Selection criteria of feasibility assessment on mini hydro power plant in Batang Sumani River Solok West Sumatera

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Abstract. In a feasibility analysis, there are many involved factors giving influences on a feasibility decision of a hydro power plant. The research aims to assess the extent of criteria benefits obtained in running an investment business activity. Results of the assessment are used as considerations in decision making, whether it is to accept or reject a power plant investment plan. Methodology used in feasibility assessment is Analytic Hierarchy Process. AHP is a simple and flexible decision making method to deal with qualitative assessment giving integration to all expert decisions through structured linkages and by weighting on some variables giving influences on feasibility aspects, such as technical aspects and non-technical aspects through instruments that are validated by project planner party, capital and investment agency, as well as provincial energy mining office and also engineering consultant. Research benefits can minimize any undesired risks, both controllable risks and uncontrollable risks. Proposed plans will be references in running each business stage, so that there will be systematic and effective work; it also facilitates supervision and control. The conclusion leads to eight important criteria giving great determinant and priority in assessment of a feasibility preparation results, so there will be a standard and valid feasibility decision.

1. Introduction

Solok region in West Sumatera is known by its coarse relief consisting of mountain (hills) and valleys. The valleys generally are watershed that can be used as water power potency. Water power is the first renewable energy source used to produce electricity. More or less 17% - 21.7% electricity production throughout the world is contributed by renewable energy [1, 2].

Water energy determines the amount of electrical power produced by the power plant in the forms of water debit and height of falling water [3]. Stages of power plant development consist of potential study, technical and non-technical feasibility study, civil building realization, mechanical and electrical, and performance analysis [4].

In potential study stage, it is to explore any information related to the purpose of power plant establishment, feasibility quantitative and qualitative criteria of a location to obtain priority of conducting a feasibility study. Meanwhile, in this feasibility study stage, there is technical feasibility assessment consisting of civil hydrology aspects and electrical mechanical aspects. Water conditions that can be used as electrical resources are ones with specific flow capacity and height from the installation. Higher flow capacity or height from the installation will lead to bigger energy to be used to produce electricity [5].
2. Literature review

According to Momin Mukherjee and Sahadev Roy, feasibility assessment has two important components namely location selection based on project feasibility criteria and power potential estimation using realistic development criteria. Main purpose of feasibility assessment is to evaluate three feasibility aspects; technical and non-technical feasibility, operational and economy. Feasibility study also depends on other factors such as project risk factors before starting the project and after running the project as well as potency of investment return [6]. An assessment in hydro power plant development must be based and refer to technical planning, designing and implementation. According to International Hydropower Association’s (IHA) and EIA (Environmental Impact Assessment) it is necessary to study environmental impact assessment to ensure that hydro power plant will not damage the environment. It should involve professionals and use their experiences in good technical combination with environmental effects.

Power plant sustainability is influenced by some factors, namely risk and political factors, economic impact benefits, operational and feasibility efficiency, location selection, design optimization, public consultation, stakeholders and supports, cultural heritage, environmental impact analysis and management system, land management and rehabilitation and environmental flow and reservoir management [7]. Assessment on hydro power plant is conducted based on turbine response on Flow Duration Curve variability, ecological negative impacts, flood and social effects. Output of hydro power plant fluctuates with river hydrology cycle [8].

To assess feasibility of small river in run-of-river type (until 2 MW), in rural areas, it has developed Economic Techno model. This model uses river data and installed burden to conduct economic analysis of the investment. Techno-economic feasibility analysis depends on local conditions, needs and resources so that it can evaluate size of turbine and nominal power of hydro power plant. This model can estimate design of main components and civil components [9].

Small Hydro Power (SHP) location assessment for project planning and development requires a high level of experience and expertise at the pre-feasibility and feasibility analysis stages. However, the assessment requires a field survey and needs analysis so that developers can make a decision on whether in the project implementation, there is FS or pre FS [10]. To ensure a feasibility policy, several methods are taken to decide on the condition based on the criteria that have been prepared by the actors and the government. There are various methods used, namely Multi Criteria and AHP Methods such as Topsis, Triangular Fuzzy Numbers (TFNS), Analytic Hierarchy Process and Data Envelopment Analysis (DEA) and Retscreen. Envelopment data analysis (DEA) is used as the main tool of analysis by mathematically modeling. To obtain the best generator, it is based on the efficiency aspect of the power plant against thermal output or on economical evaluation aspects with thermal input, outputs of fuel and electricity. There are two important indices, namely efficiency that reflects operational and investment performance [11].

Decision-making tools are based on environmental indices. Most hydroelectric power plants are installed in the most industrialized and densely populated regions. However, in remote areas due to low economic development, it leads to low utilization rate of electricity generation potential. This environmental index is the ratio formed between the powers installed with the area of a hydroelectric dam [12]. Mapping power plant resources in a certain area greatly requires location identification in renewable energy project development (SHP) using synthetic hydro network (SHN) made from digital elevation model (DEM). Large scale SHP assessment for pre-feasibility study has been conducted in United States [13]. Comprehensive assessment to obtain potency of sources using US Geological Survey (USGS) and geographic information system (GIS). Energy needs analysis should be based on location characteristics, data of water flow and head availability, and sources of hydro, future policies [14].

Feasibility studies are preceded by a pre-feasibility study with steps; Study of potential locations identified based on mapping, aerial photographs and earth maps, Economic evaluation of locations with water source levels, Analysis of reservoir environmental impacts, Hydrological aspects and sedimentation, Geological aspects are to see reservoir security and safety from earthquakes with maximum design earthquake (MDE) 0.178 g [15]. Pre-feasibility assessment of small hydroelectric
power projects in a fast and reasonable way is to predict more accurately the output of hydroelectric power generation schemes using RETScreen software [16]. Multi criteria analysis is one of quantitative project evaluation methods by examining economic, environmental and social impacts holistically. These methods are useful for offering an integrated approach to assessing economic and social factors environmental impacts simultaneously, as a practice to address social problems [17]. Electricity production hydropower produces several environmental impacts. The environmental impacts also depend greatly on specific characteristics of Fauna and flora, coastal erosion induced by dams [18].

Problems of electricity power sources of impacts of climate changes face by the world. Ratification of Kyoto protocol leads to commitment by each country to reduce pollutant emission giving the greatest direct impacts on climate changes. This leads and involves use of incentive policy on renewable sources of energy. Renewable energy sources produce energy without sacrificing natural resources. One of which is micro-hydro technology. Currently, this technology is still left behind and yet prepared to guarantee forms of attractive investment for personal investors without waiting for increased fuel prices and incentive stabilization in general, as well as renewable energy policy [19]. It is necessary for hydrology analysis to estimate fluid duration current (FDC). Current duration curve cover limits of trust based on current data uncertainty, such as rainfall, evapotranspiration and run-off mechanism. Such uncertainty is also assessed for monthly current based on simulation of daily model [20]. Low investment cost, small glass house emission and high output efficiency for power plant performance are the main keys to evaluate energy parameter for stakeholder [21].

3. Methodology
The research is started by activities of collecting data and information on quantitative and qualitative quantities through surveys in the field or locations of Sumani watershed. Data collected in Potential Study activities includes; Technical data and information about the potential of water resources (flow, discharge, and head) or watershed, data and information about the level of electrification and its growth potential, profile of local energy sources and current patterns of use and utilization, profile of needs and availability (supply-demand) electricity, and potential and development carrying capacity. Non-technical data and information about the profile and condition of the community socio-economic infrastructure, local capacity, level of participation, support and contribution of local communities to the development of power plants as new renewable energy.

Preparing Potency Feasibility Standard criteria using AHP and giving limitation and parameter (quantitative and qualitative) as feasibility benchmark of a watershed and irrigation channel potency and to be used as consideration for further feasibility study and priority, if it meets minimum criteria namely generated electricity potential, Continuity of river air flow available throughout the year, geology and geometry, distance to the PLN network. Total distance or length of the transmission network / distribution from location points to remote power light, plant location is not destructive and is not in banned cultural or natural preservation area by law and no permission to build permanent physical buildings, the number of available prospective users, level of accessibility leading to not extreme location which takes very expensive transportation technology, very extreme negative impacts on social and economic conditions, meeting international requirement standard for development of renewable energy and investment, other resources for development of power plants.

4. Results and discussion
Calculation of criteria assessment results (Table 1).
Table 1. Site selection criteria.

| No. | Criteria                          | Scoring          |
|-----|-----------------------------------|------------------|
| 1   | Heat                              | Very low        |
| 2   | Watershed                         | Damaged          |
| 3   | Water discharge                   | Very small       |
| 4   | Accessibility to location         | Far and difficult to achieve |
| 5   | Location distance from the nearest power grid | >5 KM    |
| 6   | Climate and rainfall              | Very small       |
| 7   | Whether the location status (principle permit) is already owned | 80% - 100% of locations already have a principle license |
| 8   | as the river been utilized for other activities | PLTM (H) & Irrigation is simple |

The weighting of the assessment index is the feasibility criteria using the Analytic Hierarchy Process method. It obtains eight criteria that are very decisive in the selection for the plant location on the Sumani River Solok as shown in Figure 1.

![HYDRO POWER DEVELOPMENT](image)

Figure 1. AHP method for selection hydropower plant criteria.

From the results of the discussion that the location used as the location of Hydro Power Plant is located in Kanagarian Koto Gaek Solok District, precisely located on Batang Sumani Hulu River. In conducting an analysis of investment feasibility to the Hydro Power Plant as its feasibility indicators, it consists of technical feasibility (site selection for civil building facilities, availability of water debit, civil facility planning, mechanical electrical facility planning), economic and financial feasibility, feasibility towards
social culture, and environmental feasibility. From the results of field calculations, it obtains the location of Upper Batang Sumani River in the actual head of 29 meters. While the parameters which are also the main consideration is instantaneous discharge at Sumani River upstream carried out the data of debit, it obtains measurable discharge of 15.44 m³/s.

5. Conclusion
From the result of physical analysis to civil building, then it obtains:

- The location for the intake channel is at coordinates of 00.56,40.6 LS and 100.36.25.3 BT where the irrigation dam is located; it was established during the Dutch colonial period with the width of the weir by 50 m with the height of the weir of approximately 1.2 m from the bottom of the river.
- The length of the conductor channel after field carrying is 1150 to the tranquilizer with the cross section is planned to be a trapezium-shaped open channel with a slope of 1: 0.5 using stone pairs.
- A tranquilizer is a planned building to reduce turbine flow before the flow into the penstock, the tranquilizer also serves as the final filter before the water enters the pipe and eventually enters the turbine.
- Pipe rapid (penstock) is a pipe that serves to drain the water from the sedative pond to the turbine, the size of the pipe is planned to have a diameter of 2 m, with a length of 182 m.
- Water power generated turbine 1176 kW and generator power 1 MW or kVA generator 1250 kVA.

References
[1] F S H Jui 2015 A Feasibility Study of Mini Hydroelectric Power Plant at Sahasradhara Waterfall Sitakunda, Bangladesh on Proceedings of 2015 3rd International Conference on Advances in Electrical Engineering
[2] J Dzaferovic 2012 Thesis magister feasibility study for small hydropower plant
[3] F Gallano, E Olivera and B Pereira 1998 Layman Guide Book on How To Develop a Small Hydro Site European Small Hydro Association
[4] A Damanik 2018 Buku Panduan Pengukuran Potensi Mikrohidro Kementerian ESDM dan UNDP [Online], Retrieved from: www.dosestoc.com/docs/13528777/ Panduan-studi-potensi-, 2018.
[5] M Gatte, R Kadhim and F Rasheed 2011 Using Water Energy for Electrical Energy Conservation by Building of Microhydroelectric Generation On The water Pipelines That Depend On The Difference in elevation Iraq J. Electrical and Electronic Engineering 7 2
[6] M Mukherjee and S Roy 2017 Feasibility Studies and Important Aspect of Project Management International Journal of Advanced Engineering and Management
[7] L Matejicek 2015 Multicriteria Analysis For Sources Of Renewable Energy Using Data From Remote Sensing 36th International Symposium on Remote Sensing of Environment, Berlin, Germany
[8] D I Shobayo, I A Adejumobi, O Awokola and A Akinwale 2014 An assessment of the small hydro potential of opeki river, Southwestern Nigeria Science Journal of Energy Engineering 2 3 25-31
[9] T Mandelli, E Colombo, A Redondi, F Bernardi, B B Saanane, P Mgaya and J Malisa 1996 A Small-hydro Plant Model for Feasibility Analysis of Electrification Projects in Rural Trans, Energies ISSN 1996-1073
[10] P Adhikary, P K Roy and A Mazumdar 2014 Multidimensional feasibility analysis of small hydropower project in India: a case study ARPN Journal of Engineering and Applied Sciences 9 1 80-84
[11] K Sarica and I Or 2007 Efficiency assessment of Turkish power plants using data envelopment
[12] A C C de Souza 2008 Assessment and statistics of Brazilian hydroelectric power plants: Dam areas versus installed and firm power Renewable and sustainable energy reviews 12 7 1843-1863

[13] J F Cyr, M Landry and Y Gagnon 2011 Methodology for the large-scale assessment of small hydroelectric potential: Application to the Province of New Brunswick (Canada) Renewable energy 36 11 2940-2950

[14] US Depart. Energy 2006 Feasibility Assesment of the water energy resources of the united states for New Low Power and Small Hydro Claess of Hydroelectric Plant. US Departement Energy DOE-ID_11263

[15] E Chong and P Robinso 2017 Feasibility Study for the Baleh Hydroelectric Project

[16] M I Yuce and S Yuce 2016 Pre-feasibility Assessment of Small Hydropower Projects in Turkey by RETScreen Journal-American Water Works Association 108 5 E269-E275

[17] R Morimoto 2013 Incorporating socio-environmental considerations into project assessment models using multi-criteria analysis: A case study of Sri Lankan hydropower projects Energy Policy 59 643-653

[18] A Botelho, P Ferreira, F Lima, L M C Pinto and S Sousa 2017 Assessment of the environmental impacts associated with hydropower Renewable and Sustainable Energy Reviews 70 896-904

[19] R Archetti 2011 Micro hydroelectric power: feasibility of a domestic plant Procedia engineering 21 8-15

[20] F Katal and F Fazelpour 2018 Multi-criteria evaluation and priority analysis of different types of existing power plants in Iran: An optimized energy planning system Renewable Energy 120 163-177

[21] J E Hunink, S Contreras, P Droogers and H Evolutions 2015 Hydrological pre-feasibility assessment for the Romuku hydropower plant Central Sulawesi, Indonesia