A FINANCIAL COST-BENEFIT ANALYSIS OF JOINT INVESTMENT OF BIOGAS SYSTEMS FOR ELECTRICITY GENERATION: A CASE STUDY OF SMALL AND MEDIUM SCALE SWINE FARMS IN THASADET SUB-DISTRICT MUNICIPALITY, MUANG DISTRICT, SUPHANBURI PROVINCE

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A THESIS SUBMITTED IN PARTIAL FULLFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE (TECHNOLOGY OF ENVIRONMENTAL MANAGEMENT) FACULTY OF GRADUATE STUDIES MAHIDOL UNIVERSITY 2010

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ABSTRACT

The objectives of this research are to analyze financial cost-benefit of joint investment of biogas system for electricity generation and to study factors influencing joint investment of small and medium swine farm. The questionnaires were used as tool to collect data from 39 farm owners in the study area while financial feasibility of project was done according to the principle of cost-benefit analysis. The results indicated that net present value (NPV) was 16,648,780.82 baht. Benefit – cost ratio (BCR) was 1.47 times and internal rate of return (IRR) was 12.46%. Therefore, the project was worth for investment, the risk of project was low level and the project pay back period was within 5 years 6 months.

The benefits from biogas production system are revenue from electricity and fertilizer. The project shall also reduce wastewater discharging to canal that connects to Tha Chin River of which water quality are degraded. Concerning the factors, it was found that only age, experience, number of swine and number of labors statistically influence joint investment of biogas systems for electricity generation.

KEY WORDS: COST-BENEFIT ANALYSIS/ BIOGAS SYSTEM/ JOINT INVESTMENT

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การวิเคราะห์ความคุ้มค่าทางการเงินในการลงทุนก่อสร้างระบบก๊าซชีวภาพแบบรวมกลุ่มฟาร์มเพื่อผลิตไฟฟ้า : กรณีศึกษาฟาร์มสุกรขนาดกลางและขนาดเล็ก เทศบาลตำบลเทศบาลท่าเสด็จ อำเภอเมือง จังหวัดสุพรรณบุรี

A FINANCIAL COST-BENEFIT ANALYSIS OF JOINT INVESTMENT OF BIOGAS SYSTEMS FOR ELECTRICITY GENERATION: A CASE STUDY OF SMALL AND MEDIUM SCALE SWINE FARM THASADET SUB-DISTRICT MUNICIPALITY, MAUNG DISTRICT, SUPHANBURI PROVINCE.

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บทคัดย่อ

การวิจัยนี้ มีวัตถุประสงค์เพื่อวิเคราะห์ความคุ้มค่าทางการเงินในการลงทุนก่อสร้างระบบก๊าซชีวภาพแบบรวมกลุ่ม และศึกษาปัจจัยที่มีผลต่อการรวมกลุ่มฟาร์มสุกรขนาดกลางและขนาดเล็กเพื่อผลิตไฟฟ้า โดยใช้แบบสัมภาษณ์เป็นเครื่องมือในการวิจัยและเก็บรวมรวมข้อมูลจากเกษตรกร ผู้เลี้ยงสุกรในพื้นที่ศึกษาจำนวน 39 ราย และศึกษาความคุ้มค่าทางการเงินของโครงการ โดยใช้หลักการวิเคราะห์ต้นทุนและผลประโยชน์ ผลการวิจัยพบว่า มูลค่าปัจจุบันสุทธิ (NPV) มีค่าเท่ากับ 16,648,780.82 บาท อัตราส่วนผลประโยชน์ต่อต้นทุน (BCR) มีค่าเท่ากับ 1.47 เท่า และอัตราผลตอบแทนทางการเงินของการลงทุน (IRR) มีค่าเท่ากับร้อยละ 12.46 แสดงว่าโครงการมีความคุ้มค่าต่อการลงทุน และมีความเสี่ยงต่อการลงทุนต่ำ โดยมีระยะเวลาในการคืนทุน 5 ปี 6 เดือน

ผลประโยชน์ที่ได้จากระบบผลิตก๊าซชีวภาพนี้ คือ นำก๊าซชีวภาพไปผลิตเป็นกระแสไฟฟ้าและรายได้จากการขายปุ๋ยในแต่ละปี สามารถช่วยลดปริมาณความสกปรกของน้ำเสียก่อนปล่อยสู่คลองสาขาที่เชื่อมสู่แม่น้ำท่าจีนซึ่งกำลังประสบปัญหาคุณภาพน้ำเสื่อมโทรม และพบว่าตัวแปร อายุประสบการณ์การเลี้ยงสุกร จำนวนสุกร และจำนวนแรงงานเท่านั้น ที่มีผลต่อความคิดเห็นต่อการรวมกลุ่มฟาร์มสุกรในการก่อสร้างระบบก๊าซชีวภาพเพื่อการผลิตไฟฟ้า

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CHAPTER I
INTRODUCTION

1.1 Background Justification

In the present, Thailand faces a problem of water pollution. The major source of pollutions includes domestic, industrial and agricultural wastewater discharges, especially agricultural point source like swine farm, which cause high quantity of manure, contaminated in wastewater. Swine farming needs approximately 10-20 liter/swine/day. Wastewater from the swine farm which collecing dung before washing a stall will have biochemical oxygen demand (BOD) 1,500-3,000 mg/l but if does not collect dung before washing a stall; BOD will be high as 7,000 mg/l (1). Therefore, if discharging wastewater directly to water channel without treatment, it will cause a lot of damages, especially the small channel like ditch and canal. The utilization of water channel change when water qualities are decreased. Furthermore, the impact of poor water quality may be so serious that affects economy thru decrease in public health.

Pollution Control Department by virtue of section 55 and 67 of The Enhancement and Conservation of the National Environmental Quality Act B.C. 1992 mandate notification of Ministry of Natural Resources and Environment Specifies effluent Standard for swine farms (Large, Medium and Small farm). These effluent standards become effective since February 2002 (2). As notification of Ministry of Natural Resources and Environment, the medium and small swine farms have to provide the wastewater treatment system and have to treat the wastewater to effluent standard before discharges outside farm. While the small farm which are majority and usually located near water souces, are not required to have wastewater treatment system. Hence, if the small farms have good wastewater management, it will significantly reduce impact on water souce.

Furthermore, in B.C. 2004-2005, The Pollution Control Department monitored effluent quality from swine farm in the Thachin River Basin (Chainat,

Suphanburi, Nakhonpathom and Samutsakhon Provinces). There were 93 water samples from 103 swine farms (89 percent) of which effluent do not match the effluent standard and most are medium swine farm (3). Most of swine farm have problem about system capability, operating and maintainance wastewater treatment. As a result, effluent that pass treatment system do not match standard or discharge wastewater to water resource without treatment.

Biogas system is a suitable waste treatment for solving problem about wastewater and odor from swine farm and also provides benefit to farm like generating electricity or alternative energy from biogas etc. (4). Although production of biogas from pig manure is popular it is produced in large swine farm mainly while the medium and small swine farms have some limitations for biogas production. The construction of biogas of wastewater treatment requires high investment and quite large areas. The Republic of Ireland has experienced various benefit from the biogas production from manure digestion with waste community to use as a transportation fuel, electricity and heat effectively (5).

From the mentioned problem and limitation. Swine farmers who cannot construct biogas system by themselves can group together to construct the biogas system to solve environmental problem in their area. The group can also establish Very Small Power Producer (VSPP) to produce renewable energy and sell it to Metropolitan Electricity Authority (MEA) and Provincial Electricity Authority (PEA) to reduce electricity production from fossil fuel (6). The objective of purchasing electricity from VSPP is to promote the use of domestic resource more efficiently and reduce electricity from commercial power. Which minimize imported fuel from aboard, reduce environment impact and help lighten the burden of government in manufacture and sell electricity the first of 6 month period in 2007 is 73,070 Gwh level. These produce from fossil fuel such as are Natural gas, Fuel oils and Lignite more than 90 percent. Thus electricity produced from renewable energy such as water energy, solar energy or biomass energy has less than 10 percent (7). In India, there have been small diogas systems for electricity generation in small families in rural areas which replaced inefficient kesorene lamps (8).

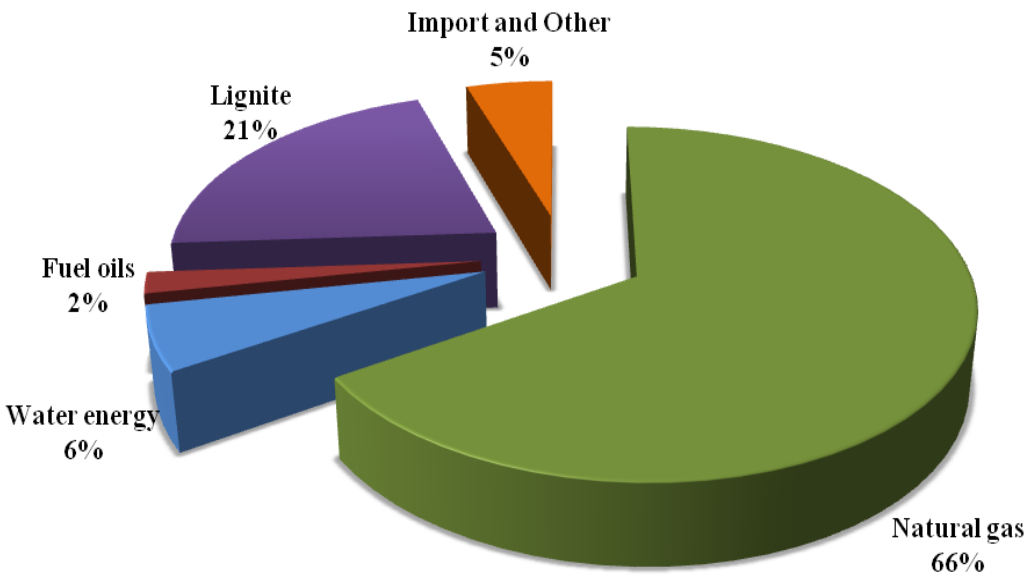

Figure 1-1: The electricity generated in 2007, separated by fuel type

Source: Energy Policy and Planning Office, 2007

From the problem mentioned above, the researcher is interested in analysis the financial worth of joint investment for construction of biogas systems in swine farms to produce electricity: a case study of Thawa canal, Thasadet Sub-district Municipality, Maung District, Suphanburi Province. The Thawa canal is a branch of canal of the Thachin River and this canal had water quality degradation from swine farms (1). Most swine farms are located along canal and drianed wastewater directly to the canal. When many swine farms drian wastewater into the same water source, that water source can no longer play a role of water receptor without water quality degraded.

This research use cost-benefit analysis principle which is taking into account project cost and benefit arising from the project and try to advise the decision upon project. In essence, worthwhile project should not have high cost, have minimal environmental impact and generate large benefit to society. It is expected that farmer can apply the finding to determine a way to resolve problem by their own. In addition, the government agencies particularly the local government concerned can applied the research in conjunction with other measures to resolve wastewater problem from swine farm in the responsible area.

1.2 Objectives of Research

1.2.1 To analyse the financial cost-benefit of joint investment of medium and small swine farm in construction of biogas systems for electricity generation.

1.2.2 To study the factor affecting medium and small swine farm in construction of biogas system for electricity generation.

1.3 Conceptual of Research

This research will analyzed the financial cost-benefit of joint investment of medium and small farm in construction of biogas systems for electricity generation. By using the cost-benefit analysis principle to assess cost-benefit in terms of money, a decision whether there should be joint construct in biogas systems for electricity generation in the study area or not can be made. The sensitivity analysis would also be carried out.

In addition, this research will study the factors which affect cooperation of swine farms in construction of biogas system for electricity generation as follows;

1.3.1 Personal factor; age, level of education, income, swine farm experience and information access.

1.3.2 Group factor; intention/ shared benefit, shared problems.

1.3.3 Farm management factor; expenses in farming, therapy technology and waste management.

1.3.4 Attitude factor/Opinion factor; attitude toward water pollution from swine farm, swine farm clustering for making biogas system.

From a cost-benefit analysis and the factor which affect cooperation of swine farms in construction of biogas system for electricity generation, they should suggest whether the joint investment for construction biogas system for electricity generation in the study area is plausible, It then, would lesd to the application of study in conjuction with other measures to resolve wastewater problems from swine farm in the study area and can be used as guideline for environment management framework /project of the local government. (Figure 1-2)

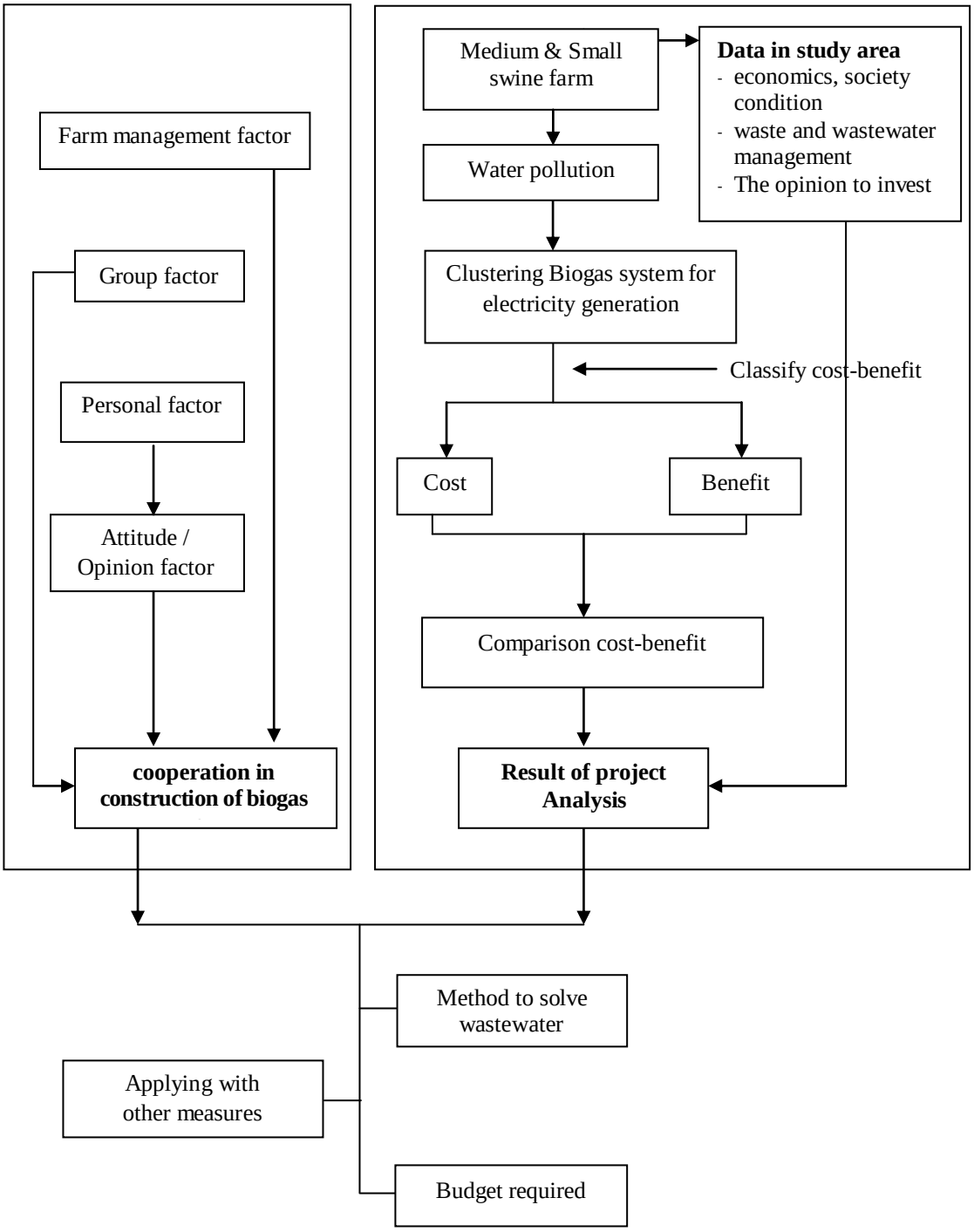

Figure 1-2: Conceptual Framework Diagram

1.4 Scope of Research

This research analyzes the financial cost-benefit analysis of joint investment of biogas systems for electricity generation by use the cost-benefit analysis principle. The life of biogas system is 15 years. The research also studies factors affecting joint invesment of medium and small swine farm for electricity generation in Thasadet Sub-district Municipality, Maung District, Suphanburi Province. The factors used in the study are as follows;

1.4.1 Personal factor; age, level of education, income, swine farm experience and information access.

1.4.2 Group factor; intention/ shared benefit, shared problems.

1.4.3 Farm management factor; expenses in farming, therapy technology and waste management.

1.4.4 Attitude factor/Opinion factor; attitude toward water pollution from swine farm, swine farm clustering for making biogas system.

1.5 Hypothesis of Research

The joint biogas project of medium and small swine farms is worth investing financially.

1.6 Expected Result

1.6.1 Know the cost-benefit analysis result of electricity generation from joint investment of biogas system for medium and small swine farm.

1.6.2 Know the factor affecting joint investment of medium and small swine farm in the construction of biogas system for electricity generation.

1.7 Expected Benefit

1.7.1 The swine farmers who cannot build their own wastewater treatment system can apply the study results of make a decision to resolve wastewater from their establishment.

1.7.2 Government agencies, particularly the local government agencies concerned, can use the research result in conjunction with other measures to resolve wastewater from swine farms in the responsible area.

1.7.3 The local government agencies concerned can apply the research result as guideline to make the environment management framework/project request budget.

1.8 Definitions

1.8.1 Biogas system means a treatment system of waste and produce biogas as MC-UASB type by adding organic matter or manure or water contaminated with manure of ferment in anaerobic condition causes gas that has fuel property (9).

1.8.2 Medium swine farm means swine farm that have Livestock Unit weighing 60 – 600 LU. (Equal amount fattened are 500 - 5,000 head) (2)

1.8.3 Small swine farm is mean swine farm at have Livestock Unit is 60 – <600 LU. (equal amount fattened are 500 - <5,000 head) (2)

1.8.4 Waste means pig dung, which is the rest of food is indigestible or digestable but can't absorbed to benefit mostly. Next is urine and the food scarps on stall ground (9).

1.8.5 Wastwater means waste in liquid state that has bio-physical conditions and chemistry components inappropriate or is the pollution perspective and cause damage on the environment (9).

CHAPTER II
LITERATURE REVIEWS

A financial cost-benefit analysis of joint investment of biogas systems for electricity generation: a case study of small and medium scale swine farm Thasadet Sub-district Municipality, Maung District, Suphanburi Province. The study reviewed literature and relevant research follows;

2.1 Economic Theory Concept

2.2 Swine Farm Waste and Wastewater Management

2.3 Biogas and Biogas Production Process

2.4 Wastewater Treatment and Biogas Production

2.5 Benefits of Biogas

2.6 Concept of Community/Organization

2.7 Study Area in General

2.8 Pilot Project: Using Technology on integrated biogas systems for waste and wastewater treatment from a swine farm

2.9 Research Related Documents

2.1 Economic Theory Concept

2.1.1 The study on return on investment of the project can include many concepts (10) as follows;

2.1.1.1 Cost - Benefit Analysis: CBA is the comparison analysis of costs and benefits in terms of financial unit to compare benefits and costs.

2.1.1.2 Cost Effectiveness Analysis: CEA is an analysis in case of multiple options to share the same goal. Different is the achievement efficiency. Therefore analysis of cost alone is not sufficient, need to bring the performance of each alternative to determine the comparative costs.

2.1.1.3 Cost Minimization Analysis: CMA is the analysis to compare between various alternatives achieved the same goal. The analysis is aimed to compare any will be the lowest cost.

2.1.1.4 Cost Utility Analysis: CUA is the same concept to CBA except that the comparison unit of the value of benefits is not in financial term but in unit of overall utilization or satisfaction.

2.1.2 Project Analysis

Analysis of the project will focus on the financial return on the overall economy to achieve efficiency in limited resource allocation. The result will be in the form of financial return to be higher, equal to or less than the costs. Criteria compared to the value of these projects are divided into 2 types.

1) Criteria type 1

Criteria for investment decisions do not have to adjust the time. It is a traditional decision-making criteria and applicable to short term project approximately 1 year, not too high financial investment and need only brief review.

2) Criteria type 2

Criteria for investment decisions with adjusting of time. In general, most projects that longer than 1 year are difficult to compare direct benefits and incurred costs in the differences of time period. Therefore benefits and costs need to be adjusted for future value by compounding calculation and discounting to identify return on investment. Appropriate discounting rate in project analysis including lost opportunity costs of capital if there is other projects that higher return on investment. Disadvantage of criteria in decision-making with adjusting of time is time consume because appropriate discounting rate need to be concerned in calculation. The advantage is that the project cover long period of time, benefits and costs occurred at different time can be comparable. The analysis of return on investment is, therefore actual.

Criteria in decision-making with adjusting of time widely commonly used are 3 types including Net Present Value: NPV, Benefit – Cost Ratio: BCR and Internal Rate of Return: IRR. Each decision criteria is calculated as follows;

2.1.2.1 Net Present Value: NPV is the net benefits received throughout the duration of the project which has adjusting of time. NPV can be negative, positive or zero depending on the amount of present value benefit (PVB) deduct by present value cost (PVC) of that project.

$$NPV = PVB - PVC$$

$$NPV = \sum_{t=0}^{n} \frac{B_t - C_t}{(1+r)^t}$$

Acceptable level of the decision-making criteria is NPV higher than zero indicate that net benefit is positive, the project is cost-effective investment.

2.1.2.2 Benefit – Cost Ratio: BCR is the value of present value benefit divided by present value cost throughout the duration of the project period.

$$BCR = PVB / PVC$$

$$BCR = \sum_{t=0}^{n} \frac{B_t / (1+r)^t}{C_t / (1+r)^t}$$

Acceptable level of the decision-making criteria is BCR higher than 1 indicate that the project is cost-effective investment. Disadvantages for this type of decision criteria is when apply to large project, high return while the costs is also high. Therefore, BCR higher than 1 but overall revenue may be less than other small projects. In this case, alternative criteria should be considered in order to avoiding errors.

2.1.2.3 Internal Rate of Return: IRR is the return on investment throughout the project period in percentage or discounting rate that net present value becomes zero or a rate that return and cost discount to equal present value. This rate is the rate of investment capabilities to create revenue to cover the investments cost.

1) Financial Internal Rate of Return: FIRR is applied for financial analysis of the project to compare with opportunity lost of capital or interest rates of loans. FIRR higher than rate of interest loans indicate the project is cost-effective investment in financial term.

2) Economic Internal Rate of Return: EIRR is applied for economic analysis of the project to compare lost opportunity cost of resources used in the project or the real interest rates of society. EIRR higher than standard, 9% per year indicate the project is cost-effective investment. (11)

IRR formula

$$\sum_{t=0}^{n} \frac{B_t - C_t}{(1+IRR)^t} = 0$$

Lost opportunity cost of capital or specific interest rate, r is set to IRR

n = Total period of the project (year)

t = Year of the project t=1, 2,…,n

B_t = Benefit of the project in the t

C_t = Cost of the project in the t

r = Discounting rate = The average rate of return or minimum

PVB = present value benefit

PVC = present value cost

The analysis of the project in view of project owner or entrepreneur will focus on net return, mentioned criteria, NPV, IRR or BCR will apply to cash flow after tax deduction but different from Department of Alternative Energy Development and Efficiency, Bureau of Energy Regulation and Conservation which is the government unit that will consider overall economic return from energy conservation in macro view not only a return to private sector. Department of Alternative Energy Development and Efficiency is therefore considered applying criteria of Economic Internal Rate of Return (EIRR). Project investment which EIRR higher than standard of 9% per year will be supported to occur. At the same time, Financial Internal Rate of Return (FIRR) will also apply. Project investment which FIRR higher than MRR+2 indicate the project is self-sufficient financial return. The project owners can invest. (11)

Factors should be taking into account in calculating FIRR and EIRR (11)

1) Energy saving will be measured by technical data with reference to evidence and concerned margin of errors that may occur.

2) Price of energy saving equipment and material should come from most reliable source and reflect reality.

3) Calculation on period of the project will refer to service life of equipment, machinery and material used in the project therefore selection of brand and suppliers are concerned.

4) Fluctuations in exchange rates affect significantly to the cost of equipment and supplies that are required to import. Fluctuations in exchange rates required to monitor price track closely, it is also affect changing of inflation and energy price.

5) Rates adjusted numbers of energy costs savings and other variable costs and investment must reflect the expectations of economic conditions that is changing. Rates are adjusted according to changing economic circumstances.

6) Inflation rate will not use in EIRR calculation because EIRR is measuring return on investment in the project using the actual value (or constant value at the year). Therefore no adjustment cost figures or the rate of energy to inflation.

2.1.3 Sensitivity Analysis of the Project

Analysis of the project using decision criteria, adjusting the time such as NPV BCR and IRR, variables used to measure the value of benefits and costs of the project are set to the exact value that will occur in the future. In fact, expectations to the future must consider the uncertainties that may arise. And may have the opportunity to analyze errors if variables of the project defined in advance. Therefore, the analysis must be repeated to view what will happen if the defined conditions has changed. There are many factors that will make risk to the project. Interesting factors are;

2.1.3.1 Output of the project, which is the source of the benefits of the project, might be expected in high volumes. In this case should be considered that if the output of the project changes from expectations how it will affect the value of output.

2.1.3.2 Cost of the project, may be changed and will increase the cost of the project.

2.1.3.3 Price, as the price used to evaluate the cost of the project is a constant price factor. It may cause false estimates. In fact, prices of factors of production-based that estimated would not be constant over a project period.

2.1.3.4 The delay in project may cause cost to the project, such as the project is not complete as scheduled may be fined according to delay period.

2.1.3.5 Technique in sensitivity analysis of the project is not complex, using above values of the factors affecting the project and change differ from the average value of the analysis. For example, cases that productivity decreased or costs increased or two cases occur simultaneously because all risks have potential to occur. Sensitivity analysis is important to investment decisions if encounter risks and uncertainties. Analysis is to test that at what level of cost increase or benefits decrease the project is not worth investment by using switching value which can be identified in 2 cases.

1) A case to identify how much cost increase in % that NPV = 0 and BCR = 1

$$SVT_C = \frac{NPV \times 100}{PV \text{ of cost}}$$

SVT_C = Switching Value Test in cost
NPV = Net present value of the project
PV of cost = Net Present value of cost

2) A case to identify how much benefits increase in % that NPV = 0 and BCR = 1

$$SVT_B = \frac{NPV \times 100}{PV \text{ of benefit}}$$

SVT_B = Switching Value Test in benefit
NPV = Net present value of the project
PV of benefit = Net present value of benefit

If SVT_C or SVT_B calculated high indicate low risk to the project

2.1.4 Classification of Costs and Benefits

2.1.4.1 Costs: often considered resources used to produce goods and services targeted to specific projects. But the economic cost would mean costs of the used of social resources. The costs will be divided as

1) Direct Costs and Indirect Costs

1.1) Direct Costs is the costs incurred directly to the projects or to the projects to be continued. This type of cost is the cost or resources required in each year from the beginning to the end. Calculating this type of costs requires cooperation from all parties involved in providing information. The direct costs include

(1) Investment Costs: this type of cost incurred to prosecute the project such as land costs, construction costs, office supply costs, and machinery and equipment costs road construction costs. These costs will be expensed in the early phase of the project. Designated projects will have the costs of this type ever.

(2) Operating Cost: this type of costs incurred during the period of project operation such as costs of raw materials in production, costs of salary and wage, traveling costs, consulting costs, utility costs, public relation costs and training costs for employees.

(3) Maintenance Cost: this type of costs is the costs for maintaining machines and equipment, buildings or relative devices which have long life-time and that require to maintain in good condition.

(4) Research and Development Cost: this type of costs is for basic research and incurred during the founding of project. This cost is considered a sunk cost which mean resources used in any activity in the past and does not affect any decision on the project. These resources cannot be brought back to use again. If the research is not encouraging this expense will lost. In terms of economic, this type of costs will not be included in the analysis.

1.2) Indirect Cost: this type of cost incurred due to the project implementation or the results of consequence impact beyond the project stage. Typically this cost not intends to happen. In reviewing the costs, should include this indirect costs to the direct costs. Example such as the dam project could result in

sedimentation of the soil increased, the cost of dredging the river also increase. The indirect costs of these projects are the cost of dredging rivers.

2) Tangible Costs and Intangible Costs

2.1) Tangible Costs: this type of cost is a measure of the cost in money, less complex and quite clear. Direct and indirect costs mentioned above can be measured in this term.

2.2) Intangible Costs: cost of this type can not be measured out clearly in money, but has economic value. The cost is mostly about sickness, the lack of education, the deterioration of natural resources and environment. However, when the costs that cannot be measured in money occur, mean that actual value of the costs incurred by the project can not identify exactly, the assessment of the project cost is difficult and will also be debatable in assessment method because of the error value will affect the decision on the project.

In addition the cost of this type may be value in measuring the cost of money paid to avoid the cost that could not be measured, for example the costs to avoid pollution caused by chemicals used in agriculture may represent the cost of pollution that can not be measured in money.

3) On-site Costs and off –site Costs

3.1) On-site Costs: considering this type of cost is the same concept as determined accrued benefits in the project site. The scope of project site need to clearly define. Therefore, costs incurred in that area called on-site costs and can be both direct and indirect costs and intangible costs.

3.2) Off-site Cost: is the costs incurred out of the project area.

4) Financial Costs and Economic Costs

4.1) Financial Costs: is the total tangible costs incurred related to the application of resources or other factors of production for defining and executing projects.

4.2) Economic Cost: is the actual cost include both tangible and intangible costs incurred to the society by bringing resources or factors of production used in projects defining or executing. The economic cost will be used in

the analysis to determine the measures/standards of government and state enterprises in principal.

However, few factors are not included in the economic analysis but will be included in the financial analysis, those are:

(1) Depreciation: in economics, once pay for investment on permanent property is a costs so calculating depreciation costs as an investment costs is a double counting in economics concept. Depreciation is only a method of accounting.

(2) Tax Payment: is not considered a true cost of investment in economics concept, but rather a category of transfer payments.

(3) Interest Payment: In economics, interest payment is not considered a cost because It is considered a true lost opportunity cost with adjusting of time by using discount rate.

(4) Debt Service: is a financial transfer, does not reflect the actual use of resources, so it is not considered as economic costs.

(5) Sunk Cost is the cost in the past and does not affect the decision on the project. Therefore sunk cost is not considered a cost in economics term.

2.1.4.2 Benefits: divided to

1) Direct Benefits and Indirect Benefits

1.1) Direct Benefits: is the return generated by the project and consistent with the goals of the project, such as electricity produced from building dams, productivity increased by building irrigation canals. In general, direct benefits of the project incurred in many forms, such as increasing of physical productivity, increasing in production value, improvement of production quality or reduction of production costs which could summary as follows:

1.1.1) Increasing of Productivity: water control systems will help farmers increase yields or pipeline expansion project will increase volume of oil throughput.

1.1.2) Production Quality Improvement: improving the quality of the products by apply point-source pollution control standards will make products price higher, such as controlling wastewater effluent standard from swine farms will contribute better quality of swine production and will high up swine prices.

1.1.3) Products Changing: changing by-products from the project cause products changing, such as the case of plastic waste from waste segregation project could be modify as a carpet or a plant pot to increase value of the plastic waste.

1.1.4) Production Costs Reduction: benefits of costs reduction in the production is a costs saving. For example, the standards set out for tax package will result in costs savings in production because manufacturers will design recyclable products that can be reused, that will also result in reducing of waste and production costs.

1.1.5) Transportation Costs Reduction: Transportation is another type of project costs therefore reducing transportation costs is a benefit, for example measures on chemical transportation regulate transportation route to the road around the city to prevent any dangers of chemicals will result in saving time and gasoline from facing traffic problem. That savings is a benefit.

1.1.6) Loss Reduction: Sometimes the benefits of the project incurred by reducing losses, such as measures set out to create hazardous materials transportation system will help reduce accidents caused by transport hazardous materials on property life and environment.

1.1.7) Changing of time and Place: Some projects result in benefits due to the production or storage of goods and marketing out at a later time when the price is higher. For example, the project to construct a warehouse of agricultural products to keep products as inventory in low price season and marketing out when the price is high. Another example on place is the project to export fruits to oversea markets that should invest on trucks to transport fruits from the farm area which is low price market to be shipped out oversea markets which the price is higher. Changing locational value is the benefits.

1.2) Indirect Benefits: is the indirect benefit arising from the project or the results of the impact in subsequent steps. The indirect benefits may be divided into the following types.

1.2.1) Indirect Benefits arised from forward-linked benefit and backward-linked benefit. This type of indirect benefits occurs when there is a project and result in value-added of goods and other services both in terms of

further used in the production or increase in the production of such raw materials. For example, irrigation projects have resulted in increased rice production and will create income or profits to other related business operators such as carriers, snacks factory that using rice as raw material. This relationship is forward-linked benefit. The increased rice production will result in the use of more factors in production such as rice strains, labor which will create income or profits for those involved. These impacts considered indirect benefits in the type of backward-linked benefits.

1.2.2 Indirect Benefits arised from externalities. Benefits of this type arise due to the project occurred and cause beneficiary side effects, for example port construction projects resulting into construct a road through the construction area, this will caused set homes and career along the cut through road. (Note: the word external impact, are used in many words in english, such as externality, spillover effect, neighborhood effect or side effect)

1.2.3) Indirect Benefits arised from multiplier effect. Benefit of this type arise due to the project occurred and cause consequence impact. For example, the project to build a dam will create more employment. It also helps workers have more purchasing power to shop or buy services. And will affect related businesses such as various consumer goods. These consequences create multiplier effect.

In addition, considering arised benefits must include both direct and indirect benefits incurred.

2) Tangible Benefit and Intangible Benefit

2.1) Tangible Benefit: this type of benefits is a measure of the benefits in money, less complex and quite clear. Direct and indirect benefits mentioned above can be measured in this term.

2.2) Intangible Benefit: benefits of this type can not be measured out clearly in money, but has economic value. Most is about health, education, employment and natural resources & environmental such as reducing mortality rates, good nutrition, reducing diseases associated with the gastrointestinal system due to improved water quality. However, when the benefits that cannot be measured in money occur, mean that actual value of the benefits incurred from defining the standard can not identify exactly. The assessment of the benefits is

difficult and will also be debatable in assessment method. The error value will affect the decision on defining the standard.

In addition, measuring the benefits of this type may be in terms of the costs of the best options caused the same benefits, such as measuring the benefits of electricity generation for residential homes from the dam project that has several objectives which may consider the cost of electricity produced by diesel power plant instead of hydro power plant from dam project.

3) On-site Benefits and Off-site Benefits

3.1) On-site Benefits: This type of benefits is a benefit occurred within the scope of operating project. It can be direct or indirect benefits, tangible or intangible benefits as mentioned above. Therefore, consider the benefits of this type must define the scope of the project site clearly.

3.2) Off-site Benefit: This type of benefits is a benefit occurred outside the scope of operating project. It can be direct or indirect benefits, tangible or intangible benefits as mentioned above.

4) Financial Benefits and Economic Benefits

4.1) Financial Benefits: is a total benefits that is tangible which occurred from bringing resources or other producing factors arising from the project to implementation and operation. Financial benefits often used in the analysis of private and state enterprise project in principal to measure the ability to create revenue to the project.

4.2) Economic Benefits: is the total return both tangible and intangible that caused to society in bringing resources or factors of production used in the project. Economic benefits measure the actual performance of resources to determine how the project is beneficial to society as a whole or how the projects lead positive results for society. For example, reducing damage to society from suspension of shrimp aquaculture in freshwater area, reducing damage to society from solving lead contamination problem.

However, certain reports are not included in economic analysis but are included in financial analysis, such as

(1) Subsidy: is not included in economic analysis because it does not represent actual returns from the resources in determining the standards but only the flow of money.

(2) Loan Receipt: is not included in economic analysis because it is transferable between owners and the users. This is not the actual production cost factors.

2.2 Swine Farm Waste and Wastewater Management

2.2.1 Wastewater

Wastewater characteristic and volume of each farm will be different depend on cleaning process, water usage, frequency rate of pen cleaning including manure handling procedure. If manure has been segregate before water cleaning process, the concentration of wastewater will be decreased. Moreover, swine heredity is another concern; generally, farmers will focus on swine breeding sanitation more than fattening so the wastewater from swine breeding will be higher volume but lower concentration.

Table 2-1 Volume and characteristics of swine farm wastewater; identify by size of farm

Wastewater characteristics	Farm size	Minimum	Maximum	Average
BOD (milligram/liter)	Large	1,255	9,000	3,000
	Medium	460	7,650	2,500
	Small	230	19,280	1,500
COD (milligram/liter)	Large	2,152	18,388	7,000
	Medium	2,578	31,096	6,800
	Small	778	40,000	4,000
SS (milligram/liter)	Large	1,304	9,530	4,800
	Medium	149	14,500	3,000
	Small	82	1,887	2,000

Table 2-1 Volume and characteristics of swine farm wastewater; identify by size of farm (cont.)

Wastewater characteristics	**Farm size**	**Minimum**	**Maximum**	**Average**
TKN (milligram/liter)	Large	367	981	540
	Medium	235	3,371	540
	Small	261	24,480	400
Wastewater rate (Litre/swine/day)	Large			10
	Medium			15
	Small			20

Source: Pollution Control Department, 2005: 3

2.2.2 Waste

Generally, waste from swine pen will composed of manure, the residue of nondigestive or nonabsorbed nutrient which is the cause of odor problem especially in poor farm management where manure is pile up on the swine pen floor, underneath or at the manure drying bed. Therefore, manure collection process before water cleaning should be concerned in the issue of moisture and fly breeding source.

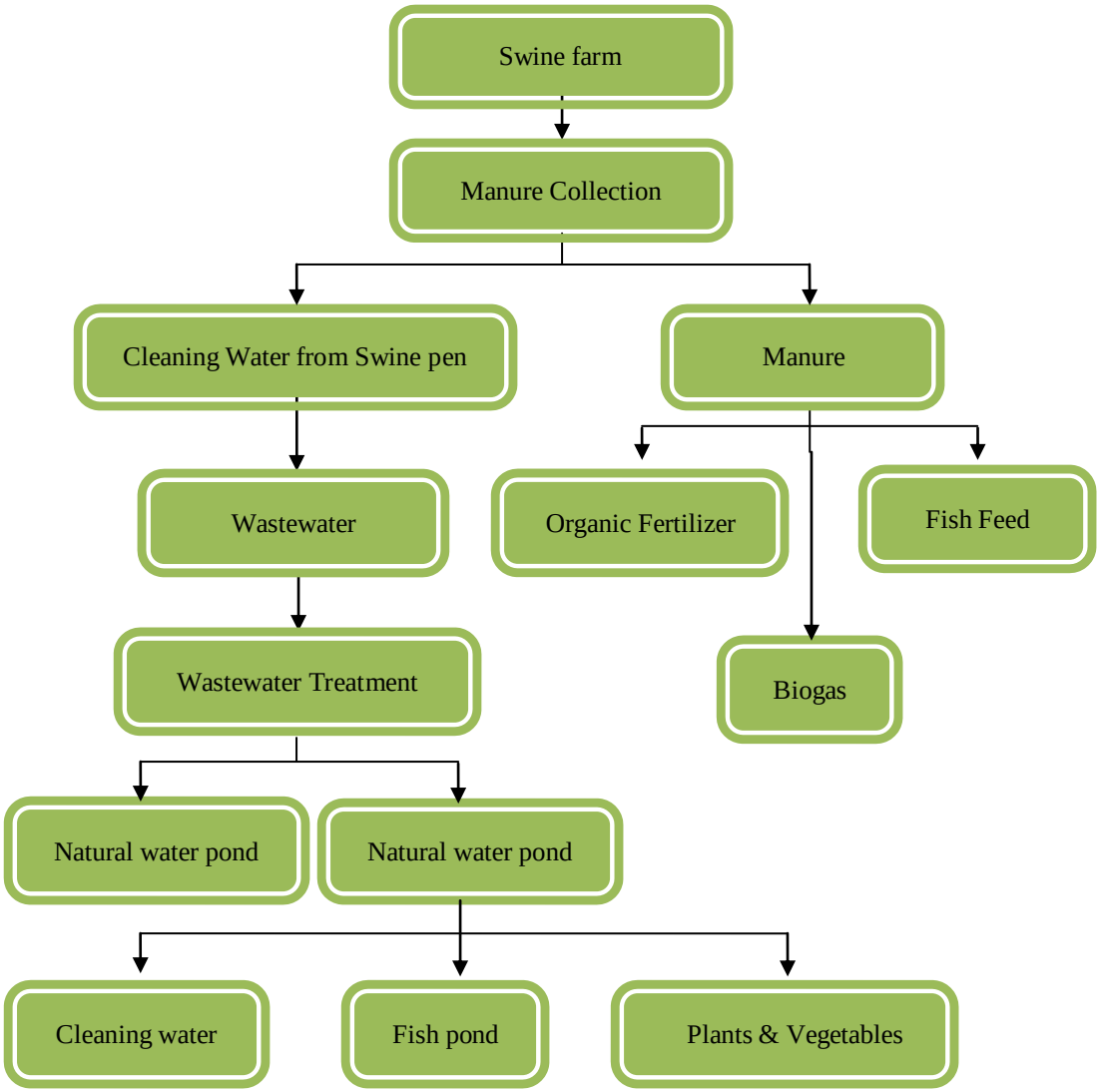

Figure 2-1 Swine farm manure and wastewater management process

Source: Pollution Control Department, 2008

Table 2-2 Amount of swine farm in Thasadet Sub-district Municipality, Maung District, Suphanburi Province.

Medium size (Farm)	**Small size (Farm)**
32	16

Source: Suphanburi Provincial Livestock Office, 2008

2.3 Biogas and Biogas Production Process

Biogas is the natural gas that produced from organic fermentation; animal manure in this case, by bacteria in an anaerobic condition. Biogas composed of various kind of gas depends on types of bacteria. Generally, the composition are methane gas (CH_4) 50-70%, Carbondioxide gas (CO_2) 30-50%, the rest will be Hydrogensulfide gas (H_2S), Nitrogen gas (N_2) and vapour.

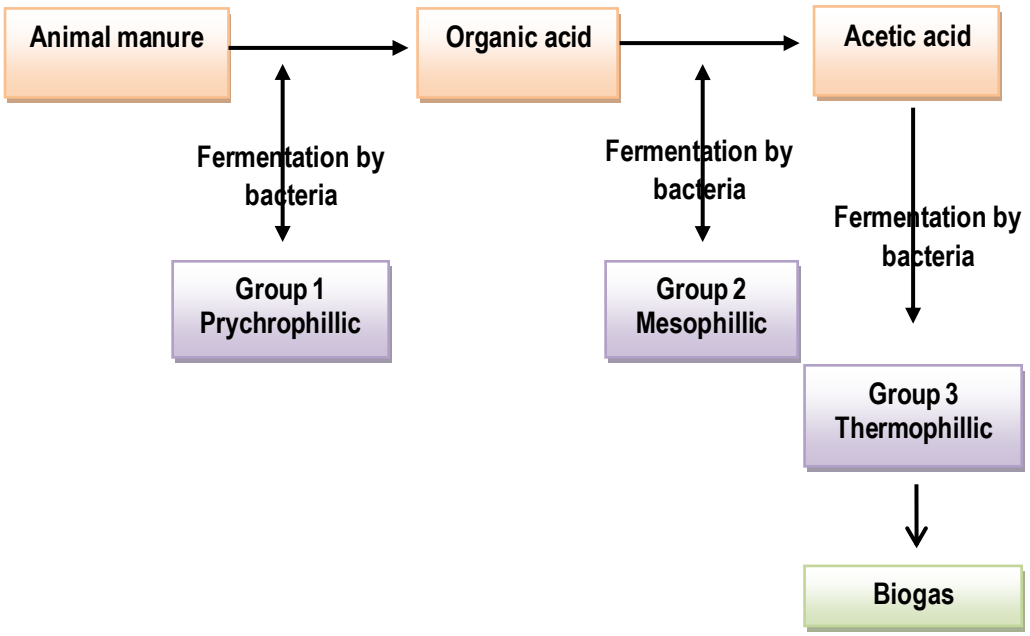

Figure 2-2 Flow diagram of biogas production

Source: Pollution Control Department, 1995

Bacteria in three groups must be in balance, if there are too much nutrient (animal manure) bacteria in group 1 and group 2 will produce too much acid which will inhibit bacteria in group 3 (No gas production). In the other way, if there are too little nutrient bacteria will grow in slow rate (less gas production). Bacteria in three groups will work in harmony with moderate mixing; too much mixing will inhibit fermentation which caused less gas production.

2.4 Wastewater Treatment and Biogas Production

Digestive tank for biogas production in Thailand has various system and application, such as H-UASB, MC-UASB, Covered Lagoon, Fixed Dome, Floating Dome, Anaerobic Pond and Anaerobic Filter. This research work will study on wastewater treatment and biogas production by MC-UASB (Medium Farm Channel Digester Up-Flow Anaerobic Sludge Blanket) which is the integrated wastewater system of pilot project in collaboration between Pollution Control Department and Biogas Technology Center, Chiangmai University.

MC-UASB wastewater treatment and biogas production system is the combined system of slow rate digestive tank and high rate digestive tank which has been designed for various type of bacteria and each bacteria will ferment in different process result to high efficiency in each digestive tank. This combination process of slow rate digestive tank and high rate digester tank sometime call Hybrid of Flow and High Rate Digesters which has key components of the system as follows: (9)

2.4.1 Collection Tank, CT

Design to collect wastewater to ensure the continuity of inlet wastewater to the system and to ensure that the mixing of wastewater and bacteria or return sludge for digestion process will be in consistent condition effect in generating fix amount of biogas with higher concentration rate of methane gas. Submersible pump in the collection tank will pump wastewater to the sand trap tank and then follow to channel digester. The pumping system control by floating level control or electrode. When wastewater flows through the sand trap tank, those sand and solid particles (Inert Materials) that suspended in the wastewater and can not be digested in the channel digester will slowly precipitated.

2.4.2 Sand Trapped Tank

The function of sand trapped tank is to separate gravel and sand sediments that may contaminate the food from ingredients components of cassava or rice bran extract, etc. Separating grit and sand from wastewater will extend channel digester life-time.

2.4.3 Channel Digester: CD

The function of channel digester is to ferment organic substance in the wastewater to change form of organic substances to the form of organic acid and into biogas. Biogas composition will be 65-70% concentrated methane, 30-35% carbondioxide gas and others as a result of anaerobic bacteria in the anaerobic condition. The degradation of organic substance from digestion process will reduce 70-80% of chemical oxygen demand (COD). Operating of channel digester system will have to return complete digestion sludge approximately 1% per day of capacity of digester channel (in the range of 40-60 sludge days). Return complete digestion sludge will be divided in two parts, one is sent to sludge drying bed, the other is sent to collection tank to add up the amount of bacteria and to support mixing function which will activate digestion process. The upper roof of channel digester will cover by PVC or HDPE plastic sheet which will collect biogas to be used. Inside the channel digester will install biogas collecting pipe to transport biogas for following use. Both in the form of thermal energy or renewable fuels to generate electricity.

In addition, channel digestive has the other function to precipitate sludge and separate heavy sludge to the bottom of channel digester. Fermented digestive sludge that collected at the bottom will be discharged to sludge drying bed or solid filter bed regularly to control sludge level in the digester to ensure that the operating condition reach the highest efficiency all the time. This special sludge discharge function is designed to reduce sludge volume and to prevent accumulative of sludge in the channel digestive. Clear wastewater will overflow from digester to Up-flow Anaerobic Sludge Blanket (UASB), high speed digester which will ferment 20-30% of residual organic substance from channel digester, result in organic substance decrease and water quality increase.

2.4.4 Up-flow Anaerobic Sludge Blanket : UASB Digestive Tank

Clear wastewater treated from channel digester will flow to UASB Digestive Tank to continue treated in anaerobic fermentation condition which would reduce organic substance resulting in decreasing COD. The combination efficiency of channel digestive system and UASB Digestive Tank will exceed 90%. However, channel digester tank and UASB Digestive Tank have different process and different

type of bacteria. Water flow in channel digester tank is horizontal while UASB Digestive Tank is Vertical Up Flow. Accumulative bacteria at the bottom will be condensed and sediment called granule. Treated wastewater from UASB Digestive Tank will be pumped to the next treatment process, if the surrounded area are farm cultivated as corn farm, sugarcane farm, cassava farm, vegetable farm, convert grass husbandry etc., treated wastewater can be used as liquid fertilizer to replace and reduce the use of chemical fertilizers. Therefore, post treatment process is not necessary or only small post treatment process is needed.

2.4.5 Sand Drying Bed

Its function is to filtrate and to dry granule or fermented sludge from channel digester tank. Dry granule will be collected and packed in bags for sales as organic fertilizer. Filtered water will be return to the post treatment system.

2.4.6 Post Wastewater Treatment System

Wastewater from primary treatment of channel digester tank and UASB Digestive Tank will be continued to post treatment. Selection of appropriate post wastewater treatment system will depend on the availability of farm and the purpose to use treated water such as available water pond area, demand used in planting grass husbandry, demand used of recycled water or to drain to the public canal which must follow water discharge standard. Post wastewater treatment for swine farm effluent has been designed with concern of natural pond treatment or mixed natural pond treatment that need lowest energy to operate and appropriate to local Thai farmers. Natural post wastewater treatment composed of Anaerobic Pond, Facultative Pond, Constructed Wetland and Polishing Pond. Wastewater pass through mixed natural treatment pond designed correctly from the engineer will be effective in the treatment and meet effluent water standard. Post wastewater treatment system consists of several steps as follow;

2.4.6.1 Anaerobic Pond is the anaerobic treatment that ferments residual organic substance from biogas producing system before discharge to continuing process in the facultative pond.

2.4.6.2 Facultative Pond is processing in semi-anaerobic condition. Its function is to reduce organic substance and minimize nitrogen residual to ensure that effluent water quality will be in harmony to the ecological system.

2.4.6.3 Constructed Wetland is the semi-anaerobic treatment pond. Its function is to reduce nitrogen matter and total suspended solid result from facultative pond by using plant absorbing process and denitrification process to precipitating suspended solid.

2.4.6.4 Polishing Pond is to conditioning treated water before recycling or discharge to the environment. Moreover, polishing pond is to collect treated wastewater for recycling to clean the animal pen especially in dry season. It can also be a fish pond to test the quality of treated water. In rainy season, excess water will overflow outside in considering no negative impact to the environment. Recycling treated water for reuse as cleaning water in the farm will reduce underground water use and reduce the costs of the farm by another way.

Besides mentioned functioning system, wastewater piping system also need to be constructed. Those included wastewater chute, wastewater piping which will deliver wastewater from each farm to the biogas producing system. Grid chamber is needed to trap debris such as plastic bags, ropes, wood, etc. from inlet wastewater to prevent any problem to the function of biogas production system.

2.4.7 Functioning of Biogas Wastewater Treatment System

Wastewater and waste from swine farms will be collected into the waste water collection tank, which is lower than the level of wastewater collection pipes to function as water storage and balancing water before pumping to sand trap tank to trap debris and grit from wastewater to ensure continuity and maximum flow to the channel digester tank. Channel digester tank is made of reinforced concrete structures, a variety of sizes depending on the number of swine or volume of wastewater. Channel digester tank has key function to digest organic substance in anaerobic digestion process same function as UASB which will receive clear wastewater from channel digester tank to reprocessing digestion. Anaerobic digestion process will generate biogas for renewable energy. Biogas contains highest 65-70% methane gas, research data show that biogas producing rate is 100-250 liter/swine/day (considering

swine feed at 60-70 kgs.) However, the volume of biogas producing is not constant depend on factors in swine breeding such as age, size, feeding, temperature, collecting channel, manure volume, concentration of wastewater and system maintenance.

After organic substance has been digested in channel digester and UASB tank, 80-90% of processed wastewater will be continuing to post wastewater treatment which composed of anaerobic pond, facultative pond, constructed wetland and polishing pond. Effluent wastewater can be used for agriculture and farming. Return sludge from digester will be pumped to the sand drying bed, and to be packed for sales as organic fertilizer after 3-4 days.

Size of the system range from 250-1,000 cubic meter which could be adjusted to optimize the farm size considering in Livestock Unit (LU), 1 LU equal 500 Kgs of live swine. Optimize biogas system (Cubic meter) to LU farm size shown in table 2.3

Table 2-3 Size of MC-UASB system to normal swine farm

Livestock Unit (LU)	**Size of biogas system (Cubic meter)**
101-180	250
181-215	300
215-280	400
281-355	500
356-425	600
426-500	700
501-570	800
571-720	1,000

Source: Pollution Control Department, M.P.T

Table 2-4 Comparison of biogas wastewater treatment: Individual to integrated farm

Criteria	Individual biogas wastewater treatment	Integrated biogas wastewater treatment
• Required area for constructing biogas producing and wastewater treatment system	Small farm, individual farmers has too limited area to construct the whole system	Using common area or purchase addition area is possible
• The investment budget compared to revenue of breeding swine	Very high for small amount	Lower due to increased average costs
• The investment budget for construction collective wastewater system	Low	Depend on the concentration of farm
• Opportunity for taking benefit from by-product such as biogas, organic fertilizer, treated wastewater for economic purpose	Low, because of less volume and non-consistency	High, because of high volume. Price depends on marketing demand.
• Flexibility in management and decision making	Very high because of ownership management	Medium to high depend on working system
• Fee for wastewater treatment or maintenance system	Not only responsible for paying their own farm only	Payment depend on agreement with the group
• Survey, design and control of construction	Repeating each specific farm	Once
• Time require from start to complete	Short (4-6 months)	Longer, depend on readiness of the group
• Treatment efficiency	Under effluent standard	Under effluent standard

Source: Pollution Control Department, M.P.T

2.5 Benefits of Biogas

2.5.1 Advantage in Agriculture

Sludge from biogas digestion can be used as a fertilizer and a better quality than fresh manure because during digestion process, nitrogen compound in manure has been transformed into ammonia that plant can use more easily. The other plant nutrients (including phosphorous, potassium, magnesium as well as secondary food elements needed to grow remain in the digested sludge. Overflow sludge from biogas digestion not only substitute chemical fertilizer but also benefit for improving soil condition.

2.5.2 Benefits in Improving the Environment

Utilizing animal manure for biogas digestion result in decreasing manure in that area which certainly improve surrounded environment. Digestion manure in anaerobic condition for a long period (30 days) result in killing most pathogen and parasite eggs which improve community health and sanitation. Moreover, utilizing manure for biogas digestion will help protect leaching of manure contamination to natural public water. Water pollution is certainly minimized due to processed manure contain less organic matter.

2.5.3 Energy Benefits

Biogas is a renewable energy that can substitute firewood, charcoal, oil etc. Biogas can be use for cooking same as LPG, more convenient than firewood or charcoal. Biogas is a clean energy, no smoke and that make surrounding environment clean. Biogas can be used as a source of energy for gas lamp or electricity generator, also can be used for warming baby swine or substitute fuel engine.

Table 2-5 Energy comparison to 1 cubic meter of biogas

Fuel	Volume	Unit
Cooking gas (LPG)	0.46	Kilogram
Diesel oil	0.60	Liter
Crude oil	0.55	Liter
Electricity	1.20	KiloWatt-hour

Source: Biogas Technology Center, 2551

Moreover, there is now promoting power generation from renewable energy. Resolution of the cabinet October 3, 2000 approved regulations, a special case for power purchase from SPP projects to encourage power generation by using substitute fuel such as waste, agricultural residues or biogas from animal farm by assigned National Energy Policy Office (NEPO) and 3 electricity generation authorities to cooperate on this issue. Later, on May 14, 2002 cabinet has resolved draft regulation on power purchase from very small renewable power generation, draft regulation on operating power generator in parallel with the system of l Electricity Authorization (supply function) for power supply up to 1 MW, request form for power supply & power link system. The power generators are interested in generating and distributing power according to such policy must follow relevant regulations that can be summarized as follows.

1) Very small renewable power generator means private, government, state enterprises and public that have their own generator and supply power to Electricity Authorization (supply function) for distribution and have supply volume up to 1 MW. Categories of power generating process are as follows;

1.1) Power generating from renewable energy such as wind power, solar power, small hydro power, very small hydro power and biogas etc.

1.2) Power generating from waste, agricultural residues, waste form industrial or agricultural production, products processed from waste or agricultural residues, or from industrial or agricultural production, garbage, timber from reforestation for fuel, etc.

1.3) Power generating from return steam from industrial or agricultural production used fuel mentioned in item 1 or 2 above.

2) Power generators have qualification mentioned above could fill in the request form for power supply & power link system and submit to Electricity Authorization (supply function) which will purchase power from VSPP (very small power plant). Electricity Authorization (supply function) will consider to purchase power according to detail specified in that request form for VSPP.

3) In purchasing power, power price has been set by subtract net metering method. Electrical charge in each month is as followings;

3.1) In the months that VSPP net electricity consumption higher than net energy generation, Electricity Authorization (supply function) will charge only the difference of electricity unit in retail electricity rates according to electricity consumption type of that power producer plus retail Ft charge in that month.

3.2) In the months that VSPP net electricity consumption lower than net energy generation, Electricity Authorization (supply function) will purchase only the difference of electricity unit in wholesale electricity rates compare to average volume that Electricity Generating Authority of Thailand sales to Electricity Authorization (supply function) plus average wholesale Ft charge in that month.

In addition VSPP must follow safety standard and power link system standard according to regulation on operating power generator in parallel with the system of Electricity Authorization (supply function) for power supply up to 1 MW. (11)

2.6 Concept of Community/Organization

Social cultures around the world have formed organizations and social groups that are not relative in various forms. These social groups and organizations often have 4 major basic characteristics as follows; (12)

1) Member qualification and characteristics have been defined. Some people may be restricted not to participate in the group member.

2) Membership to the group or organization based on the intention and common interests.

3) Groups/Organizations structure or model is certainly clear.

4) Member have participation and proud of their involvement to the groups/organizations.

Moreover, Assistant Professor Dr.Nantiya Hutanuwat and Associate Professor Dr.Narong Hutanuwat (13) have mentioned principal basic to groups/ organizations as follows;

1) Should be formed by individuals with the same or similar interest, demand and purpose because it will help understanding and discussion easier.

2) Culture should be similar because the ideas, beliefs and way of life will benefit to the integration and general management.

3) Should have homes in the same area for easy communication. Because most villagers will communicate through words of mouth more than other methods.

2.6.1 Important and necessity of Groups/Organizations

2.6.1.1 Unfair competition from development of Thai country has changed our base from agricultural to industrial developments which cause rapid social change. Rural society which is an agricultural society is weak and fall in a disadvantageous situation, poverty and underdeveloped condition, difference between urban and rural areas grow more, the growth of the city is not supportive of rural development as it should. Adjustment of rural people/farmers to the changes and take chances contend with difficulties. Adaptation to survive is need by means of 2 methods as follows;

1) Fighting alone, such as advanced farming, find a temporary and permanent job in the urban, etc.

2) Group integration: is another method that could help farmers to survive. Integration could be official by means of legal registration or establish according to regulation of various government agencies. Another is a non-official integration which establish by farmers to implement any activities to support their needs and objectives.

2.6.1.2 Integration to survive: group integration of rural people/farmers is very important. It is a tool to fight for survival (13). Development

agencies of public and private are awared of the importance of group integration to resolve problems and to develop better quality of life.

2.6.1.3 Group integration to increase wisdom: integration of farmers benefit in transfer of technology from government agencies or private entities. Also support to manage learning among them by means of a study tour. Therefore see that, when the farmers are integrating in group will contribute to the learning process leading to increase the power of wisdom.

2.6.1.4 Group integration to increase bargaining power: when farmers stand alone there is no bargaining power because of economic weakness always lead them to disadvantages condition. Group integration or community unit create power to farmers and increased bargaining power both in economic and political. Increase bargaining power from group integration can be divided into 3 types. Those are; (13)

1) Economic&Trade Bargaining Power: when farmers are grouping together, their yield volume will add up and attracted business traders to make deal on trading which helps farmers have the advantage in negotiating prices. Moreover, buying production factor in high volume will lower the prices and may also include the agreement terms of production volume within the group to prevent oversupply to the market problem. The problem that force farmers in the economic market.

2) Financial Bargaining Power: group integration enables joint venture among farmers in variety form of savings which become a base in the capital management. The farmers can use the savings to negotiate a higher amount of credit.

3) Political Bargaining Power: political bargaining power both at policy and operation levels of government can be done in several ways include protest for justice, claims to state the rights of citizens and also integration as an association network or national federation to negotiate government policy that affect farmers.

2.6.2 Intergration on purpose has 3 meanings as follows; (13)

2.6.2.1 Economic Purpose means groups or organizations that have activities to increase revenue for member families by encouraging members to create new activities such as planting lemon, swine breeding, weaving to sell or seeking source of funds for members to increase current agricultural products.

2.6.2.2 Social Purpose means groups or organizations that have activities to develop better quality of life such as money savings to the need of necessity, focus on children's nutrition, learning of children, etc.

2.6.2.3 Political Purpose means groups or organizations that have activities operation as part of the community such as village development, or negotiate with agencies outside the community to get into the budget for public activities of the community, or communicate with outside organizations/individuals.

2.6.3 Meaning of integration as the founder and group structure: divided into official and non-official, each has meaning as follows; (13)

2.6.3.1 Official Group is a group with permanent structure, formal responsibility specified, clear on operating regulation, not easy to change or terminate and conference or meeting schedule a certain time.

2.6.3.2 Non-official Group is a group without regulation, group structure is not complex, short time set up, change according to situation and easy to terminate. Status of members will remain as long as members are interested in group activities

Considering group structure (13) can be divided in 2 types as follows;

1) Simple Group Structure: the group will be Chairman, Deputy Chairman or Group Leader and Deputy Group Leader. All group members will share ideas, planning activities together, participate in certain activities of the group or the whole. Bringing their own property for separate activity is possible.

2) Complex Group Structure: the group has clear objectives, role and responsibility of group leader and members identified, divided to several functions, have certain regulation. Activities typically are the type that members share ownership of assets and conduct all activities together.

2.6.4 Factors that cause initial integration of people divided to 4 types (13) as follows;

2.6.4.1 Economic Factor: people will integrate, given that the integration can provide their economic benefit such as loan capital in occupation, enhance knowledge of such professionals.

2.6.4.2 Social Factors: Integration will meet the social needs of individuals such as to be recognized, to be loved, emotional attachment, family or relatives. Group found in every society because group is the basis of human, we are a member of the group automatically since born (12).

2.6.4.3 Technology Factors: technology affect life and relationships between people in society significantly such as agricultural technology often has new development that farmers will need to seek knowledge, coupled with government agencies often provide training, technology transfer in group. Therefore, integration in group of farmers will contributing to technology transfer and to enable easier acceptance of new technologies.

2.6.4.4 Biological and psychological factors: individual desire to response needs of friends or group for the emotional warmth, by meeting and have conversation with people who their satisfied and pleasure or who have similar interests. Or integrate in group to have security benefits, welfare benefits result due to anxiety and fear of people.

In addition, Direk Ruekrai mentioned that the basis of farmers is the factors directly related to techniques acceptance, new method or changes due to agriculture, such as

1) Social basis: The research found that women generally accept change faster than the men. Educated farmers and higher experiences farmers will frequent to listen to more news and/or more participation in ideas exchange meeting among neighbor on occupational issue, accept change faster and more. Of age, research found that acceptance in adolescents is the fastest and slow down respectively when age increased.

2) Essential communication basis of farmers is the ability to access information including reading, listening, logic thought. At the same time, ability in

speaking, writing is the supplement in the matter of understanding between the neighbors themselves providing the confidence to make more changes.

3) Other basis: farmers who have motivation and mentality, and/or obtain more information, and/or have good attitude to change, interested in the problems and needs of their professional activities and of a neighbor are likely to accept changes more and faster, respectively.

From the literature review related concepts and factors that cause groups/organizations may conclude and classify factors affecting integration as follows

1) Personal Factors include age, level of education, income, experience in swine farm, recognition news/technology.

2) Factors Based Together include purpose/co-benefits, confronting the problem together

3) Factors of Farm Management include costs in farm management, treatment technology and waste management in farm, number of swine.

4) Factors in Attitudes/Opinions include attitudes/opinions on water pollution problem caused by swine farm and attitudes toward integrated swine farms in the construction of biogas systems.

2.7 Study Area in General

2.7.1 The general conditions of Thasadet Sub-district Municipality

Thasadet Sub-District Municipality. Traditionally, District area is in the west of Maung District, Suphanburi Province. Distance from that Muang District office is about 15 km, total area is 51 square kilometers territory and county as follows

North stretch to	Sanamcre Sub-District, Maung District.
South stretch to	Salakao Sub-District, Bangkoong Sub-District,
East stretch to	Banpho Sub-District, Donphothong Sub-District, Maung District.
West stretch to	Plubplachai Sub-District, Uthong District

2.7.2 Terrain

Condition in most area is plain area suitable for cultivation, such as rice cultivation, farming and animal husbandry.

2.7.3 Climate Condition

Climate characteristics of Thasadet Sub-District Municipality is similar to other area in the central zone, summer is very hot, fairly cold in winter and heavy rain in rainy season. Plain area in general, some area have temporary flood in great flood season.

2.7.4 Occupations

Most people have career in agriculture and commerce includes rice cultivation, farming and animal husbandry. (Swine, dairy cattle beef, chicken, duck, etc.) Trading and workers.

2.7.5 Population

2.7.5.1	Total population is	13,952
	Men	6,853
	Women	7,099
2.7.5.2	Number of households	3,440

(Information as of June 2007)

2.8 Pilot Project: Useing Technology on Integrated Biogas Systems for Waste and Wastewater Treatment from a Swine Farm

Pilot Project: The use of technologies on integrated biogas systems for waste and wastewater treatment from a swine farm arising from Pollution Control Department. Ministry of Natural Resources and Environment has seen the importance of developing animal husbandry and farm management of individual farmers. By with Biogas Technolog Center, Chiang Mai University to construct the integrated system of waste disposal and wastewater treatment systems that will manage by local. The project has selected Thahin Sub-district local administration, Sathing phra District,

Songkhla for a study site of wastewater treatment system demonstration to solve the problems of deterioration of water quality of Songkhla Lake. (9)

The model of wastewater treatment system of that pilot project (9) is as follows;

1) Is a biogas wastewater treatment system size, 600 cubic meters

2) Required area for construction wastewater treatment system demonstration is approximately 8.5 rai, biogas systems 2.5 rai and post wastewater treatment system 6 rai.

3) 7 list of participants from swine farm.

4) Approximately 2,400 the total number of swines.

From the literature review about the pilot project on the use of technologies on biogas systems for waste and wastewater treatment from a swine farm. Researchers are interested on study and finding information about social economic, waste and wastewater management of swine farms, opinion of swine farm owner to invest on biogas system, integrated farms, problems and obstacles in participating the project, as well as study on affecting on integrated swine farms to construct biogas system from farmers participated the pilot project. The objectives of the study are as follows;

1) To provide information from the above pilot project to study compared with the data of the study area.

2) To conduct the factors affecting the integration of the swine farm biogas system constructed from the pilot area apply to the study area.

3) To bring problems and barriers in participating and integrating in the project from the pilot areas for analysis to obtain feedback on the integration for study area.

2.9 Research Related Documents

Annop Suknakorn (14) examined the financial investment of biogas production from swine manure in Ratchaburi province. Data to study is the primary data from the survey sample of 12 cases by sampling a specific farm with biogas digester tank size 100 cubic meters. The analysis of costs and returns based on the

value of net present value (NPV) benefits to costs ratio (BCR) and financial rate of return (IRR) of the project 15 years old. And divided into 3 case studies. Case 1: Funded by Nationnal Energy Policy Office (NEPO) and no loan from Bank for Agriculture and Agricultural Co-operatives (BAAC). The financial analysis at the discounting rate 1.5% and 2.25 % has valuable indicators according to discounting rate as follows; NPV is equal to THB 221,019.60 and THB 195,383.73, and BCR is equal to 1.28 and 1.25 and the IRR both 2 levels discounting rate charged is equal to 11% and a value equal to the change in cost 27.88% and 25.49%, change in the value of benefits equal to 21.80% and 20.31% respectively. In this case, found that this project will be cost-effective investment. Case 2: Without funding from Nationnal Energy Policy Office (NEPO) and no loan from Bank for Agriculture and Agricultural Co-operatives (BAAC). The financial analysis at the discounting rate 1.5% and 2.25 % has valuable indicators according to discounting rate as follows; NPV is equal to THB 149,019.60 and THB 123,383.73, and BCR is equal to 1.19 and 1.16 and the IRR both 2 levels discounting rate charged is equal to 7% In this case, found that this project will be cost-effective investment. Case 3: Funded by Nationnal Energy Policy Office (NEPO) and loan from Bank for Agriculture and Agricultural Co-operatives (BAAC). The financial analysis at the discounting rate 9%, 12%, 15% and 2.25 % has valuable indicators according to discounting rate as follows; NPV is equal to THB 92,276.76, THB 41,712.05 and THB 2,371.38, BCR is equal to 1.14, 1.07,1.004 and the IRR is equal to 17%, 16% and 15.28%. In this case, found that this project will be cost-effective investment. The study of 3 cases showed that case 1 is the highest financial return when 2 and 3 returns less, respectively. **The benefits from biogas production, biogas is used to fuel the power supply machine and as LPG.**

Ubolwan Khunprom (15) has conducted financial and economic analysis of renewable energy project from biogas production from animal manure. Using costs-benefits analysis as a tool to assess the feasibility of financial and economic project. Factors of production and yield estimate with constant prices. The financial and economic analysis charged with long-term government bond interest rates at discounting rates. This study used 3 indicators; those are net present value (NPV) benefits to costs ratio (BCR) and internal rate of return (IRR). Primary data applied in

this study obtained by interviewing the owner of S. P. M Farm Ltd. located in Paktho District, Ratchaburi Province.

The study found that case 1: Funded by government, discounting rate 2%, NPV is equal to THB 20,898,133, BCR is equal to 2.04 and FIRR is equal to 24.11 2. Case 2: without funding from government at actual financial discounting rate 2%, NPV is equal THB 16,747,568, BCR is equal to 1.82 and FIRR is equal to 15.16 From both cases concluded that the investment of farm biogas pond building is feasible. **The benefits from biogas production system is to generate electricity within the farm itself, revenue from selling of fertilizer each year and salvage value is the remaining value of that machine after the economic life of the project ended.**

At actual discounting rates 5%, NPV is equal to THB 20,727,179 BCR is equal to 2.44 and FIRR is equal to 29.49 Concluded that the project is economically feasible.

Kamolthip Yuenyung (16) has studied the feasibility of renewable energy from waste in the swine farm biogas systems case study Photharam District, Ratchaburi. The study aimed to analyze returns and production costs of renewable energy from waste in swine farms and sensitive analysis of the project in the case of a change of variable in the decision. The sizing of biogas system set at 50 and 100 cubic meters and studies only the small, medium and large swine farms of Photharam District, Ratchaburi Province. The survey total of 61 samples and questionnaire is a tool of study. For the analysis of costs and returns and project sensitivity will use both financial and economics analysis. The consideration criteria are NPV, BCR, FIRR and EIRR.

The research concluded that 1. If set the social opportunity costs loss at 8%, biogas system size 50 cubic meters, financial analysis value equal to NPV THB 194,801 and BCR equal to 2.81 and the economic analysis has value NPV equal to THB 117,974, BCR value equal to 2.22 And at the biogas system size 100 cubic meters, financial analysis has value equal to NPV THB 414,834 Baht and BCR values equal to 3.54 and the economic analysis has value NPV equal to THB 281,556 BCR equal to 2.90 shows that both sizes biogas systems are costs-effectve should be

invested. 2. Analysis of 3 case, before the change, costs increased 10% and the system used for 10 years, utilize renewable energy equivalent to 3 LPG gas tanks per month, discounting rates 8, 10, 12 และ 14 respectively, found that biogas systems size 50 cubic meters, FIRR value equal to 53.27, 44.94 and 31.32 EIRR value equal to 29.69, 24.55 and 15.15 And at the size of biogas system 100 cubic meters FIRR value equal to 73.48, 62.13 and 55.23 and EIRR equal to 42.85, 38.82 และ 32.04 will see that value that will result FIRR and EIRR discounting rate 8%, 10%, 12% and 14% are equal in those analysis of 3 cases and a downward trajectory, but still worth the investment. Shows that medium-sized farms are feasible and costs effective investment than small farms. And whether investments in biogas systems 50 cubic meters or 100 cubic meters will have low risk investment to the operator. **The benefits from biogas production are LPG fuel plus revenue from selling fertilizer each year.**

Bodin Lurlertyot (17) have evaluated investment projects on biogas production from Praves Swine Farms, Muang District, Chiang Rai. Tools used to collect information include interviews, raw data collected from Praves Farm and The Project on Promoting Biogas Production from Animal Husbandry Farms of Biogas Technology Center, Chiang Mai University. Then analysed the data to assess the investment result of Praves Farm construction on biogas wastewater treatment which is a medium size farm, total bank loan financial investment THB 1,510,387, interest rate 6%, with construction fund THB 289,500. Praves Farm has returned on the construction of biogas wastewater treatment system in the form of energy saving and revenues from selling of fertilizer around 17,550 baht per month. The return capital period of Praves Farm biogas wastewater treatment system will be 10 years 2 months 17 days less than the system lifetime 15 years. Net present value (NPT) is equal to THB 308,801.58 higher than zero and yield reduction purchase equal to 6.89 higher than interest rate 6% per year. **The benefits from biogas production system are to generate electricity within the farm itself and revenue from selling of fertilizer each year.**

Kamthorn Anurukchuwong (18) has analysed the efficiency and economic return of electricity from biogas production of medium-sized swine farm. The production systems that has been analysed are integrated system of renewable energy and pollution control system caused by farm. The analysis system consists of biogas production digester from swine manure, gas supply power generator and induction power generator. By making measurements of the volume and composition of biogas that feed to the engines, amount of electric power and the quality of power produced to calculate the performance of the system. Payback period analysis of the system calculated from biogas digester sized 200 cubic meters, lifetime of 15 years, running time 10 hours a day, maximum capacity of approximately 18 KW. Price of electricity produced calculated according to Time of Use (TOU) of Provincial Electricity Authority of Thailand for small scale business. At all costs, excluding the cost of environmental impact and own investment without funds. A rate of return on investment IRR equal to 35.42% with a payback period of 3 years. **The benefits from biogas production system are to generate electricity within the farm itself and revenue from selling of fertilizer each year.**

Review of documents related to research and costs benefits analysis will be seen that the feasibility study or costs-effective investment in the past, most of the studies on swine farms medium or large or two sizes and study on each farm only. Method used was analysis of costs and benefits (Costs - Benefit Analysis) using criteria NPV, IRR and B/C Ratio. Most benefits from biogas production system was to generate electricity within the farm itself and revenue from selling of fertilizer each year which were not found any studies analyzing the cost of financial investment in the construction of biogas as an integrated farms to sell electricity rebate to electricity organization: a case study of swine farms on small and medium size whatsoever.

CHAPTER III
MATERIALS AND METHODS

This research is the financial cost-benefit analysis of joint investment of biogas systems for electricity generation: a case study of small and medium scale swine farm Thasadet Sub-district Municipality, Maung District, Suphanburi Province. The study divided into two sections. The first section is to study economic, social, waste management of swine fram, attiudes of farm owner on joint investment of biogas, and the relationship of various factors affecting medium and small swine farm for joint investment of biogas system for electricity generation by using Interview Schedule and In-depth interview. The second section is to study financial feasibility of the project by using cost-benefit analysis.

Section 1

3.1 Population

The population in this research is the 39 medium and small swine frams in Thasadet Sub-district Municipality, Maung District, Suphanburi Province (19).

29 medium swine frams

10 small swine frams

3.2 Materials of Research

The materials of this study are questionnaire and in-depth interview, details as follows

3.2.1 Questionnaire – for owner of swine farm in the study area to collect data in the economic, social, waste management and attitudes of farm owner on joint investment of medium and small scale swine farms to construct biogas system for

electricity generation and related factor. The questionnaire is divided into 5 sections, as follows

Section 1 Persanal, economics and social data

Section 2 Farm general data

Section 3 Waste and wastewater management in swine farms

Section 4 Opinion on joint investment of swine farm for biogas construction to electricity generation

Section 5 Problem and obstacle on joint investment of swine farm for biogas system construction for electricity generation and suggestion

3.2.2 Questionnaire – for swine frams owner who participate in pilot project of using swine farm waste and wastewater management technology for biogas production in Songkhla Lake, Thahin sub-district, Sathing Phra district, Songkhla province. To collect data in the economics, social, waste management, attitudes of farm owner on joint investment of biogas system, problem and obstacle and related factor affecting medium and small swine farm for joint investment of biogas system.

3.2.3 In-depth interview – for related agencies to examine measures to resolve wastewater problem from the existing swine farm including the future plan/framework for solving wastewater problem.

3.3 Collecting Data

This research uses primary data from the survey by questionnaire and in-depth interview. The data was collected data from swine farms which participated in the pilot project and farms in the study area to analyze related factor affecting on joint investment of medium and small swine farms to construct biogas system.

3.4 Effective Testing of Materials

3.4.1 Questionnaire and in-depth interview used in this study were designed according to theories, conceptual framework and was checked by the thesis committee.

3.4.2 Questionnaire and in-depth interview were verified for the accuracy of content in order to obtain needed information.

3.4.3 Questionnaire was tested with 8 medium and small swine farms in Sanamcre sub-district, Maung district, Suphanburi province while in-depth interview was tested with farmers in Thahin sub-district, Sathing phra district, Songkhla province and related agencies before adjusting in order to obtain the answer with precision, accuracy and does not impede the process of collecting data.

3.5 Data analysis and Statistic

The data obtained from questionnaires and interview in each section was organize and recorded to calculate statistical inference using a program SPSS FOR WINDOWS. The analysis as follows,

3.5.1 The general description of the data using descriptive statistics including Frequency, Percentage, Arithmetic Mean and Standard Deviation (SD).

3.5.2 Attitude comparison among agriculturist in medium and small swine farm using t-test.

3.5.3 The relationship between independent and dependent variables using analysis of variance.

For swine farmer attitude on joint investment of biogas system for electricity generation will consider the factor that are expected to be related to investment in these systems of medium and small swine farms using the 5 Likert type responses as follows:

Opinion Level	Scores
Most	5
Much	4
moderate	3
Less	2
Least	1

Measuring the opinions of swine farm joint investment in the construction of biogas construction for electricity generation is divided into 3 levels by adding scores in attitudes category of 39 farmers using criteria for classification organized as follows:

High level = Attitude score more than 75 percent of total score
Moderate level = Attitude score between 50-75 percent of total score
Low level = Attitude score less than 50 percent of total score

Section 2

3.1 Collecting Data

This section used secondary data from technical documents, research reports as well as information from related agencies. These datas are

3.1.1 Number of swine farmers from Livestock Suphanburi office.

3.1.2 Data of pilot project on joint investment of biogas system from Pollution Control Department.

3.1.3 Information about wastewater treatment and biogas production from Technology biogas institute, Chiangmai University.

3.2 Data analysis and Statistic

3.2.1 Descriptive Method – assessing value or the environment impact is to evaluate the products and service that cannot measure monetary value. The researcher is to review the reports, research documents, and consider environment impacts and benefits from joint investment of electricity generation from biogas system from swine farms in the character of positive or negative benefit to the society and the environment. The information is to support or oppose the investment decision.

3.2.2 Quantitative Method –With discount method and 15 years service life of biogas system which is 15 years. Thereafter, cost-benefit analysis can indicate whether the financial return on joint investment for electricity generation from biogas system from swine farms is worthy investment or not. The standard net present value (NPV), benefit – cost ratio (BCR) and internal rate of return (IRR) were used in financial cost-benefit analysis using actual costs and benefits to investor (20).

3.2.2.1 Net Present Value (NPV) is the net benefits received throughout the duration of the project which has adjusting of time. NPV can be negative, positive or zero depending on the amount of present value benefit (PVB) deduct by present value cost (PVC) of that project.

$$NPV = PVB - PVC$$

$$NPV = \sum_{t=0}^{n} \frac{B_t - C_t}{(1+r)^t}$$

Acceptable level of the decision-making criteria is NPV higher than zero indicate that net benefit is positive, the project is cost-effective investment.

3.2.2.2 Benefit – Cost Ratio (BCR) is the value of present value of benefit divided by present value of cost throughout the duration of the project period.

$$BCR = PVB / PVC$$

$$BCR = \sum_{t=0}^{n} \frac{B_t / (1+r)^t}{C_t / (1+r)^t}$$

Acceptable level of the decision-making criteria is BCR higher than 1 indicate that the project is cost-effective investment. Disadvantages for this type of decision criteria is when apply to large project, high return while the costs is also high. Therefore, BCR higher than 1 but overall revenue may be less than other small projects. In this case, alternative criteria should be considered in order to avoiding errors.

3.2.2.3 Internal Rate of Return: IRR is the return on investment throughout the project period in percentage or discounting rate that net present value becomes zero or a rate that return and cost discount to equal present value. This rate is the rate of investment capabilities to create revenue to cover the investments cost.

IRR formula

$$\sum_{t=0}^{n} \frac{B_t - C_t}{(1+IRR)^t} = 0$$

Lost opportunity cost of capital or specific interest rate, r is set to IRR

n = Total period of the project (year)
t = Year of the project t=1, 2,…,n
B_t = Benefit of the project in the t
C_t = Cost of the project in the t
r = Discounting rate = The average rate of return or minimum
PVB = present value benefit
PVC = present value cost

3.2.2.4 Sensitivity Analysis of the Project

Because all risks have potential to occur, sensitivity analysis is important to investment decisions if encounters risks or uncertainties. Analysis is to test that at what level of cost increase or benefits decrease so that the project is not worth investment by using switching value which can be carried out 2 cases.

1) A case to identify how much cost increase in % that NPV = 0 and BCR = 1

$$SVT_C = \frac{NPV \times 100}{PV \text{ of cost}}$$

SVT_C = Switching Value Test in cost
NPV = Net present value of the project
PV of cost = Net Present value of cost

2) A case to identify how much benefits increase in % that NPV = 0 and BCR = 1

$$SVT_B = \frac{NPV \times 100}{PV \text{ of benefit}}$$

SVT_B = Switching Value Test in benefit
NPV = Net present value of the project
PV of benefit = Net present value of benefit

High calculated SVT_C or SVT_B indicate low risk to the projec

CHAPTER IV
RESULTS AND DISCUSSIONS

This research is a financial cost-benefit analysis of joint investment of biogas systems for electricity generation: a case study of small and medium scale swine farm Thasadet Sub-district Municipality, Maung District, Suphanburi Province. The study included two sections. The first section was to study economic and social condition, waste management, conception of farm owner on biogas system joint investment, and factors affect on small and medium farms for joint biogas system to generate electricity. The second section was to study financial possibility of project using cost-benefit analysis. The results can be concluded as follows:

4.1 Result of economic and social condition, waste management, swine farmer opinion on the joint investment of biogas system, and factors affected on clustering small and medium swine farms on biogas system management for electricity generation.

The results were divided into:

1. Personnel factors: age, education levels, farming experience, news perception and knowledge
2. Farm management: swine numbers, labor numbers, labor types, water supply in the farms, net income
3. Waste and wastewater management in swine farms
4. Farmer opinion on farm clustering for biogas construction to generate electricity
5. Comparison on average score opinion of swine farm clustering for biogas construction to generate electricity
6. Impact factor analysis on opinion of swine farm clustering for biogas construction to generate electricity by variation analysis

7. Problem and obstacle of swine farm clustering for biogas construction to generate electricity

8. Government supporting farmers for biogas system investment, swine farm clustering

9. SWOT Analysis for pilot project using swine farm waste and waste water management technology for biogas production in Songkhla lake, Thahin Sub-district, Sathing Phra District, Songkhla province.

4.1.1 Personnel Factors

1) Age: Most swine farmers were in 50-59 year old (53.8 %) and the average age of the farms was 50.59. In medium farm size, most farmers were 50-59 year old (53.6%) and the average age of the farmers was 51, while in the small farm size, most farmers were 40-49 year old (50%) and the average age of the farmers was 49.40.

2) Education level: The most education level of the farmers was secondary school or vocational certificate (48.7%). In the medium farm size, most of farmer education level was primary school (55.2%), while in the small farm size, most of farmer education level was secondary school or vocational certificate (50%).

3) Farming experience: Most of farming experience was 5-10 years (41%) and the average farming experience was 12.31 years. In medium and small farm, most farmers had experience about 5-10 years (37.5% with average of 12.76 years and 50% with average of 11 years, respectively).

4) Source of news and knowledge: Most farmers got biogas information from governmental officers (28.3%). In the medium farm size, the farmers got biogas information from governmental officers (31%), while in the small farm size; the farmers got biogas information from television (30%) and neighbor (30%).

Table 4-1 Personall factors, economic and social condition, classified by farm sizes

Variable	Medium farm		Small farm		Total	
	Number	Percent	Number	Percent	Number	Percent
Age (year)						
Less than 30	-	-	-	-	-	-
30-39	1	3.4	-	-	1	2.6
40-49	9	31.0	5	50.0	14	35.9
50-59	17	53.6	4	40.0	21	53.8
Over than 60	2	6.9	1	10.0	3	7.7
Average age	51.0		49.40		50.59	
SD	5.120		7.691		5.816	
Minimum	40		32		32	
Maximum	60		60		60	
Education level						
Non	2	6.9	-	-	2	5.1
Primary school	16	55.2	3	30.0	19	48.7
Secondary school/vocational certificate	8	27.6	5	50.0	13	33.3
Diploma/high vocational certificate	1	3.4	2	20.0	3	7.7
Undergraduate school	2	6.9	-	-	2	5.1
Graduate school	-	-	-	-	-	-
Farm experiences						
Less than 5 years	1	3.4	-	-	1	2.6
5-10 years	11	37.9	5	50.0	16	41.0
11-15 years	9	31.0	4	40.0	13	33.3
16-20 years	6	20.7	1	10.0	7	17.9
Over than 21 years	2	6.9	-	-	2	5.1
Average experience	12.76		11		12.31	
SD	6.028		4.667		5.704	
Least experience	2		5		2	
Most experience	30		20		30	

Table 4-1 Personall factors, economic and social condition, classified by farm sizes (cont.)

Variable	Medium farm		Small farm		Total	
	Number	Percent	Number	Percent	Number	Percent
Knowledge sources						
Newspaper	8	27.6	2	20.0	10	25.6
Radio	2	6.9	-	-	2	5.1
Television	4	13.8	3	30.0	7	17.9
Magazine	-	-	-	-	-	-
Brochorch	-	-	-	-	-	-
Advertisement poster	-	-	-	-	-	-
Family members	2	6.9	-	-	2	5.1
Neighbor	3	10.3	3	30.0	6	15.4
Club	-	-	-	-	-	-
Government officer	9	31.0	2	20.0	11	28.2
Others	1	3.4	-	-	1	2.6

Source: The result of study

4.1.2 Farm Management Factors

1) Swine numbers: Most farmers raised 500-1000 swine (46.2%), and average numbers of swine was 817.44.

2) Labor numbers: Most farmer owners employed 2 labors (43.6%). In the medium farm, most farmers employed 2 labors (51.7%) while in the small farm, most farmers employed one labor (70%).

3) Water supply in farms: Most farmers used public water resources (87.2%). In the medium and small farm sizes, most farmers used public water resources, 82.8% and 100% respectively.

4) Net income: Most farmers had net income about 3,000,001 – 4,000,000 baht/year (40%), and the average net income was 3,295,500 baht/year. In the medium farm, most farmers had net income about 3,000,001 – 4,000,000 baht/year (47.6%) and average net income was 3,523,000 baht/year while in the small farm, most farmers had net income about 1,000,000 – 2,000,000 and 2,000,001-3,000,000 baht/year (33.3%) and average net income was 2,847,000 baht/year.

Table 4-2 Farm management factors, classified by farm sizes

Variable	Medium farm		Small farm		Total	
	Number	**Percent**	**Number**	**Percent**	**Number**	**Percent**
Swine numbers						
Less than 500	-	-	10	100	10	25.6
500-1000	18	62.1	-	-	18	46.2
1001-1500	7	24.1	-	-	7	17.9
1501-2000	4	13.8	-	-	4	10.3
Average swine	1010.34		258.00		817.44	
SD	518.476		84.169		557.238	
Minimum	500		130		130	
Maximum	2000		400		2000	
Labor						
1	3	10.3	7	70.0	10	25.6
2	15	51.7	2	20.0	17	43.6
More than or equal 3	11	37.9	1	10.0	12	30.8
Average	2.4		1.5		2.23	
SD	0.949		0.972		1.038	
Minimum	1		1		1	
Maximum	4		4		4	
Water supply						
Irrigation	5	17.2	-	-	5	12.8
Underground water	-	-	-	-	-	-
Well	-	-	-	-	-	-
Public water resource	24	82.8	10	100	34	87.2
Others	-	-	-	-	-	-
Net income (baht)						
Less than 1,000,000	-	-	-	-	-	-
1,000,000 – 2,000,000	-	-	3	33.3	3	10.0
2,000,001 – 3,000,000	8	38.1	3	33.3	11	36.7
3,000,001 - 4,000,000	10	47.6	2	22.2	12	40.0
More than 4,000,001	3	14.3	1	11.1	4	13.3
Average	3,523,000		2,847,000		3,295,500	
Lowest income	2,219,000		1,199,000		1,199,000	
Highest income	4,764,000		4,568,000		4,764,000	

Source: The result of study

4.1.3 Waste and Wastewater Management in Farm

1) Stable cleaning: Most farmers cleaned the swine stables once a day (66.7%). In the medium and small farm, they cleaned once a day, 62.1% and 80%, respectively.

2) Swine feces collection: The 100% of farmer collected swine feces before clean the stables.

3) Swine feces utilization: All farmers made fertilizer from dried swine feces.

4) Wastewater treatment: Most farmers used non-air filter system for wastewater treatment (69.2%). In the medium and small farm sizes, non-air filter were used the most about 72.4% and 60%, respectively.

5) Reasons of biogas system not used in swine farms: The main reason (35.9%) was high investment budget and limited areas. In the medium farm, the main reason was limited construction areas (54.2%) while in the small farm, the main reason was high investment budget (70%).

6) Gas systems for wastewater treatment: Most farmers used biogas fixed dome wastewater treatment (80%). In the medium farm, most farmers used biogas fixed dome wastewater treatment (80%) while the small farm had no gas system for wastewater treatment.

7) Biogas utilization: Most farmers used biogas from wastewater treatment for cooking (60%).

8) Reasons of biogas selection: The main reason for farmers using the biogas system was the biogas utilization (80%).

Table 4-3 Waste and wastewater management in farms classified by farm sizes

Variable	Medium farm		Small farm		Total	
	Number	Percent	Number	Percent	Number	Percent
Stable cleaning						
No cleaning	-	-	-	-	-	-
Once /day	18	62.1	8	80.0	26	66.7
Twice/day	11	37.9	2	20.0	13	33.3
More than twice/day	-	-	-	-	-	-
Swine feces collection						
No collection	-	-	-	-	-	-
Everyday	29	100	10	100	39	100
Every two days	-	-	-	-	-	-
Not often	-	-	-	-	-	-
Swine feces utilization						
Dumping to public water source	-	-	-	-	-	-
Dumping to pond in farm	-	-	-	-	-	-
Leaving on ground	-	-	-	-	-	-
Animal fed	-	-	-	-	-	-
Dried fertilizer	29	100	10	100	39	100
Wastewater treatment						
No treatment	-	-	3	30.0	3	7.7
Non-air filter	21	72.4	6	60.0	27	69.2
Stabilization Pond	-	-	-	-	-	-
Natural treated pond	3	10.3	1	10.0	4	10.3
Biogas system	5	17.2	-	-	5	12.8
Others	-	-	-	-	-	-
Reasons of biogas system not used						
High investment	7	29.2	7	70.0	14	35.9
Difficult maintenance	3	12.5	1	10.0	4	10.3
Not sufficient feces	1	4.2	1	10.0	2	5.1
Limited areas	13	54.2	1	10.0	14	35.9
Choking of pipe system	-	-	-	-	-	-
Others	-	-	-	-	-	-

Table 4-3 Waste and wastewater management in farms classified by farm sizes (cont.)

Variable	Medium farm		Small farm		Total	
	Number	Percent	Number	Percent	Number	Percent
Gas systems						
Fixed Dome	4	80.0	-	-	4	80.0
Cover Lagoon	-	-	-	-	-	-
MC-UASB	-	-	-	-	-	-
Others	1	20.0	-	-	1	20.0
Biogas utilization						
Cooking	3	60.0	-	-	3	60.0
Light energy	2	40.0	-	-	2	40.0
Heat energy	-	-	-	-	-	-
Fuel	-	-	-	-	-	-
Others	-	-	-	-	-	-
Reason of using biogas utilization	4	80.0	-	-	4	80.0
Biogas utilization	-	-	-	-	-	-
Feces fertilizer	-	-	-	-	-	-
Odor and insect solution	1	20.0	-	-	1	20.0
Gain suggestion	-	-	-	-	-	-
Others						

Source: The result of study

4.1.4 The opinion on swine farm clustering for biogas construction to generate electricity

The opinion on swine farm clustering for biogas construction to generate electricity was to assess opinions: wastewater problem, clustering biogas system construction and management, effective and usefulness of clustering biogas system, wastewater solving cooperation, and education and supporting from government, the total was 18 questions with highest possible score of 90.

The results showed that most farmers opinions were in moderate level: 50-75 scores, 74.4%, and the average score of opinion was 49.38. Classified by farm sizes, most of farmer opinion score in medium farm size was in moderate level (75.9%) and average score was 49.21, while most farmer opinion score in small farm size was in moderate level (70%) and average score was 49.90 (Table 4-4).

The opinion scores of wastewater problem, construction and clustering biogas system management, effective and usefulness of clustering biogas system, wastewater solving cooperation, and opinion of education and supporting from government, were in moderate levels; 46.2%, 76.9%, 56.4%, 76.9% and 46.2%, respectively.

Table 4-4 Opinion on swine farm clustering for biogas system construction for electricity generation, classified farm sizes

Variable	Medium farm		Small farm		Total	
	Number	Percent	Number	Percent	Number	Percent
Overall opinion (90 scores)						
Minimum level(< 45 scores)	7	24.1	2	20.0	9	23.1
Moderate level (45-67.5 scores)	22	75.9	7	70.0	29	74.4
Maximum (> 67.5 scores)	-	-	1	10.0	1	2.6
Average	49.21		49.90		49.38	
SD	7.078		8.723		7.418	
MIN	34		39		34	
MAX	63		68		68	
Wastewater problem opinion (15 Scores)						
Minimum level (< 7.5 scores)	13	44.8	3	30.0	16	41.0
Moderate level (7.5-11.5 scores)	14	48.3	4	40.0	18	46.2
Maximum level (>11.25 score)	2	6.9	3	30.0	5	12.8
Average	8.00		9.60		8.41	
SD	2.268		2.797		2.479	
MIN	3		6		3	
MAX	13		14		14	
Construction and clustering biogas system management (30 scores)						
Minimum level (< 15 scores)	6	20.7	2	20.0	8	20.5
Moderate level (15-22.5 scores)	22	75.9	8	80.0	30	76.9
Maximum level (> 22.5 scores)	1	3.4	-	-	1	2.6

Table 4-4 Opinion on swine farm clustering for biogas system construction for electricity generation, classified farm sizes (cont.)

Variable	Medium farm		Small farm		Total	
	Number	Percent	Number	Percent	Number	Percent
Average	17.10		16.40		16.92	
SD	3.363		2.757		3.199	
MIN	9		11		9	
MAX	25		20		25	
Effective and usefulness of clustering biogas system (15 scores)						
Minimum level (< 7.5 scores)	7	24.1	5	50.0	12	30.8
Moderate level (7.5-11.5 scores)	18	62.1	4	40.0	22	56.4
Maximum level (>11.25 scores)	4	13.8	1	10.0	5	12.8
Average	8.76		8.00		8.56	
SD	2.278		2.357		2.292	
MIN	3		5		3	
MAX	14		12		14	
Cooperative wastewater solving (20 scores)						
Minimum level (< 10 scores)	3	10.3	1	10.0	4	10.3
Moderate level (10-15 scores)	22	75.9	8	80.0	30	76.9
Maximum level (> 15 scores)	4	13.8	1	10.0	5	12.8
Average	12.17		12.50		12.26	
SD	2.522		2.593		2.510	
MIN	8		9		8	
MAX	17		18		18	
Opinion on knowledge and supporting from government (10 scores)						
Minimum level (< 5 scores)	9	31.0	3	30.0	12	30.8
Moderate level (5-7.5 scores)	14	48.3	4	40.0	18	46.2
Maximum level (> 7.5 scores)	6	20.7	3	23.1	9	23.1
Average	5.86		6.00		5.90	
SD	1.866		2.357		1.971	
MIN	3		3		3	
MAX	9		10		10	

4.1.5 Comparison of average farmer opinion scores on clustering swine farms for biogas system to generate electricity

Classified by farm sizes, the opinion scores of wastewater problem, construction and Clustering biogas system management, effective and usefulness of clustering biogas system, wastewater solving cooperation, and opinion of education and supporting from government, were in moderate levels and not different significantly from average opinion scores between farm size groups(P>0.05) (Table 4-5).

Table 4-5 Comparison of average farmer's opinion scores on clustering swine farms for biogas system construction to generate electricity, classified by farm sizes

Variable	Medium farm size		Small farm size		t	Sig.
	$\bar{x}$	SD	$\bar{x}$	SD		
Overall opinion	49.21	7.078	49.90	8.723	0.25	0.803
Wastewater problem opinion	8.00	2.268	9.60	2.797	1.81	0.078
Construction and Clustering biogas system management	17.10	3.363	16.40	2.757	0.59	0.556
Effective and usefulness of clustering biogas system	8.76	2.278	8.00	2.357	0.90	0.374
Cooperative wastewater solving	12.17	2.522	12.50	2.593	0.35	0.727
Opinion of knowledge and supporting from government	5.86	1.866	6.00	2.357	0.19	0.852

Source: The result of study

4.1.6 Analysis of average farmer's opinion scores on clustering swine farms for biogas system to generate electricity

The farmer opinion scores on clustering swine farms for biogas system to generate electricity were studied. Two variance analysis methods were used:

1) Personal factors affected on farmers' opinion on clustering swine farms for biogas system to generate electricity.

Dependent variable

Farmer's opinion scores on clustering swine farms for biogas system to generate electricity

Independent variable

Age, education level, farming experience, news source and knowledge

Variance analysis

The independent variables; age, education level, farming experience, news source and knowledge affected dependent variable that was the opinion on clustering swine farm for biogas system to generate electricity. When considering each variable, the results showed age and farming experience affected on the opinion on clustering swine farm for biogas system to generate electricity ($P<0.05$) (Table 4-6).

Table 4-6 Variance analysis of personal factors effect on farmers' opinion on clustering swine farms for biogas system to generate electricity

Source of Variation	Sum of square	DF	Mean of square	F	Sig of F
Age	76.754	2	38.377	1.143	0.033*
Education level	0.386	2	0.193	0.224	0.801
Farming experience	35.994	2	17.997	0.540	0.042*
Knowledge source	34.470	2	17.235	1.169	0.322

Source: The result of study

2) Farm management factor effect on farmers' opinion on clustering swine farms for biogas system construction to generate electricity.

Dependent variable

Farmer's opinion scores on clustering swine farms for biogas system to generate electricity.

Independent variable

Swine numbers, labor, labor types, water supply on farms, and net income.

Variance analysis

Independent variable**;** swine numbers, labor numbers, labor types, water supply on farms, and net income affected dependent variable that was the opinion on clustering swine farm for biogas system to generate electricity. When considering each variables, the results showed that swine numbers ($P<0.05$) and labor ($P<0.01$) have effect on the opinion on clustering swine farm for biogas system to generate electricity (Table 4-7).

Table 4-7 Variance analysis of farm management factor effect on farmers' opinion on clustering swine farms for biogas system to generate electricity

Source of Variation	Sum of square	DF	Mean of square	F	Sig of F
Swine numbers	7019.452	2	509.726	0.481	0.022*
Labor	1.613	2	0.806	0.738	0.001**
Water supply on farms	0.196	2	0.098	0.091	0.914
Net income	174.852	2		1.019	0.314

Source: The result of study

4.1.7 Problem and obstacle of clustering swine farm for biogas to generate electricity

The main obstacle of medium farm was limited construction areas (31%) while the main obstacle of small farm sizes was hard maintenance (50%) (Table 4-8).

Table 4-8 Problem and obstacle of clustering swine farms for biogas system to generate electricity

Problem and obstacle	Medium farm		Small farm	
	Number	Percent	Number	Percent
1. Limited construction areas	9	31.0	2	20.0
2. Difficult maintenance	5	17.2	5	50.0
3. Scattering of farms	5	17.2	1	10.0
4. Others	3	10.3	1	10.0
5. Unidentified reason	7	24.1	1	10.0
Total	29	100.0	10	100.0

Source: The result of study

4.1.8 Government supporting for farmers for biogas construction of clustering swine farms to generate electricity

From the interviewing the swine farmers, for medium farm, the government foundation or funding for biogas construction by clustering farm was the most required (37.9%). In case of small farm, the government foundation or funding and knowledge supporting were the most required (40%) (Table 4-9).

Table 4-9 Required government support for clustering swine farms on biogas construction

Required government support	Medium farm		Small farm	
	Number	Percent	Number	Percent
1. Providing public areas	3	10.3	2	20.0
2. Supporting knowledge of clustering swine farms on biogas construction and usefulness	7	24.1	4	40.0
3. Foundation establishment or funding for clustering swine farms on biogas construction	11	37.9	4	40.0
4. Others	3	10.3	-	-
5. Non specific reason	5	17.2	-	-
Total	29	100.0	10	100.0

Source: The result of study

4.1.9 SWOT Analysis

Pilot project using swine farms wastewater and waste treatment with biogas system from clustering farm in wetland "Songkhla lake", Thahin Sub-districtc, Sathing Phra District, Songkhla province, was carried out and operated since 2004. The biogas for cooking was one of the benefits. In the present (2008), the operation was stopped because of flood since 2005. The treatment system was damaged. Therefore, the TAO of Thahin contacted the company who could repair the system.

Impact factors of swine farm biogas system construction were studied from the pilot project and were presented in SWOT Analysis:

Table 4-10 SWOT Analysis

Strengths	**Weaknesses**
1. Farmers concerned about wastewater in Songkhla lake which reduced on quantity of aquatic animals and their decline in incomes. 2. Strong cooperation of farmer for wastewater solution by establishing Songkhla lake conservation group for monitoring water quality. 3. Local government pleayed important role in solving environmental problem. 4. Distance between farms was not too far, so waste collection from all farm was possible. 5. System construction area was available. 6. Most studied swine farms were family related	1. Swine farm was on Songkhla lake. 2. Only affected farmers cooperated on wastewater project, got affect. 3. Local government had no budget for training on “wastewater management” and “biogas system”. 4. Farmers lacked the knowledge and understanding about wastewater and biogas waste treatment technology. 5. Maintenance and repairing system budget was very high.

Table 4-10 SWOT Analysis (cont.)

Opportunities	**Threats**
1. Biogas Technology Center, Chiang Mai University, supported academic knowledge. 2. Budget was supported by government section such as Pollution control department, Energy Policy and Planning Office Ministry of Energy 3. Meeting of concerned parties was provided before launching the project.	1. Flooding can damage wastewater treatment system. 2. Involving agencies has never done soil analysis before carrying out the project, so soil erosion did happen when flooding. 3. Communities near Songkhla Lake had no wastewater treatment before discharging to public water source.

Source: The result of study

The pilot project of swine farm waste and wastewater treatment by using clustering biogas system in Songcla Lake, Thahin Sub-district, Sathing Phra District, Songkhla province, was analyzed by SWOT. The result showed that the strengths, opportunities, weaknesses and threats can used as guideline and suggestion for farmers in Thasadet Sub-district Municipality, Maung District, Suphanburi Province, to effectively implement the joint investment biogas system to generate electricity. The guideline and suggestion was as follows;

Table 4-11 Guideline and suggestion for farmer in Thasadet Sub-district Municipality, Maung District, Suphanburi Province

The pilot project of swine farm waste and wastewater treatment by using clustering biogas system in Songkhla lake, Thahin Sub-district, Sathing Phra District, Songkhla province.	**The joint investment of swine farm in biogas system to generate electricity, Thasadet Sub-district Municipality, Maung District, Suphanburi Province.**
Strengths 1. Farmers concerned about waste water in Songkhla lake effect on decreasing amount of aquatic animals, so their incomes were declined.	**Guideline and Suggestion** 1. Government section should provide waste water information and knowledge by cooperation with groups such as the natural waterway conservation project, let the farmers and

Table 4-11 Guideline and suggestion for farmer in Thasadet Sub-district Municipality, Maung District, Suphanburi Province (cont.)

The pilot project of swine farm waste and wastewater treatment by using clustering biogas system in Songkhla lake, Thahin Sub-district, Sathing Phra District, Songkhla province.	**The joint investment of swine farm in biogas system to generate electricity, Thasadet Sub-district Municipality, Maung District, Suphanburi Province.**
2. Strong cooperation of farmer for wastewater solution by established Songkhla lake conservation group for monitoring water quality 3. Local governors played the important role for solve environmental problem. 4. Distance between farms was not too far, so waste collection from all farm was possible. 5. System construction area was available. Most studied swine farms were family relationship. 6. Most studied swine farms were family related.	people in that area brainstorm cause of wastewater problem, impact, landscape improvement in the riparian zone. Sense of belonging for their natural resources and environment and the good cooperation of farmer should arise for solving these problems. 2. Local government should play important role for environmental solution in their own areas by pushing plan/project related to wastewater from swine farms and securing necessary the budget. 3. Survey of scatterred swine farms showed that the relationship among farms and number of swine was high so electricity should be produced and sold in the electricity market. 4. Government agencies should search for the public areas for treatment system construction
Opportunities 1. Biogas Technology Center, Chiang Mai University supported academic knowledge. 2. Budget was supported by government section such as Pollution control department, Energy Policy and Planning Office Ministry of Energy 3. Meeting of concerned parties was provided before starting the project.	**Guideline and suggest** 1. All related government sections should work in integrated manner. 2. Before the construction, local government should set the meeting for project stakeholders, following Prime Minister's office regulations about listenning to people's opinion, 2005.

Table 4-11 Guideline and suggestion for farmer in Thasadet Sub-district Municipality, Maung District, Suphanburi Province (cont.)

The pilot project of swine farm waste and wastewater treatment by using clustering biogas system in Songkhla lake, Thahin Sub-district, Sathing Phra District, Songkhla province.	**The joint investment of swine farm in biogas system to generate electricity, Thasadet Sub-district Municipality, Maung District, Suphanburi Province.**
Weaknesses 1. Swine farm was on Songkhla Lake. 2. Farmers cooperated on waste water project, got affect. 3. Local government had no budget for training about "wastewater management" and "biogas system". 4. Farmers lacked of the knowledge and understanding about waste water and waste treatment technology, biogas system. 5. Maintenance and repairing system budget was so high.	**Guideline and suggestion** 1. In Thasadet sub-district municipality, most swine farms near Thawa canal, have run for 10 year with no construction areas for wastewater treatment. Government agencies should provide knowledge of wastewater management before releasing to public water source according to the law. Moreover, farm clustering for biogas system to generate electricity should be fully supported by the government. 2. Government section should provide activities, workshop, knowledge, and raise awareness of wastewater problem and impact on society, to farmers and villagers. 3. Local government should allocate budget for swine farm wastewater management, such as providing farm competition for high quality livestock, training swine farm wastewater management for farmers on biogas system. The result of the project shall make farmers learn and understand about swine farm waste and wastewater treatment technology and biogas system, and usefulness of biogas system. Such information can encourage the farm clustering.

Table 4-11 Guideline and suggestion for farmer in Thasadet Sub-district Municipality, Maung District, Suphanburi Province (cont.)

The pilot project of swine farm waste and wastewater treatment by using clustering biogas system in Songkhla lake, Thahin Sub-district, Sathing Phra District, Songkhla province.	**The joint investment of swine farm in biogas system to generate electricity, Thasadet Sub-district Municipality, Maung District, Suphanburi Province.**
	4. Agencies who have the responsibility to support academic technique for treatment system construction should study landscape characteristics and then select the most appropriate treatment system because this could minimize budget for repairing the system.
Threats 1. Flooding can damage wastewater treatment system. 2. There was no soil analysis before undertaking the project and soil erosion did happen when flooded. 3. Communities near Songkhla Lake had no wastewater treatment before discharging to the lake.	**Guideline and suggest** 1. There should be survey of soil characteristic at waste treatment system construction site. 2. Not only, wastewater problem in Thawa canal occurred in Thasadet sub-district municipality, but volume of wastewater accumulated from Doem Bang Nang Buat district and flowed to Thasadet sub-district, also. The canal was deteriorated. Most communities near Thachin river had no wastewater treatment. Therefore, government should solve the problem in systematic manner. Moreover, local government near the river should manage wastewater in their own areas.

Source: The result of study

4.2 Result of Financial Cost – Benefit Analysis of the Project

A financial cost-benefit analysis of joint investment of biogas systems for electricity generation: a case study of small and medium scale swine farm Thasadet Sub-district Municipality, Maung District, Suphanburi Province, was considered and classified financial capital and direct profit every year during the project life. The market price was used, and the criterion was net present value (NPV), benefit – cost ratio (BCR) and internal rate of return (IRR) by defined project period at 15 years and 8% discount rate.

4.2.1 Analysis of selected appropriate biogas system

From survey in Thasadet Sub-district Municipality, Maung District, Suphanburi Province, there were 29 medium farms and 10 small farms. Moreover, they are year round operation. The total swine in the area was 31,880 while there were 5 farms with 3,600 swines that had biogas wastewater treatment system. This financial worth for clustering farm type for biogas system construction to generate electricity covered farms with no biogas wastewater treatment system and hence the total swines was 28,280.

According to biogas system size selection (MC-UASB), 1 m^3 is needed for every 8 swines (21).

Biogas system size = number of swine / 8
= 28,280 / 8
= 3,535 m^3

Therefore, the size of biogas system for investment from clustering swine farms to generate electricity: a case study of medium and small scale swine farms in Thasadet Sub-district Municipality, Maung District, Suphanburi province estimate was 4000 m^3.

4.2.2 Estimation of the benefit and cost

4.2.2.1 Estimation of the benefit

1) Estimation of amount of produced biogas

Estimation of volume of produced biogas from MC-UASB system was based on assumption of stable volume of waste input. The rate of produced gas /livestock unit was 0.85 m^3/livestock unit.

- Calculation of livestock unit

Net swine weight = number of swine x average swine weight/unit
= 28,280 x 60
= 1,696,800 kg

where 60 kg/unit was average swine weight

Livestock unit = Net of swine weight (kg) / 500
= 1,696,800 / 500
= 3,394

- Calculation of volume of produced gas

Amount of produced gas = Livestock unit x 0.85
= 3,394 x 0.85
= 2,885 m^3/day

Therefore, volume of produced gas from biogas system, MC-UASB was 2,885 m^3/day.

1) Estimation of volume of electricity generated

Produced gas will be transformed to electricity. One m^3/day can generate 1.2 kwh/m^3 of electricity.

- electricity = volume of produced biogas x 1.2
= 2,885 x 1.2
= 3,462 kwatt-hr

Electricity from biogas can be sold. The electricity price was based on electricity value plus FT of wholesale and rate of fuel increase. The base of electricity value was 2.9278 baht/unit, average FT of wholesale in December 2008 was 0.7730 baht, and rate of biogas fuel price increase was 0.30 baht. As a result, price of electricity sold was 4.0 baht/unit.

Value of electricity generated (baht/year)

= electricity generated x price x days

= 3,462 x 4.0 x 365

= 5,054,520 baht/year

Hence, the electricity generated and its value were 3,462 Kwh and 5,054,520 baht/year, respectively (Table 4-10).

2) Estimation of amount of produced organic fertilizer

With the operation of biogas system, MC-UASB type, sediment water was rotated to wastewater pond or CT pond for organic matter to decompose completely and less sediment water is released to sediment drying areas comparing to the old biogas system. Moreover, volume of fertilizer depends on number of swine, swine size, volume of feces, concentration of TSS in fermented feces liquid and period of drying (effected on humidity and weight in fertilizer). The rate of fertilizer process was 0.68 kg/livestock unit at 15% humidity.

- Value of produced organic fertilizer = livestock unit x 0.68

= 3,394 x 0.68

= 2,308 kg/day

The survey in Thasadet sub-district, Muang district, Suphanburi, found that market value of dried swine feces for fertilizer production was 1.25 baht/kg

- Value of produced organic fertilizer (baht/year)

= Volume of produced organic fertilizer x market value x day

= 2,308 x 1.25 x 365

= 1,053,025 (baht/year)

Volume of produced organic fertilizer and it value were 2,308 kg/day and 1,053,025 baht/year, respectively (Table 4-12).

Table 4.12 Estimation of benefit, price and total value from joint investment of biogas system for electricity generation

Quantitative Benefit	**Day/year**	**Market price (Baht)**	**Volume**	**Convert biogas to electricity**	**Total value (baht/year)**
1. Compensated energy: electricity (K watt -Hour)	365	4.0	3,462	1.2 K watt -Hour	5,054,520
2. Fertilizer from the process (kg)	365	1.25	2,308	-	1,053,025
Total					**6,107,545**

Note: Value of benefits from the project with the assumption that output and price are constant over project life

4.2.2.2 Estimation of cost

1) Estimation of financial comprised 2 sections, investment cost and operation cost.

Investment cost of biogas system was incurred in the first year under construction condition or hypothesis "no obstacle and accidental events that effected on delayed construction". The land rent is assumed constant over project life. Operation costs, which were pond maintenance, generator and pump maintenance, engine maintenance and labor, were also assumed constant over time. This study excluded water and electricity costs because water use is neglectible and electricity can be used from one generated.

2) Capital estimation in the table 4-13 which based on 2008 price including equipment and labor cost for biogas system construction was 12,713,900 baht. Construction labor cost was 20% (2,542,780 baht) of equipment with 7% VAT (1,067,968 baht). Design consultant, construction supervision, operation and maintenance costs for 1 year were 1,056,000 baht. The connection cost to Provincial Electricity Authority's grid was 290,000 baht. Operating costs, that were pond maintenance, generator and pump maintenance, engine maintenance and labor cost, was 147,000 42,000 and 30,000 baht/year, respectively. Cleaning labor cost of 3 persons (cleaning, collecting feces to biogas system, and collecting dried feces) was 3,910 baht/month or 140,760 baht/year (Table 4-14).

Table 4-13 Estimation of investment cost from joint investment of biogas system for electricity generation

List	Amount	Unit	Value (baht/year)
1. Collection Tank	1	pond	162,800
2. Sand Trapped Tank	1	pond	137,000
3. Channel Digester, size 4,000 m^3	1	pond	1,203,800
4. Stabilization Pond	1	pond	258,500
5. Up-flow Anaerobic Sludge Blanket	1	pond	588,500
6. Sand Drying Bed	32	Bed	489,600
7. Post Wastewater Treatment System	1	Set	2,000,000
- Anaerobic Pond	2	pond	
- Facultative Pond	2	pond	
- Water Hyacinth Pond	2	pond	
- Polishing Pond	1	pond	
8. Control Room	1	room	160,000
9. Water supply in constructed areas and collected wastewater system	1	Set	4,530,000
10. Equipment of operation and set of electricity production from biogas system	1	Set	3,183,700
Total of equipment and labor cost (List 1-10)			**12,713,900**
11. Constructing labor	20%		2,542,780
12. Vat	7%		1,067,968
Total of net construction			**16,324,648**
13. Design consultant, construction control, operating and maintenance for 1 year			1,056,000
14. Land rental (1,200 baht/rai/year)	13.5	Rai	16,200
Total of biogas construction			**17,686,848**
15. Approval design value for electricity motor	1	Time	15,000
16. Testing safety system cost	1	Time	50,000
17. Setting/changing/testing and checking motor, include equipment	1	Set	25,000
18. Synchronizing Check Relay setting cost (Electricity authority station)	1	Set	200,000
Total of connecting electricity process for selling (list14-17)			**290,000**
Total cost of starting investment			**17,686,848**

Table 4.14 Estimation of operation cost from joint investment of biogas system for electricity generation

List of operating cost	Market price (baht)	Amount	Cost (baht/year)
1. Gas pond system, generator and pump maintenance	147,000	1	147,000
2. Engine maintenance	42,000	1	42,000
3. Labor cost	30,000	1	30,000
4. Labor cost (cleaning)	3,910	3	140,760
Total			**359,760**

4.2.2.3 Cashflow and decision criteria

With net cashflow per year (benefit minus cost per year), 15-year service life and 8% discount rate, net present value (NPV), benefit – cost ratio (BCR), internal rate of return (IRR) and project sensitivity analysis were calculated by Microsoft Excel program. The financial analysis data was in Table 4-15 and summary was in Table 4-16

The result of analysis showed that net present value (NPV) was 16,648,780.82 baht, benefit – cost ratio (BCR) was 1.47, and internal rate of return (IRR) was 12.46%. The 3 standard project assessments was very high showing worthiness of the investment.

Table 4-15: A financial cost-benefit analysis of joint investment of biogas systems for electricity generation.

(Unit: Bath)

List/year no.	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Total
Benefit																	
- Value of electricity sale		5,054,520	5,054,520	5,054,520	5,054,520	5,054,520	5,054,520	5,054,520	5,054,520	5,054,520	5,054,520	5,054,520	5,054,520	5,054,520	5,054,520	5,054,520	75,817,800
- Income of fertilizer sale		1,053,025	1,053,025	1,053,025	1,053,025	1,053,025	1,053,025	1,053,025	1,053,025	1,053,025	1,053,025	1,053,025	1,053,025	1,053,025	1,053,025	1,053,025	15,795,375
Total		6,107,545	6,107,545	6,107,545	6,107,545	6,107,545	6,107,545	6,107,545	6,107,545	6,107,545	6,107,545	6,107,545	6,107,545	6,107,545	6,107,545	6,107,545	91,613,175
Cost																	
- Net construction cost of biogas system	16,324,648																16,324,648
- Cost of Design consultant, construction control, operating and maintenance	1,056,000																1,056,000
- Land rent	16,200	16,200	16,200	16,200	16,200	16,200	16,200	16,200	16,200	16,200	16,200	16,200	16,200	16,200	16,200	16,200	259,200
- Electricity connecting system	290,000																290,000
- Gas pond system maintenance		147,000	147,000	147,000	147,000	147,000	147,000	147,000	147,000	147,000	147,000	147,000	147,000	147,000	147,000	147,000	2,205,000.00
- Generator and pump maintenance		42,000	42,000	42,000	42,000	42,000	42,000	42,000	42,000	42,000	42,000	42,000	42,000	42,000	42,000	42,000	630,000.00
- Engine maintenance		30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	450,000.00
- Labor cost		140,760	140,760	140,760	140,760	140,760	140,760	140,760	140,760	140,760	140,760	140,760	140,760	140,760	140,760	140,760	2,111,400.00
Total	17,686,848	375,960	375,960	375,960	375,960	375,960	375,960	375,960	375,960	375,960	375,960	375,960	375,960	375,960	375,960	375,960	23,326,248.00
Net cash flow	-17,686,848	5,731,585	5,731,585	5,731,585	5,731,585	5,731,585	5,731,585	5,731,585	5,731,585	5,731,585	5,731,585	5,731,585	5,731,585	5,731,585	5,731,585	5,731,585	68,286,927.00
- Reducing corporate income tax, 30%	0	1,719,476	1,719,476	1,719,476	1,719,476	1,719,476	1,719,476	1,719,476	1,719,476	1,719,476	1,719,476	1,719,476	1,719,476	1,719,476	1,719,476	1,719,476	25,792,140.00
- Cost and corporate income tax																	
Total	17,686,848	2,095,436	2,095,436	2,095,436	2,095,436	2,095,436	2,095,436	2,095,436	2,095,436	2,095,436	2,095,436	2,095,436	2,095,436	2,095,436	2,095,436	2,095,436	49,118,388.00
Discount Rate 8%	1	0.926	0.857	0.794	0.735	0.681	0.630	0.583	0.540	0.500	0.463	0.429	0.397	0.368	0.340	0.315	
PVB	0	5,655,586.67	5,234,166.07	4,849,390.73	4,489,045.58	4,159,238.15	3,847,753.35	3,560,698.74	3,298,074.30	3,053,772.50	2,827,793.34	2,620,136.81	2,424,695.37	2,247,576.56	2,076,565.30	1,923,876.68	52,268,370.11
PVC	17,686,848.00	1,940,373.74	1,795,788.65	1,663,776.18	1,540,145.46	1,426,991.92	1,320,124.68	1,221,639.19	1,131,535.44	1,047,718.00	970,186.87	898,942.04	831,883.09	771,120.45	712,448.24	660,062.34	35,619,589.29
NPV	-17,686,848.00	3,715,212.93	3,438,377.41	3,185,614.55	2,948,900.12	2,732,246.23	2,527,628.67	2,339,059.55	2,166,538.86	2,006,054.50	1,857,606.47	1,721,194.76	1,592,807.27	1,476,456.11	1,364,117.06	1,263,814.34	16,648,780.82

BCR	1.47
FIRR	12.46%
SVT_c	46.74
SVT_B	31.85

4.2.2.4 Project Sensibility Analysis

In this study, this sensitivity analysis aimed to determine what cost and benefit variation would make the project not worth investing using switching value method.

1) Case of cost increasing that NPV = 0, BCR = 1

$$SVT_C = \frac{NPV \times 100}{PV \text{ of cost}}$$

$$= \frac{16{,}648{,}780.82 \times 100}{35{,}619{,}589.29}$$

$$= 46.74$$

SVT_C = Switching Value Test of cost

NPV = Net Present Value

PV of cost = Preset Value of cost

2) Case of benefit reduction such that NPV = 0, BCR = 1

$$SVT_B = \frac{NPV \times 100}{PV \text{ of benefit}}$$

$$= \frac{16{,}648{,}780.82 \times 100}{52{,}268{,}370.11}$$

$$= 31.85$$

SVT_B = Switching Value Test of Benefit

NPV = Net Present Value

PV of benefit = Preset Value of benefit

This analysis showed that cost can increase up to 46.74 % and benefit can reduce by 31.85 and high SVT_C and SVT_B indicate low risk of project.

Table 4-16 Summary of financial Analysis

Discount Rate	**NPV (Bath)**	**BCR (Times)**	**FIRR (%)**	**SVT_C (%)**	**SVT_B (%)**
8%	16,648,780.82	1.47	12.46	46.74	31.85

Source: The result of study

4.2.2.5 Payback Period

Pay Back period of investment: case study of medium and small swine farm , Thasadet Sub-district Municipality, Maung District, Suphanburi Province swine farm clustering biogas system is at 5 years and 6 months as calculation shown in Table 4-17.

Table 4-17 Payback Period

Year	Cash income	Cash in flow	Net cash flow each year	Net cash flow
1	0	17,686,848	-17,686,848	-17,686,848
2	6,107,545	2,095,436	4,012,109	-13,674,739
3	6,107,545	2,095,436	4,012,109	-9,662,630
4	6,107,545	2,095,436	4,012,109	-5,650,521
5	6,107,545	2,095,436	4,012,109	-1,638,412
6	6,107,545	2,095,436	4,012,109	2,373,697

Source: The result of study

Payback Period $5 + \frac{2,373,697}{4,012,109}$ = 5.59 years = 5 years 6 months

4.3 Discussion

4.3.1 From analyzing joint investment in swine farm project: case study of Tha Wa canel, Thasadet Sub-district Municipality, Maung District, Suphanburi Province, it is found that this is a worthwhile investment project, short payback period, which corresponds to the study of Annop Suknakorn (14), Ubolwan Khunprom (15) and Kamolthip Yuenyung (16) on Cost-Benefit Analysis of Investment of Biogas Systems from munure which found that the project is attractive for investment of Biogas Systems from manure which found that the project is attractive for investment also. In addition, the joint investment of biogas systems for electricity generation with no extra cost to swine farmers can reduce water pollution from swine farms, induce income from electricity generating, reduce imported energy and increase electricity generated from renewable source. Review of documents related to this research and

cost-benefit analysis reveals that the feasibility study or costs-effective investment in the past mostly done on medium or large swine farms. Method used was analysis of costs and benefits (Costs - Benefit Analysis) using NPV, IRR and B/C Ratio. Most benefits from biogas system were to generate electricity for use within the farm itself and revenue from fertilizer sold each year. No study analyzed the investment in the biogas as an integrated farms to sell electricity to electricity authority using biogas production by MC-UASB

From factors that affect medium and small swine farm clustering for biogas system construction in Thasadet Sub-district Municipality, Maung District, Suphanburi Province, it was found that only age (50-59 years), experience (5-10 years), number of pig (500-1,000 pigs) and number of labor (2 labors) affect attitude toward swine farm clustering for biogas system investment to generate electricity. Concerning attitude of farmers, it was found thatAttitude toward waste water rank in medium level (amount 18 farms equal to 46.2%) show that local people realize in pollution especially in waste water pollution and realize that this is a mutual problem in local area.

1) Attitude toward wastewater was in medium level (amount 18 farms equal to 46.2%) which showed that local people realized in pollution especially water pollution and realized that this was a mutual problem in local area.

2) Attitude toward efficiency and benefit of biogas system clustering was in medium level (amount 22 farms equal to 56.4%) showing that swine farmers somewhat know and understand about biogas system and think that biogas system is not worthwhile.

3) Attitude toward cooperation in wastewater treatment rank in medium level (amount 30 farms equal to 76.9%) show that local swine farmer are ready to solve wastewater pollution in case of critical level.

4) Attitude toward information and support from government was in medium level (amount 18 farms equal to 46.2%) showing that swine farmers got information and support in various aspects from government and related organizations. However, there is no integration in solving problem.

4.3.2 Source of fund for joint investment

Source of fund for the investment in biogas system may be mutual investment of clustering farmers (buy share) according to ratio of investment to number of pigs in each farm. If share price was 200 baht each and there are 28,280 pigs, there would initially be 5,656,000 baht for investment.

However, the total fund required was 17,686,848 baht. Therefore, the group has to get loan of 12,030848 baht from the bank. Concerning loan, the committees of energy conservation permits that department of alternative energy development and efficiency to support conservation and alternative energy project. It aims to encourage and induce investment in energy conservation and alternative energy project by lending at less than 0.5% per year rate of interest and let financial institution manage the loan with allowed rate for operation and risk not more than 4% per year. The financial institution is responsible for loan and interest and must pay back by installment to the fund in 7 years.

This joint investment project has to pay principle and interest back in every end of the year from the 1^{st} year to 7^{th} year. In this first seven year, the remaining cash can be paid back as dividend to all farmers according to the number of share holding. After 8 years of operation, all share holder would receive the profit without any reduction (Table 4-18).

Table 4-18 Loan payback and benefit

(Unit: thousand baht)

year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
loan	12,031	10,312	8,593	6,875	5,156	3,437	1,719	-	-	-	-	-	-	-	-	-
Net cash flow	-	4,012	4,012	4,012	4,012	4,012	4,012	4,012	4,012	4,012	4,012	4,012	4,012	4,012	4,012	4,012
Loan payback	-	1,719	1,719	1,719	1,719	1,719	1,719	1,719	-	-	-	-	-	-	-	-
Interest	-	541	464	387	309	232	155	77	-	-	-	-	-	-	-	-
cash flow remaining	-	1,752	1,829	1,907	1,984	2,061	2,139	2,216	4,012	4,012	4,012	4,012	4,012	4,012	4,012	4,012
Benefit per share (baht per share)	-	62	65	67	70	73	76	78	142	142	142	142	142	142	142	142

Source: The result of study

CHAPTER V
CONCLUSIONS AND RECOMMENDATION

This research is a financial cost-benefit analysis of joint investment of biogas systems for electricity generation: a case study of small and medium scale swine farm Thasadet Sub-District Municipality, Maung District, Suphanburi Province. The objective was to analysis financial cost-benefit of joint investment of biogas systems for electricity generation and to study factors affected small and medium swine farm in joint investment of biogas systems for electricity generation.

The case was quantitative study including two sections. The first section was to study socio-economic condition, waste management and conception of farm owners on biogas system joint investment. The questionnaires were used as the tool to collect the data from 39 swine farmers (29 medium farmers and 10 small farmers), in Thasadet Sub-District Municipality, Maung District, Suphanburi Province. The questionnaire elicits personal information, socio-economic conditions, general farm information, waste management and wastewater from swine farm, opinion, problem and obstacle, and suggestion on swine farm clustering for biogas system construction for generating electricity. Data were analysis by SPSS for windows and presented as percentage, average, SD, group average differentiation test and variation analysis. Moreover, the questionnaire were used for swine farm enterprisers who joined pilot project of wastewater management from swine farm in water basin, Songkhla lake, Thahin Sub-District, Sathing phra District, Songkhla Province. The in-depth interview was carried out for involving departments. The second section was to study financial possibility of project using cost-benefit analysis. The results can be concluded as follows;

5.1 Conclusion of socio-economic condition, waste management, swine farmer opinion on the joint investment in biogas system, and factors affected on small and medium swine farms in joint investment on biogas system for electricity generation

5.1.1 Personal Factors

Half of swine farmers were 50-59 years old, and graduated from primary school. Two third of studied group have 5-10 years experience. Most of them got news and knowledge from government officers.

When classified by farm sizes, the result showed that farmers in medium farms were older than those in small farms. The farmers in small farms have higher education than those in medium farms. The farmer in medium farms had more experience than those in small farms. Most farmers in medium farms got news and knowledge from government officers while most farmers in small farm got news and knowledge from television and neighbors.

5.1.2 Farm management factors

Most farmers raised 500-1000 swines and employed two workers. The average annual income was 3,295,500 baht. Generally, water supply in farms came from public resource (Thawa canal). The water bill was less than electricity bill. Water from stall cleaning was the cause of water pollution.

When classified by farm sizes, the farmers in small farms have less workers than those in medium farms. The average number of swine in small farm was 258 while that in medium farm was 1,010. Two third of small farms employed a worker. The average annual income of farmers in small farm was 2,847,000 baht while that in medium farm was 3,523,000 baht. There was no differentiation between small and medium farm concerning water supply which came from public water source (Thawa canal).

5.1.3 Waste management and wastewater in swine farm

Waste management in all farms was similar, stall cleaning was carried out daily (66.7%) and feces were collected for fertilizer production. Wastewater treatment, anaerobic bucket filter system, was used in farm (69.2%). The biogas system was not used in farm because the investment was high, and there was no place for construction. In case of biogas system, the fixed dome was used (80%). The reason of installing biogas system was usage of biogas for cooking.

5.1.4 Opinions on the joint investment in biogas system to generate electricity

Overall opinions of most swine farmers was medium level (score 50-75%), 74.4%, and the average score of opinion was 49.38.

When considering each attitudes such as wastewater, construction and management of clustering biogas system, effectiveness and usefulness of clustering system biogas, cooperation in wastewater solution, and knowledge and support from government, the results showed that farmer opinions were all at medium levels, 46.2, 76.9, 56.4, 76.9 and 46.2, respectively.

Comparison of farmer opinion average scores on the biogas joint investment showed the opinion average scores of small and medium farm owner in all five points were not statistically different ($P>0.05$).

5.1.5 Effect of personal factors on swine farm clustering for biogas construction to generate electricity

Age and work experience in farm affected on opinion of farm clustering for biogas construction to generate electricity ($P<0.05$).

5.1.6 Farm management factor on opinion of swine farm clustering for biogas construction to generate electricity

Numbers of swine and numbers of labor affected on opinion of farm clustering for biogas construction to generate electricity ($P<0.05$).

5.1.7 Problem and obstacle on swine farm clustering for biogas construction to generate electricity

The problem and obstacle of swine farmer in small and medium farms to band together for biogas construction to generate electricity were complicated maintenance. It is possible that the farmers are lacked of knowledge and the MC-UASB biogas wastewater treatment system comprised of many components. Next, construction sites were limited because the area was located close to the city. Finally, the small and medium farms were scatterred over five villages; Moo1, Moo 2, Moo3, Moo5 and Moo 6, along two canals. Therefore, the investment for waste collection system alone was high.

5.1.8 Encouragement and support from government for joint investment on biogas system construction to generate electricity

Campaign by government should be launched to support the swine farm clustering for biogas constructing investment to generate electricity. In the opinion of farmers, first of all, the government should partially support budget or fund to provide biogas system for the cluster due to high investment cost. Moreover, income of swine farms was sometimes unstable because of price fluctuation. Farmers tend to avoid large expenditures and reserve cash for low price period. The system would reduce pollution in the community. Information on biogas system and its usefulness should be educated since most farmers are lacked of knowledge. Training, such as technical suggestion, alternative energy application, should be provided. The last support needed was public area for construction.

5.2 Conclusion of project financial worth

A financial cost-benefit analysis of joint investment of biogas systems for electricity generation: a case study of small and medium scale swine farm Thasadet Sub-district Municipality, Maung District, Suphanburi Province, considered direct benefits and costs over the project life assuming 15-year service life of the biogas system and 8% discount rate.

1.2.1 Estimation of benefit

Table 5-1 Estimation of benefit

Quantitative Benefit	Day/year	Market price (baht)	Amount	Convert biogas to electric	Price value (Baht/year)
1. Alternative energy:electric (Watt-hour)	365	2.80	3,902	1.2 Watt-hour	5,696,920
2. Fertilizer output from system (kg)	365	1.25	2,602	-	1,187,163
Total					**6,884,083**

Source: The result of study

5.2.2 Estimation of cost

The investment cost based on 2008, including equipment and material, and labor costs for biogas system construction, was 12,713,900 baht. Construction fee was 20% of material and labor costs which was 2,542,780 baht. Vat at 7% was 1,067,968 baht. Designing, construction supervision and system operating and maintenance costs before actual operation were 1,056,000 baht. Grip connection cost was 290,000 baht. The operating costs (gas system, electricity generator and pump, motor, and labor costs) were 219,000 baht/year with another 140,760 baht/year for 3 cleaners.

1.2.3 Financial cost-benefit analysis of investment on clustering farm type for biogas system construction to generate electric power

Net present value (NPV) was 16,648,780.82 baht. Benefit – cost ratio (BCR) was 1.47 times and internal rate of return (IRR) was 12.46%. They were high which indicated that the project was worth investing.

Switching value was used for testing the changing level of benefit and cost that will make the project be not worthwhile. The result showed that cost could increase by 46.74% and the benefit could decrease by 31.85%. The SVT_C and SVT_B values of the project were fairly high and, thus, the risk of the project was low.

The payback period of the project was approximately 5 years 6 months and that was muchshorter than 15-year project life.

Concerning fund for the joint investment in biogas system in Thawa canal, Srakeaw district, Suphanburi provinve, one portion of fund can come from each farmer in the form of share holder. Number of share holding depends on number of swine. If the share price is 200 baht and there were 28,280 swines (28,280 stocks), 5,656,000 baht would be available for investment.

However, the total investment budget for the project was 17,686,848 baht. The group can borrow 12,030,848 baht from the Energy Conservation Foundation (rate not over 4.5% per year). The installment of loan principle and interest must be completed within 7 years. The project dividend shall be about 70 baht/share during the first 7 years and 140 baht/share thereafter.

1.3 Recommendations of the results

5.3.1 The joint investment of biogas systems for electricity generation of small and medium swine farms in Thasadet Sub-district Municipality, Maung District, Suphanburi Province will make the group be Very Small Power Producer (VSPP) for renewable energy sold to Metropolitan Electricity Authority (MEA) and Provincial Electricity Authority (PEA) reducing electricity generated by fossil fuel. Therefore, the management should be done by establishing cooperative system. The farmer who faced the obstacle of wastewater management because of lack of fund and knowhow can band together as a group or cooperative and earn income from electricity sale with less wastewater discharged. The members of cooperative system must buy share of the project. The earning shall be in the form of dividend. In return, each share holder must feed wastewater from swine farm thru collection pipe to be treated at the biogas system site. Number of share holding should be proportion number of swine.

5.3.2 This case study can be adapted and used in other areas for wastewater management from swine farms and be local government guideline of project planning for environmental management. Local government can request fund

for the environmental project from environmental foundation or government agencies. If the action plans are approved by provincial office of the national environment board, the budget will be supported by government under power designated to local government. The criterion for funding is different from year to year. Moreover, the Energy Conservation Foundation will be the prime source for fund since the foundation's objective are for investment and improving performance of energy conservation and pollution problem (source from energy). The project, however, must be heard publicly before approving by the foundation committee.

1.4 Recommendation for future researches

5.4.1 The joint investment for biogas system in term of economic benefit and cost analysis should be investigated.The implicit benefit such as decreasing of water pollution and foul odor from swine farms can be valued in monetary term with valuation methods. This study focused on only explicit benefits and costs or actual benefits and costs to the group. The economic benefit-cost analysis will provide complete picture of the joint investment. The worthiness of a project economically shall make that project be even more attractive.

5.4.2 The joint investment for biogas system does have another potential tangible benefit. The group can register the biogas system as a CDM project under Kyoto Protocol.The mechanism is aimed to encourage the developed countries to voluntarily participate in greenhouse gas reduction in sustainable manner. As a CDM project, the joint investment for biogas system shall be even more worthwhile financially with additional revenue from carbon market.

REFERENCES

1. สำนักงานสิ่งแวดล้อมภาคที่ 5. แผนจัดการคุณภาพสิ่งแวดล้อมระดับภาค พื้นที่ลุ่มน้ำท่าจีนและลุ่มน้ำคาบเกี่ยว (ลุ่มน้ำเจ้าพระยาและลุ่มน้ำน้อย) พ.ศ. 2550-2554, 2550.
2. Pollution Control Department Ministry of Natural Resources and Environment. Filtration Handbook Use, the Care and Maintain the Wastewater Treatment System from the Swine Farm of Livestock Development Standard, 2003.
3. Pollution Control Department Ministry of Natural Resources and Environment. The Training Reinforces Potential of Swine Farm Wastewater Management in Thachin Basin Area. Bkk; 2007. 1p.
4. Pollution Control Department Minitry of Science Technology and Environment. Swine Farm wastewater management by Biotechnology Handbook. Bkk; 2538. 14p.
5. J.D. Murphy and E. McKeogh. The benefits of integrated treatment of wastes for the production of energy. Energy. 2006. 31(2-3): 294-310.
6. National Committee Energy Policy Office. Taking Buy Very Small Power Producer (VSPP). [Online]. April 2008 Available from: http://www.eppo.go.th/vrs/VRS56-04-vspp.html.
7. สำนักงานนโยบายและแผนพลังงาน. สถานการณ์พลังงานไทยในช่วง 6 เดือนแรกของปี 2550. วารสารนโยบายพลังงาน 2550; (77):31.
8. Tushar Jash and Sujay Basu. Development of a mini-biogas digester for lighting in India. Energy. 1999; 24(5): 409-11.
9. Pollution Control Department Ministry of Natural Resources and Environment. Technology of Waste and Wastewater Treatment from Clustering Biogas manual, M.P.T
10. Pollution Control Department Ministry of Natural Resources and Environment. Guideline Economics Impact Analysis from Standard Score Specification Controls the Pollution Source Handbook, 2003.

11. กรมพัฒนาพลังงานทดแทนและอนุรักษ์พลังงาน. วิธีการคำนวณค่าผลตอบแทนทางการเงินและทางเศรษฐศาสตร์.[Online]. เข้าถึงได้จาก: http://www2.dede.go.th/webpage/ef_irr.htm. [วันที่สืบค้น 9 เมษายน 2551).
12. ณรงค์เดช นวลมีชื่อ. บทบาทของการรวมกลุ่มต่อการถ่ายทอดเทคโนโลยีในท้องถิ่นกรณีศึกษา : กลุ่มสตรีอาสาทอผ้าหนองขาว อำเภอท่าม่วง จังหวัดกาญจนบุรี. [วิทยานิพนธ์ปริญญาวิทยาศาสตรมหาบัณฑิต สาขาวิชาเทคโนโลยีที่เหมาะสมเพื่อการพัฒนาทรัพยากร. นครปฐม: วิทยาศาตร์ มหาวิทยาลัยมหิดล; 2544.
13. ผศ.ดร.นันทิยา หุตานุวัตร และรศ.ดร.ณรงค์ หุตานุวัตร. การพัฒนาองค์กรชุมชน. พิมพ์ครั้งที่ 1. กรุงเทพมหานคร: สถาบันพัฒนาองค์กรชุมชน (องค์กรมหาชน); 2546.
14. อรรณพ สุขนคร. การวิเคราะห์ทางการเงินของการลงทุนผลิตก๊าซชีวภาพจากมูลสุกรในพื้นที่จังหวัดราชบุรี. [วิทยานิพนธ์ปริญญาวิทยาศาสตรมหาบัณฑิต สาขาวิชาเศรษฐศาสตร์เกษตร]. กรุงเทพมหานคร: วิทยาศาตร์ มหาวิทยาลัยเกษตรศาสตร์; 2546.
15. อุบลวรรณ ขุนพรหม. การวิเคราะห์ทางการเงินและเศรษฐกิจของโครงการผลิตก๊าซชีวภาพจากมูลสัตว์ เพื่อเป็นพลังงานทดแทน. [วิทยานิพนธ์ปริญญาเศรษฐศาสตรมหาบัณฑิต สาขาวิชาเศรษฐศาสตร์]. กรุงเทพมหานคร: เศรษฐศาสตร์ มหาวิทยาลัยธุรกิจบัณฑิตย์; 2547.
16. Kamolthip Yuenyung. The Possibility of Producing Alternative Fuel from Swine Farm using Biogas System from Case Study at Photaram District, Rajaburi Province. [Thesis The Degree of Master of Economic, Economic]. Bkk.; 2004.
17. บดินทร์ ลือเลิศยศ. การประเมินผลการลงทุนโครงการผลิตก๊าซชีวภาพจากมูลสุกร ของประเวศฟาร์ม ในอำเภอเมือง จังหวัดเชียงราย. [การค้นคว้าอิสระปริญญาบริหารธุรกิจมหาบัณฑิต]. เชียงใหม่: บริหารธุรกิจ มหาวิทยาลัยเชียงใหม่; 2547.
18. กำธร อนุรักษ์ชูวงษ์, เจนศักดิ์ เอกบูรณะวัฒน์. การวิเคราะห์ระบบผลิตไฟฟ้าจากก๊าซชีวภาพของฟาร์มสุกรขนาดกลาง. วิศวกรรมสารเอเชียอาคเนย์ 2549; (2): 59-68.
19. สำนักงานปศุสัตว์จังหวัดสุพรรณบุรี. รายชื่อฟาร์มเลี้ยงสุกรปลอดสารกลุ่มเบต้าอะโกนิสท์หรือสารเร่งเนื้อแดงในพื้นที่จังหวัดสุพรรณบุรี. [Online]. เข้าถึงได้จาก: http://www.dld.go.th/pvlo_spr/0000.htm. (วันที่สืบค้น 13 พฤษภาคม 2551).
20. Anthony EB, David HG, Aidan RV, David LW. Cost - Benefit analysis concepts and practice. New Jersey: Prentice Hall; 1996.
21. Technology Biogas Institute Chiang Mai. Biogas Theory.[Online] March 2008. Available from: http://teenet.chiangmai.ac.th/btc/introbiogas02.php.

APPENDICES

APPENDIX A

แบบสัมภาษณ์

เลขที่แบบสัมภาษณ์.....

เรื่อง การวิเคราะห์ความคุ้มค่าทางการเงินในการลงทุนก่อสร้างระบบก๊าซชีวภาพแบบรวมกลุ่มฟาร์มเพื่อผลิตไฟฟ้า : กรณีศึกษาฟาร์มสุกรขนาดกลางและขนาดเล็ก เทศบาลตำบลท่าเสด็จ อำเภอเมือง จังหวัดสุพรรณบุรี

.....

แบบสัมภาษณ์ฉบับนี้เป็นส่วนหนึ่งของการทำวิทยานิพนธ์ โดยนางสาวสุภัทรา อ่ำเกิด นักศึกษาปริญญาโท หลักสูตรปริญญาวิทยาศาสตรมหาบัณฑิต สาขาวิชาเทคโนโลยีการบริหารสิ่งแวดล้อม (ภาคพิเศษ) คณะสิ่งแวดล้อมและทรัพยากรศาสตร์ มหาวิทยาลัยมหิดล ขอให้ผู้ตอบแบบสัมภาษณ์ กรุณาตอบคำถามทุกข้อให้ตรงกับความเป็นจริงมากที่สุด เพราะคำตอบของท่านจะเป็นประโยชน์อย่างยิ่งต่อการศึกษาวิจัยในครั้งนี้ โดยคำตอบที่ได้รับจะถือเป็นความลับ และจะนำเสนอผลการวิจัยในลักษณะรวมๆ เท่านั้น

ชื่อฟาร์ม.....

เลขที่.....หมู่ที่.....ตำบล.....อำเภอเมืองฯ จังหวัดสุพรรณบุรี

ชื่อผู้ให้สัมภาษณ์ (นาย/นาง/นางสาว) .....

บ้านเลขที่.....หมู่ที่.....ตำบล.....อำเภอเมืองฯ จังหวัดสุพรรณบุรี

ตำแหน่งหน้าที่รับผิดชอบ.....

วันที่สัมภาษณ์.....

ชื่อผู้สัมภาษณ์.....

ส่วนที่ 1 ข้อมูลส่วนบุคคล สภาพเศรษฐกิจ และสังคม

<u>คำชี้แจง</u> โปรดตอบทุกข้อด้วยการทำเครื่องหมาย / ลงใน ( ) ที่ท่านต้องการระบุเป็นคำตอบ และเติมตัวเลขหรือข้อความลงในช่องว่าง

1. เพศ ( ) ชาย ( ) หญิง
2. อายุ ..... ปี

3. ระดับการศึกษาสูงสุด

( ) 1. ไม่ได้เรียนหนังสือ ( ) 2. ประถมศึกษา

( ) 3. มัธยมศึกษา/ปวช. ( ) 4. อนุปริญญา/ปวส./ปวท.

( ) 5. ปริญญาตรี ( ) 6. สูงกว่าปริญญาตรี

4. ท่านประกอบอาชีพการเลี้ยงสุกรมาเป็นเวลา.....ปี

5. ปัจจุบันท่านเป็นสมาชิกกลุ่มหรือสมาคมผู้เลี้ยงสุกรหรือไม่

( ) 1. ไม่เป็น

( ) 2. เป็น ระบุชื่อกลุ่มหรือสมาคม.....

6. ท่านเคยรับทราบข่าวสารหรือความรู้เรื่องระบบก๊าซชีวภาพหรือไม่

( ) 1. เคย ( ) 2. ไม่เคย

6.1 ท่านเคยรับทราบข่าวสารหรือความรู้เรื่องระบบก๊าซชีวภาพ จากแหล่งใด

( ) 1. หนังสือพิมพ์ ( ) 2. วิทยุ

( ) 3. โทรทัศน์ ( ) 4. วารสาร

( ) 5. แผ่นพับหรือใบปลิว ( ) 6. ป้ายโฆษณาต่างๆ

( ) 7. สมาชิกในครอบครัว ( ) 8. เพื่อนบ้าน

( ) 9. กลุ่มหรือสมาคม ( ) 10. เจ้าหน้าที่ของรัฐ

( ) 11. อื่นๆ ระบุ.....

7. ท่านมีใบอนุญาตประกอบกิจการที่เป็นอันตรายต่อสุขภาพหรือไม่

( ) 1. มี ออกให้โดย.....

เมื่อวันที่.....วันหมดอายุ.....

( ) 2. ไม่มี

ส่วนที่ 2 ข้อมูลทั่วไปของฟาร์ม

<u>คำชี้แจง</u> โปรดตอบทุกข้อด้วยการทำเครื่องหมาย / ลงใน ( ) ที่ท่านต้องการระบุเป็นคำตอบ และเติมตัวเลขหรือข้อความลงในช่องว่าง

1. ประเภทและจำนวนสุกรที่เลี้ยง

   ( ) 1. สุกรพ่อ – แม่พันธุ์ จำนวน.....ตัว

   ( ) 2. สุกรขุน จำนวน.....ตัว

   ( ) 3. ลูกสุกร จำนวน.....ตัว

   รวมจำนวนฟาร์มสุกรทั้งหมด.....ตัว

2. ฟาร์มสุกรของท่านมีพื้นที่ทั้งหมด.....ไร่.....งาน.....ตารางวา

   ( ) 1. เป็นพื้นที่ของตนเอง จำนวน.....ไร่.....งาน.....ตารางวา

   ( ) 2. เป็นที่ดินเช่า จำนวน.....ไร่.....งาน.....ตารางวา

3. จำนวนโรงเรือน

   ( ) 1. โรงเรือนสุกรพ่อ – แม่พันธุ์ จำนวน.....หลัง

   ( ) 2. โรงเรือนสุกรขุน จำนวน.....หลัง

4. ปริมาณมูลสุกร/วัน ประมาณ..... กิโลกรัม/วัน

5. ท่านมีแรงงานที่ใช้ในการเลี้ยงสุกร จำนวน.....คน ได้แก่

   ( ) 1. แรงงานจากครอบครัวของท่าน จำนวน.....คน

   ( ) 2. แรงงานรับจ้าง จำนวน.....คน

6. ท่านนำน้ำจากแหล่งใดมาใช้ภายในฟาร์ม

   ( ) 1. น้ำประปา ( ) 2. น้ำใต้ดิน ( ) 3. น้ำบ่อตื้น

   ( ) 4. แหล่งน้ำสาธารณะ ( ) 5. อื่นๆ โปรดระบุ.....

7. ฟาร์มสุกรของท่านอยู่ห่างจากแหล่งน้ำสาธารณะ (ชื่อแหล่งน้ำ).....

   ประมาณ.....(เมตร/กิโลเมตร)

8. ฟาร์มสุกรของท่านเคยประสบปัญหาเรื่องน้ำท่วมหรือไม่

( ) 1. เคย เมื่อปี พ.ศ..... ( ) 2. ไม่เคย

9. ท่านมีค่าใช้จ่ายจากการเลี้ยงสุกร จำนวน.....บาท/ปี

( ) 1. ค่าลูกสุกรที่ซื้อมาขุน จำนวน.....บาท/ปี

( ) 2. ค่าอาหารสุกร จำนวน.....บาท/เดือน

( ) 3. ค่าวัคซีนและยารักษาโรคสุกร จำนวน.....บาท/เดือน

( ) 4. ค่าจ้างคนงานเลี้ยงสุกร จำนวน.....บาท/เดือน

( ) 5. ค่าน้ำสำหรับเลี้ยงสุกร จำนวน.....บาท/เดือน

( ) 6. ค่าไฟฟ้าสำหรับเลี้ยงสุกร จำนวน.....บาท/เดือน

( ) 7. อื่นๆ..... จำนวน.....บาท/เดือน

10. ท่านมีรายได้สุทธิ (หักค่าใช้จ่ายแล้ว) จากการเลี้ยงสุกร จำนวน.....บาท/ปี

( ) 1. รายได้จากการจำหน่ายลูกสุกร จำนวน.....บาท/เดือน

( ) 2. รายได้จากการจำหน่ายสุกรขุน จำนวน.....บาท/เดือน

( ) 3. รายได้จากการขายมูลสุกร จำนวน.....บาท/เดือน

( ) 4. อื่นๆ..... จำนวน.....บาท/เดือน

ส่วนที่ 3 การจัดการของเสียและน้ำเสียภายในฟาร์ม

<u>คำชี้แจง</u> โปรดตอบทุกข้อด้วยการทำเครื่องหมาย / ลงใน ( ) ที่ท่านต้องการระบุเป็นคำตอบ และเติมตัวเลขหรือข้อความลงในช่องว่าง

1. ท่านล้างทำความสะอาดคอกสุกรบ่อยครั้ง เพียงใด

( ) 1. ไม่มีการล้าง ( ) 2. ล้างวันละ 1 ครั้ง

( ) 3. ล้างวันละ 2 ครั้ง ( ) 4. ล้างมากกว่าวันละ 2 ครั้ง

2. ก่อนการล้างทำความสะอาดคอก ท่านเก็บกวาดมูลสุกรออกจากพื้นคอกก่อนหรือไม่

( ) 1. ไม่เก็บกวาด ( ) 2. เก็บกวาดทุกวัน

( ) 3. เก็บกวาดวันเว้นวัน ( ) 4. นานๆ ครั้ง ระบุ.....วัน/ครั้ง

2.1 ท่านนำมูลสุกรที่เก็บกวาดออกจากพื้นคอกไปใช้ประโยชน์อย่างไร

( ) 1. กวาดทิ้งลงแหล่งน้ำสาธารณะโดยตรง ( ) 2. ทิ้งลงบ่อพักในฟาร์ม

( ) 3. ปล่อยทิ้งให้ซึมลงพื้นดินนอกฟาร์ม ( ) 4. นำไปเป็นอาหารสัตว์

( ) 5. นำไปตากแห้งเป็นปุ๋ยไว้ใช้หรือขาย ( ) 6. อื่นๆ ระบุ.....

3. ปัจจุบันท่านมีวิธีในการบำบัดน้ำเสียที่เกิดจากการเลี้ยงสุกรในฟาร์มของท่านอย่างไร

( ) 1. ไม่มีการบำบัด ( ) 2. ใช้ระบบถังกรองไร้อากาศ

( ) 3. ใช้ระบบบ่อปรับเสถียร ( ) 4. ใช้บ่อบำบัดธรรมชาติ

( ) 5. ใช้ระบบก๊าซชีวภาพ ( ) 6. อื่นๆ ระบุ.....

ปริมาณน้ำเสียที่เข้าสู่ระบบบำบัด.....ลูกบาศก์เมตร/วัน

ระบบบำบัดใช้พื้นที่ประมาณ.....ตารางเมตรหรือไร่

3.1 เหตุผลที่ทำให้ท่านตัดสินใจไม่นำระบบก๊าซชีวภาพมาใช้ภายในฟาร์มสุกรคือข้อใด

( ) 1. ใช้งบประมาณในการลงทุนสูง ( ) 2. ดูแลและบำรุงรักษาระบบยาก

( ) 3. ปริมาณมูลสัตว์มีไม่เพียงพอ ( ) 4. ไม่มีพื้นที่ว่างสำหรับก่อสร้างระบบ

( ) 5. ระบบรางและท่อส่งน้ำเสียมักอุดตัน ( ) 6. อื่นๆ ระบุ.....

3.2 ระบบก๊าซชีวภาพที่ท่านนำมาใช้ในการบำบัดน้ำเสีย เป็นรูปแบบใด

( ) 1. แบบโดมคงที่ (Fixed Dome) ( ) 2. แบบพลาสติกคลุมบ่อ (Covered Lagoon)

( ) 3. แบบบ่อหมักรางและบ่อยูเอเอสบี (MC-UASB) ( ) 4. อื่นๆ ระบุ.....

3.3 ท่านนำก๊าซชีวภาพที่ได้จากระบบบำบัดน้ำเสียไปใช้ในด้านใด

( ) 1. ใช้เป็นก๊าซหุงต้ม ( ) 2. ใช้เป็นพลังงานให้แสงสว่าง

( ) 3. ใช้เป็นพลังงานความร้อน ( ) 4. ใช้แทนน้ำมันเชื้อเพลิง ( ) 5. อื่นๆ ระบุ.....

3.4 เหตุผลสำคัญที่สุด ที่ท่านตัดสินใจนำระบบก๊าซชีวภาพมาใช้ภายในฟาร์มสุกรคือข้อใด

( ) 1. ได้ก๊าซชีวภาพไปใช้ประโยชน์ ( ) 2. ได้ปุ๋ยจากกากมูลสุกรไปใช้ประโยชน์

( ) 3. ลดกลิ่นเหม็นและแมลงวันรบกวน ( ) 4. ได้รับคำแนะนำจากหน่วยงานที่เกี่ยวข้อง

( ) 5. อื่นๆ ระบุ.....

ส่วนที่ 4 แบบวัดความคิดเห็นต่อการรวมกลุ่มฟาร์มสุกรในการก่อสร้างระบบก๊าซชีวภาพเพื่อการผลิตไฟฟ้า

<u>คำชี้แจง</u> โปรดทำเครื่องหมาย / ลงในช่องว่างที่ตรงกับความรู้สึกและความคิดเห็นของท่านมากที่สุดตามข้อความต่อไปนี้

ข้อความ	มากที่สุด	มาก	ปานกลาง	น้อย	น้อยที่สุด
1. ท้องที่ของท่านกำลังประสบปัญหากลิ่นเหม็นรบกวน และน้ำในแม่น้ำ คู คลองเน่าเสียจากฟาร์มสุกร					
2. ท่านต้องร่วมรับผิดชอบต่อปัญหาความเน่าเสียของแม่น้ำ คู คลอง ที่เกิดจากการเลี้ยงสุกร					
3. ของเสียและน้ำเสียจากฟาร์มสุกรทำให้น้ำในแม่น้ำ คู คลอง นำมาใช้ประโยชน์ไม่ได้					
4. พื้นที่ที่ใช้ในการก่อสร้างระบบก๊าซชีวภาพแบบรวมกลุ่มฟาร์ม					
5. งบประมาณในการลงทุนก่อสร้างระบบก๊าซชีวภาพแบบรวมกลุ่มฟาร์ม เมื่อเทียบกับรายได้ที่เกิดจากการเลี้ยงสุกร					
6. ความคล่องตัวในการบริหารจัดการและการตัดสินใจในระบบก๊าซชีวภาพแบบรวมกลุ่มฟาร์ม					
7. ค่าบำรุงรักษาระบบก๊าซชีวภาพแบบรวมกลุ่มฟาร์ม					
8. ระยะเวลาในการเริ่มก่อสร้างระบบก๊าซชีวภาพแบบรวมกลุ่มฟาร์มจนแล้วเสร็จสมบูรณ์					
9. ระบบก๊าซชีวภาพแบบรวมกลุ่มฟาร์ม ดูแลและบำรุงรักษายาก					

ส่วนที่ 4 แบบวัดความคิดเห็นต่อการรวมกลุ่มฟาร์มสุกรในการก่อสร้างระบบก๊าซชีวภาพเพื่อการผลิตไฟฟ้า (ต่อ)

ข้อความ	มากที่สุด	มาก	ปานกลาง	น้อย	น้อยที่สุด
10. ผลพลอยได้จากระบบแบบรวมกลุ่มฟาร์มในด้านเศรษฐกิจได้แก่ เชื้อเพลิงทดแทน ปุ๋ยอินทรีย์ น้ำที่ผ่านการบำบัด					
11. ความสามารถในการบำบัดน้ำเสียของระบบก๊าซชีวภาพแบบรวมกลุ่มฟาร์ม					
12. การรวมกลุ่มฟาร์มสุกรในการก่อสร้างระบบก๊าซชีวภาพเพื่อการผลิตไฟฟ้า สามารถลดปัญหามลพิษในแม่น้ำ คู คลอง ได้					
13. ท้องที่ของท่านเหมาะสมที่จะมีการก่อสร้างระบบก๊าซชีวภาพแบบรวมกลุ่มฟาร์มสุกรเพื่อการผลิตไฟฟ้า					
14. ท่านต้องการให้ท้องที่ของท่านเป็นพื้นที่ตัวอย่างในการก่อสร้างระบบก๊าซชีวภาพแบบรวมกลุ่มฟาร์มสุกรเพื่อการผลิตไฟฟ้า					
15. ถ้ามีกฎหมายบังคับให้ฟาร์มสุกรทุกขนาดต้องทำการบำบัดให้ น้ำที่ทิ้งออกภายนอกฟาร์มมีค่าอยู่ในเกณฑ์มาตรฐานน้ำทิ้งที่กำหนด ท่านต้องการจะรวมกลุ่มฟาร์มเพื่อก่อสร้างระบบก๊าซชีวภาพ					
16. ท่านยินดีเข้าร่วมโครงการ ถ้าในท้องที่ของท่านมีการก่อสร้างระบบก๊าซชีวภาพแบบรวมกลุ่มฟาร์มสุกรเพื่อการผลิตไฟฟ้า					
17. ท่านต้องการชมการรวมกลุ่มฟาร์มสุกรในการก่อสร้างระบบก๊าซชีวภาพเพื่อการผลิตไฟฟ้า จากพื้นที่ตัวอย่าง					
18. หน่วยงานภาครัฐ ควรส่งเสริมการรวมกลุ่มฟาร์มสุกรในการก่อสร้างระบบก๊าซชีวภาพเพื่อผลิตไฟฟ้าเพื่อลดปัญหาการเน่าเสียของแม่น้ำ คู คลอง ที่เกิดจากการเลี้ยงสุกร					

ส่วนที่ 5 ปัญหาและอุปสรรคที่มีผลต่อการรวมกลุ่มฟาร์มสุกรในการก่อสร้างระบบก๊าซชีวภาพเพื่อการผลิตไฟฟ้า รวมทั้งข้อเสนอแนะ

<u>คำชี้แจง</u> กรุณาระบุปัญหา อุปสรรค และข้อเสนอแนะในการแก้ไขปัญหาอุปสรรคที่มีผลต่อการรวมกลุ่มฟาร์มสุกรในการก่อสร้างระบบก๊าซชีวภาพเพื่อการผลิตไฟฟ้าที่เหมาะสม ตามความคิดของท่าน

5.1 ปัญหาและอุปสรรคที่ทำให้ท่านไม่คิดจะเข้ารวมกลุ่มฟาร์มสุกรในการก่อสร้างระบบก๊าซชีวภาพเพื่อการผลิตไฟฟ้า คืออะไร

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5.2 ในความคิดเห็นของท่าน ท่านคิดว่าหน่วยงานราชการที่เกี่ยวข้อง ควรดำเนินการอย่างไร จึงจะทำให้เกิดการรวมกลุ่มฟาร์มสุกรในการก่อสร้างระบบก๊าซชีวภาพเพื่อการผลิตไฟฟ้า ในท้องที่ของท่าน

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5.3 ท่านคิดว่าสิ่งใดเป็นการสร้างแรงจูงใจแก่ผู้ประกอบการในการลงทุนก่อสร้างระบบก๊าซชีวภาพแบบรวมกลุ่มฟาร์มสุกรเพื่อการผลิตไฟฟ้า

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5.4 ข้อคิดเห็นและข้อเสนอแนะอื่นๆ

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APPENDIX B

แบบสัมภาษณ์
สำหรับผู้ประกอบการเลี้ยงสุกรที่มีการรวมกลุ่มฟาร์มเพื่อผลิตก๊าซชีวภาพ

เรื่อง การวิเคราะห์ความคุ้มค่าทางการเงินในการลงทุนก่อสร้างระบบก๊าซชีวภาพแบบรวมกลุ่มฟาร์มเพื่อผลิตไฟฟ้า : กรณีศึกษาฟาร์มสุกรขนาดกลางและขนาดเล็ก เทศบาลตำบลท่าเสด็จ อำเภอเมือง จังหวัดสุพรรณบุรี

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แบบสัมภาษณ์ฉบับนี้เป็นส่วนหนึ่งของการทำวิทยานิพนธ์ โดยนางสาวสุภัทรา อ่ำเกิด นักศึกษาปริญญาโท หลักสูตรปริญญาวิทยาศาสตรมหาบัณฑิต สาขาวิชาเทคโนโลยีการบริหารสิ่งแวดล้อม (ภาคพิเศษ) คณะสิ่งแวดล้อมและทรัพยากรศาสตร์ มหาวิทยาลัยมหิดล ขอให้ผู้ตอบแบบสัมภาษณ์กรุณาตอบคำถามทุกข้อให้ตรงกับความเป็นจริงมากที่สุด เพราะคำตอบของท่านจะเป็นประโยชน์อย่างยิ่งต่อการศึกษาวิจัยในครั้งนี้ โดยคำตอบที่ได้รับจะถือเป็นความลับ และจะนำเสนอผลการวิจัยในลักษณะรวมๆ เท่านั้น

แบบสัมภาษณ์ฉบับนี้มี 5 ตอน ประกอบด้วย:

ตอนที่ 1 ถามเกี่ยวกับข้อมูลส่วนบุคคล สภาพเศรษฐกิจ และสังคม

ตอนที่ 2 ถามเกี่ยวกับข้อมูลทั่วไปของฟาร์ม

ตอนที่ 3 ถามเกี่ยวกับการจัดการของเสียและน้ำเสียภายในฟาร์ม

ตอนที่ 4 แบบวัดความคิดเห็นต่อการรวมกลุ่มฟาร์มสุกรในการก่อสร้างระบบก๊าซชีวภาพเพื่อการผลิตไฟฟ้า

ตอนที่ 5 ถามเกี่ยวกับปัญหาและอุปสรรคที่มีผลต่อการรวมกลุ่มฟาร์มสุกรในการก่อสร้างระบบก๊าซชีวภาพเพื่อการผลิตไฟฟ้า รวมทั้งข้อเสนอแนะ

ชื่อฟาร์ม.....

เลขที่.....หมู่ที่.....ตำบล.....อำเภอ..... จังหวัด.....

ชื่อผู้ตอบแบบสอบถาม (นาย/นาง/นางสาว) .....

บ้านเลขที่..... หมู่ที่.....ตำบล.....อำเภอ..... จังหวัด.....

ตำแหน่งหน้าที่รับผิดชอบ.....

ส่วนที่ 1 ข้อมูลส่วนบุคคล สภาพเศรษฐกิจ และสังคม

<u>คำชี้แจง</u> โปรดตอบทุกข้อด้วยการทำเครื่องหมาย / ลงใน ( ) ที่ท่านต้องการระบุเป็นคำตอบ และเติมตัวเลขหรือข้อความลงในช่องว่าง

1. เพศ ( ) ชาย ( ) หญิง
2. อายุ ..... ปี
3. ระดับการศึกษาสูงสุด

( ) 1. ไม่ได้เรียนหนังสือ ( ) 2. ประถมศึกษา

( ) 3. มัธยมศึกษา/ปวช. ( ) 4. อนุปริญญา/ปวส./ปวท.

( ) 5. ปริญญาตรี ( ) 6. สูงกว่าปริญญาตรี

4. ท่านเริ่มประกอบอาชีพการเลี้ยงสุกรมาเป็นเวลา.....ปี
5. ปัจจุบันท่านเป็นสมาชิกกลุ่มหรือสมาคมผู้เลี้ยงสุกรหรือไม่

( ) 1. ไม่เป็น

( ) 2. เป็น ระบุชื่อกลุ่มหรือสมาคม.....

6. ท่านเคยรับทราบข่าวสารหรือความรู้เรื่องระบบก๊าซชีวภาพหรือไม่

( ) 1. เคย ( ) 2. ไม่เคย

6.1 ท่านเคยรับทราบข่าวสารหรือความรู้เรื่องระบบก๊าซชีวภาพ จากแหล่งใด (ตอบได้มากกว่า 1 ข้อ)

( ) 1. หนังสือพิมพ์ ( ) 2. วิทยุ

( ) 3. โทรทัศน์ ( ) 4. วารสาร

( ) 5. แผ่นพับหรือใบปลิว ( ) 6. ป้ายโฆษณาต่างๆ

( ) 7. สมาชิกในครอบครัว ( ) 8. เพื่อนบ้าน

( ) 9. กลุ่มหรือสมาคม ( ) 10. เจ้าหน้าที่ของรัฐ

( ) 11. อื่นๆ ระบุ.....

7. ท่านมีใบอนุญาตประกอบกิจการที่เป็นอันตรายต่อสุขภาพหรือไม่

( ) 1. มี ออกให้โดย.....

เมื่อวันที่.....วันหมดอายุ.....

( ) 2. ไม่มี

ส่วนที่ 2 ข้อมูลทั่วไปของฟาร์ม

<u>คำชี้แจง</u> โปรดตอบทุกข้อด้วยการทำเครื่องหมาย / ลงใน ( ) ที่ท่านต้องการระบุเป็นคำตอบ และเติมตัวเลขหรือข้อความลงในช่องว่าง

1. ประเภทและจำนวนสุกรที่เลี้ยง

( ) 1. สุกรพ่อ – แม่พันธุ์ จำนวน.....ตัว

( ) 2. สุกรขุน จำนวน.....ตัว

( ) 3. ลูกสุกร จำนวน.....ตัว

รวมจำนวนฟาร์มสุกรทั้งหมด.....ตัว

2. ฟาร์มสุกรของท่านมีพื้นที่ทั้งหมด.....ไร่.....งาน.....ตารางวา

( ) 1. เป็นพื้นที่ของตนเอง จำนวน.....ไร่.....งาน.....ตารางวา

( ) 2. เป็นที่ดินเช่า จำนวน.....ไร่.....งาน.....ตารางวา

3. จำนวนโรงเรือน

( ) 1. โรงเรือนสุกรพ่อ – แม่พันธุ์ จำนวน.....หลัง

( ) 2. โรงเรือนสุกรขุน จำนวน.....หลัง

4. ปริมาณมูลสุกร/วัน ประมาณ..... กิโลกรัม/วัน

5. ท่านมีแรงงานที่ใช้ในการเลี้ยงสุกร จำนวน.....คน ได้แก่

( ) 1. แรงงานจากครอบครัวของท่าน จำนวน.....คน

( ) 2. แรงงานรับจ้าง จำนวน.....คน

6. ท่านนำน้ำจากแหล่งใดมาใช้ภายในฟาร์ม (ตอบได้มากกว่า 1 ข้อ)

( ) 1. น้ำประปา ( ) 2. น้ำใต้ดิน ( ) 3. น้ำบ่อตื้น

( ) 4. แหล่งน้ำสาธารณะ ( ) 5. อื่นๆ โปรดระบุ.....

7. ฟาร์มสุกรของท่านอยู่ห่างจากแหล่งน้ำสาธารณะ (ชื่อแหล่งน้ำ).....

ประมาณ.....(เมตร/กิโลเมตร)

8. ฟาร์มสุกรของท่านเคยประสบปัญหาเรื่องน้ำท่วมหรือไม่

( ) 1. เคย เมื่อปี พ.ศ..... ( ) 2. ไม่เคย

9. ท่านมีค่าใช้จ่ายจากการเลี้ยงสุกร จำนวน.....บาท/ปี

( ) 1. ค่าลูกสุกรที่ซื้อมาขุน จำนวน.....บาท/ปี

( ) 2. ค่าอาหารสุกร จำนวน.....บาท/เดือน

( ) 3. ค่าวัคซีนและยารักษาโรคสุกร จำนวน.....บาท/เดือน

( ) 4. ค่าจ้างคนงานเลี้ยงสุกร จำนวน.....บาท/เดือน

( ) 5. ค่าน้ำสำหรับเลี้ยงสุกร จำนวน.....บาท/เดือน

( ) 6. ค่าไฟฟ้าสำหรับเลี้ยงสุกร จำนวน.....บาท/เดือน

( ) 7. อื่นๆ..... จำนวน.....บาท/เดือน

10. ท่านมีรายได้สุทธิ (หักค่าใช้จ่ายแล้ว) จากการเลี้ยงสุกร จำนวน.....บาท/ปี

( ) 1. รายได้จากการจำหน่ายลูกสุกร จำนวน.....บาท/เดือน

( ) 2. รายได้จากการจำหน่ายสุกรขุน จำนวน.....บาท/เดือน

( ) 3. รายได้จากการขายมูลสุกร จำนวน.....บาท/เดือน

( ) 4. อื่นๆ..... จำนวน.....บาท/เดือน

ส่วนที่ 3 การจัดการของเสียและน้ำเสียภายในฟาร์ม

<u>คำชี้แจง</u> โปรดตอบทุกข้อด้วยการทำเครื่องหมาย / ลงใน ( ) ที่ท่านต้องการระบุเป็นคำตอบ และเติมตัวเลขหรือข้อความลงในช่องว่าง

1. ท่านล้างทำความสะอาดคอกสุกรบ่อยครั้ง เพียงใด

( ) 1. ไม่มีการล้าง ( ) 2. ล้างวันละ 1 ครั้ง

( ) 3. ล้างวันละ 2 ครั้ง ( ) 4. ล้างมากกว่าวันละ 2 วัน

2. ก่อนการล้างทำความสะอาดคอก ท่านเก็บกวาดมูลสุกรออกจากพื้นคอกก่อนหรือไม่

( ) 1. ไม่เก็บกวาด ( ) 2. เก็บกวาดทุกวัน

( ) 3. เก็บกวาดวันเว้นวัน ( ) 4. นานๆ ครั้ง ระบุ.....วัน/ครั้ง

2.1 ท่านนำมูลสุกรที่เก็บกวาดออกจากพื้นคอกไปใช้ประโยชน์อย่างไร (ตอบได้มากกว่า 1 ข้อ)

( ) 1. กวาดทิ้งลงแหล่งน้ำสาธารณะโดยตรง ( ) 2. ทิ้งลงบ่อพักในฟาร์ม

( ) 3. ปล่อยทิ้งให้ซึมลงพื้นดินนอกฟาร์ม ( ) 4. นำไปเป็นอาหารสัตว์

( ) 5. นำไปตากแห้งเป็นปุ๋ยไว้ใช้หรือขาย ( ) 6. อื่นๆ ระบุ.....

3. ก่อนเข้าร่วมโครงการนำร่องระบบการจัดการน้ำเสียรวมจากฟาร์มสุกร ของกรมควบคุมมลพิษ ท่านมีวิธีในการบำบัดน้ำเสียที่เกิดจากการเลี้ยงสุกรในฟาร์มของท่านอย่างไร

( ) 1. ไม่มีการบำบัด ( ) 2. ใช้ระบบถังกรองไร้อากาศ

( ) 3. ใช้ระบบบ่อปรับเสถียร ( ) 4. ใช้บ่อบำบัดธรรมชาติ

( ) 5. ใช้ระบบก๊าซชีวภาพ ( ) 4. อื่นๆ ระบุ.....

3.1 ระบบก๊าซชีวภาพที่ท่านนำมาใช้ในการบำบัดน้ำเสีย เป็นรูปแบบใด

( ) 1. แบบโดมคงที่ (Fixed Dome)

( ) 2. แบบพลาสติกคลุมบ่อ (Covered Lagoon)

( ) 3. แบบบ่อหมักรางและบ่อยูเอเอสบี (MC-UASB)

4. ในช่วงเข้าร่วมโครงการนำร่องระบบการจัดการน้ำเสียรวมจากฟาร์มสุกร ของกรมควบคุมมลพิษ กลุ่มของท่านใช้ระบบก๊าซชีวภาพรูปแบบใด

( ) 1. แบบโดมคงที่ (Fixed Dome)

( ) 2. แบบพลาสติกคลุมบ่อ (Covered Lagoon)

( ) 3. แบบบ่อหมักรางและบ่อยูเอเอสบี (MC-UASB)

ปริมาณน้ำเสียที่เข้าสู่ระบบบำบัด.....ลูกบาศก์เมตร/วัน

ระบบบำบัดใช้พื้นที่ประมาณ.....ตารางเมตรหรือไร่

4.1 กลุ่มของท่านนำก๊าซชีวภาพที่ได้จากระบบบำบัดน้ำเสียไปใช้ในด้านใด

( ) 1. ใช้เป็นก๊าซหุงต้ม ( ) 2. ใช้เป็นพลังงานให้แสงสว่าง

( ) 3. ใช้เป็นพลังงานความร้อน ( ) 4. ใช้แทนน้ำมันเชื้อเพลิง

( ) 5. อื่นๆ ระบุ.....

4.2 เหตุผลที่ท่านตัดสินใจเข้าร่วมโครงการนำร่องระบบการจัดการน้ำเสียรวมจากฟาร์มสุกร ของกรมควบคุมมลพิษ คือข้อใด

( ) 1. ได้ก๊าซชีวภาพไปใช้ประโยชน์ ( ) 2. ได้ปุ๋ยจากกากมูลสุกรไปใช้ประโยชน์

( ) 3. ลดกลิ่นเหม็นและแมลงวันรบกวน ( ) 4. มีพื้นที่ว่างภายในฟาร์มไม่เพียงพอ

( ) 5. ใช้งบประมาณในการลงทุนน้อย ( ) 6. ได้รับคำแนะนำจากหน่วยงานที่เกี่ยวข้อง

( ) 5. อื่นๆ ระบุ.....

4.3 เหตุผลที่ทำให้โครงการนำร่องระบบการจัดการน้ำเสียรวมจากฟาร์มสุกร ของกรมควบคุมมลพิษ ไม่ประสบความสำเร็จในพื้นที่ของท่านคือข้อใด

( ) 1. ดูแลและบำรุงรักษาระบบยาก ( ) 2. ระบบรางและท่อส่งน้ำเสียมักอุดตัน

( ) 3. ระบบบำบัดไม่มีประสิทธิภาพ ( ) 4. ไม่ได้รับความร่วมมือจากสมาชิกกลุ่ม

( ) 5. ปริมาณก๊าซชีวภาพที่ได้ไม่เพียงพอ ( ) 6. ปริมาณมูลสัตว์มีไม่เพียงพอ

( ) 7. ไม่ได้รับการสนับสนุนจากหน่วยงานของรัฐอย่างต่อเนื่อง ( ) 8. อื่นๆ ระบุ.....

ส่วนที่ 4 แบบวัดความคิดเห็นต่อการรวมกลุ่มฟาร์มสุกรในการก่อสร้างระบบก๊าซชีวภาพเพื่อการผลิตไฟฟ้า

<u>คำชี้แจง</u> โปรดทำเครื่องหมาย / ลงในช่องว่างที่ตรงกับความรู้สึกและความคิดเห็นของท่านมากที่สุดตามข้อความต่อไปนี้

ข้อความ	มากที่สุด	มาก	ปานกลาง	น้อย	น้อยที่สุด
1. ท้องที่ของท่านกำลังประสบปัญหากลิ่นเหม็นรบกวน และน้ำในแม่น้ำ คู คลองเน่าเสียจากฟาร์มสุกร					
2. ท่านต้องร่วมรับผิดชอบต่อปัญหาความเน่าเสียของแม่น้ำ คู คลอง ที่เกิดจากการเลี้ยงสุกร					
3. ของเสียและน้ำเสียจากฟาร์มสุกรทำให้น้ำในแม่น้ำ คู คลอง นำมาใช้ประโยชน์ไม่ได้					
4. พื้นที่ที่ใช้ในการก่อสร้างระบบก๊าซชีวภาพแบบรวมกลุ่มฟาร์ม					
5. งบประมาณในการลงทุนก่อสร้างระบบก๊าซชีวภาพแบบรวมกลุ่มฟาร์ม เมื่อเทียบกับรายได้ที่เกิดจากการเลี้ยงสุกร					
6. ความคล่องตัวในการบริหารจัดการและการตัดสินใจในระบบก๊าซชีวภาพแบบรวมกลุ่มฟาร์ม					
7. ค่าบำรุงรักษาระบบก๊าซชีวภาพแบบรวมกลุ่มฟาร์ม					
8. ระยะเวลาในการเริ่มก่อสร้างระบบก๊าซชีวภาพแบบรวมกลุ่มฟาร์มจนแล้วเสร็จสมบูรณ์					
9. ระบบก๊าซชีวภาพแบบรวมกลุ่มฟาร์ม ดูแลและบำรุงรักษายาก					
10. ผลพลอยได้จากระบบแบบรวมกลุ่มฟาร์มในด้านเศรษฐกิจได้แก่ เชื้อเพลิงทดแทน ปุ๋ยอินทรีย์ น้ำที่ผ่านการบำบัด					
11. ความสามารถในการบำบัดน้ำเสียของระบบก๊าซชีวภาพแบบรวมกลุ่มฟาร์ม					

ส่วนที่ 4 แบบวัดความคิดเห็นต่อการรวมกลุ่มฟาร์มสุกรในการก่อสร้างระบบก๊าซชีวภาพเพื่อการผลิตไฟฟ้า (ต่อ)

ข้อความ	มากที่สุด	มาก	ปานกลาง	น้อย	น้อยที่สุด
12. การรวมกลุ่มฟาร์มสุกรในการก่อสร้างระบบก๊าซชีวภาพเพื่อการผลิตไฟฟ้า สามารถลดปัญหามลพิษในแม่น้ำ คู คลอง ได้					
13. ท้องที่ของท่านเหมาะสมที่จะมีการก่อสร้างระบบก๊าซชีวภาพแบบรวมกลุ่มฟาร์มสุกรเพื่อการผลิตไฟฟ้า					
14. ท่านต้องการให้ท้องที่ของท่านเป็นพื้นที่ตัวอย่างในการก่อสร้างระบบก๊าซชีวภาพแบบรวมกลุ่มฟาร์มสุกรเพื่อการผลิตไฟฟ้า					
15. ถ้ามีกฎหมายบังคับให้ฟาร์มสุกรทุกขนาดต้องทำการบำบัดให้ น้ำที่ทิ้งออกภายนอกฟาร์มมีค่าอยู่ในเกณฑ์มาตรฐานน้ำทิ้งที่กำหนด ท่านต้องการจะรวมกลุ่มฟาร์มเพื่อก่อสร้างระบบก๊าซชีวภาพ					
16. ท่านยินดีเข้าร่วมโครงการ ถ้าในท้องที่ของท่านมีการก่อสร้างระบบก๊าซชีวภาพแบบรวมกลุ่มฟาร์มสุกรเพื่อการผลิตไฟฟ้า					
17. ท่านต้องการชมการรวมกลุ่มฟาร์มสุกรในการก่อสร้างระบบก๊าซชีวภาพเพื่อการผลิตไฟฟ้า จากพื้นที่ตัวอย่าง					
18. หน่วยงานภาครัฐ ควรส่งเสริมการรวมกลุ่มฟาร์มสุกรในการก่อสร้างระบบก๊าซชีวภาพเพื่อผลิตไฟฟ้าเพื่อลดปัญหาการเน่าเสียของแม่น้ำ คู คลอง ที่เกิดจากการเลี้ยงสุกร					

ส่วนที่ 5 ปัญหาและอุปสรรคที่มีผลต่อการรวมกลุ่มฟาร์มสุกรในการก่อสร้างระบบก๊าซชีวภาพเพื่อการผลิตไฟฟ้า รวมทั้งข้อเสนอแนะ

<u>คำชี้แจง</u> กรุณาระบุปัญหา อุปสรรค และข้อเสนอแนะในการแก้ไขปัญหาอุปสรรคที่มีผลต่อการรวมกลุ่มฟาร์มสุกรในการก่อสร้างระบบก๊าซชีวภาพเพื่อการผลิตไฟฟ้าที่เหมาะสม ตามความคิดของท่าน

5.1 ปัญหาและอุปสรรคในการดำเนินงานโครงการนำร่องระบบการจัดการน้ำเสียรวมจากฟาร์มสุกร (รวมกลุ่มฟาร์มสุกรเพื่อการก่อสร้างระบบก๊าซชีวภาพ) คืออะไร

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5.2 ในความคิดเห็นของท่าน ท่านคิดว่ามีปัจจัยอะไรบ้างที่ทำให้เกิดการรวมกลุ่มฟาร์มสุกรเพื่อการก่อสร้างระบบก๊าซชีวภาพในพื้นที่ของท่าน

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5.3 ท่านคิดว่าหน่วยงานภาครัฐ ภาคเอกชน และผู้ประกอบการเลี้ยงสุกร ควรดำเนินการอย่างไร จึงจะทำให้การรวมกลุ่มฟาร์มสุกรเพื่อก่อสร้างระบบก๊าซชีวภาพดำเนินการได้อย่างต่อเนื่องและมีประสิทธิภาพ

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5.4 ท่านคิดว่าสิ่งใดเป็นการสร้างแรงจูงใจแก่ผู้ประกอบการในการลงทุนก่อสร้างระบบก๊าซชีวภาพแบบรวมกลุ่มฟาร์มสุกรเพื่อการผลิตไฟฟ้า

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5.5 ข้อคิดเห็นและข้อเสนอแนะอื่นๆ

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APPENDIX C

แบบสัมภาษณ์เชิงลึก
สำหรับหน่วยงานที่เกี่ยวข้อง

เรื่อง การวิเคราะห์ความคุ้มค่าทางการเงินในการลงทุนก่อสร้างระบบก๊าซชีวภาพแบบรวมกลุ่มฟาร์มเพื่อผลิตไฟฟ้า : กรณีศึกษาฟาร์มสุกรขนาดกลางและขนาดเล็ก เทศบาลตำบลท่าเสด็จ อำเภอเมือง จังหวัดสุพรรณบุรี

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แบบสัมภาษณ์ฉบับนี้เป็นส่วนหนึ่งของการทำวิทยานิพนธ์ โดยนางสาวสุภัทรา อ่ำเกิด นักศึกษาปริญญาโท หลักสูตรปริญญาวิทยาศาสตรมหาบัณฑิต สาขาวิชาเทคโนโลยีการบริหารสิ่งแวดล้อม (ภาคพิเศษ) คณะสิ่งแวดล้อมและทรัพยากรศาสตร์ มหาวิทยาลัยมหิดล ขอให้ผู้ตอบแบบสัมภาษณ์กรุณาตอบคำถามทุกข้อให้ตรงกับความเป็นจริงมากที่สุด เพราะคำตอบของท่านจะเป็นประโยชน์อย่างยิ่งต่อการศึกษาวิจัยในครั้งนี้ โดยคำตอบที่ได้รับจะถือเป็นความลับ และจะนำเสนอผลการวิจัยในลักษณะรวมๆ เท่านั้น

แบบสัมภาษณ์ฉบับนี้มี 4 ตอน ประกอบด้วย:

ตอนที่ 1 ถามเกี่ยวกับสภาพทั่วไปและข้อมูลพื้นฐาน

ตอนที่ 2 ถามเกี่ยวกับสถานการณ์และประเด็นปัญหาด้านสิ่งแวดล้อมในพื้นที่รับผิดชอบ

ตอนที่ 3 ถามเกี่ยวกับแผนงาน/โครงการ/กิจกรรม แก้ไขปัญหาของเสียและน้ำเสียจากฟาร์มสุกรของหน่วยงาน

ตอนที่ 4 ถามเกี่ยวกับปัญหา อุปสรรค และข้อเสนอแนะ

ชื่อผู้ให้สัมภาษณ์.....

ตำแหน่ง.....

สังกัดหน่วยงาน.....

ที่ตั้งหน่วยงาน.....

เบอร์โทรศัพท์.....โทรสาร.....

E-mail.....

<u>ตอนที่ 1</u> สถานภาพทั่วไปและข้อมูลพื้นฐาน

<u>คำชี้แจง</u> โปรดตอบคำถามทุกข้อด้วยการเติมข้อความลงในช่องว่าง

1. ลักษณะที่ตั้ง.....

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2. เนื้อที่.....

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3. ลักษณะภูมิประเทศและอาณาเขตติดต่อ.....

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4. จำนวนประชากร.....

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5. ด้านทรัพยากรธรรมชาติและสิ่งแวดล้อม.....

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ตอนที่ 2 <u>สถานการณ์และประเด็นปัญหาด้านสิ่งแวดล้อมในพื้นที่รับผิดชอบ</u>

<u>คำชี้แจง</u> โปรดตอบคำถามทุกข้อด้วยการเติมข้อความและแสดงความคิดเห็นลงในช่องว่าง

1. หน่วยงานของท่านมีภารกิจหลัก/ อำนาจหน้าที่/ขอบเขตงานของหน่วยงานในด้านสิ่งแวดล้อมอย่างไรบ้าง

1.1 .....

1.2.....

1.3.....

1.4.....

2. ในพื้นที่รับผิดชอบของท่านมีผู้ประกอบการเลี้ยงสุกรจำนวน.....ราย

2.1 ผู้ประกอบการเลี้ยงสุกรขนาดกลาง จำนวน .....ราย

2.2 ผู้ประกอบการเลี้ยงสุกรขนาดกลาง จำนวน .....ราย

3. จัดลำดับความสำคัญเร่งด่วนของปัญหาด้านสิ่งแวดล้อมในพื้นที่ และมีแนวทางหรือมาตรการในการแก้ไขปัญหาที่ผ่านมาอย่างไร

3.1 .....

การแก้ไขปัญหา.....

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3.2.....

การแก้ไขปัญหา.....

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3.3.....

การแก้ไขปัญหา.....

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3.4.....

การแก้ไขปัญหา .....

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4. รอบปีที่ผ่านมาจนถึงปัจจุบัน หน่วยงานของท่านเคยได้รับเรื่องร้องเรียนกรณีฟาร์มสุกรปล่อยกลิ่นเหม็นรบกวนหรือปล่อยน้ำเสียลงสู่แหล่งน้ำสาธารณะหรือไม่ และมีแนวทางหรือมาตรการในการแก้ไขปัญหาดังกล่าวอย่างไร

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5. หน่วยงานของท่านเคยจัดอบรม สัมมนา หรือให้ความรู้แก่เกษตรกรผู้เลี้ยงสุกรในเรื่องการจัดการของเสียและน้ำเสียจากฟาร์มสุกร หรือไม่

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6. ท่านคิดว่าท้องที่ของท่านเหมาะสมที่จะมีการก่อสร้างระบบก๊าซชีวภาพแบบรวมกลุ่มฟาร์มสุกรเพื่อการผลิตไฟฟ้า หรือไม่ (แสดงเหตุผล)

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7. ท่านคิดว่ามีปัจจัยอะไรบ้างที่มีผลต่อการรวมกลุ่มฟาร์มสุกรในการก่อสร้างระบบก๊าซชีวภาพเพื่อการผลิตไฟฟ้า (แสดงเหตุผล)

7.1 .....

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7.2 .....

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7.3 .....

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7.4 .....

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<u>ตอนที่ 3</u> แผนงาน/โครงการ/กิจกรรม แก้ไขปัญหาของเสียและน้ำเสียจากฟาร์มสุกรของหน่วยงาน

1. รอบปีที่ผ่านมา หน่วยงานของท่านมีการดำเนินงานตามแผนงาน/โครงการ/กิจกรรมเพื่อการแก้ไขปัญหาของเสียและน้ำเสียจากฟาร์มสุกรหรือไม่ อย่างไร (หรือแนบเอกสารรายละเอียดแผนงาน/โครงการ)

ที่	โครงการ	วัตถุประสงค์	เป้าหมาย (ผลผลิต)	งบประมาณและที่มา (บาท)	ผลลัพธ์ที่คาดว่าจะได้รับ	หน่วยงานรับผิดชอบ

2. หน่วยงานของท่านมีการจัดทำแผนงาน/โครงการ/กิจกรรมเพื่อการแก้ไขปัญหาของเสียและน้ำเสียจากฟาร์มสุกรที่จะเกิดขึ้นในอนาคตหรือไม่ อย่างไร (หรือแนบเอกสารรายละเอียดแผนงาน/โครงการ)

ที่	โครงการ	วัตถุประสงค์	เป้าหมาย (ผลผลิต)	งบประมาณและที่มา			ผลลัพธ์ที่คาดว่าจะได้รับ	หน่วยงานรับผิดชอบ
				2552 (บาท)	2553 (บาท)	2554 (บาท)		

3. หน่วยงานของท่านเคยให้การสนับสนุนหรือส่งเสริมในการจัดสร้างระบบบำบัดน้ำเสียแก่ผู้ประกอบการเลี้ยงสุกรในพื้นที่รับผิดชอบบ้างหรือไม่ อย่างไร

<u>ตอนที่ 4</u>ปัญหา อุปสรรค และข้อเสนอแนะ

<u>คำชี้แจง</u> กรุณาระบุปัญหา อุปสรรค และข้อเสนอแนะในการแก้ไขปัญหาอุปสรรคที่มีผลต่อการรวมกลุ่มฟาร์มสุกรในการก่อสร้างระบบก๊าซชีวภาพเพื่อการผลิตไฟฟ้าที่เหมาะสม ตามความคิดของท่าน

4.1 หน่วยงานของท่านมีปัญหาและอุปสรรคในการจัดการแก้ไขปัญหาของเสียและน้ำเสียจากฟาร์มสุกรในพื้นที่รับผิดชอบหรือไม่ อย่างไร

4.2 ท่านคิดเห็นอย่างไรเกี่ยวกับโครงการก่อสร้างระบบก๊าซชีวภาพแบบรวมกลุ่มฟาร์มสุกรเพื่อการผลิตไฟฟ้า

เห็นด้วย เพราะ ---

ไม่เห็นด้วย เพราะ ---

4.4 ข้อคิดเห็นและข้อเสนอแนะอื่นๆ ---

BIOGRAPHY

NAME	Miss Supattra Um-Kerd
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