ECONOMIC AND FINANCIAL DEVELOPMENT OF SOLAR PHOTOVOLTAIC TECHNOLOGY

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ECONOMIC AND FINANCIAL DEVELOPMENT OF SOLAR PHOTOVOLTAIC TECHNOLOGY

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Electricity is playing important role to give access of the people doing activities. However, with unequal distribution of electricity between western and eastern region part of Indonesia, many people in eastern region such as Tomia island in Southeastern Sulawesi still suffering about limited access to electricity for daily life. This research aims to produce economic and financial feasibility about solar photovoltaic which expected to reduce non – renewable energy usage, to improve global climate and also to increase people welfare. It will use a simulation from economic and financial approach to produce targeted output. The result shows the best scenario for Solar PV installment is by using hybrid system which integrates current fuel-based generator and solar photovoltaic. It will be placed in four rural locations: Kulati; Dete; Lamanggau; and Kahianga-Wawotimu that will be integrated in one area. The number of beneficiaries is about 987 houses. The result also shows a maximum available internal rate of return with positive benefit cost ratio and lower cost of electricity.

Keywords: Benefit cost ratio, Electricity, Feasibility, Internal rate of return, Rural areas.

1 INTRODUCTION

In Indonesia, electricity consider as one of major contributor for nation's GDP whereby its average growth reach 7.5% per year. It is considered stable and forecasted to increase in greater level in the future. However, most of electricity resources are provided from fossil energy such as coal and petroleum (Narayan 2007). Fossil energy contributes for about 66.1% and the rest 4.87% is supported from renewable energy (exclude hydro energy) (Ministry of Energy and Mineral Resources 2014a). Currently, electricity in Indonesia mostly generated and distributed from PT. PLN (Persero) – a State Owned Enterprise (SOE). From 44,124 MW of total power plant energy in the country, 32.10% is produced by PLN while the rest are produced from Independent Power Producer (IPP) with 10.29% and 1.73% from Private Power Utility (PPU).

There were also fact about 19.85% of Indonesian people still unable to properly access the electricity (Ministry of Energy and Mineral Resources 2014b). In this matter, government attempts to reduce the gaps of electricity access by initiating the development of 35,000 MW of power plant to increase the electrification ratio. However, both electricity development and accessibilty were poorly experienced in Eastern Region of Indonesia (Smith 2013). Thus align with a number of power plant development will be concentrated in Sumatera and Java Islands (84.1%) as western region of Indonesia.

It is a different story for people at Tomia Island in Southeast Sulawesi who mainly depends on diesel generator for their daily rural life. As shown in Figure 1, PT PLN only intend to develop power plant in Wangi – wangi (No. 1 in yellow box) and Bau – bau (No. 2 in yellow box) without considering Tomia Island. A low viability and high potential to endanger ecosystem of coral reef in Tomia Island National Park area are argued as two main reasons to discharge this area from the electricity network distribution plan. As the result, the people of Tomia still have to use non – renewable energy as their main power despite threatening the environment (Williams *et al.* 2012).

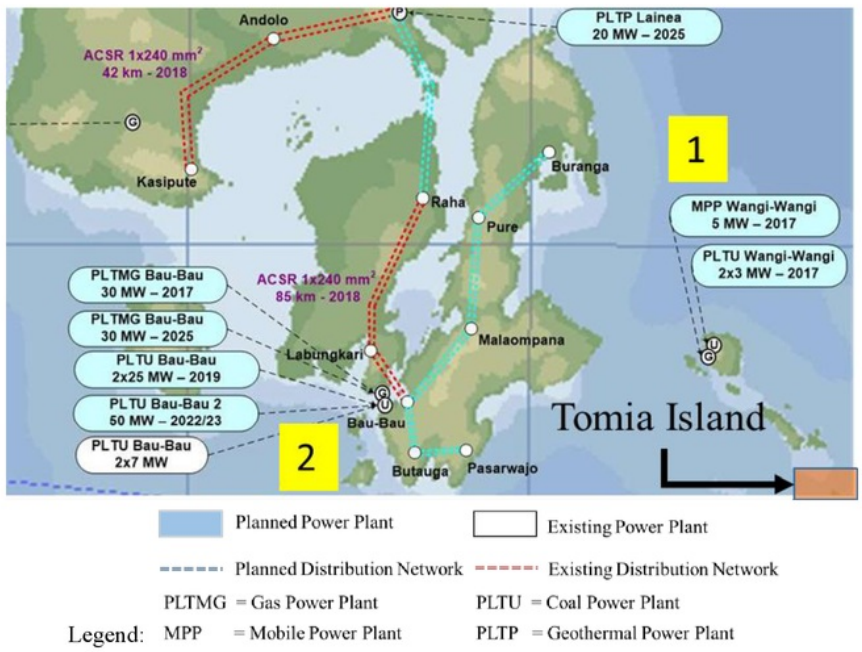

Figure 1. PT PLN plan in developing power plant and network distribution of electricity for 2015 – 2024 in southeast Sulawesi (in Indonesia).

On contrary, this area is experiencing massive solar heat for its daily life. With this potential, the development may no longer suitable using conventional electricity network system. It requires a breakthrough approach that combined with local potential to provide electricity access for the people through Solar Photovoltaic (PV). This research aims to produce economic and financial feasibility for Solar PV development in Tomia Island. It is expected to reduce non – renewable energy usage from the people in eastern region of Indonesia particularly Tomia Island by providing access to electricity to increase people welfare with cleaner energy.

2 RESEARCH PARAMETERS

In calculating the feasibility of Solar Photovoltaic (PV) development, four scenarios are proposed to accommodate the needs of Solar PV for five villages in Tomia Island. The villages consist of Kulati, Dete, Kahianga, Wawotimu and Lamanggau with number of beneficiaries estimated around 987 houses.

Table 1. Scenario of solar PV configuration.

	Configuration	Initial Cost (US$)	O & M Cost (US$)	Available Electricity
Scenario 1	Solar PV in 5 villages	6,191,250	14,520	710 kW
Scenario 2	Solar PV + diesel based generator in 5 villages	3,935,318	92,904	480 kW (PV) and 162 kW (Diesel)
Scenario 3	Solar PV in 4 villages	6,076,083	19,227	740 kW
Scenario 4	Solar PV + diesel based generator in 4 villages	3,552,407	113,094	360 kW (PV) and 128 kW (Diesel)

Scenario #1 and #3 are using only Solar PV for each villages in Tomia Island, meanwhile Scenario #2 and #4 are using hybrid system which integrate existing diesel generator and new installed Solar PV. Both scenarios in #3 and #4 only consider 4 villages where Kahianga and Wawotimu installed in one place, since the location of the two adjacent villages below 10 km thus create more efficient configuration.

IC and OM cost generated from HOMER – energy simulation software that produce optimal generator system configuration. The software automatically calculate the PV system cost by consider capital cost, replacement cost, operation and maintenance cost, fuel and profit. Further, the revenue is calculated based on electricity users, Cost of Energy (COE) and kiloWatt-hour (kWh) usage in the future.

In term of initial cost, scenario #1 has the highest cost but produce the lowest operation and maintenance cost. On the other hand, scenario #4 has the lowest initial cost but generate the highest operation and maintenance cost. This condition happened because the configuration in scenario #2 and #4 are combining Solar PV with existing diesel – based generator. It requires periodic maintenance and needs non – renewable fuel to run the system, thus O&M cost excalated five to six times higher than scenario #1 and # 3.

3 RESULT AND DISCUSSION

3.1 Financial & Economic Analysis

In calculating the analysis, transmission and distribution cost are exluded from consideration. The battery expected to have a life cycle for 20 operating years without maintenance cost. Financial simulation produces Internal Rate of Return (IRR), Net Present Value (NPV), and Benefit Cost Ratio (BCR). The project is feasible if IRR > i; where i is the interest rate, NPV shows positive value and BCR > 1.0 (Mondal and Islam 2011). Moreover, Economic Rate of Return (ERR) will consider the project cost that consist of initial cost (IC) and O&M cost; and benefit components such as direct benefit. It calculated from the potential in conducting productive business to boost individual and community/groups income. The financial feasibility analysis of the four scenarios is shown in following table.

Based on the table 1 and 2, installation of Solar PV in every village in scenario #1 and #3 (with COE of US$0.83 /kwh and US$ 0.82 /kwh) require higher cost than the hybrid system. Yet both scenarios provide greener energy and lower cost of operation and maintenance.

In general, scenario #1 shows the highest NPV and BCR, meanwhile scenario #4 rules in COE, IRR and ERR parameter. For that reason, scenario #4 is more preferable compared to other scenario. It shows a maximum available IRR and ERR with lower COE. BCR for scenario #4 also shows positive value of 1.27. Following sensitivity analysis will then be used to seek optimum result for Cost of Energy.

Table 2. Four scenarios of solar PV installation in Tomia Island.

Scenario	COE	IRR	NPV	ERR	BCR
Scenario #1	0.83	11.06%	IDR 35,348,461,462.03	20.69%	1.33
Scenario #2	0.67	11.23%	IDR 23,190,887,468.49	31.04%	1.18
Scenario #3	0.82	9.70%	IDR 23,022,995,429.58	22.70%	1.16
Scenario #4	0.68	12.91%	IDR 29,761,494,785.19	33.31%	1.27

3.2 Sensitivity Analysis

Sensitivity analysis is conducted by using Monte Carlo Simulation and Microsoft Excel Tools. The two main parameters are IRR and B/C Ratio. Cost of Energy (COE) is selected as the sensitive variable because it has direct impact to the electricity purchasement by adopting PV. Although marginal project requires B/C ratio equal to 1, this simulation is also expected to produce IRR above 10% and B/C ratio above 1 to maintain the sustainability during the 20 years of operation. Intervention of COE value is ranging from US$ 0.51 to US$ 0.68.

Table 3. COE sensitivity on scenario #4.

	COE	IRR	NPV	B/C Ratio
Scenario #4	0,68	12,91%	IDR29.761.494.785,19	1,27
Scenario #4	0,62	11,22%	IDR20.861.572.348,65	1,17
Scenario #4	0,60	10,67%	IDR18.101.906.476,85	1,14
Scenario #4	0,56	9,54%	IDR12.582.574.733,26	1,08
Scenario #4	0,52	8,34%	IDR 7.063.242.989,67	1,02
Scenario #4	0,51	8,03%	IDR 5.683.410.053,77	1,00

Initial simulation was conducted with COE equals to 0.51. At this value, B/C Ratio is equal to 1; however IRR value was about 8.03%, or below expected target. Therefore, this COE considered unfeasible. COE at 0.6 for scenario #4 was the minimum target for COE option since it produced IRR at 10.67% with B/C Ratio of 1.14. COE with value of 0.68 produced higher IRR and B/C ratio, but it will be affected the electricity price. Considering this circumstances, COE with 0.6 is selected as the best alternative. Using COE at 0.60 as baseline, the average of electricity price for Tomia Island was estimated in range of IDR 105,006 to IDR 201,537 per month.

3.3 Ability to Pay (ATP) & Willingness to Pay (WTP) Justification for Scenario #4

Income is one of the main factors that will affect the purchasing power to public utility services such as electricity and water. From field survey were held to 100 random households, the residents of Lamanggau village have been provided free electricity that runs about 12 hours/day from private entity. The other villages use communal generator that runs for about 4 – 6 hours with two types of billing: TV users and non-TV users.

Since current billing has two types distinguished from TV users and non – TV users so the price also varies from below IDR 100,000/month and IDR 100,000-250,000/month. The number of people who pay below IDR 100,000/month was higher than those who pay for IDR 100,000-250,000/month with 58.47% and 39.83% respectively. In term of willingness to pay, 85.14% of them expected to pay electricity below IDR 100,000/month. However, according to their ability to pay through electricity expenditure, 54.73% are managed to pay the bill at IDR 100,000-250,000/month and 27.03% are able to accommodate the price for more than IDR 250,000/month.

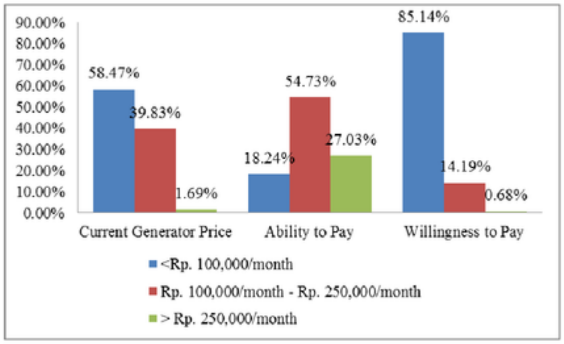

Figure 2. Comparison of current price of generator with ATP and WTP in Tomia Island.

Based on the analysis, the people tend to select a low price as their willingness to pay despite their ability to pay for much higher price. One of the reason is because dissatisfaction on low service quality, therefore they will be likely to have a low WTP, albeit higher ATP. The gap between ability to pay and willingness to pay can be reduced by improving electrical service from 4 hours to 24 hours although it might increase the tariff. It will then balance their expectation of using the electricity in daily life. Therefore, COE value about 0.60 is recommend to be implemented in rural area of Tomia Island.

4 CONCLUSION

Electricity is playing important role to give access of the people doing activities. However, with unequal distribution of electricity between western and eastern region, many people in eastern region such as Tomia Island in Southeast Sulawesi still suffering from limited access to electricity in their rural daily life.

Based on the analysis of financial and economic feasibility of four scenarios proposal, scenario #4 is selected as the best scenario. The scenario has configuration of solar PV installation with hybrid system where integrates current fuel-based generator and new solar PV generation. This scenario shows a maximum available IRR and ERR with lower COE compared to the other scenario. BCR for scenario #4 also shows positive value with 1.27.

Furthermore, sensitivity analysis showed COE with 0.6 selected as the best alternatives to be implemented which produces electricity price ranging from IDR 105,006 to IDR 201,537 per month. This value is slightly higher from the current price of electricity. However, considering the availability of 24/7 electricity, there are various prospective and productive activities that can be done by the people. Therefore, the installation of solar PV expected as initial action to improve the quality of life for the people in Eastern Indonesia particularly Tomia Island.

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