Study and model development of renewable energy investment feasibility under willingness and ability to pay approach

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Abstract. Solar PV power plant investment in Indonesia is one amongst the alternative for electricity supply to maintain electrical reliability supply and to maximize local energy potential for remote areas. An objective approach in terms of ability and willingness to pay of the community at study location becomes the basis for revenue potential calculation of on this study. Assessment of investment feasibility including economic incentive calculation becomes more important if incentive is required in order to improve return of investment and at the time to provide good quality of energy supply at the lowest possible cost. Community characteristics data on study location is processed using statistical methods and micropower optimization simulation to generate PV system specification and all component needed to invest. To increase the return of investment the economic incentive scenarios are generated to provide alternatives to optimize the economic feasibility while maintaining the technical feasibility based on the ability and willingness to pay of the community, and not inflicting financial loss to the incentive giver. The results of investment feasibility calculation, with various scenarios built for investment alternatives, PV investment is economically feasible based on common investment analysis criteria such as expected NPV (net present value), IRR (internal rate of return), and PBP (payback period).

1. Introduction

This paper brings together two stakeholders at the same time, both Government and investors which has different interests, in the development of renewable energy. Renewable energy is unlikely to develop without involving both party. The Government needs funds from investors for renewable energy project’s financing while investors will only finance projects if the rate of return is considered feasible.

In several cases when development projects or programs have to be implemented, to achieve a feasible rate of return, the Government needs to provide incentives in a certain amount and over a certain period. The problem is how much and for how long reasonable incentives need to be provided by the Government to achieve a reasonable investment feasibility or to help improve its feasibility.

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In principle, the development of engineering projects always considers two things: technical feasibility and economic viability, generally known as investment feasibility assessment or techno-economic assessment or engineering economics\cite{1}. This method has been conducted into various projects and researches and give various results \cite{2} \cite{3}. The model built on this research brings together technical feasibility and economic viability for the Government that provides incentives and investors. As for the state-of-the-art, the model in this research can deliver the best alternative options for providing incentives and investment value to obtain optimum returns for the Government and investors while still meeting the technical feasibility and economic viability principles.

2. Theoretical background

2.1. Electric utility organization

Electric utility organization is part of utility organization operates to provide high-quality electric service for is designated service area. In doing its operation, it invests initial capital, consumes labor and materials with cost of electricity accumulated to be total cost including return to investors. In these operations its objective is to produce electricity at the lowest possible cost\cite{4}. Based on ownership, there are two types of electric utility organization: government owned and private owned. Regardless of the differences of utility ownership type, there are no effect on the society since their role is on the power cost side as shown in figure 1. Therefore, society’s willingness and ability to pay the power cost, must be considered when assessing the feasibility of electric utility investment.

![Figure 1. Cost to Society depicted Society’s role in electric utility revenue potency. The power cost paid by society becomes revenue for electric utility organization.](image)

2.2. Willingness and ability to pay

When objectively assessing revenue potency from community side, it is necessary to consider willingness to pay (WTP) and ability to pay (ATP). As the name implies, ATP describe how much community can pay the price given to them, therefore the price applied for a product shall not exceed the value of ATP. On the other side, WTP contained user’s perception of product related to the level of product quality, availability to meet the needs of society, and usage level of the community which also serve as an important variable. Various research regarding WTP and ATP is presented in \cite{5}–\cite{7}. There are three conditions related with WTP and ATP relation: ATP bigger than WTP, ATP smaller than WTP, and ATP equals WTP\cite{8}. Ideal condition is when ATP equals with WTP.

2.3. Engineering economics

In economic activity, cash in and cash out is depicted using cash flow diagram\cite{1}. Using the cashflow diagram, the investment feasibility assessment is performed using the economic indicators such as Net Present Value (NPV), Internal Rate of Return (IRR), and Discounted Payback Period (DPBP).

2.3.1. Net Present Value (NPV). NPV is a simple calculation of difference between the present value of cash inflows and outflows. NPV compares the value of an investment today to the future value of the money based on inflation and returns. It is one of the most effective value to assess the profitability of a long-term project. A positive value of NPV indicates a favourable investment.

\[
NPV = \sum_{k=0}^{N} R_k \left( \frac{P}{F}, i \%, k \right) - \sum_{k=0}^{N} E_k \left( \frac{P}{F}, i \%, k \right)
\]
Among them, \( R_k \) is net revenue potency on year \( k \), \( E_k \) is net expenditure, include investment done on year \( k \), \( i\% \) is annual interest rate/expected internal rate of return, and \( N \) is study period.

2.3.2. Internal Rate of Return (IRR). Internal rate of return (IRR) is an economic indicator that analyses the profitability of a project by comparing to the discount rate. Investment is more favourable as the difference between IRR and discount rate becomes larger.

\[
\sum_{k=0}^{N} R_k (P / F, i \%, k) = \sum_{k=0}^{N} E_k (P / F, i \%, k)
\]  

(2)

2.3.3. Discounted Payback Period (DPBP). Payback period (PBP) describes the time needed to return the initial investment. This indicates the risk and liquidity instead of standing as a base of investment decision making. When the PBP calculation consider the time value of money, terms discounted payback period is used.

\[
DPBP = N \quad \text{when} \quad \sum (R_k - E_k) - Investment \geq 0
\]  

(3)

Among them, \( I_0 \) is initial investment cost, and \( NCF \) is net cashflow for each year.

2.4. Multiple linear regression

Multiple linear regression is a regression analysis that explains the relationship between response variables (dependent variable) with more than one predictor (independent variable) to measure the intensity of the relationship between two or more variables and make predictions of the estimate of the value of the dependent variable based on the independent variable.

The general additive multiple regression model equation is

\[
Y| = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \cdots + \beta_k x_k + \epsilon
\]  

(4)

Where \( E(\epsilon) = 0 \) and \( V(\epsilon) = \sigma^2[9] \). It is assumed that \( \epsilon \) is normally distributed.

3. Methodology

The investment feasibility assessment in this study begins with investment and O/M cost calculation using HOMER 2.68 program. In parallel, The ATP model for revenue potency is built using descriptive statistics and multiple linear regression equations. The tool used to build the ATP model is the IBM SPSS Statistics 22 software. Then the model is validated using the classic assumption test and model significance test. Various alternative is developed using techno-economics assessment to give the best alternative options for providing incentives and investment value to obtain optimum returns. Overall work flow described above is shown in figure 2.

![Figure 2. Workflow of investment feasibility study.](image-url)
In this study, several assumptions to represent real investment condition were made for the development model as follows:

1. Before tax calculation is assumed for the economic feasibility assessment
2. Data on community’s ability to pay is obtained from fishing and plantation villages
3. Willingness to pay of community in study location equal with their ability to pay
4. Investment is totally capitalized by investor internal funding
5. This study assumes the build-operate-transfer (BOT) investment scheme, the concession period of the BOT project is ten years exclude construction period, and that the salvage value of the fixed asset of the BOT project is not considered. After the concession period expires, the facilities of the BOT project should be returned to the Government unconditionally.

4. Model validation
There are seven principles as foundation that provide a comprehensive doctrine for developing the investment feasibility assessment: (i) develop the alternatives; (ii) focus on the differences; (iii) use a consistent viewpoint; (iv) use a common unit of measure; (v) consider all relevant criteria; (vi) make risk and uncertainty explicit; (vii) revisit your decisions [1]. Various alternatives developed in this model satisfy techno-economic feasibility principles above.

5. Result and analysis

5.1. Initial investment and cost estimation
Initial investment and cost for PV system is shown in table 1. Investment cost consists of PV array, batteries, bi-directional converter include all accessories, balance of plant, and other investment fixed and variable cost. O/M cost consists of fix and variable cost includes land leasing, operator salary, etc.

| Component      | Remarks       | Capital ($) | O&M ($/year) |
|----------------|---------------|-------------|---------------|
| PV             | 270 kW        | 901,796     | 32,150        |
| Battery        | 264 cells     | 410,256     | 67,241        |
| Converter      | 72 kW         | 72,388      | 2,712         |
| BOS and Others |               | 37,216      | 21,510        |
| Total Investment |              | 1,421,656   | 123,612       |
| Energy sold    |               | 169,515 kWh/yr | |

5.2. Revenue potency
Optimized linier regression model for ATP calculated using IBM SPSS Statistics 22 is shown in equation (5).

\[ ATP_i = 274.617,106 + 4.500,237C \]  

Among them, \( ATP_i \) is respondent ATP (IDR/Month/household) and C is household energy consumption per month (kWh/month).

Considering household energy consumption and household population in study location, it is found that revenue potency in USD is $283,716.46/year.

5.3. Incentive and investment scheme alternatives
Using techno-economic principle, a model interface which calculate cashflow component found on section 4.1 and 4.2 is built. When investment feasibility analysis shows that the investment is economically not feasible, seven scenarios of reasonable incentive scheme as shown in table 2 were delivered to make investment economically feasible, objective according to the ability and willingness to pay of the community, and not inflicting financial loss to the incentive giver.
Table 2. Incentive scenarios built for not feasible investment.

| Type      | Description                                                                 |
|-----------|-----------------------------------------------------------------------------|
| Scenario 1| high flat incentive is given during whole study period or until expected PBP achieved |
| Scenario 2| higher flat incentive is given for the first five years continued with lower flat incentive for the rest five years or until expected PBP achieved |
| Scenario 3| positive gradient incentive during whole study period or until expected PBP achieved |
| Scenario 4| negative gradient incentive during whole study period or until expected PBP achieved |
| Scenario 5| negative gradient incentive is given for the first five years continued with lower flat incentive for the rest five years or until expected PBP achieved |
| Scenario 6| high flat incentive is given only for the first five years |
| Scenario 7| negative gradient incentive is given only for the first five years |

Figure 3. Result of investment feasibility assessment.
Figure 3 (left-hand side) show techno-economic feasibility assessment initial result for investment without incentive and when investment is optimized with seven incentive scenarios to achieve reasonable feasibility at 10%, 12%, and 16% IRR (A – C – E) respectively. It is shown that when initial result investment which is not feasible is optimized by seven incentive scenarios, the investment becomes economically feasible.

Seven incentive scenarios in the right-hand side gives alternatives for investment scheme at 10%, 12%, and 16% IRR (B – D – F) respectively. Result show that with increasing of the expected IRR, the incentive value needed to optimize the initial result investment significantly increases.

6. Conclusion

Taken the ATP of community and proposed incentive scenarios, renewable energy-based power plant investment feasibility model is built and fulfill economic feasibility/techno-economic criteria, objective according to the community condition, and not inflicting financial loss to the incentive giver. ATP linier regression model on study location is a function of household monthly energy consumption with positive correlation. With ATP model, revenue potency calculation is objective according to community condition. The economic feasibility model built in this study is flexible enough to calculate many investment alternatives using incentive scenario so the optimized assessment results is economically feasible and not inflicting financial loss to the incentive giver.

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