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Economic analysis of cow manure biogas as energy source for electricity power generation in small scale ranch

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Abstract

Economic analysis of biogas application as energy source for electricity power generation is needed to motivate the user candidates (cow farmers) and to influence the government policy with the final goal is the larger implementation of biogas system for many purpose and the reducing of fossil fuels energy sources consumption. The economic analysis of 2 kW biogas power generation is done by determining the equipment installation and the raw material and operational needed, and with the data of electricity and organic fertilizer prices do the analysis by calculating the profit and loss, cash flow, and the economic parameters, i.e. Net Present Value (NPV), Internal Rate of Return (IRR), Profitability Index (PI), Average Rate of Return (ARR), and Payback Period (PP). Analysis result show that 2 kW electricity power generated from cow manure biogas as energy source together with the utilization of solid fertilizer from the digester sludge are economically acceptable to be implemented in small scale ranch. The IRR, PI, ARR, and PP values are respectively 18.6%-32.3%, 1.5-2.2, 15.4%-29.4%, and 3.3-5.1 years. Labor cost significantly influence the feasibility, higher than the influence of land investment. To get higher profit, it is suggested that the farmers do the daily digester operation and equipment maintenance themselves to reduce the operational cost.

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Keywords: economic analysis; biogas power generation; profit and loss; cash flow; economic parameters

1. Introduction

Biogas as flammable gas found from organic waste was firstly known as swamp gas and in long time period with the fluctuation of fossil fuel price, today biogas become one of the potential environmentally friendly renewable

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energy source. In Indonesia, the implementation of biogas technology goes slowly, and government had just given seriously attention in the some recent years. Small scale cow manure biogas digesters have been installed in various farm areas in Indonesia by financial support from the government. However, offering the application of this technology is often unattractive for the users (cow farmers). The policies support from the government is also still very little. To be converted to electricity energy, biogas has high potency as much as 100 gram of cow manure potentially produce electricity energy approximately of 32303.93 joule [1]. It is considered that the implementation of this technology will give many advantages including economic profit. Many researchers have done feasibility study in utilization of biogas for many purpose such as energy source for power generation [2, 3], as fuel for heat and power generation [4], for substituting households daily energy need [5], and biogas integration system that produce compost organic, liquid fertilizer and electricity from the biogas [6]. Except the research done in Philippine that investigate the feasibility of biogas in very small scale farm [5], the said researches were done in large scale, i.e. pig manure biogas to generate 150 kW electrical power [4], integrated biogas system from 80 cows manure [6], biogas electricity power from 35,000 ton cow manure slurry annually [2], and 250 kW_{el} biogas electrical power [3].

The utilization of biogas is feasible for large scale ranch [2, 3, 4] and the feasibility is reality for low cost integration system [6]. In very small scale ranch in Philippine, the feasibility of a domestic biodigester programme will vary much per geographical area [5]. The farmer's raising pattern that let the cattle roam freely imply in the difficult to collect the manure and just little manure left to be fed into a biodigester. The economic study then focusing in pig farmers, the result show that for small farmers raising 3 pig (equivalent with 1 cow)the biogas digester programme is not feasible with IRR -11% [5]. The feasibility will be higher with the larger runch scale, the IRR of biogas digester programme in small farmers raising 6 pigs will be 3% [5]. However, according to Arias (2009) [6], improving and optimizing the digester at low scale, maintaining a low cost system may be a solution to improve the financial indicators. It was also known that the expensive price of the digester in Philippine caused the low feasibility of domestic biogas biodigester programme in this country [5].

In Indonesia, commonly cow farmers maintain their cow together one with other farmers, raising approximately 10-50 cows in a remote location to prevent manure pollution to people. Considering that the price of biogas biodigester in Indonesia is lower than in Philippines and the different farmer pattern in raising their cattle in which the cows are maintained centrally in communal corrals, cow manure domestic biodigester programme in Indonesia may be profitable. Therefore, this research will study an economic analysis of biogas digester programme as energy source for electricity power generation in small scale ranch raising 10-50 cows in Indonesia. The research also considering the solid fertilizer produced from the digester. The purpose of this research is to strengthen the support in the persuading the government to make more policies in the promotion and utilization of biogas as one of feasible alternative energy and in the persuading the farmers to apply this technology to increase their income.

The biogas production is done by leaving organic waste in closed digester with the present of various anaerobic microorganisms. The organic compound will be digested by the microorganisms through catabolism process and resulting biogas as the side product. The methane content in the biogas can reach 70% volume [7] with high energy content that can be used as fuel for cooking in the smallest scale and in larger scale for other purpose like power generation. The nutrition and the organic content in the sludge residue are still high, the biogas digestion produces a clean, high-grade fuel gas, and the residue can be used as a good fertilizer [8].

Livestock manure is the main raw material (substrate) for biogas production because the high availability and the easy of degradation due to the early degradation had happened in the digestion tract and the organic compound in the manure will be simple organic compounds. Compared with complex organic compounds having lignin bonding like plant garbage, the degradation of manure will be faster. The naturally existence of anaerobic bacteria in the manure will trigger the biogas process without the addition of any starter [9], anaerobic digestion from livestock manure is considered as the simplest technology in biogas production.

To produce electricity energy, the biogas is sent to the Generator-Set that utilize the heat of the combustion of methane in the biogas and convert it to electrical power. Biogas conversion is done by modifying the fuel system on a conventional generator set to become a biogas generator [10]. The electricity energy that can be generated will depend on the amount of biogas supplied to Gen-Set. Fig. 1 show the simple process scheme of cow manure biogas system applied by Puslit Telimek LIPI.

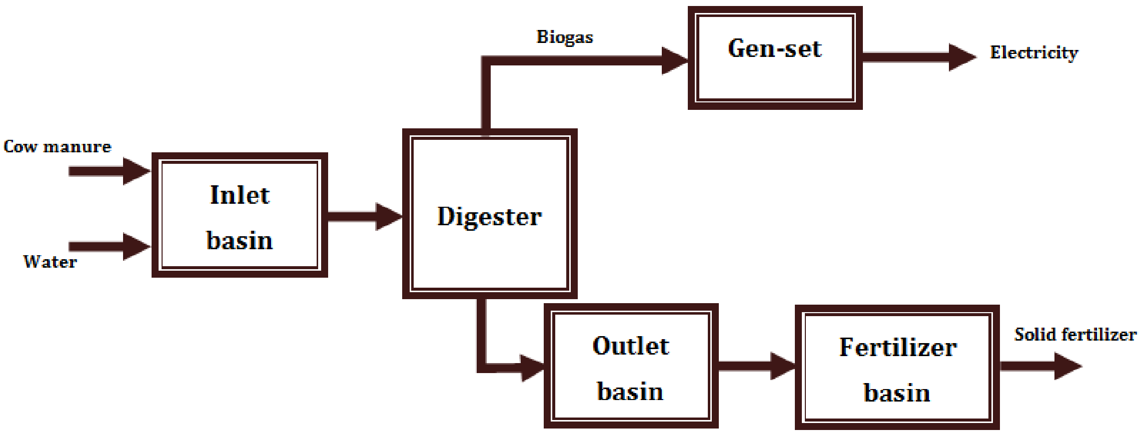

Fig. 1. The simple process scheme of cow manure biogas system

2. Methods

Economic analysis is done based on the biogas installation scheme presented in Fig. 1, the operation needs, and the price of the products. The analysis is limited only in the utilization of biogas as energy source for power generation and not for others purpose like cooking. The analysis also considering the value of solid fertilizer resulted from the digestion sludge.

2.1. Data required

For analysis purpose, there are needed to calculate the amount of cow manure have to be fed daily to the digester to generate some amount of power, the amount of water to dilute the manure, the amount of fertilizer produced, and the volume of digester to convert manure to biogas. The calculations are done based on the amount of power want to be generated.

Based on previous research that 100 gram or 0.1 kg of cow manure will potentially produce biogas that can be used to generate power of 0.008973 kWh [1], the rate of cow manure have to be fed to digester to generate some amount of electrical energy, m_s (kg/day), can be calculated by:

$$m_s = \frac{E}{0.008973} \times 0.1 \tag{1}$$

with E is the electricity energy to be generated (kWh/day).

The rate of water to dilute the manure is calculated based on the good ratio of manure and water in biogas process which is 1:1 [11]. The rate of water to be fed to the digester to produce the biogas (m_a, kg/day) is calculated by:

$$m_a = \frac{1}{1} \times m_s \tag{2}$$

Total feeding rate to the digester (m_t, kg/day) is the summation of manure rate and water rate, as follow:

$$m_t = m_s + m_a \tag{3}$$

Then, the total volumetric rate of the material feeding (F, m^3/day) is calculated by dividing total mass rate with density of the material:

$$F = \frac{m_s + m_a}{\rho} \tag{4}$$

with ρ is the density of slurry (mixture of manure and water) to be fed in to digester (kg/m^3).

The digester volume is calculated by multiplyingmaterial volumetric rate with minimum retention time of material to make anaerobic microorganisms growth well without wash out. To ensure the safety of the digester, the multiplication result then be multiplied with safety factor as follow:

$$V = (1+a)\left\{\tau\left(\frac{m_s + m_a}{\rho}\right)\right\} \tag{5}$$

with V is digester volume (m^3), a is safety factor, and τ is retention time (days).

The amount of fertilizer resulted is calculated by assume the solid fertilizer as the solid residue that not be degraded by microorganisms. The solid residue is the deduction of total solid in raw material with the amount of organic compound in raw material that be degraded by microorganisms to produce biogas in anaerobic digestion process. The nutrition that is used for microorganisms growth will be leaved in the sludge residue and together with organic compounds that not be degraded can be utilized as fertilizer. The organic compound degraded is the multiplication of organic content in raw material with conversion factor. The fertilizer resulted, m_p (kg/day), is calculated by:

$$m_p = \left(1 - f.\frac{VS}{100}\right) \times \frac{TS}{100} \times m_s \tag{6}$$

with TS is total solid content in raw cow manure (% weight), VS is organic content in raw cow manure (% weight dry base), and f is degradation conversion factor.

2.2. Economic analysis calculation

The economic analysis begins with the calculation of working capital, investment cost, and operational cost that is needed to operate the production process. With knowing the price of electricity energy and fertilizer, the analysis then continued by calculating the value of profit, cash flow, and economic parameters i.e. Net Present Value (NPV), Internal Rate of Return (IRR), Profitability Index (PI), Average Rate of Return (ARR), and Payback Period (PP) according to Suliyanto (2010) [12].

Working capital is the capital needed to operate the production process in one period of working capital rotation, from when the raw material is bought until the time when the realization of cash received [13]. Working capital components in biogas power generation system are component cost to repair and maintain the building and installation, component cost to buy raw material, component cost to provide electricity, and component cost for labor payment, as follow:

$$\text{WC} = \sum\left(\text{building and installation repairement and maintenance, raw material, electricity, labor}\right) \tag{7}$$

where WC is working capital.

Total investment value include the component investment for building, equipment, land and working capital:

$$\text{Invesment value} = \sum\left(\text{invesment cost for building, equipment, land, working capital}\right) \tag{8}$$

The operational cost consist of cost for building and equipment repairement and maintenance, cost for purchasing raw material, cost for providing the supply of electricity energy, and cost to pay labor who do the system operation. Operational cost is calculated annually, as follow:

$$\text{Operational cost}=\sum\left(\text{building and equipment repairement and maintenance, raw material, electricity supply, labor}\right) \quad (9)$$

Net profit value can be calculated by deducting sales value with annually costs needed during production operation process, i.e. operational cost and depreciation cost, and the calculation result is then deducted again with tax that must be paid. When annually turnover is less than 600,000,000.00 IDR, the value of tax will be 0 [12]. Net profit value is calculated as:

$$\text{Net profit=sales value-operation cost-depreciation cost-tax} \quad (10)$$

There are 2 type of cash flow commonly used in economic study, the cash flow needed for new investment is named as net out cash flow, while theannually cash flowsthat are obtained as the result of investment is named as incoming cash flow. The annually incoming cash flow is also known as proceeds [12]. Cash accumulation is the deduction of the out cash flow with the incoming cash flow. The economic parameters that will be calculated are Net Present Value (NPV), Internal Rate of Return (IRR), Profitability Index (PI), Average Rate of Return (ARR), and Payback Period (PP). NPV value is the deduction result of the present value of proceeds with the present value of initial invesment cost. The cash flow calculation is done by assume the discount rate approximately of 10%. The formulas used to calculate the economic parameters are [12]:

$$NPV=\sum_{t=0}^{n}\frac{A_t}{(1+k)^t} \quad (11)$$

with k is discount rate, At is cash flow in period t, and n is the last period when the cash flow is expected. The formula to calculate Internal Rate of Return is:

$$\sum_{t=0}^{n}\left[\frac{A_t}{(1+r)^t}\right]=0 \quad (12)$$

with r is the interest rate that make the present value (PV) of proceeds same with the present value of capital outlays. This interest rate is the real rate of return of the production activity (IRR). For others parameters the formulas are presented in Equation 13, 14, and 15 as follow:

$$\text{PI}=\frac{\sum \text{PV of proceeds}}{\text{PV of initial investment}} \quad (13)$$

$$ARR=\frac{\text{average profit after tax}}{\text{initial investment}}\times 100\% \quad (14)$$

$$\text{PP=the last year when cash accumulation positif}+\frac{\text{the last positif cash accumulation value}}{\text{the proceeds in the first year when cash accumulation negatif}} \quad (15)$$

3. Discussion

The economic analysis in this research is done for small scale ranch, with target to generate electricity power of 2 kW that run for 24 hours per day, therefore the electricity energy to be generated is 48 kWh per day. The data obtained from literatures are cow manure total solid content approximately of 20.5% weight in wet bases [14], include degraded compounds i.e. protein 12.5% weight dry base, cellulose 31% weight dry base, starch 12.5% weight dry base, and hemicellulose 12% weight dry base [15], and the minimum retention time in biogas production approximately of 10-15 days [16]. By using Equation 1-6, there are obtained the rate of cow manure to be fed to digester as much as 534919.4 gram per day (534.9194 kg per day) and the digester volume of 16.7162 m^3 when the safety factor is 0.25 or 25%. Due to the conversion factor used in the previous research about 60% [1], it is obtained the solid fertilizer from the digester sludge approximately of 64917.82 gram per day or 64.9178 kg per day.

Based on the manure production from a typical 1,400 pound (700 kg) foreign milk cow as much as 112 pound (56 kg) [15], the amount of cow to produce the said manure is 9.5521 or it is needed at least 10 cow to generate the electricity power. However, in case in Indonesia that the cow is smaller and the manure produced is less, more cow have to be maintained to generate the amount of power. For example, if one cow only producing 10-30 kg manure a day, the minimum amount of cow needed will be 18-54. Amount of manure needed, amount of cow to produce the manure, and digester volume resulted from the calculation can be seen in Table 1.

Table 1. Amount of manure, cows, and digester volume to generate 2 kW electricity power.

Component	Need
Electricity running time	24 hours/day
Manure feeding	534.9194 kg/day
Maintained cow	10 cows producing 56 kg/day manure or 18-54 cows producing 10-30 kg/day manure
Digester volume	16.7162 m^3

Farmer condition will influence investment value and operational cost. In some conditions in Indonesia, rural area is still larger and farmers have larger land that have not been processed or utilized for any purpose. In this case, investment of biogas as energy source for electricity power generation does not need cost for land investment. It is also considered that the operational of biogas system is relatively easy, simple, and just need short time that the farmers can do digester feeding and maintaining the installation as part of their activity in raising their cows. In this case, the farmers do not need to pay some labors to operate the biogas system. Therefore, this research will study economic feasibility of small scale biogas power generation system in various farmers investment condition, i.e. in the case that both land investment and labor operation cost is required (Case A), in the case that land investment is not required but labor cost is required (Case B), in the case that labor cost is not required but land investment is required (Case C), and in the case that both land investment and labor cost is not required (Case D).

Working capital is calculated by assuming that 1 period of working capital rotation is 1 month. Cost for the building maintenance and the installation maintenance is set to 25,000.00 IDR per month respectively. Based on cow manure price of 40.00 IDR per kg [11] (it is assumed that manure is bought from the farmers because the manure have an economic value), the cost needed to provide manure monthly is 641,903.32 IDR. To provide the water for biogas production the electricity supply cost is fixed as much as 50,000.00 IDR monthly. To operate the process, it is employed 2 labors that work part time with the main job is feeding the digester daily and doing installation repairement and maintenance. Due to their little job, the labor cost monthly is fixed as much as 200,000.00 IDR/labor. Working capital calculation for various farmers conditions are presented in Table 2.

Table 2. Working capital components.

Component	Cost, IDR			
	Case A	Case B	Case C	Case D
Building and installation maintaining and repairement	50,000.00	50,000.00	50,000.00	50,000.00
Manure purchase cost	641,903.32	641,903.32	641,903.32	64,1903.32
Water pump electricity supply	50,000.00	50,000.00	50,000.00	50,000.00
Labour cost	400,000.00	400,000.00	-	-
Total	1,141,903.32	1,141,903.32	741,903.32	741,903.32

Working capital is not influenced by land investment because this investment is not routine cost needed for production operation. Therefore, the value of working capital is same in Case A compared with Case B, and in Case C compared with Case D.

The investments cost for equipment include investment cost for digester, investment for Gen-Set, and investment for water pump. Based on the digester volume needed, it is used 2 digesters with volume of 9 m^3 with price 14,000,000.00 IDR/digester [17], including installation cost. The price of 2 kW Gen-Set is 6,000,000.00 IDR [17] and water pump is 500,000.00 IDR. The investment cost for building include investment for inlet basin as much as 1,500,000.00 IDR [17], investment for outlet basin as much as 1,500,000.00 IDR [17], investment for water wells as much as 3,000,000.00 IDR, investment of fertilizer basin (fertilizer vessel) 10,000,000.00 IDR and investment of Gen-set house as much as 10,000.000.00 IDR [17]. The depreciation value is set to 10% per year without salvage value. It is estimated that the land required is 100 m^2 and the land price is 100,000.00 IDR per m^2. Table 3 show the calculation of investment value in the beginning first year for various farmers investment condition.

Table 3. Initial investment value.

No	Component	Investment value, IDR			
		Case A	Case B	Case C	Case D
1	Gen-Set house	10,000,000.00	10,000,000.00	10,000,000.00	10,000,000.00
2	Water well	3,000,000.00	3,000,000.00	3,000,000.00	3,000,000.00
3	Inlet and outlet basin	3,000,000.00	3,000,000.00	3,000,000.00	3,000,000.00
4	Effluent fertilizer basin	10,000,000.00	10,000,000.00	10,000,000.00	10,000,000.00
5	2 Biogas digesters (@ 9 m3)	28,000,000.00	28,000,000.00	28,000,000.00	28,000,000.00
6	Biogas Gen-Set 2 kW	6,000,000.00	6,000,000.00	6,000,000.00	6,000,000.00
7	Water pump	500,000.00	500,000.00	500,000.00	500,000.00
8	Land	10,000,000.00	-	10,000,000.00	-
9	Working capital	1,141,903.32	1,141,903.32	741,903.32	741,903.32
	Total	71,641,903.32	61,641,903.32	71,241,903.32	61,241,903.32

Besides by land investment and building and installation purchase cost, total investment value is also influenced by labor cost, the requirement of labor cost to do the daily system operation will affect in the increasing of working capital that further more imply in the increase in total investment value. Due to this reason, the total investment values are different for each case studied. The highest investment cost is the investment cost for land due to the high land price and working capital do not influence total investment value significantly due to the short period of working capital rotation. The arrangement of the farmers condition with investment value from the highest to the lowest is Case A, Case C, Case B, and Case D.

The component of operational cost include component cost for maintaining and repairment the building and installation for 12 month as much as 600,000.00 IDR, the component cost to buy cow manure as raw material for 10 month operation as much as 6,419,033.23 IDR, component cost to provide electricity for powering the water pump as much as 500,000.00 IDR, and component cost to pay labors that do the operational digester system and maintain the building and installation as much as 4,800,000.00 IDR. The operational cost is calculated by assuming the inflation 8% per year. The calculation of operational cost in various farmer conditions is presented in Table 4.

In accordance with its influence in working capital, land investment do not influence the operational cost, however the operational cost is significantly influenced by labour cost. Therefore the operational cost is same in Case A and Case B, and in Case C and Case D.

Income is obtained from electricity energy sale (or the saving from the utilization of electricity energy generated from biogas) and organic fertilizer sale. The price of PLN electricity energy for household purpose from July to September 2013 with power limiting of 2200 VA is 947.00 IDR per kWh, and the load cost is 75,760.00 IDR per month [18]. The organic solid fertilizer price is 500.00 IDR per kg [11]. By using Equation 10-15 the economic parameters is resulted, as shown in Table 5.

Table 4. Operational cost calculation

Component	Operational cost year 1, IDR			
	Case A	Case B	Case C	Case D
Building and installation maintaining and repairment	600,000.00	600,000.00	600,000.00	600,000.00
Water pump electricity supply	500,000.00	500,000.00	500,000.00	500,000.00
Manure purchase cost	6,419,033.23	6,419,033.23	6,419,033.23	6,419,033.23
Labour cost	4,800,000.00	4,800,000.00	-	-
Total	12,319,033.23	12,319,033.23	7,519,033.23	7,519,033.23

Table 5. The value of economic parameters

Economic parameters	Value			
	Case A	Case B	Case C	Case D
NPV (IDR)	36,139,407.09	37,815,816.64	76,619,018.95	78,295,428.50
IRR (%)	18.6767	21.1009	27.3843	31.2995
PI	1.5044	1.6135	2.0755	2.2785
ARR (%)	15.4421	17.9473	25.2893	29.4187
PP (years)	5.1348	4.5233	3.8271	3.3493

According to Table 5, the economic parameters of NPV, PI, PP, and IRR show that investment of cow manure biogas as energy source for electricity power generation in small scale ranch is economically acceptable for all of investment condition, the NPV value is positive between 36,000,000.00 IDR and 79,000,000.00 IDR, the value of PI is more than 1 approximately between 1.5 and 2.2, the PP value between 3.3 and 5.1 years, and the IRR value is high enough more than 18% approximately between 18.6% and 32.3%, significantly higher than the discount rate value 10%.

The feasibility also can be seen from the high ARR value approximately between 15.4% and 29.4%. ARR is the comparison between average annually profit and investment value, higher ARR value show higher average annually profit when it is compared with the investment value, that further more imply the higher economic acceptance. To analyze the rank of the economic feasibility of each case clearly, the value of each economic parameter is then presented in Fig. 2.

Since all economic parameters is calculated based on the value of profit, proceeds and investment, the feasibility rank of each case according to different parameter is same (Fig. 2). The rank of investment feasibility is compiled by observing the high value of NPV, IRR, PI, and ARR, and the low value of PP. Fig. 2 show that the lowest feasibility will happen if the farmer condition is Case A, in which both land investment and labor cost are required. The requirement of land investment will increase investment value, that mean more investment cost (capital) must be returned. The requirement of labor cost will also imply in the increasing of working capital and operational cost that further more increase the investment value and decrease the profit value, since the profit value is obtained from the deduction of sales with operational and depreciation cost. When the investment value is higher and the profit value is lower, the IRR, ARR, PI, and NPV value will also be lower, the time needed to return the investment will be longer, and the feasibility will be lower. The opposite of Case A is Case D when both land investment and labor cost not required, therefore, the highest feasibility is obtained. The feasibility rank from the lowest to the highest is in Case A, Case B, Case C, and the highest is in Case D.

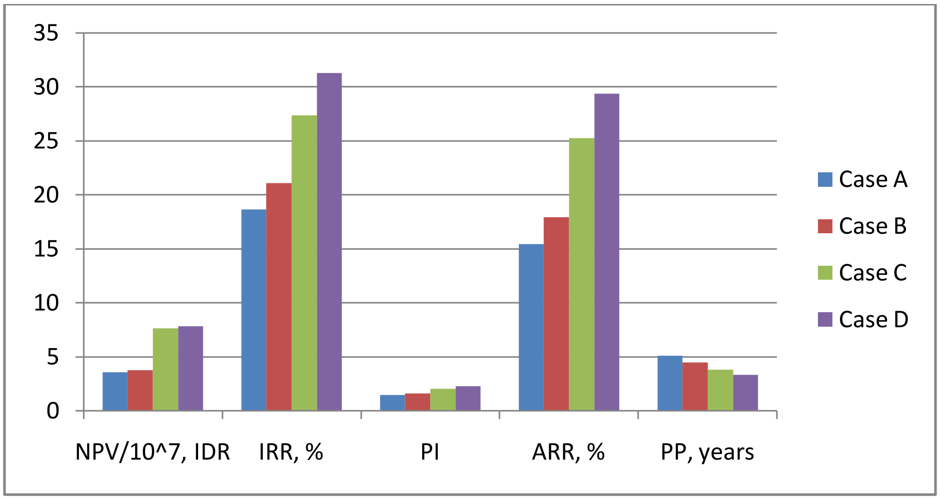

Fig. 2. Result of economic analysis.

By looking at the economic parameters in Fig. 2, there are known that the requirement of labor cost will significantly decrease the economic feasibility higher than the decreasing of feasibility that is caused by land investment (the decreasing of feasibility in Case D to Case B is higher than the decreasing of feasibility in Case D to Case C). It is mean that labor cost reduce the profit significantly that further more reducing the proceeds and significantly imply in the feasibility value. The requirement of land investment will also influence the feasibility, but the effect is little, the requirement of land investment just decreasing the feasibility slightly (can be well understood by comparing Case C and Case D, and by comparing Case A and Case B). Due to the higher impact of labor cost, the investment of cow manure biogas for electricity power generation will be highly feasible in the case when labor cost is not required, both for the requirement of land investment and not (Case C and Case D). The NPV values are approximately between 76,000,000.00 IDR and 79,000,000.00 IDR, the IRR and ARR values more than 25%, the PI values more than 2 and the payback periods between 3.3 and 3.8 years. With the reason that labor cost influence the feasibility higher than land investment, it is suggested that the daily digester operation is done by the farmers themselves to reduce labor operational cost.

4. Conclusion

The investment of biogas as energy source for electricity power generation in small scale ranch that maintain 18-54 cows and produce 10-30 kg manure/cow/day in Indonesia is economically acceptable for all farmer investment condition. The feasibility will be higher in the case when land investment and labor cost is not required. Labor cost significantly influence profit and economic feasibility much higher than the influence of land investment. In order to obtain the higher profit, it is suggested that the daily digester operation is done by the farmers themselves to reduce labor operational cost. The result of analysis show that the value of IRR, PI, ARR, and PP are approximately of 18.6%-32.3%, 1.5-2.2, 15.4%-29.4%, and 3.3-5.1 years respectively.

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References

[1]Wresta, A., Sudibyo, H.,"The Potency of Electric Power from Cow Manure Biogas Installation in Various Provincies in Indonesia," in Seminar Nasional Rekayasa Energi, Mekatronik, dan Teknologi Kendaraan, Bandung, 2013.
[2]Electrigaz Technologies Inc., “Feasibility Study – Biogas Upgrading and Grid Injection in the Fraser Valley, British Columbia”, prepared for BC Innovation Council, Electrigaz Final Report, June, 2008
[3]Lietuvos Zemes UKIO Konsultavimo Tarnyba, “Biogas Feasibility Study-UAB Dotnuva Experimental Farm, Substantiation of Biogas Power Plant Construction” Baltic Sea Region Programme, 2007-2013
[4]Patania, F., Gagliano, A., Nocera, F. and Galesi, A., “Feasibility study of biogas in CHP plant for a pig farm”, International Conference on Renewable Energies and Power Quality (ICREPO’12), Santiago de Compostela (Spain), 28th to 30th March, 2012, European Association for the Development of Renewable Energies, Environment and Power Quality (EA4EPQ), 2012.
[5]Teune, B., Orprecio, J., Dalusung, A. and Yeneza, G., “Feasibility Study of A National Biogas Programme on Domestic Biogas in The Philippines”, SNV Netherlands Development Organisation and Winrock International, April 2010.
[6]Agriculture Engineer Joaquin Viquez Arias, “Case Study: Technical and economic feasibility of electricity generation with biogas in Costa Rica” Environmental Ag. Program Coordinator, Dos Pinos Dairy Farmers Cooperative, 2009
[7] Tortora, G. J., Funke, B. R., Case, C. L., Microbiology, An Introduction. 10th ed., United State: Pearson Benjamin Cummings, Pearson Education Inc. 2010.
[8]Fulford, D., Running A Biogas Programme: A Handbook, ITDG Pubblishing, London1988.
[9]Wresta, A. and Budhijanto, W., "The Effect of the Addition of Active Digester Effluent for Start-Up Accelerator in Anaerobic Digestion of Soybean Curd Industry Waste Water (Basic Research for Biogas Power Generation)," Journal of Mechatronics, Electrical Power & Vehicular Technology, vol. 03, pp. 81-86, 2012.
[10] Arifin, M., Saepudin, A., Santosa, A., “Study of Biogas For Power Generation at PesantrenSaungBalong Al-Barokah, Majalengka, West Java”, Journal of Mechatronics, Electrical Power, and Vehicular Technology, vol. 02, pp. 73-78, 2011.
[11] Marta, F., "Kotoran Sapi Pun Menjadi Duit," in Kompas, 2010.
[12] Suliyanto, “Studi Kelayakan Bisnis: Pendekatan Praktis”, Penerbit ANDI Yogyakarta, 2010.
[13] Miswanto, “Kebijakan dalam Penentuan dan Pendanaan Modal Kerja Perusahaan” Jurnal Economia, Volume 8, Nomor 2, Oktober, page 181-195, 2012.
[14] Syafruddin, R., "Strategi Start-Up Produksi Biogas dari Campuran Sampah Buah," Tesis, Chemical Engineering, Gadjah Mada University, Yogyakarta, 2011.
[15] Burke, D. A., Dairy Waste Anaerobic Digestion Handbook, Environmental Energy Company, Hill Street Olympia, 2001.
[16] Deublin, D., Steinhauser, A., Biogas from Waste and Renewable Resources, Weinheim:WILEY-VCHVerlag GmbH and Co. KgaA, 2008.
[17] KBUT (Koperasi Bina Usaha Telimek), “Daftar Harga Instalasi Biotrik”, Puslit Telimek LIPI, 2012.
[18] Kementerian ESDM, “Peraturan Menteri Energi dan Sumber Daya Mineral Republik Indonesia Nomor 30 Tahun2012 tentang Tarif Tenaga Listrik yang Disediakan oleh Perusahaan Perseroan (Persero) PT Perusahaan Listrik Negara”, 2012.