Total benefit		-356	-247	-136	-22	93	211	332	454	580	707	837	970	1,106	1,244	1,385	1,529	1,675	1,825	1,978	2,133
NPV	US$	3,648																			
Pay back	Year	4.3																			
IRR	%	32%																			

KT31 - Southern part

	Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Total investment capital	US$	-540																			
Benefit of substitute of energy	US$	103	105	107	110	112	114	116	119	121	123	126	128	131	134	136	139	142	145	147	150
Total benefit		-437	-332	-224	-115	-3	111	227	346	467	590	716	845	976	1,109	1,245	1,384	1,526	1,671	1,818	1,969
NPV	US$	2,733																			
Pay back	Year	4.1																			
IRR	%	24%																			

Composite - Northern Part

	Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Total investment capital	US$	-471																			
Benefit of substitute of energy	US$	95	97	99	101	103	105	108	110	112	114	116	119	121	124	126	129	131	134	136	139
Total benefit		-376	-278	-179	-78	26	131	239	348	460	574	691	809	931	1,054	1,180	1,309	1,440	1,573	1,710	1,849
NPV	US$	2,769																			
Pay back	Year	5.5																			
IRR	%	26%																			

Composite - Miền Nam

	Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Total investment capital	US$	-529																			
Benefit of substitute of energy	US$	95	97	99	101	103	105	107	110	112	114	116	119	121	123	126	128	131	134	136	139
Total benefit		-433	-336	-237	-136	-32	73	180	290	402	516	632	750	871	995	1,120	1,249	1,380	1,513	1,649	1,788
NPV	US$	2,271																			
Pay back	Year	5.5																			
IRR	%	22%																			

Nylon bag - Northen part				
	Year	1	2	3
Total investment capital	US$	-143		
Benefit of substitute of energy	US$	95	97	99
Total benefit		-47	50	149
NPV	US$	111		
Pay back	Year	1.5		
IRR	%	139%		

Nylong bag - southern part				
	Year	1	2	3
Total investment capital	US$	-171		
Benefit of substitute of energy	US$	110	113	115
Total benefit		-61	52	167
NPV	US$	113		
Pay back	Year	1.4		
IRR	%	114%		

KT1- Northen Part																				
	Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Total investment capital	US$	-344																			
Benefit of substitute of energy	US$	102	104	106	109	111	113	115	118	120	122	125	127	130	132	135	138	140	143	146	149
Total benefit		-242	-138	-31	77	188	301	416	534	653	776	900	1,028	1,157	1,290	1,425	1,562	1,703	1,846	1,992	2,141
NPV	US$	4,332																			
Pay back	Year	3.5																			
IRR	%	45%																			

KT2- southern part																
	Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Total investment capital	US$	-419														
Benefit of substitute of energy	US$	93	95	97	99	101	103	105	107	109	112	114	116	118	121	123
Total benefit		-325	-230	-133	-34	67	171	276	383	492	604	718	834	953	1,073	1,197
NPV	US$	3,068														
Pay back	Year	4.3														
IRR	%	30%														

Annex 4: Analysis results of interview

Annex 5: Some applied biogas models in Vietnam

1. Vacvina model of Research and Community Development Center (CCRD)

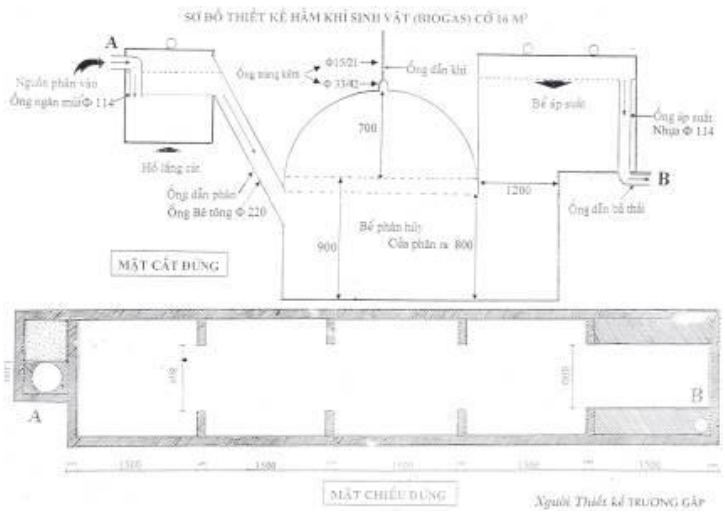
Description: Digester was built by brick and had cylinder shape. Digester had installed with stable or toilet by siphon system. Gas is collected in other separated plastic bag hanging in the kitchen. The gas pressure makes up by the weight putting in the top of plastic tank or using a rubber rob wrapping round gas storage bag.

Advantages: This type is simple in construction

Disadvantages:

- Construction needs many materials because the form of digester is larger and the wall is thicker;
- The pressure at the corners of the digester wall is very high, causing cracks.
- The corners are non-operation places, thus reducing the real volume of digester.

2. Cylinder domed tube digester by Truong Gap (Da Nang)



Fixed dome digester by Truong Gap

Description: The digester is designed with a tube with cylinder dome that developed since 1984. The author is Vice director of Centre for Applied New Energy of Da Nang.

Strong point:

+ Familiar construction engineering
+ Gas tight due to having dome
+ Higher gas yield thank to tube shape.

Weak point:

– Nhược điểm chung của loại hình hộp.
– Having similar weak points of other parallelepiped models
– Cumbersome, big non-working volume especially compensation tank

3. DRAC 1 and DRAC -3 of Centre of Rural Development Assistant (RDAC)

Description: Lower part of digester is cylinder form made by brick. Spherical fixed dome in upper of digester has manufactured in workshop by composite. All parts of the plants are built underground. In some places, it is replaced the composite fixed dome by ferro concrete dome.

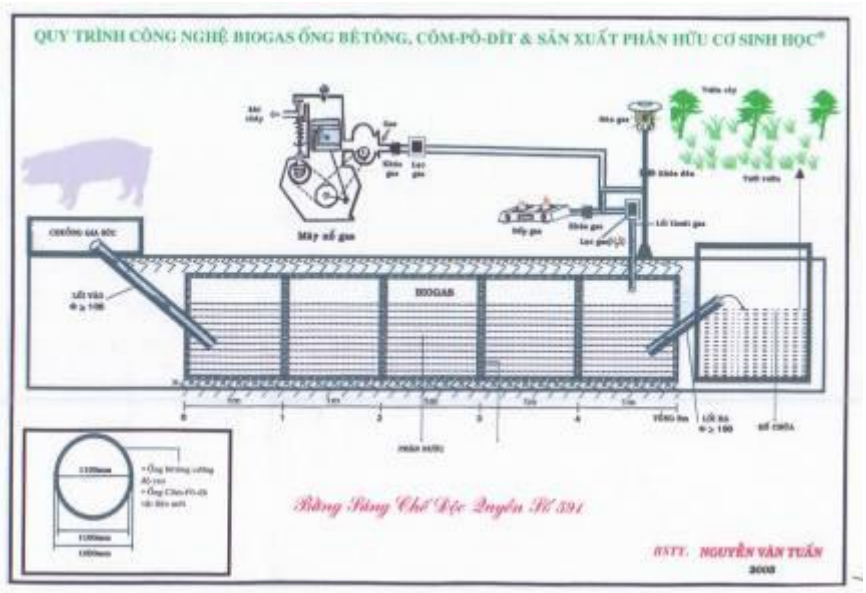
Advantage: This type is simple in construction, gas storage dome is manufactured in workshop; hence it is easier to ensure its qualification. The surface area of slurry in the digester is often changed with the moving of slurry level, hence it is limited the taking of scum.

Disadvantages: Beside the disadvantages as the mentioned above parallelepiped type, according to the design by Center of Clean Water, Sanitation and Rural Environment, we learn that this type has many specific disadvantages as follows:

- The type of RDAC have not manhole, hence during time the plants having operational problems, gas dome must be removed out for repairing.
- The lower end of gas pipe places lower than overflow code, leading scum will flow into the gas pipe and block it.
- The height of compensating tank is too deeply, leading the maximum pressure is too high to cracking the wall of digester.
- Because the lower outlet pipe reachs the digester bottom, almost alive parasitic worm egg accumulation at these areas will be pulled outward easily together with digested slurry flow and the sanitary quality of outgoing digested slurry can not be ensuared.

4) Horizontal precasted tube by Minh Tuan (University of Forestry and Agriculture in HoChiMinh city)

Description: Working under Centre for Technology and Environmental and Natural Resource Management (under University of Forestry and Agriculture), Vet. Nguyen Van Tuan has developed the horizontal precasted tube made by concrete or composite. According to the author, this model has the patent licence and deployed in provinces of Binh Duong and Dong Nai with hundred of plants of 4 cubic meters to hundred cubic meters.



Strong point:

+ No need to construct, easy installation
+ Easy to keep gas tight
+ Higher efficient due to tube shape.

Weak point:

– High cost investment.

5. The type of Can tho University

Project cooperation between Germany and Thailand has developed a biogas plant called TG-BP type (Thailand Germany Biogas Program). The origin of this type is CAMATEC type (Center of Agricultural Mechanize and Rural Technology), which was applied in Tanzania by Germany.

Characteristic of this type is a hemispherical digester. There is weak ring at 30^{o} of the gas dome from the center of bottom.

Advantages:

- Suitable for high water-table places due to shallow digester.
- Design was calculated by a computer program.

Disadvantage

- High cost than other models
- Complicated construction.

Annex 6: Detail construction of demonstration pilots

Construction of KT31

Construction steps are summarized as follows:

- Select construction site
- Define main parameter (diameter of digester)
- Soil excavation: A hole with outside diameter of bottom of 306 cm and 249 cm depth was excavated. In Hanoi, thank to solid soil, the hole was digged upright and no landslide was recorded during excavation. In Tien Giang, the hole was digged with the slopping of 1:1.5 as water table is high.
- Concrete digester's bottom: Concrete of 200# with stone 1*2 of 12cm thick. After defining centre point and radius of the bottom, frame of concrete should be made. A wooden plank or a fiberboard can be used for the frame. Simpler way to make a frame is laying brick method. Frame has to be fixed during concreting. Macadam has to be cleaned before mixing. Concrete materials were mixed by volume each material before mixing with water. Ratio of cement:sand:macadam is 1:2:3 respectively. This ratio ensures concrete reach #200 as compress resisting intensity when manual mixing method is applied. Concrete should be at site precasted within frame and carefully compressed to get rid of soft of concrete as it leads to water leakage.
- Construction of digester's wall: Wall of KT31 has cylinder shape. In case of size 10,1m3, inner dimension of digester is 268cm and height is 257cm from the upper surface of bottom. When construction of wall, brick is put horizontally. Wall reaches 12cm thick after plastering in case of Northern brick is used and about 10 cm thick in case Southern brick is used. Brick is solid, not crack, and have compress resist intensity of #75 upward. Mortar is made from cement and sand, reaching #75. During construction, a plump-line should be used to ensure the upright of wall and radius of digester. Bricks are constructed alternate to make closed cycle. The construction and the plastering work of the dome wall should be carried out at the same time and ensuring the plaster layers must be thick.
- Install inlet pipe
- Concrete plate separating digestion section and compensation section. The concreting was carried out with two ways. 1, concreting into 4 small plates on the ground then install each to the wall (applied for Tien Giang) and 2, at site concrete on the wall (applied for Hanoi). Digester' cover has brim shape with outer diameter of 160cm and 8cm thick. 2 holes with diameter of 15cm and 10cm respectively are made oppositely on the cover. These two holes are open for the installation of inlet and outlet pipes. Cover was concreted of #200 with ϕ6 steel rods are laid as blade of a fan. Steel rods were connected with ϕ6 steel.
- Plastering
- Fill in
- Installation of composite dome: The composite dome is a hemisphere with diameter of 180cm and made of composite material. After concrete plate reach required intensity, the installation of composite dome can begin. The dome was put on the cover and fixed to the cover by bolts 12. Bolts have to be fixed tightly to ensure digester can resist to pressure of gas. On the brim of composite dome, 10 small holes were made to install 10 bolts.
- Install pipeline, valve, gas meter and biogas appliances; test water-tight and gas-tight.

Total time for both construction and installation of KT31 was 10 labor days and the same for the North and the South. As it was the first time this kind of model was constructed by masons. When masons are trained and be familiar, labor days may cut down.

Construction of composite model

Installation steps are summarized:

- Select site for digester
- Define main parameter (diameter of hole)
- Excavation: For selected sized of 10 cubic meters, the outer diameter of digester is 260cm. In Hanoi, a hole with diameter of bottom of 270cm and 260 cm deep was digged vertically. In Tien Giang, hole was digged with slopping of 1:1.5 due to high lever water table. The hole has parameter of 290cm * 260cm.
- Connect all parts of composite digester:
    - Before connecting, grinder or sandpaper was used to grind at connection place.
    - Make connection glue: mix well 1,6kg of plastic with powder. In sunny day, use 2 third of "lavie bottle cap". In rainy day or cold day, increase two time water. This kind of connection glue is used for connecting both brim of digester and ears of digester.
    - Connect ear: Select a plane surface then upturn upper ear and lower ear together. A mason goes inside two ears then press connection glue outside and inside the brim of ears. After press, tight bolts. Re-press one more time both outside and inside the brim of ears.
    - Connect ears: locate ear by marking on digester where to connect ears. Use prepare connection glue on brims of ear and digester then press glue on the surface of digester where connect ears. Mason goes inside digester and presses well all bolts and connect all bolts.
    - Drill a hole for gas pipe: use driller 10 to make a hole at the middle of upper digester wall. A drilled hole should have an inner diameter of 21mm. Press connection glue (like washer) and screw inner 21 mm and screw outer 21mm together. Press well connection glue surrounding both inner screw and outer screw.
- Low composite digester into digged hole and fix by rod. The hole had to be checked to remove all pointed thing or solid thing like rock or brick inside the hole before lowing digester. Bottom of hole has to be in pan-shape. Bottom was cover with a layer of sand.
- Install inlet and outlet pipes: PVC pipes of 110 mm were put on the ears of composite digester. Bricks were constructed to enclose the ears. Two concrete plates were put on the mouth of inlet and outlet to prevent rain water getting into digester.
- Install gas pipeline, gas meter and gas appliances; test water-tightness and gas-tightness.

Total time need for installation of composite model is 3.5 days in the North and 4 days in the South. The installation was done by Project masons under close observation of the technician from Thanh Loc Company Ltd,.

Installation of nylon bag digester

In the comparison with the two above models, nylon bag digester needs a rather simple installation. 3 nylon layers were used to made digester. Then it put in a hole which already prepared. The installation was finished with the cover of some bamboo screens. The installation includes following steps:

- Select site for installation of nylon bag digester
- Define main parameters
- Soil excavation: for the size of 10 cubic meters, the hole of 1,2m * 1,2m * 10m was digged in Hanoi. Hole's edge was digged vertically and no landslide was recorded during excavation. In Tien Giang, the hole of 11 m x 1.4m x 1.2m was digged with the slopping of 1:1.5 as high water table.
- Three nylon layers were put together as per following steps:
    - Two technicians put their hands between layers to separate totally the first nylon layer.
    - Slip second layer into first layer. The second layer was inside thus be ensure completely not any small holes or any damage;
    - Correct every angle of two layers. Separate the third layer then slip into the two layer as per below diagram. The third layer is outer layer.
    - Correct angle of the third layer.
- Installation of inlet and outlet pipes:
    - PVC or glazed-terra cotta pipes can be used
    - Insert pipe into nylon bag. Make many nylon folds around pipe the tie tightly with elastic band.
- Put nylon bag digester into the hole:
    - Check hole to remove all sharp or pointed things.
    - Fix two ends of nylon bag with two crossed tree branches. Pipes were installed to the position of 35-40cm from the bottom of the hole.
    - Pumping and correct the nylon bag to make sure no fold in the bag.
- Installation of gas bag:
    - A T-shaped was made of PVC with outer diameter of 21mm. The long pipe is 30cm and two shorter pipes are 5cm length.
    - Two nylon layers of 5m were slipped into each other.
    - Manipulation was as per below diagram. A PVC pipe was put into the nylon bag then fixed tightly to the bag. The other end of bag was tied tightly.
    - The bag was hung vertically or horizontally at ventilating place, avoid direct sunny ray or pointed things.
    - When using gas, a heavy thing can be hung under the bag or tie the bag with an elastic band to create pressure for the bag.
- Installation of gas pipeline, safety valve, gas appliances
- Fill in with soil, put a heavy thing on nylon digester then cover digester with bamboo screens.

Manipulation should be very careful so as not to damage the bag or create gas leakage at holing-place on the digester.

Total time needed for installation of nylon bag digester was 2,5days for the North and 2 days for the South. Project masons installed the two digesters under observation of the Consultant.

The installation of nylon bag digester was rather quick and easy. Masons do not need training.

Construction of KT1 and KT2

Construction steps are summarized as follows:

- Select construction site
- Define main parameter (diameter of digester)
- Soil excavation: For selected sizes, a hole with dimension of 3m x 2.6m was digged for KT1 and a hole with dimension of 3mx2.9m was digged for KT2. In Hanoi, thank to solid soil, the hole was digged upright and no landslide was recorded during excavation. In Tien Giang, the hole was digged with the slopping of 1:1.5 as water table is high.
- Concrete digester's bottom: Concrete of 200# with stone 1*2 of 12cm thick. After defining centre point and radius of the bottom, frame of concrete should be made. A wooden plank or a fiberboard can be used for the frame. Simpler way to make a frame is laying brick method. Frame has to be fixed during concreting. Macadam has to be cleaned before mixing. Concrete materials were mixed by volume each material before mixing with water. Ratio of cement:sand:macadam is 1:2:3 respectively. This ratio ensures concrete reach #200 as compress resisting intensity when manual mixing method is applied. Concrete should be at site precasted within frame and carefully compressed to get rid of soft of concrete as it leads to water leakage.
- Construction of digester's wall: Wall was constructed in dome-shape. Bricks were laid horizontally, having 12cm thick after plastering and 10cm when Northern brick and Southern brick are used respectively. Bricks should be solid and not crack, having #75 compress resist intensity. Mortar is mixed of cement and sand, having #75 mark. During construction, a plump-line should be used to ensure the upright of wall and radius of digester. Brick is constructed so as not to coincide its vessel.
- Installation of inlet and outlet pipes
- Installation of pipeline, valve, gas meter and biogas appliances; test water-tight and gas-tight.

Total days necessary for construction of KT1 was 8.5 days and for KT2 was 9.2 days. As masons are familiar with KT1 and KT2 so the construction was quick and favorable.

Annex 7: National Technical Regulation on surface water quality

CỘNG HÒA XÃ HỘI CHỦ NGHĨA VIỆT NAM

QCVN 08 : 2008/BTNMT

QUY CHUẨN KỸ THUẬT QUỐC GIA VỀ CHẤT LƯỢNG NƯỚC MẶT

National technical regulation on surface water quality

HÀ NỘI -2008

QCVN 08 : 2008/BTNMT

Lời nói đầu

QCVN …….. : 2008/BTNMT do *Ban soạn thảo quy chuẩn kỹ thuật quốc gia về chất lượng nước* biên soạn, Tổng cục Môi trường và Vụ Pháp chế trình duyệt, ban hành theo Quyết định số /2008/QĐ-BTNMT ngày ..... tháng … năm 2008 c ủa Bộ trưởng Bộ Tài nguyên và Môi trường.

QUY CHUẨN KỸ THUẬT QUỐC GIA VỀ CHẤT LƯỢNG NƯỚC MẶT

National technical regulation on surface water quality

1. QUY ĐỊNH CHUNG

1.1. Phạm vi áp dụng

1.1.1. Quy chuẩn này quy định giá trị giới hạn các thông số chất lượng nước mặt.

1.1.2. Quy chuẩn này áp dụng để đánh giá và kiểm soát chất lượng của nguồn nước mặt, làm căn cứ cho việc bảo vệ và sử dụng nước một cách phù hợp.

1.2. Giải thích từ ngữ

Nước mặt nói trong Quy chuẩn này là nước chảy qua hoặc đọng lại trên mặt đất: sông, suối, kênh, mương, khe, rạch, hồ, ao, đầm,….

2. QUY ĐỊNH KỸ THUẬT

Giá trị giới hạn của các thông số chất lượng nước mặt được quy định tại Bảng 1.

Bảng 1: Giá trị giới hạn các thông số chất lượng nước mặt

TT	Thông số	Đơn	Giá trị giới hạn			
			A		B	
			A1	A2	B1	B2
1	pH		6-8,5	6-8,5	5,5-9	5,5-9
2	Ôxy hoà tan (DO)	mg/l	≥ 6	≥ 5	≥ 4	≥ 2
3	Tổng chất rắn lơ lửng (TSS)	mg/l	20	30	50	100
4	COD	mg/l	10	15	30	50
5	BOD_5 (20^oC)	mg/l	4	6	15	25
6	Amoni (NH^+_4) (tính theo N)	mg/l	0,1	0,2	0,5	1
7	Clorua (Cl^-)	mg/l	250	400	600	-
8	Florua (F^-)	mg/l	1	1,5	1,5	2
9	Nitrit (NO^-_2) (tính theo N)	mg/l	0,01	0,02	0,04	0,05

10	Nitrat (NO^-_3) (tính theo N)	mg/l	2	5	10	15
11	Phosphat (PO_4^{3-})(tính theo P)	mg/l	0,1	0,2	0,3	0,5
12	Xianua (CN^-)	mg/l	0,005	0,01	0,02	0,02
13	Asen (As)	mg/l	0,01	0,02	0,05	0,1
14	Cadimi (Cd)	mg/l	0,005	0,005	0,01	0,01
15	Chì (Pb)	mg/l	0,02	0,02	0,05	0,05
16	Crom III (Cr^{3+})	mg/l	0,05	0,1	0,5	1
17	Crom VI (Cr^{6+})	mg/l	0,01	0,02	0,04	0,05
18	Đồng (Cu)	mg/l	0,1	0,2	0,5	1
19	Kẽm (Zn)	mg/l	0,5	1,0	1,5	2
20	Niken (Ni)	mg/l	0,1	0,1	0,1	0,1
21	Sắt (Fe)	mg/l	0,5	1	1,5	2
22	Thuỷ ngân (Hg)	mg/l	0,001	0,001	0,001	0,002
23	Chất hoạt động bề mặt	mg/l	0,1	0,2	0,4	0,5
24	Tổng dầu, mỡ (oils & grea se)	mg/l	0,01	0,02	0,1	0,3
25	Phenol (tổng số)	mg/l	0,005	0,005	0,01	0,02
26	Hoá chất bảo vệ thực vật Clo hữu cơ Aldrin+Dieldrin Endrin BHC DDT Endosunfan (Thiodan) Lindan Chlordane Heptachlor	 mg/l mg/l mg/l mg/l mg/l mg/l mg/l mg/l	 0,002 0,01 0,05 0,001 0,005 0,3 0,01 0,01	 0,004 0,012 0,1 0,002 0,01 0,35 0,02 0,02	 0,008 0,014 0,13 0,004 0,01 0,38 0,02 0,02	 0,01 0,02 0,015 0,005 0,02 0,4 0,03 0,05
27	Hoá chất bảo vệ thực vật phospho hữu cơ Paration Malation	 mg/l mg/l	 0,1 0,1	 0,2 0,32	 0,4 0,32	 0,5 0,4
28	Hóa chất trừ cỏ 2,4D 2,4,5T Paraquat	 mg/l mg/l mg/l	 100 80 900	 200 100 1200	 450 160 1800	 500 200 2000
29	Tổng hoạt độ phóng xạ	Bq/l	0,1	0,1	0,1	0,1
30	Tổng hoạt độ phóng xạ	Bq/l	1,0	1,0	1,0	1,0
31	E. Coli	MPN/ 100ml	20	50	100	200
32	Coliform	MPN/ 100ml	2500	5000	7500	10000

Ghi chú: Việc phân hạng nguồn n ước mặt nhằm đánh giá và kiểm soát chất lượng nước, phục vụ cho các mục đích sử dụng n ước khác nhau:

A1 - Sử dụng tốt cho mục đích cấp n ước sinh hoạt và các m ục đích khác như loại A2, B1 và B2.

A2 - Dùng cho mục đích cấp nước sinh hoạt nhưng phải áp dụng công nghệ xử lý phù hợp; bảo tồn động thực vật thủy sinh, hoặc các mục đích sử dụng như loại B1 và B2.

B1 - Dùng cho mục đích tưới tiêu thủy lợi hoặc các mục đích sử dụng khác có yêu cầu chất lượng nước tương tự hoặc các mục đích sử dụng như loại B2.

B2 - Giao thông thủy và các mục đích khác với yêu cầu nước chất lượng thấp.

3. PHƯƠNG PHÁP XÁC ĐỊNH

3.1. Lấy mẫu để quan trắc chất lượng nước mặt thực hiện theo hướng dẫn của các tiêu chuẩn quốc gia:

- TCVN 5992:1995 (ISO 5667 -2: 1991) - Chất lượng nước- Lấy mẫu. Hướng dẫn kỹ thuật lấy mẫu.

- TCVN 5993:1995 (ISO 5667 -3: 1985) - Chất lượng nước- Lấy mẫu. Hướng dẫn bảo quản và xử lý mẫu.

- TCVN 5994:1995 (ISO 5667 -4: 1987) - Chất lượng nước - Lấy mẫu. Hướng dẫn lấy mẫu ở hồ ao tự nhiên và nhân tạo.

- TCVN 5996:1995 (ISO 5667 -6: 1990) - Chất lượng nước - Lấy mẫu. Hướng dẫn lấy mẫu ở sông và suối.

3.2. Phương pháp phân tích xác định các thông số chất lượng nước mặt thực hiện theo hướng dẫn của các tiêu chuẩn quốc gia hoặc tiêu chuẩn phân tích tương ứng của các tổ chức quốc tế:

- TCVN 5499 -1995. Chất lượng nước – Xác định oxy hoà tan - Phương pháp Winkler.

- TCVN 6625 -2000 (ISO 11923 -1997) - Chất lượng nước- Xác định chất rắn lơ lửng bằng cách lọc qua cái lọc sợi thuỷ tinh.

- TCVN 6001 -1995 (ISO 5815 -1989) - Chất lượng nước - Xác định nhu cầu oxi sinh hoá sau 5 ngày (BOD_5) - Phương pháp cấy và pha loãng.

- TCVN 6491 -1999 (ISO 6060 -1989) - Chất lượng nước - Xác định nhu cầu oxy hoá học.

- TCVN 6494 -1999 - Chất lượng nước - Xác định các ion Florua, Clorua, Nitrit, Orthophotphat, Bromua, Nitrat và Sunfat hoà tan bằng sắc ký lỏng ion.

- TCVN 6194 -1996 (ISO 9297 -1989) - Chất lượng n ước – Xác đ ịnh Clorua. Ph ương pháp chu ẩn độ bạc nitrat với chỉ thị cromat (ph ương pháp MO).

- TCVN 6195 -1996 (ISO 10359 -1-1992) - Chất lượng n ước – Xác định florua. Ph ương pháp d ò điện hóa đối với n ước sinh hoạt v à nước bị ô nhiễm nhẹ.

- TCVN 6178 -1996 (ISO 6777 -1984) - Chất lượng n ước – Xác đ ịnh nitrit. Phương pháp trắc phổ hấp thụ phân tử.

- TCVN 6180 -1996 (ISO 7890 -3-1988) - Chất lượng n ước – Xác định nitrat - Phương pháp trắc phổ dùng axit sunfosalixylic.

- TCVN 5988 -1995 (ISO 5664 -1984) - Chất lượng n ước - Xác đ ịnh amoni - Phương pháp chưng cất và chuẩn độ.

- TCVN 6181 -1996 (ISO 6703 -1-1984) - Chất lượng n ước – Xác định xyanua tổng.

- TCVN 6336 -1998 (ASTM D 2330 -1988) - Phương pháp thử chất hoạt động bề mặt bằng metylen xanh.

- TCVN 5991 -1995 (ISO 5666 -3-1984) - Chất lượng n ước - Xác đ ịnh thủy ngân tổng số bằng ph ương pháp quang ph ổ hấp thụ nguy ên tử không ngọn lửa – Phương pháp sau khi vô cơ hóa v ới brom.

- TCVN 6002 -1995 (ISO 6333 -1986)) - Chất lượng n ước – Xác đ ịnh mangan – Phương pháp trắc quang dùng fomaldoxim.

- TCVN 6053 -1995 (ISO 9696 -1992) - Chất lượng n ước - Đo tổng hợp độ phóng xạ anpha trong n ước không mặn - Phương pháp ngu ồn dày.

- TCVN 6177 -1996 (ISO 6332 -1988) - Chất lượng n ước – Xác đ ịnh sắt bằng phương pháp trắc phổ dùng thuốc thử 1,10-phenantrolin.

- TCVN 6193 -1996 (ISO 8288 -1986) - Chất lượng n ước – Xác đ ịnh coban, niken, đ ồng, kẽm, cadimi v à chì. Ph ương pháp tr ắc phổ hấp thụ nguyên tử ngọn lửa.

- TCVN 6197 –1996 (ISO 5961 -1994) - Chất lượng nước – Xác đ ịnh cadimi bằng phương pháp trắc phổ hấp thụ nguyên tử.

- TCVN 6222 -1996 (ISO 9174 -1990) - Chất lượng n ước – Xác đ ịnh crom tổng – Phương pháp trắc phổ hấp thụ nguyên tử.

- TCVN 6626 -2000 (ISO 11969 -1996) - Chất lượng n ước – Xác đ ịnh

asen. Phương pháp đo hấp thụ nguyên tử (kỹ thuật hydrua).

- TCVN 6216-1996 (ISO 6439–1990) - Chất lượng nước - Xác định chỉ số phenol. Phương pháp trắc phổ dùng 4-aminoantipyrin sau khi chưng cất.

- TCVN 5070-1995 - Chất lượng nước - Phương pháp khối lượng xác định dầu mỏ và sản phẩm dầu mỏ

- TCVN 6053-1995 (ISO 9696–1992) - Chất lượng nước - Đo tổng hợp độ phóng xạ anpha trong nước không mặn. Phương pháp nguồn dày.

- TCVN 6219-1995 (ISO 9697–1992) - Chất lượng nước - Đo tổng hợp độ phóng xạ beta.

- TCVN 6187-1-1996 (ISO 9308-1-1990) Chất lượng nước - Phát hiện và đếm vi khuẩn coliform, vi khuẩn coliform chịu nhiệt và Escherichia coli giả định. Phần 1: Phương pháp màng lọc.

Các thông số quy định trong Quy chuẩn này chưa có tiêu chuẩn quốc gia hướng dẫn phương pháp phân tích thì áp dụng các tiêu chuẩn phân tích tương ứng của các tổ chức quốc tế.

4. TỔ CHỨC THỰC HIỆN

Qui chuẩn này áp dụng thay thế cho TCVN 5942:1995 - Chất lượng nước - Tiêu chuẩn chất lượng nước mặt trong Danh mục các tiêu chuẩn Việt Nam về môi trường bắt buộc áp dụng ban hành kèm theo Quyết định số 35/2002/QĐ-BKHCNMT ngày 25 tháng 6 năm 2002 của Bộ trưởng Bộ Khoa học, Công nghệ và Môi trường.

Trường hợp các tiêu chuẩn quốc gia viện dẫn trong Quy chuẩn này sửa đổi, bổ sung hoặc thay thế thì áp dụng theo văn bản mới.

Annex 8: Analyze result

1. Analyze result in the North

HỘI KHKT PT HÓA – LÝ & SINH HỌC VN
TRUNG TÂM PHÂN TÍCH VÀ MÔI TRƯỜNG
Điện thoại/Fax: 04.8 561 279

CỘNG HÒA XÃ HỘI CHỦ NGHĨA VIỆT NAM
Độc lập – Tự do – Hạnh phúc

CHẤT LƯỢNG NƯỚC THẢI

Đơn vị gửi mẫu: Công ty Cổ phần Tư vấn Phát triển Năng lượng bền vững
Địa chỉ: Số 4 ngõ 64 ngách 49 phố Nguyễn Lương Bằng
Phường Ô Chợ Dừa – Đống Đa – Hà Nội
Loại mẫu: Nước hầm biogas
Số lượng: 8 mẫu
Ký hiệu:
W1: Đầu vào của hầm KT1
W2: Đầu ra của hầm KT1
W3: Đầu vào của túi ny lông
W4: Đầu ra của túi ny lông
W5: Đầu vào của hầm compozit
W6: Đầu ra của hầm compozit
W7: Đầu vào của hầm KT31
W7: Đầu ra của hầm KT31

	BOD_5 (mg/l)	COD (mg/l)	Colifom (MPN/100ml)
W1	24.359	78.420	$3,2.10^7$
W2	156	264	$5,6.10^4$
W3	6.450	45.450	$4,5.10^6$
W4	193	333	$7,9.10^5$
W5	33.290	91.854	$4,6.10^7$
W6	195	325	$8,1.10^5$
W7	35.421	82.400	$6,8.10^8$
W8	130	235	$6,3.10^5$

Hà nội, ngày 02 tháng 04 năm 2010

Trung tâm PT&MT

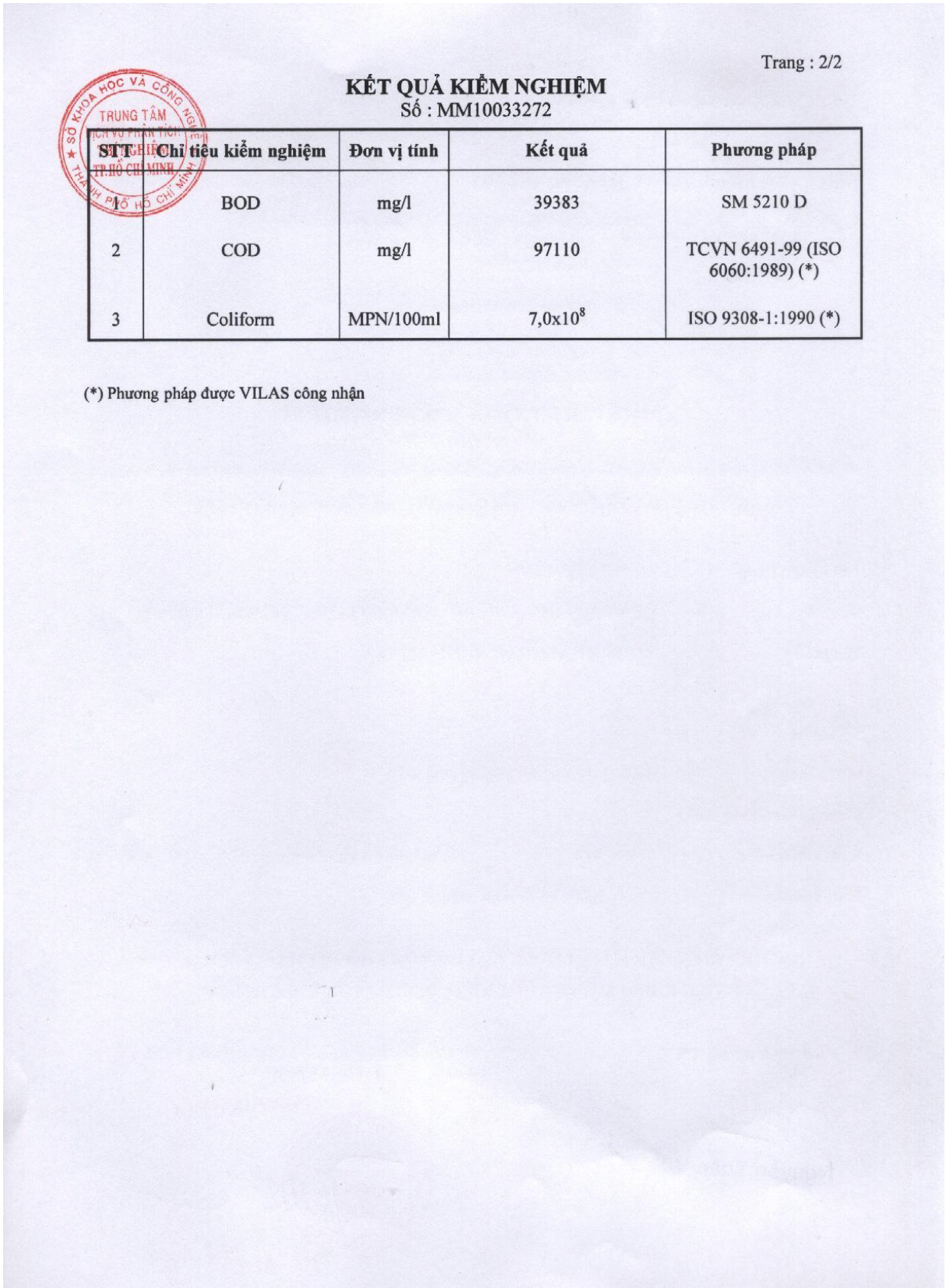
TRUNG TÂM PHÂN TÍCH VÀ MÔI TRƯỜNG

GIÁM ĐỐC
PGS.TS. Ngô Huy Du

Cán bộ phân tích
Nguyễn Thị Hồng Hạnh
Nguyễn Hữu Lai

2. Analyze result in the South

2.1 KT31 – inlet sample



Trang : 2/2

KẾT QUẢ KIỂM NGHIỆM

Số : MM10033272

STT	Chỉ tiêu kiểm nghiệm	Đơn vị tính	Kết quả	Phương pháp
1	BOD	mg/l	39383	SM 5210 D
2	COD	mg/l	97110	TCVN 6491-99 (ISO 6060:1989) (*)
3	Coliform	MPN/100ml	$7,0x10^8$	ISO 9308-1:1990 (*)

(*) Phương pháp được VILAS công nhận

2.2 KT31 – outlet sample

KẾT QUẢ KIỂM NGHIỆM
Số : MM10033273

STT	Chỉ tiêu kiểm nghiệm	Đơn vị tính	Kết quả	Phương pháp
1	BOD	mg/l	141	SM 5210 D
2	COD	mg/l	878	TCVN 6491-99 (ISO 6060:1989) (*)
3	Coliform	MPN/100ml	$4,0x10^5$	ISO 9308-1:1990 (*)

(*) Phương pháp được VILAS công nhận

2.3 Composite – inlet sample

SỞ KHOA HỌC VÀ CÔNG NGHỆ THÀNH PHỐ HỒ CHÍ MINH
TRUNG TÂM DỊCH VỤ PHÂN TÍCH THÍ NGHIỆM THÀNH PHỐ HỒ CHÍ MINH

KẾT QUẢ KIỂM NGHIỆM
Số : MM10033274

STT	Chỉ tiêu kiểm nghiệm	Đơn vị tính	Kết quả	Phương pháp
1	BOD	mg/l	39983	SM 5210 D
2	COD	mg/l	99450	TCVN 6491-99 (ISO 6060:1989) (*)
3	Coliform	MPN/100ml	$4,6x10^7$	ISO 9308-1:1990 (*)

(*) Phương pháp được VILAS công nhận

2.4 Composite - outlet sample

Trang : 2/2

KẾT QUẢ KIỂM NGHIỆM
Số : MM10033275

STT	Chỉ tiêu kiểm nghiệm	Đơn vị tính	Kết quả	Phương pháp
1	BOD	mg/l	107	SM 5210 D
2	COD	mg/l	234	TCVN 6491-99 (ISO 6060:1989) (*)
3	Coliform	MPN/100ml	$2,8x10^4$	ISO 9308-1:1990 (*)

(*) Phương pháp được VILAS công nhận

2.5 KT2 – inlet sample

SỞ KHOA HỌC VÀ CÔNG NGHỆ THÀNH PHỐ HỒ CHÍ MINH
TRUNG TÂM DỊCH VỤ PHÂN TÍCH THÍ NGHIỆM TP HỒ CHÍ MINH

KẾT QUẢ KIỂM NGHIỆM
Số : MM10033276

STT	Chỉ tiêu kiểm nghiệm	Đơn vị tính	Kết quả	Phương pháp
1	BOD	mg/l	28683	SM 5210 D
2	COD	mg/l	85410	TCVN 6491-99 (ISO 6060:1989) (*)
3	Coliform	MPN/100ml	$4,0x10^7$	ISO 9308-1:1990 (*)

(*) Phương pháp được VILAS công nhận

2.6 KT2 – outlet sample

SỞ KHOA HỌC VÀ CÔNG NGHỆ THÀNH PHỐ HỒ CHÍ MINH
TRUNG TÂM DỊCH VỤ PHÂN TÍCH THÍ NGHIỆM THÀNH PHỐ HỒ CHÍ MINH

KẾT QUẢ KIỂM NGHIỆM
Số : MM10033277

STT	Chỉ tiêu kiểm nghiệm	Đơn vị tính	Kết quả	Phương pháp
1	BOD	mg/l	1108	SM 5210 D
2	COD	mg/l	10121	TCVN 6491-99 (ISO 6060:1989) (*)
3	Coliform	MPN/100ml	$2,8x10^5$	ISO 9308-1:1990 (*)

(*) Phương pháp được VILAS công nhận

2.7 Nylon bag – inlet sample

SỞ KHOA HỌC VÀ CÔNG NGHỆ THÀNH PHỐ HỒ CHÍ MINH
TRUNG TÂM DỊCH VỤ PHÂN TÍCH THÍ NGHIỆM TP.HỒ CHÍ MINH

KẾT QUẢ KIỂM NGHIỆM

Số : MM10033278

STT	Chỉ tiêu kiểm nghiệm	Đơn vị tính	Kết quả	Phương pháp
1	BOD	mg/l	13183	SM 5210 D
2	COD	mg/l	77220	TCVN 6491-99 (ISO 6060:1989) (*)
3	Coliform	MPN/100ml	$4,8x10^7$	ISO 9308-1:1990 (*)

(*) Phương pháp được VILAS công nhận

2.8 Nylon bag – outlet sample

KẾT QUẢ KIỂM NGHIỆM
Số : MM10033279

STT	Chỉ tiêu kiểm nghiệm	Đơn vị tính	Kết quả	Phương pháp
1	BOD	mg/l	6453	SM 5210 D
2	COD	mg/l	6160	TCVN 6491-99 (ISO 6060:1989) (*)
3	Coliform	MPN/100ml	$7,5x10^6$	ISO 9308-1:1990 (*)

(*) Phương pháp được VILAS công nhận

Annex 9: Record Sheet of gas yield

BẢNG THEO DÕI SẢN LƯỢNG KHÍ CHO MIỀN BẮC					
Ngày	Đơn vị	KT31	Compozit	Túi ny lông	KT2
Chỉ số đầu	dm3	0	0	0	0
5/1		2400	1980	800	3400
6/1		2400	2240	900	3500
7/1		2400	2000	900	3600
8/1		2700	2000	950	3800
9/1		2700	2200	1300	3780
10/1		2900	2400	1250	3900
11/1		2900	2860	1260	4000
12/1		3000	2500	1280	3780
13/1		3200	2500	1260	3800
14/1		3400	2540	1300	4100
TB		2800	2240	1120	3776

* Ghi chú: Sản lượng khí được tính bằng chỉ số tại thời điểm đo trừ chỉ số của lần đo liền kề trước đó

BẢNG THEO DÕI SẢN LƯỢNG KHÍ CHO MIỀN NAM					
Ngày	Đơn vị	KT31	Compozit	Túi ny lông	KT1
Chỉ số đầu	dm3	0	0	0	0
18/1		2560	1880	1560	2980
19/1		2640	1780	1670	3220
20/1		2660	1980	1800	3000
21/1		2880	1960	1560	3120
22/1		2980	2000	1660	3120
23/1		3200	2100	1740	3240
24/1		3200	1960	1800	3200
25/1		3220	2220	1800	3140
26/1		3240	1800	2000	3200
27/1		3200	1960	1980	3000
TB		2958	1964	1757	3122

* Ghi chú: Sản lượng khí được tính bằng chỉ số tại thời điểm đo trừ chỉ số của lần đo liền kề trước đó