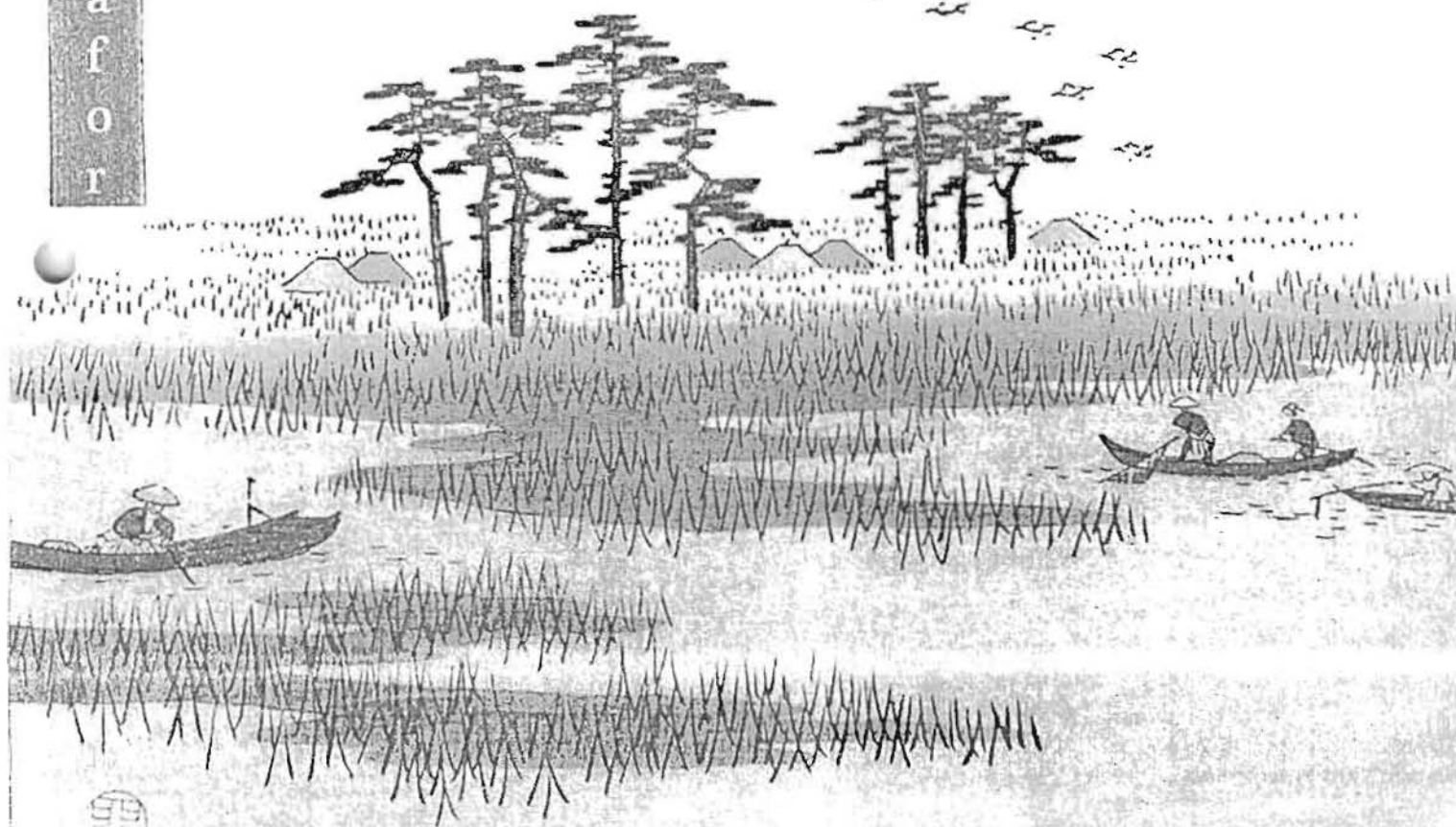


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The Asian Conference on Sustainability, Energy and the Environment

Osaka, Japan 2012

The Asian Conference on Sustainability, Energy and the Environment

Conference Proceedings 2012

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*Development of Electrical Generation System for Small Scale Pig Farm in Thailand
Rural Area*

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The Asian Conference on Sustainability, Energy and the Environment

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Abstract:

In Thailand total dairy pig in farm is estimated to be 5.4 million, mostly 1,574 farms is medium scale, which are approximately 2.3 million of pigs and 140 large farms were 1.5 million of pigs. The wastewater generated in the farm cause significant environmental problems. Biogas technology has been studied and applied in small, medium, and large scale projects. Operated as small businesses or cooperatives, there was several ways biogas technology can benefit a community. This research was presented a development of electrical generation system for small scale pig farm. Consider at 50 m³ of fixed dome. Biogas used to be the fuel for used gasoline engine 1500 cc. to drive induction generator, 5.5 kW, 380 V, 4 pole, with grid connection. From the experiment, it had found that the relationship between speed of induction generator, electrical power supply to grid, for find optimizing point of induction generator work done. The experiment supply electrical power to grid and comparison of electrical cost with and without electrical generation system. The result showed that 70 % of electrical cost was saved when the system was connected with the electrical generation system. This system have payback period at 2nd year.

1. Introduction

Renewable Energy is energy derived from resources that are regenerative or for all practical purposes non-depleting beside environmentally benign. By these qualities, renewable energy sources are fundamentally different from fossil fuels. Mankind's traditional uses of wind, water, and solar energy and geothermal are Renewable Energy is energy derived from resources that are regenerative or for all practical purposes non-depleting beside environmentally benign. By these qualities, renewable energy sources are fundamentally different from fossil fuels. Mankind's traditional uses of wind, water, and solar energy and geothermal are widespread in developed and developing countries; but the mass production of energy using renewable energy sources has become more commonplace recently, reflecting the major threats of climate change, depletion of fossil fuels, and the environmental, social and political risks of fossil fuels. Consequently, many countries promote renewable energies through tax incentives and subsidies. The role of new and renewable energy has been assuming increasing significance in recent times with the growing concern for the country's energy security. Vice versa fraction remains of consequence from agricultural industries and garbage from human and animal productivity can be used as a renewable energy source has. This will help maintain energy resources from nature as not to decrease. And maintain the balance of the world.

Since the 1940's and World War II. However, only since becoming a category of appropriate technology (a community development concept of the 1970's) have biogas systems enjoyed widespread success and failure. Why should biogas systems contribute to the community development process in both the developed and developing worlds?

This research was presented a development of electrical generation system for small scale pig farm in Thailand rural area. Biogas used to be the fuel for gasoline engine 1500 cc. to drive induction generator. Small scale system the induction generator was optimization. Because, low cost and easy to maintenance than synchronous generator.

2 Theory

2.1 Biogas

Biogas produced in AD-plants or landfill sites is primarily composed of methane (CH_4) and carbon dioxide (CO_2) with smaller amounts of hydrogen sulphide (H_2S) and ammonia (NH_3). Trace amounts of hydrogen (H_2), nitrogen (N_2), carbon monoxide (CO), saturated or halogenated carbohydrates and oxygen (O_2) are occasionally present in the biogas. Usually, the mixed gas is saturated with water vapors and may contain dust particles and siloxanes.

Table 1. Biogas Components

Type	Quantity
Methane (CH_4)	50 – 70 %
Carbon dioxide (CO_2)	25 – 35 %
Nitrogen (N_2)	2 – 7 %
Hydrogen (H_2)	1 – 5 %
Carbon monoxide (CO)	Slightly
Hydrogen sulphide (H_2S)	Slightly
Other	Slightly

The characteristics of biogas are somewhere in-between town gas (deriving from cracking of coles) and natural gas. The energy content is defined by the concentration of methane. 10 % of CH_4 in the dry gas correspond to approx. one kWh per m^3 .

2.2 Mechanism of Extraction

The fermentation process for formation of methane from cellulosic material through the agency of a group of organisms belonging to the family 'Methano bacteriaceae' is a complex biological and chemical process involving three main stages.



Fig. 1 Stage of mechanism of extraction

-Stage 1 Hydrolysis Process

Bacteria break down complex organic materials, such as carbohydrates and chain molecules, fruit acid material, protein and fats. The disintegration produces acetic acid, lactic acid, botanic acid, methanol, ethanol and butanol, as well as carbon dioxide, hydrogen, H_2S and other non-organic materials. In this stage the chief micro-organism are ones that break down polymers, fats, proteins and fruit acids, and the main action is the butanoic fermentation of polymer

-Stage 2. Actogenesis Process

In this stage, bacteria produce acetic acid and produced hydrogen and carbon dioxide population in to biogas.

-Stage 3. Methanogenesis Process

The simple organic materials and carbon dioxide that have been produced are either oxidized or reduced to methane by micro-organisms, the chief ones being the methane producing micro-organisms of which there are many varieties.

This stage may be represented by the following overall reactions:



Individual reactions include:

1. Acid breakdown into methane.



11. Oxidation of ethanol by CO_2 to produce methane and acetic acid.



iii. Reduction with hydrogen of carbon dioxide to produce methane.

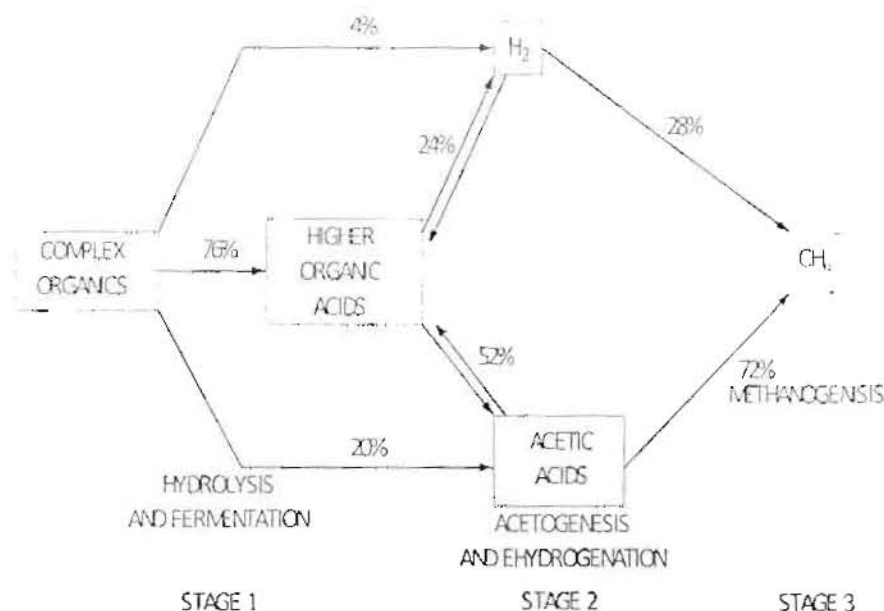


Fig. 2 Individual reactions include

A careful balance should be maintained between the two stages. If the first stage proceeds at a much higher rate than the second, acid will accumulate and inhibit the fermentation in the second stage, slow it down and actually stop it.

2.3 Fixed dome digester

Biogas is made by fermenting organic waste in a biogas digester. The size of a digester can vary from a small household system to a large commercial plant of several thousand cubic meters. Simple biogas digester designs have been developed; the Chinese fixed dome digester and the Indian floating cover biogas digester (shown in Fig. 3). The digestion process is the same in both digesters but the gas collection method is different in each. In the floating cover type, the water sealed cover of the digester rises as gas is produced and acts as a storage chamber, whereas the fixed dome type has a lower gas storage capacity and requires good sealing if gas leakage is to be prevented. Both have been designed for use with animal waste or dung. The waste is fed into the digester via the inlet pipe and undergoes digestion in the digestion chamber. The temperature of the process is quite important because methane-producing bacteria do their work best at temperatures between 30 – 40°C or 50 – 60°C. It takes from 2 to 8 weeks to digest a load of waste, depending on the temperature. The left-over slurry is removed at the outlet for use as a fertilizer

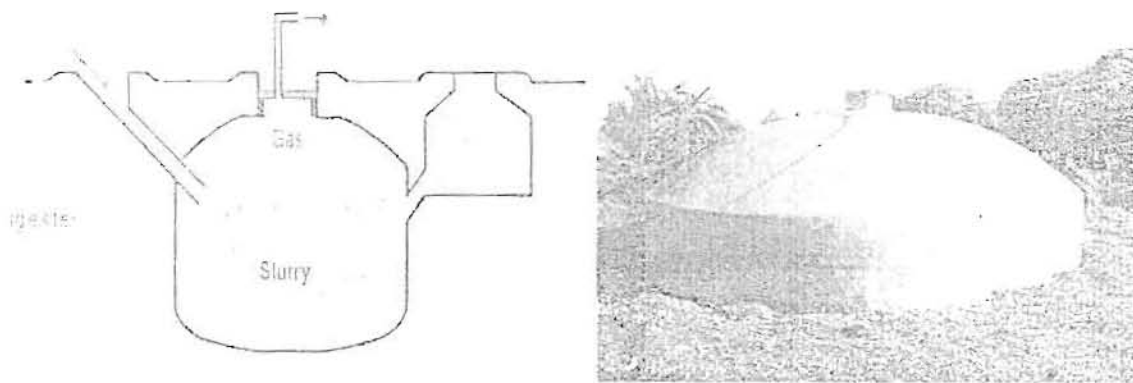


Fig. 3 Fixed dome digester

2.4 Methane Production

- Air tightness: Breakdown of organic materials in the presence of oxygen produces CO_2 and in absence of it produces methane. Thus it is crucial to have the Biogas pit airtight and watertight.

- Temperature: Temperature for fermentation will greatly affect biogas production. Depending on prevailing conditions methane can be produced within a fairly wide range of temperatures. However, the micro-organisms which take part in methane fermentation have the optimum activity at 30°C - 40°C . The production of biogas is fastest during summer and it decreases at lower temperatures during winter. Also methanogenic micro-organisms are very sensitive to temperature changes a sudden change exceeding 3°C will affect production, therefore one must ensure relative stability of temperature.

- pH: The micro-organism require a neutral or mildly alkaline environment will be detrimental a too acidic or too alkaline environment will be detrimental. Ideal pH value is between 7.0- 8.0 but can go up or down by further 0.5. The pH value depends on the ratio of acidity and alkalinity and the carbon dioxide content in the biogas digester, the determining factor being the density of the acids. For the normal process of fermentation, the concentration of volatile acid measured by acetic acid should be below 2000 parts per million, too high a concentration will greatly inhibit the action of the methanogenic micro-organisms.

- Solid Contents: Suitable solid contents of raw materials are 7-9%. Dilution should be in the ratio of 4:5 or in equal proportion.

- C/N ratio: A specific ratio of carbon to nitrogen must be maintained between 25:1 and 30:1. The ratio varies for different raw materials.

- Water Content: This should be about 90% of the weight of the total contents. With too much water the rate of production per unit volume in the pit will fall, preventing optimum use of the digester. If the water content is too low, acetic acid will accumulate, inhibiting the fermentation process and hence production and also thick scum will be formed on the surface. The water content differs according to the raw material used for fermentation.

- Nature of organic materials: Materials rich in cellulose and hemi-cellulose with sufficient protenaceous substance produce more gas. Complex polysaccharides are more favorable for methane formation while only protenaceous materials produce little quantity of gas. Lignin as such does not contribute of the gas production.

- Supplementary nutrients: In case of pig dung, as if contain all the nutrients need by organisms for the production of methane there is no necessity for addition of nutrients to it.

- Reaction period: Under optimum conditions 80-90% of total gas production of is obtained within a period 3-4 weeks. Size of the fermentation tank also decides the reaction period.

- Gas output: The exact amount of gas produced depends on various factors. In the first instance the amounts of animal droppings vary from animal to animal, feed given to animal, season of year,

whether the animal is stable bound or a free-grazing type etc. The following table gives an idea of the amount of gas available from different types of raw material. The figures however are likely to vary very widely

Material	Amount of gas (m ³ kg of fresh material)	
	Winter	Summer
Cattle dung	0.036	0.092
Night-soil	-	0.04
Pig dung	0.07	0.10
Poultry droppings	0.07	0.16

2.4 Induction Generators

The technology of induction generator is based on the relatively mature electric motor technology. Induction motors are perhaps the most common types of electric motors used throughout the industry. Early developments in induction generators were made using fixed capacitors for excitation, since suitable active power devices were not available. This resulted in unstable power output since the excitation could not be adjusted as the load or speed deviated from the nominal values. This approach became possible only where a large power system with infinite bus was available, such as in a utility power system. In this case the excitation was provided from the infinite bus. With the availability of high power switching devices, induction generator can be provided with adjustable excitation and operate in isolation in a stable manner with appropriate controls.

Induction generator also has two electromagnetic components: the rotating magnetic field constructed using high conductivity, high strength bars located in a slotted iron core to form a squirrel cage; and the stationary armature similar to the one described in the previous paragraph for PM technology. Figure 4 shows the construction of a typical induction generator in a cross sectional view.

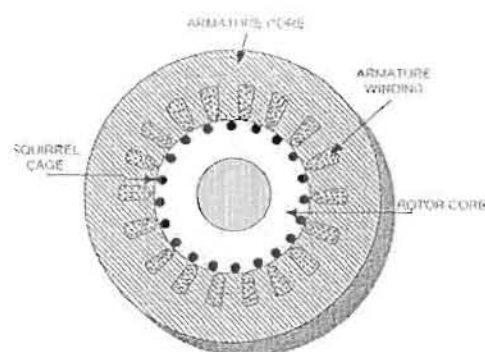


Fig.4 Squirrel cage induction generator cross-sectional view

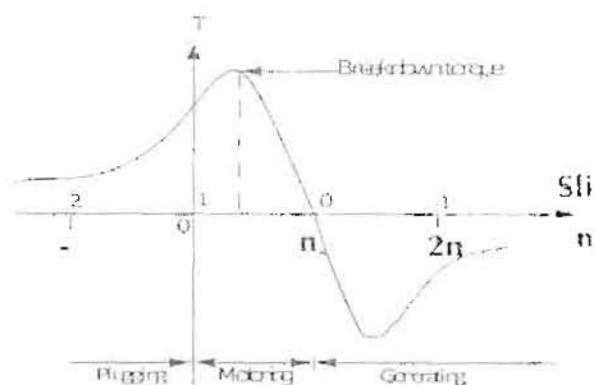


Fig. 5 Characteristic of torque and speed

2.5 Grid connected Induction Generator

Induction machine connected to grid system induction machine was operating as motor. Used prime mover driven induction machine have rotor speed than synchronous speed ($N_r > N_s$) induction machine operating as generator. Real power supplied to grid system and grid system supplied active power to induction machine used to excited electromagnetic field. Output voltage and output frequency same as grid system

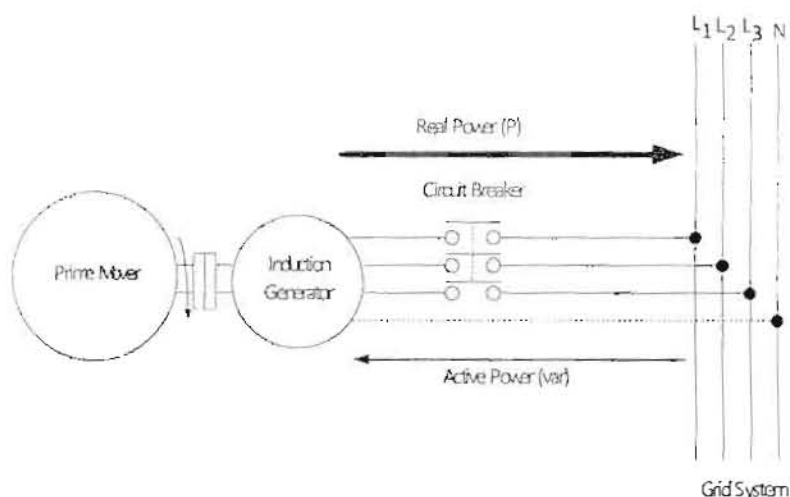


Fig. 6 Grid connection

2.6 Stationary engines (CHP)

Biogas can be used for all applications designed for natural gas. Not all gas appliances require the same gas standards. There is a considerable difference between the requirements of stationary biogas applications and fuel gas or pipeline quality. The utilization of biogas in internal combustion engines is a long established and extremely reliable technology. Thousands of engines are operated on sewage works, landfill sites and biogas installations. The engine sizes range from 45kW (which corresponds to approximate 12 kW_{el}) on small farms up to several MW on large scale landfill sites. Gas engines do have comparable requirements for gas quality as boilers except that the H₂S should be lower to guarantee a reasonable operation time of the engine. Otto engines designed to run on petrol are far more susceptible to hydrogen sulphide than the more robust diesel engines. For large scale applications (> 60 kW_{el}) diesel engines are therefore standard. Occasionally, organic silica compounds in the gas can create abrasive problems. If so, they should be removed. A diesel engine

can be rebuilt into a spark ignited gas engine or a dual fuel engine where approx. 8-10 % of diesel are injected for ignition. Both types of engines are often applied. The dual fuel engine has higher electricity efficiency. The requirements for the gas upgrading are the same: small CHP (< 45 kW_{el})

3. Experimental Setup

This experimental used two type of gasoline engine 1500 cc. to drive induction generator, 5.5 kW 380 V, 4 pole, with grid connection. Compare efficiency of engine A with engine B. Engine A was direct injection. Engine B was carburetor.

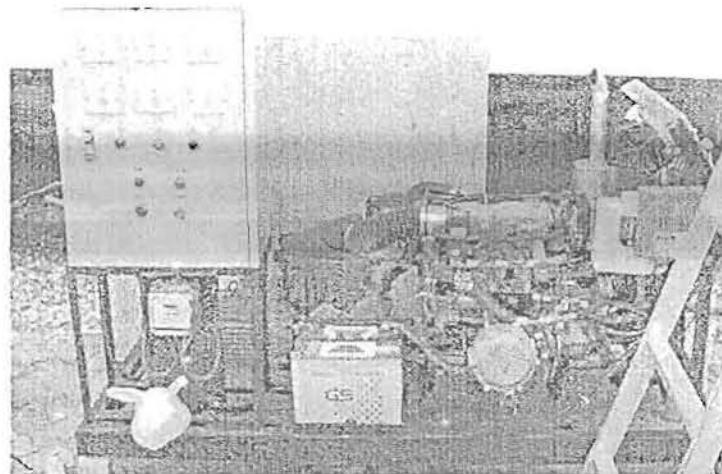
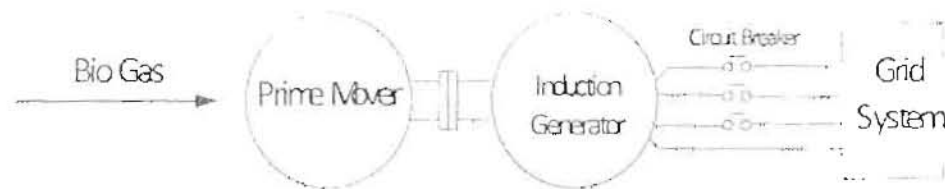


Fig. 7 Experimental setup of small scale pig farm

Component of biogas for test system: Methane (CH₄) 70.4 %, Carbon dioxide (CO₂) 24.6 %, Oxygen (O₂) 0.3 %, Other□ 4.7 %

4. Experimental Result

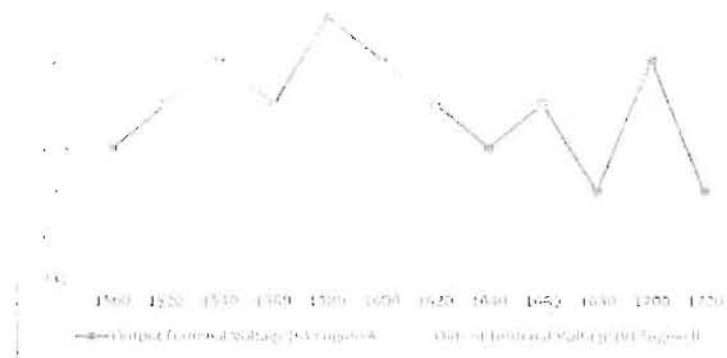


Fig. 8 Speed and output voltage of induction generator

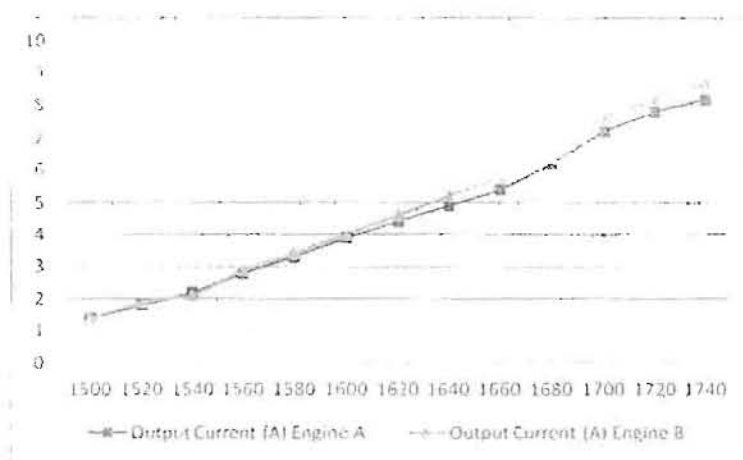


Fig. 9 Speed and output current of induction generator

There results in fig. 8, fig. 9 show speed of induction generator, output voltage and output current. Induction generator supplied power to grid is 1500-1740 rpm.

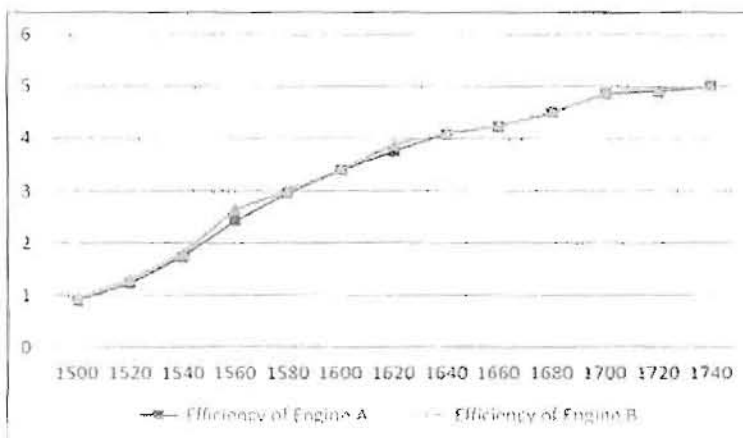


Fig. 10 Speed and output power of induction generator

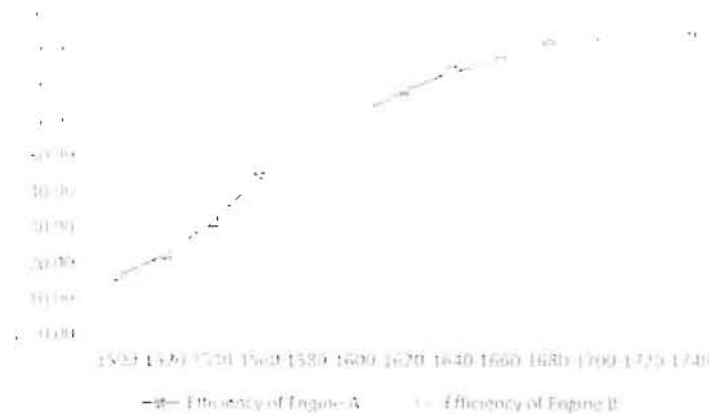


Fig. 11 Speed and efficiency of induction generator

There result in fig.10 at 1740 rpm, induction generator supplied output power at rate power 5 kW. Find optimization point for operate this system

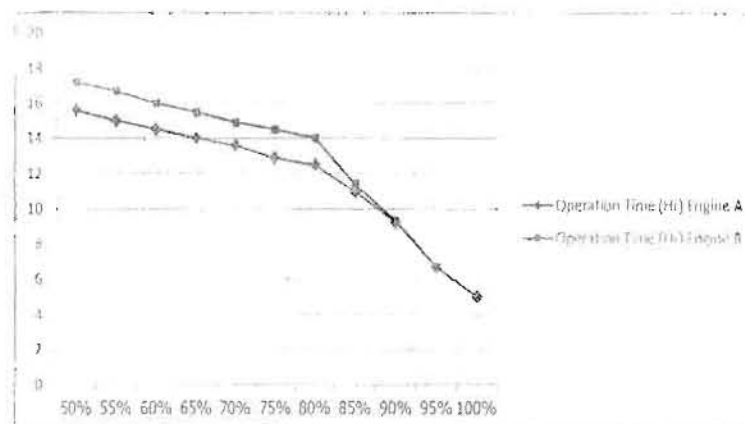


Fig. 12 Efficiency and time period of induction generator

From the result in fig.12 optimization of time period is 14 hour per day and 80 % efficiency of induction generator with engine A and optimization of time period is 16 hour per day and 80 % efficiency of induction generator with engine B. Since was carburetor engine suitably to biogas.

5. Economic Analysis

Induction generator has 1660 rpm. of speed and output power supplied at 4.5 kW. Biogas flow rate 0.00082 m³/s. One cubic meter of biogas has energy 21.5 MJ.

$$\begin{aligned}
 P_{in} &= 21.5 \times 0.00082 \\
 &= 0.01736 \text{ MJ/s} \\
 &= 17.63 \text{ kJ/s} \\
 &= 17.63 \text{ kW}
 \end{aligned}$$

Total efficiency of system from biogas to electrical power

$$\eta = \frac{P_{out}}{P_{in}} \times 100$$

$$= \frac{4.5 kW}{17.63 kW} \times 100$$

$$= 25.52 \%$$

Output power is 4.5 kW x 12 hour

= 54 kW-h per day and 1620 kW-h per month

unit price = 3.5 Baht/kW-h, Ft = 0.5683 Baht/kW-h

- Electrical Power Price = 5,827 Baht/Month

- Ft = 920 Baht/Month

- Vat = 475.44 Baht/Month

Total save cost per month = 7,267.44 Baht/Month

Total save cost per year = 87,209.28 Baht/Month

Installation cost

- 50 m³ Digester cost = 86,000 Baht

- Electrical generation system = 34,000 Baht

- Total installation cost = 120,000 Baht

- Maintenances cost = 20,000 Baht/Year

Interest rate for SME at 5% per year

Net present value present by

$$NPV = TIC - \sum_{t=0}^n \left[\frac{T_t}{(1+i)^t} \right]$$

TIC = Total installation cost

T_t = Total Cost in every year

i = Interest rate

t = Number of year

Payback period present by

$$\sum_{t=1}^n R_t \geq TIC$$

R_t = Total receive cost

Table 3. Economic analysis

Year	income	expense	Total	Net Present Value
0	0	120,000	-120,000	-120,000
1	87,209.28	20,000	64,008.84	-55,991.16
2	87,209.28	20,000	60,960.8	4,969.64

$$R_t = 64,008.84 + 60,960.8 = 124,969.64 \text{ Baht}$$

$$R_i > TIC$$

6. Conclusion

System proposed was saving electricity cost at 70% in every month and payback period in 2 year. If develop this system to high efficiency, this system almost important to community energy. Because, this solving of energy crisis and environment problem.

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