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Investing in Renewable Energy: Decarbonizing Power Plant Industry with the Feasibility Study of Mini-Hydro Project

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A B S T R A C T

This study aims to analyze and determine the feasibility study of a mini-hydro project with a capacity of 2 x 3 MW in West Java, Indonesia. This research is a qualitative research with a case study approach. The selection of participants in this study used a purposive sampling technique, where the data collected was obtained from primary and secondary data. The data analysis used in this research is cash flow projection evaluation by calculating Payback-Period (PBP), Net Present Value (NPV) and Internal Rate of Return (IRR). Based on the calculations that have been made, the investment feasibility indicators for the projects to be funded are the Payback Period of 8 years and 3 months, the NPV of IDR 3,977 million and the IRR of 11.22% so that the mini-hydro project is said to be feasible to run.

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INTRODUCTION

Renewable energy is becoming increasingly important due to several factors, including economic issues, energy security, and environmental concerns. Amin et al., (2022), renewable energy sources such as solar, wind, and hydro power produce little to no greenhouse gas emissions, which can help reduce the negative impact of climate change. Marks-Bielska et al., (2020), Renewable energy sources are often domestically sourced, which can help reduce dependence on foreign energy sources and increase energy security. The renewable energy sector is growing rapidly, and investing in renewable energy can create jobs and stimulate economic growth. Unlike non-renewable energy sources such as fossil fuels, renewable energy sources are sustainable and can be replenished over time. As technology improves and economies of scale are achieved, the cost of renewable energy is decreasing, making it more competitive with non-renewable sources. Overall, the importance of renewable energy is clear, and it is essential that we continue to invest in and develop renewable energy sources to ensure a sustainable and secure energy future.

The renewable energy sector is growing rapidly. According to Sabishchenko (2021), investing in renewable energy can have several economic benefits, including creating jobs in areas such as manufacturing, installation, and maintenance. As technology improves and economies of scale are achieved, the cost of renewable energy is decreasing, making it more competitive with non-renewable sources. This can lead to reduced energy costs for consumers and businesses. Imaningsih et al., (2022), investing in renewable energy can stimulate economic growth by creating new industries and markets, attracting investment, and increasing exports. Renewable energy sources are often domestically sourced, which can help reduce dependence on foreign energy sources and increase energy security. Felice et al., (2021) a study on Renewable Energy Communities (RECs) in Belgium found that the amount of installed flexible technology, such as heat pumps or electric vehicles, can significantly reduce the operational costs of RECs, making them economically beneficial. So, investing in renewable energy can have significant economic benefits, including job creation, reduced energy costs, increased economic growth, improved energy security, and operational cost savings.

Mini-hydro projects are a part of renewable energy. A mini-hydro power plant is a type of renewable energy source that generates electricity from the energy of falling water. It is a small-scale hydroelectric power plant that typically generates less than 10 megawatts of electricity. Mini-hydro power plants can be installed in rivers, streams, or other waterways, and they can provide a reliable source of electricity to remote areas that are not connected to the grid. Mini-hydro projects can play a critical role in providing access to electricity in developing countries, including Indonesia. One of the interesting mini-hydro projects to study is around big cities, especially on Java Island. This research takes a case study of a mini-hydro project in West Java. According to BPS (2022), West Java is the second largest province on the island of Java with an area of 35,377.76 km^2 with access to electricity below the surrounding provinces such as Central Java, Yogyakarta and DKI Jakarta.

Investing in renewable energy, including mini-hydro projects can face several challenges, including the integration of renewable energy into the grid can be challenging due to the intermittent nature of some renewable sources. This requires strategic governance of the distribution/transmission interface, appropriate triggers for timely grid investment, and the development of services offered to the networks (Zavody, 2014). According to Yousif (2020), in terms of technical problems, renewable energy technologies are still developing, and there can be technical problems associated with their installation and operation. This can lead to increased costs and delays in project implementation. While the cost of renewable energy is decreasing, it can still be more expensive than non-renewable sources in some cases. This can make it difficult to attract investment and compete in the energy market. According to Omoregie (2018), financing renewable energy projects can be challenging, particularly in developing countries where there may be limited access to capital markets or where investors may be hesitant to invest due to perceived risks. In terms of regulatory barriers, policies and regulations can create barriers to the development of renewable energy, such as subsidies for non-renewable sources or lack of incentives for renewable energy investment. Despite these challenges, investing in renewable energy is essential for a sustainable and secure energy future. Governments, businesses, and investors must work together to overcome these challenges and continue to develop and invest in renewable energy sources, including mini-hydro projects.

LITERATURE REVIEW

Renewable Energy

According to He et al., (2022), renewable energy refers to energy that is generated from natural resources that are replenished over time and do not deplete, such as sunlight, wind, rain, tides, and geothermal heat. Unlike non-renewable energy sources, such as fossil fuels, renewable energy sources are sustainable and have a lower impact on the environment. Renewable energy is becoming increasingly important as the world seeks to reduce its reliance on fossil fuels and transition to a more sustainable energy system. In 2018, the global installed capacity of renewable energy reached approximately 2378 GW, and for the fourth consecutive year, the new installed capacity of renewable energy exceeded the new installed capacity of fossil fuels and nuclear energy.

Renewable energy technologies have to ensure the balance of several conflicting objectives with different factors. The development of renewable energy technologies has to ensure the balance of several conflicting objectives with different factors. For example, the uncertainty of renewable energy has an increasingly prominent impact on power system planning and operation. Renewable energy such as wind and solar energy is greatly affected by the external weather. To measure the uncertainty of renewable energy more accurately, researchers have proposed various methods, such as a renewable energy scenario generation method based on a conditional generation countermeasure network and combination weighting method (CWM-CGAN). In conclusion, renewable energy is a sustainable and environmentally friendly source of energy that is becoming increasingly important as the world seeks to reduce its reliance on fossil fuels.

Mini-Hydro Power Plant

Pangarso et al., (2022), a mini-hydro power plant (MHPP) is a type of hydroelectric power plant that generates electricity using the energy of falling water. It is typically smaller in size and capacity than a conventional hydroelectric power plant, with a capacity of less than 10 MW. MHPPs are usually located in areas with small streams or rivers, and they can be used to provide electricity to remote communities or to supplement the power supply of larger grids. They are also considered to be a renewable and environmentally friendly source of energy, as they do not emit greenhouse gases or other pollutants. Technical due diligence is an important part of the bankability due diligence carried out by banks for the construction of MHPPs (Saratian et al., 2022). It involves assessing the technical feasibility and risks associated with the project, including the design, construction, and operation of the power plant. This process is carried out on submitted project documents and onsite verification to sample MHPPs to determine if the project is ready to be financed from a technical point of view. MHPPs are a promising source of renewable energy, particularly in areas with small streams or rivers. They can provide electricity to remote communities and supplement the power supply of larger grids, while also being environmentally friendly.

Feasibility Study

A feasibility study is an assessment of the practicality and potential success of a proposed project or venture. It is typically conducted before the project is initiated to determine whether it is technically, financially, and operationally feasible. The study involves gathering and analyzing data on various aspects of the project, such as market demand, competition, resources, and risks, to determine whether the project is viable and worth pursuing. The results of the feasibility study are used to make informed decisions about whether to proceed with the project, modify it, or abandon it altogether (Eales at al., 2022). Among the cash flow evaluation tools that are often used in feasibility study studies are the Pay-Back Period (PBP), Net Present Value (NPV) and Internal Rate of Return (IRR). PBP is the investment return period without taking into account the discount rate. NPV is the accumulated value of cash flows from operational activities and investment activities which are discounted for a certain period, to be used as an indicator in assessing the feasibility of a project. IRR is a discount rate that causes the NPV value to be zero (0).

METHODOLOGY

This study uses case study approach. According to Sarwono (2013), research using a qualitative approach is based on phenomenological theory, symbolic interaction and constructionism. Some of the keywords in qualitative research, namely process, understanding, complexity, interaction and people. The process of conducting research is an emphasis on qualitative research. Qualitative research is also concerned with finding the truth about the phenomenon in the context in which the research is conducted (ideographic). According to Rahardjo (2017), a case study is a series of scientific activities carried out intensively, in detail and in depth about a program, event, and activity, either at the individual level, a group of people, institutions, or organizations to gain in-depth knowledge about the event. In this case, the researcher wants to analyze and find out the feasibility of the mini-hydro project. This study uses a purposive sampling technique, in which the sample selection is based on the subjective considerations of the researcher because it is considered appropriate in providing the desired information (Ferdinand, 2014). The sample in this study is one project of mini-hydro in West Java that is owned by one of the biggest energy companies in Indonesia. The reasons for choosing the object of research were that the company had complete legality and permits. The data collected in this study were obtained from primary and secondary data. Primary data is obtained from observation in the project site, while the secondary is obtained from technical reports, the legality of production reports, and other supporting data, both internal and external.

The data analysis method in this study uses the calculation of the Pay-back Period (PBP), Net Present Value (NPV) and Internal Rate of Return (IRR). The payback period for a mini-hydro project can be calculated using various methods, including the undiscounted payback period and the discounted payback period. The undiscounted payback period is calculated by dividing the lump-sum cost by the size of the revenue, and it is one of the most simple and widespread methods in world practice. However, it has a number of disadvantages, the main one being that it does not distinguish between projects with the same amount of cumulative income but are different in their distribution by year (Loginovskiy & Ya, 2016). The discounted payback period takes into account the time value of money and is calculated by determining the time it takes for the discounted cash inflows to equal the initial investment (Dai et al., 2022). Other methods for calculating the payback period include probabilistic approaches and fuzzy-set-based evaluation (Kim et al., 2013; Kotsyuba, 2020; Hašková et al., 2022). If the project's payback period $\leq$ the payback period of investment funds, then the business is feasible to run.

$$n + \frac{a - b}{c - b} \times 1 \text{ year}$$

The Net Present Value (NPV) is a financial metric used to evaluate the profitability of an investment project. It takes into account the time value of money by discounting future cash flows to their present value using a discount rate. The NPV is calculated by subtracting the initial investment from the sum of the present values of the expected cash inflows. A positive NPV indicates that the project is expected to generate a profit, while a negative NPV indicates that the project is expected to result in a loss. The specific NPV for a mini-hydro project will depend on various factors, such as the size and capacity of the project, the cost of construction and operation, the revenue generated, and the discount rate used in the calculation. Therefore, it is not possible to provide a specific answer to what the net present value for a mini-hydro project is without considering the specific details of the project (Gaspars, 2019; Dai et al., 2022; HamdAllh et al., 2020; Kim et al., 2013). If the NPV is positive, then the business is feasible to run.

$$NPV = -I_0 + \sum_{t=0}^{n} \frac{At}{(1+r)^t}$$

The Internal Rate of Return (IRR) is another financial metric used to evaluate the profitability of an investment project. It is the discount rate that makes the net present value of the expected cash inflows equal to the initial investment. In other words, it is the rate at which the project breaks even. The IRR is often used in conjunction with the net present value to evaluate investment opportunities. A higher IRR indicates a more profitable project, while a lower IRR indicates a less profitable project. The specific IRR for a mini-hydro project will depend on various factors, such as the size and capacity of the project, the cost of construction and operation, the revenue generated, and the discount rate used in the calculation. Therefore, it is not possible to provide a specific answer to the internal rate of return for a mini-hydro project without considering the specific details of the project (Dai et al., 2022; Gaspars, 2019; Mingxia, 2015; Loginovskiy & Ya, 2016; Cheremushkin, 2016). If the IRR value $\geq$ discount rate, then the business is feasible to run.

$$0 = NPV = \sum_{n=0}^{N} \frac{CFn}{(1+IRR)^n}$$

RESEARCH RESULT

This project has a capacity of 6 MW (2 x 3 MW) and will be located on the downstream side of a river in the West Java region. The company has carried out land acquisition and determined points for the location of dams, sand traps, waterways, headponds and powerhouses. The company has also appointed EPC contractors and electrical mechanics. The design of this mini hydro project is known as follows:

Tabel 1. The Design of this Mini Hydro Project

No.	Items	Notes
1	Waterway	2.017 m
2	Penstock	301 m
3	Head	72 m
4	Machine	Andritz Hydro

This project is also supported by legality in the form of a Power Purchasing Agreement with several counterparties, including a state-owned electricity company. The contract with the engine supplier is currently still in the negotiation process regarding technical matters of contract implementation, while the price value has been finalized. After the process of preparing the company's legality was carried out, they obtained a principle permit and a location permit with the West Java regional government. The entity also entered into an MoU with a state-owned company as an off-taker of this project. Administrative and technical matters are prepared by the company team. The Power Purchase Agreement (PPA) is entered into with the counterpart, with a term of 15 years. Licensing to the Director General of Electricity regarding the approval of electricity rates. Permits must be available before being submitted to the Director General of Electricity to start the mini-hydro project. Then it enters the construction process and is operational worthy for further commercial operation.

Based on the results of field observations, the technical highlights obtained are as follows:

Tabel 2. The Results of Field Observations

No	Description	Notes
1	Location	West Java
2	Technology	Run of River
3	Installed Capacity	2 x 3.00 MW
4	Head	72 m
5	Debit	13.30 m3/sec
6	Waterway	2.017 m
7	Penstock	301 m
8	Turbin Type	Francis Horizontal
9	Transmission Line from power house to grid	0.5 km
10	Cathment Area	231 km2

The topographical conditions around the mini hydro development project site are mostly hills with slopes from steep to very steep, with cover vegetation in the form of shrubs to community rice fields. The length of the main river to the location of the planned tapping building is 37.2 km with an average slope of 3.16%. Rivers and streams with a catchment area of 1 sq km or more have a total length of 150 km. The scheme for using river flow water for project operations is to drive 3 (three) turbine units which are estimated at Qmaximum = 16.72 m3/second, Qplan = 12.4 m3/second (Probability 75%), and minimum = 5.41 m3/second (or 40% Qplan or equivalent to a probability of 90%). In the dry season it is projected that the mini hydro will still be able to operate, and the water needs for the project will always be fulfilled throughout the year. From the results of an analysis of the average river flow discharge of 12.4 m3/s, it is estimated that the use of river water will not have a negative impact on the socio-economic life of the community because the use of river flows only makes use of a portion of the existing discharge. Based on the design discharge, high availability of effective fall and efficiency of the generator-transformer turbine at rated conditions, the project has the following outputs:

- Installed capacity: 2 x 3 MW
- Transformer Efficiency: 98%
- Switchgear&cable Eficiency: 99%
- Self-use: 97%
- Losses transmission: 97.9%
- Number of hours a day: 24 hours
- Number of effective days: 365 days
- Estimated energy production: ±34,600 MWh/year
- Capacity factor: 65%

Project Feasibility Analysis

Tabel 3. The project cost for mini-hydro development is as follows

Description phase of project		Project Cost in IDR	
Licenses		Rp.	1,000,000,000
Premium of acqusition		Rp.	20,000,000,000
Project management		Rp.	11,000,000,000
Total		**Rp.**	**32,000,000,000**
Land of project		Rp.	4,000,000,000
Civil Work		Rp.	156,200,000,000
Mechanical and Electrical Work		Rp.	52,910,000,000
Total		**Rp.**	**213,110,000,000**
- IDC			32,799,772,661
- Project Costs (exc. Interest During Construction)			245,110,000,000
- Project Cost (excl. Permit and Interest During Construction)		Rp.	213,110,000,000
Total Investment (Incl, IDC)		Rp.	277,909,772,661
- Bank Financing (69% from Project Cost)	69%	Rp.	192,632,272,661
- Self Financing	31%	Rp.	85,277,500,000
- % Bank Financing on Project cost (exc. IDC)			79%

The investment feasibility of the mini-hydro project is prepared with the following assumptions:

a. The projected revenue from selling and buying electricity for mini-hydro project is the same for the term of the agreement (15 years), with the basic assumptions for calculating:
   Availability of electricity per year:
   - Plant 1 37,500MWh/year
   - Plant 2 34,600MWh/year, or
   - Equivalent to capacity factor: Rp656,- per kWh.
b. COGS and SGA during the commercial period or tend to increase every year (assuming according to PPA for 15 years).
c. COGS to income is between 4% to 8%.
d. SGA to revenue is between 0.4% to 0.8%.
e. Financing period to be provided by investors is 9 years with a grace period of 2 years.
f. This project is still under construction.
g. The funding price provided is equivalent to 11% p.a.

The investment feasibility ratio for the project to be funded is as follows:

- Payback Period: 8 years 3 months
- NPV: Rp3.977 million
- IRR: 11,22%

Thus, the mini-hydro investment project in the West Java region above is considered feasible.

DISCUSSION

The Risk Mitigation of The Project

Tabel 4. Internal Factors

Risk Identification	Mitigation/Consideration
Risk of dependency on the key person	Entities in the form of PTs and companies have been supported by an organizational structure that has separated and delegated responsibilities and authorities.

Tabel 5. Eksternal Factors

Risk	Mitigation/Consideration
Construction Risk	The company cooperates in the development of mini-hydro projects with civil contractors and suppliers/machinery/M&E contractors who are quite bona fide, competent and have experience in their fields. In addition, the company will also charge fees/penalties if the work progress of the contractor is delayed. The company's business group has good credibility in completing the projects carried out.
Contract Risk	PPA has been signed between the company and the state-owned electricity company with a contract duration of 15 years after COD. For the state-owned electricity company, this mini-hydro project is a power plant that has economic value compared to other power plants, due to the higher price of diesel and gas fuel compared to using potential energy from flowing rivers.
Availability of river water	Based on the results of the feasibility study, based on various assumptions made, the flow of river water is sufficient to provide water for the mini-hydro project.
Cost Over Run Risk	In the event of a cost over run and cash flow deficiency during the construction process, there is a shareholder/guarantor who is responsible for increasing capital and overcoming this.

CONCLUSIONS AND RECOMMENDATIONS

Based on the projection calculations that have been made, the investment feasibility indicators for projects to be funded are as follows:

- Payback Period: 8 years 3 months
- NPV: Rp3.977 million
- IRR: 11,22%

Sensitivity analysis is carried out on the project cash flow with several scenarios as follows:

- We have conducted a stress test with a projected reduction in revenue of up to 15%, the mini-hydro project is still feasible to finance, with an indicator of the Debt Service Coverage Ratio (DSCR) > 1x. However, if revenue drops ≥16% then the DSCR becomes <100% and the project is not eligible to be invested.
- If a customer's project experiences an increase in operating costs (COGS and SGA) by 370%, then based on the stress tests we have conducted, the customer's project is still eligible to be financed with a DSCR > 1x.

Meanwhile, if COGS & SGA increase ≥371%, the project becomes unfit to be financed (DSCR <1x).

- We have conducted a stress test, with the company's projected sales to experience a decline of 4%, so the DSCR is >1.1 x. The PLTMH development project is still feasible to be financed with the following conditions:

Payback period:	8 years 3 months
NPV:	Rp1,96 billion
IRR:	11,11%

- We have conducted a stress test, with the company's sales projections being the same but costs (COGS & SGA) increasing by 175%, so the DSCR is >1.1x. The mini-hydro project development project is still feasible to be financed with the following conditions::

Payback period:	8 years 3 months
NPV:	Rp217 million
IRR:	11,0%

- If the decline in sales exceeds 4% and the increase in operational costs (COGS and SGA) exceeds 175%, the development of a mini-hydro project becomes unfit for funding.

Based on the assumptions that have been prepared based on the conditions in the field, the mini-hydro investment project in the West Java region is considered feasible. The feasibility indicators obtained are a positive NPV of IDR 3,977 million, an IRR of 11.22% and a payback period of 8 years and 3 months. Several important keys in the feasibility of this project are the captive market of the state-owned electricity company which needs to be maintained and strengthened with PPA. Second, it is necessary to monitor development progress so that the project can run commercially according to schedule, in this case the company can also involve project progress appraisal consultants. Third, a project sponsor is needed as a form of mitigating the company's financial condition, especially if overrun costs occur. Fourth, based on the projected Payback Period, the timeframe for returning funds to investors must be more than 8 years and 3 months. In this project, a payback period of 9 years is proposed with a grace period of 2 years.

ADVANCED RESEARCH

Still conducting further research to find out more about Investing in Renewable Energy: Decarbonization of the Power Generation Industry with Feasibility Study of Mini-Hydro Projects

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