Economic analysis on the application of solar panels on an aquaculture

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Abstract. An initial economic feasibility study of solar panels application for electricity energy source of an aquaculture in Jakarta was conducted to investigate the potential solar panel as the energy alternative for the electricity source. Currently, the source of electricity is mainly from gasoline. Therefore, the aims of this study include the investigation of the improvement of the life cycle cost (LCC), the net present value (NPV) and The Saving Investment Rate (SIR), as well as the payback period. In order to fulfill these objectives, software namely “Building Life Cycle Cost” or BLCC is applied. The results show that the SIR is more than 1, which means the use of solar panels is considerably beneficial for the aquaculture. The type of solar panels used in this study is a transparent panels made of amorphous solar cell with the efficiency of 0.079.

Keywords: economic analysis, SIR, LCC, NPV, payback period

1. Introduction

The local government of Indonesia is now actively doing to improve its urban economics. Jakarta, the capital city of Indonesia that is becoming an extensive urban area and it has spread out to the islands in the northern. There are several island in its northern region and the inhabitants are mostly fisherman. Currently, the island is now an urban area whereas some of the inhabitants are still fisherman and are having aquaculture as their main income.

Essentially, that aquaculture required electricity to run not only the fish production but also to maintain the condition of the water such as its temperature and its ph balance. A study shows that the need of electricity to fulfill that requirement is around 270 KWh per day in average [2]. This number is quite tremendous since the temperature of the water should be maintain at around 20 degree Celcius for 24 hours, and resulted in high electricity consumption. Currently, the source of electricity is mostly from gasoline. In relation to the need of electricity, a study revealed that the cost for gasoline can be around 45.5 million per year for a smaller area [3].

Additionally, according to the Indonesian Energy Outlook, the use of fossil fuel as the electricity source should be reduced at around 30% by 2030 and it is valid for industry sectors. Based on the data made by the Ministry of Energy, the most potential renewable energy are solar energy, bio energy, and geothermal consecutively [4]. The last two options are preferably produced on the ground, whereas, the study investigate the energy alternative that can be integrated with the aquaculture facilities. Therefore, energy source from sun is selected.
Solar cell technology is promising today, on the other hand, the use for an aquaculture is still unconsidered. Therefore the objective of this study can be listed as follows:

1. To compare "life cycle cost" between roof using solar panel and without using solar panels
2. To investigate the Saving Investment Ratio when using solar panels as the rooftop.
3. To investigate the payback period

2. The methodology

2.1 Building Life Cycle Cost
As explained earlier, this study applies a software called Building Life Cycle Cost (BLCC) version 5 which is developed by the US Department of Energy. This software is particularly useful for analyzing and predicting the "cost" and benefits of energy conservation-oriented projects. In addition, another advantage is to evaluate two or three alternative systems to see the lowest life cycle cost.

The aspects required for the calculation of this study are energy cost and capital component. The capital component is include: (a) investment cost, (b) replacement cost and (c) operating, maintenance and repairs, including annually and non-annually recurring costs. As for the analysis, the parameters are service life, inflation rate and discount rate.

2.2 The PV selling price
Determination of the price of solar panels is determined by Specifications of solar panels, in particular is Watt peak. Figure 5 shows the price trend of solar panels per Watt peak that has a significant reduction. From the picture it can be seen that in general, the retail price of solar panels declined considerably of about 18% over one year.

![Figure 1. Graph of the development of the price of solar panels per Watt Peak per April 2019. Source: Solarbuzz, https://www.pv-magazine.com/features/investors/module-price-index/](image)

2.3 The selling cost of energy
The "energy cost" here is determined by the cost of gasoline used for the aquaculture since the based case currently uses gasoline for the electricity source. The type of gasoline is the Solar where the price per liter is 6,500 rupiah or around 0.7 USD. The amount of gasoline used in this study is 7000 liter for a year [3]. Therefore, the energy cost is 45.5 million rupiah. And the investment for the generator with the specification of 5 KVA is 40 million rupiah.
2.4 The capital Investment
The amount of investment for solar panel systems (including inverters, structures and installation costs) is determined at US $ 1.50 per Watt peak. The Watt peak of a solar panel is determined by the amount of power in a predetermined condition called "Standard test condition (STC)" in which the solar radiation is 1000 W / m², the Air Mass (AM) is 1.5 and the temperature is 25 °C. Since the electricity should be provide for 24 hours operation, therefore additional batteries are also included.

The costs for operations and maintenance are calculated in the form of annual fees [5], which in this cost also includes insurance costs. In general the cost for maintaining PV systems is quite cheap compared to conventional electricity costs. For the annual fee is determined about 1% of the initial investment cost of the PV system.

2.5 The service life
The calculations for service life in this study are based on the warranty period issued by the manufacturer. This study applies 25 years for service life as it is known that in general, the warranty of solar panels is 25 years.

2.6 Inflation rate
The development of inflation rate or inflation rate in Indonesia can be seen in Fig. From the table can be seen that the average inflation rate in Indonesia is about 3-6.5%. In this simulation study the determined inflation rate is 6%, in order to anticipate the rise of inflation.

![Figure 2. Graphs and tables of inflation rate in Indonesia](https://data.worldbank.org/)

2.7 The discount rate
In the calculation of "life cycle cost" is also required parameters to calculate the "present value" is useless to anticipate price increases in the service time span (service life time). The present value is determined by the "Discount rate" number. For this study the figure is taken from the Bank Indonesia Rate (BI Rate). Table 2 illustrates the development of Bank Indonesia (BI) rate. A conservative number of 6% is used for the simulation.

| Year | Average BI Rate |
|------|----------------|
| 2018 | 6.00%          |
| 2017 | 4.75%          |
| 2016 | 5.25%          |

Table 1. History of BI rate in 2011-2014
Source: [https://www.bi.go.id/id/moneter/BI-7day-RR/data/Contents/Default.aspx](https://www.bi.go.id/id/moneter/BI-7day-RR/data/Contents/Default.aspx)
2.8 The floating net cage system

The floating net cage system is constructed using pile system and transparent solar panels which made of amorphous solar cell [6]. The specification of the transparent solar panels that is used in this study is 56 Wp and the efficiency is 7.9%.

3. Results and Discussion

The energy cost for this study used a study of [3]. The study calculated the overall energy electricity per day is 90.28 KWh or 32,954 KWh per year that include the machine for water circulation, maintenance and the safeguard house. The capacity of generator used for one day electricity needed, as mentioned in the previous sub chapter, is 5 KVA for 24 hours operation. However, generally this capacity can only be applied 80%.

The total solar panels with the specification of 56 Wp and the efficiency of 0.079 is 435 panels. The total number of solar panels is calculated based on: (1) the average daily solar insolation for Jakarta region or 4.5 KWh/m² [7], (2) the power reduction variable (20%), and (3) the efficiency of the solar panel (0.079). Additional batteries are also included for the initial investment. The total batteries is 295 with the specification of 12V 100ah. The calculation of the battery number also considers 0.85 energy loss, 60% energy for energy process, and two days autonomies. The initial cost for the integrated solar panels and the Keramba needs a shelter to allocate the inverters and batteries. The cost for the shelter is determined at 200 million IDR for 100 m² building. The building specification is based on the standard specification for one story building that is applied in Indonesia.

As for the based case, the initial cost is determined by the price of the generator and the electricity equipment. The generator specification is 5KVa [3]. Furthermore, the type gasoline used for the electricity source is gasoline. The energy cost for the 7000 liter of Bio Solar gasoline in 2019 is determined at 0.21 USD per KWh.

Table 2 shows the Life Cycle Cost figure can be improved for 25 years, and there is a reduction in expenditure of 7,357 USD. The comparison of "present value" and "annual value" of each roof can be seen in Table 3. It can be seen that the value of Present value and Annual Value reduced around 7.7%.

The "Saving to Investment Ratio (SIR)" figure is 1.09. SIR is the value of comparison between savings and initial investment costs. Alternative construction, in this case is a solar panel roof, is "cost effective". Furthermore, the “Payback” simulation results appear in the year 11.

| Table 2. Comparison of "Life Cycle Cost" between Keramba with and without solar panel |
|---------------------------------------------------------------|
| Keramba without solar panel (USD) | Keramba with solar panels (USD) |
| 1 USD = 14,500 IDR | 1 USD = 14,500 IDR |
| **Initial Cost** | **83,941** |
| This cost include the generator systems and electricity equipment | The total solar panels (435 panels), shelter for PV system and 295 batteries |
| **Annual energy cost** | **82,389** |
| **Annual maintenance cost** | **10,266** |
| **Total Life cycle cost** | **95,620** | **88,263** |
| This cost 1% from the initial cost of the PV system only | This cost is 1% from the initial cost of the PV system only |
Table 3. Comparison of Present value and Annual Value

| Component                  | Keramba without solar panel | Keramba with solar panel |
|----------------------------|-----------------------------|--------------------------|
|                            | present value (USD)         | annual value (USD)       |
| Initial Cost (IDR)         | 2,965                       | 232                      |
|                            | 83,941                      | 6,567                    |
| Annual energy cost         | 82,389                      | 6,445                    |
|                            | 0                           | 0                        |
| Annual maintenance cost    | 10,266                      | 803                      |
|                            | 4,322                       | 338                      |
| Total Life cycle cost      | 95,620                      | 7,480                    |
|                            | 88,263                      | 6,905                    |

4. Conclusion

This study has simulated a large production of electricity from a solar panel made of transparent amorphous silicone technology with an efficiency of 7.9% and 56 Watt peak. The use of the roof of solar panels is "cost effective", this advantage is seen from the improvement of Life cycle cost value of 7.7% and SIR value of more than one or 1.09. Another benefit is that after 11 years the return value of investment and the rest for 14 years (from service life time of solar panel which is 25 years old) the user can reap the result from the electricity production. The SIR is slightly improved since the use of solar technology, amorphous transparent solar panel. Essentially, this technology is still low in the efficiency. However, since the need of light for the Keramba, only this technology that is possible to be applied at the aquaculture. Essentially, this technology is responsive for tropical climate as the cell has disorder cell structure [8].

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