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Business Performance and Sustainability of On-Grid Mini Hydro Power Plants in Indonesia

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ABSTRACT
This paper analyses the business sustainability of on-grid mini hydropower plants. It helps to improve the implementation effectiveness of renewable energy in Indonesia. The sustainable business of on-grid mini hydropower plants is a key for increasing renewable portion and emission reduction. Twelve mini hydro installations with more than one-year operational record were studied. Panel data from 27 respondents were collected in 2018 and analysed qualitatively using stakeholder theory and resource-based theory.
The on-grid mini hydropower plants were built and operated at certain cost and the revenue is derived from the sales of electricity. The feed-in-tariff determined by the government policy and each mini hydropower plant has different competitive advantage. Although five mini hydropower plants agreed on the business sustainability throughout the power purchase agreement, only one of them has met the profit expectation. Cost overrun in construction, less profitability and cash flow issue are problems identified in the mini hydropower plants business.

Keywords: *business performance, sustainability, mini hydro, renewable energy, stakeholder theory, resource-based theory*

1. INTRODUCTION

The total installed capacity of the power generation in Indonesia is 60.8 GW, of which the total contribution of renewable energy is of about 9.5 GW. The installed capacity of the hydropower plants is of about 5.5 GW (*Statistik Ketenagalistrikan*, 2017; Irena, 2019). In 2016, there were 41 mini hydropower plants with a total capacity of 134 MW operated commercially by some independent power producers (IPPs) in Indonesia (*Statistik EBTKE*, 2016***)***. While the performance and sustainability of large hydropower plant in Indonesia have been tested over a long time the state electricity company (PLN), the performance and sustainability of mini hydropower plants operated by independent power producer have not been largely explored. The potential of hydropower plant resource, in a total of about 75 GW (BPPT, 2018) may add more climate-friendly electricity in the future.
The key success factors of profitable and sustainable on-grid mini hydropower plant business are analysed in this paper to improve the effectiveness of renewable energy investment decisions, construction and operation. This paper explains how synergy among resources with a competitive advantage and the government policy of on-grid mini hydropower plants generate business performance and sustainability. Stakeholder theory is used to analyse the importance of synergy among parties directly involves in the mini hydro business either as suppliers, partners and consumers. The resource-based theory is used to analyse the relative competitive advantage position of each mini hydro being studied.
Masini and Menichetti (2012) indicates that the empirical study on business performance and sustainability in renewable energy is limited. This paper adds more empirical business research for on-grid mini hydro business using data from Indonesia.
Newbert (2007) has indicated that 53% resource-based theory received empirical support. Barney and Arikan (2001) has emphasised the importance of the resource-based theory logic implementation in empirical research to get a consistence result. This paper explains why research inconsistency indicated by Newbert (2007) has occurred.

2. LITERATURE REVIEW

The productivity of resources, cost competitiveness and favourable revenue, including capabilities, are primary sources of profitability. Government, public, social organizations, customers, suppliers, lenders and environment are stakeholders for an on-grid mini hydropower plant business. Each stakeholder has its respective role and influence on business performance. The

understanding of the relationships among resources, capabilities, competitive advantage, profitability and sustainability offered by parties directly involved in the business is essential to make informed investment decisions, efficient construction and operation of the on-grid power plant business. The practical implementation of stakeholder and resource-based theories in renewable energy business still needs further development for improving the effectiveness of investment decisions.

2.1 Stakeholder Theory and Resource-based Theory (RBT)

The stakeholder theory explains the synergy or co-operation among parties involved in the business to achieve their respective interest. Whenever the interest of each party has been fulfilled then the business will work accordingly. Otherwise, the business will not work. Business owners, employees, suppliers and creditors expect reasonable revenue. Customers expect a reliable and affordable product. By nature, a company interacts each other with its stakeholders. A company activities or corporate actions may have positive or negative impacts to its stakeholders. Stakeholder theory emphasizes the importance of value creation (economy), political (power-sharing), rights and obligations among parties. Supportive relations among parties involved in the business activities are important for the success of the business and simultaneously fulfill the interest of each party. Good synergy among parties involved in a business such as government, public, social organizations, suppliers, lenders, customers and environment will generate better performance (Freeman, 1984; Choi and Wang, 2009). Ability to create good inter-relationship among business stakeholders is a source of competitive advantage (Ireland et al., 2013).

The resource-based theory explains the use of production factors such as capabilities, in the form of physical, human, management resources, in generating superior profitability (Barney, 1991). Resources in a business perspective are tangible or intangible strengths and weaknesses controlled or managed by a company or internal factors (Wernerfelt, 1989). The production factors or resources such as assets, competence, human resources, financial resources, management systems owned or controlled by a company are called internal factors. Resources, permits, loans, business licenses controlled by other organizations/parties are called external factors. The internal factors constitute strengths and weaknesses, while the external factors provide threats and opportunities to entrepreneurs. Internal factors and external factors may change and disturb the existing business equilibrium. The resource-based theory is focused on the internal strengths or competitive advantage of a company capable of exploiting opportunities (external factors) and minimizing weaknesses and threat that are required for achieving expected profitability and maintaining the performance in a sustainable way (Grant, 1999; Barney, 1991). From the perspective of management strategy, sustainable business requires a good match of internal and external factors. The synchronization between resource competitive advantage and management effectiveness are keys to the success of the business performance and sustainability (Sirmon et al., 2011).

The resource-based theory (RBT) is about maximizing benefits produced per unit cost (competitive output) through efficient production, organization, effective adaptation to maintain durable heterogeneity and elimination of wastes (Barney, 2002; Teece et al., 1997). Performance differences among competing firms are attributable to the differences in their resources with intrinsic differential level of productivity (Barney, 1991; Peteraf, 1993, Peteraf & Barney, 2003). Superior resources are valuable, scarce and durable (Newbert, 2007; Collis and Montgomery, 2008). Resources and internal capabilities can be physical, human or organization (Barney, 1991). The examples of physical resources are factory building, machines, process, raw materials, money, patent, permits. Skill, knowledge and attitude are the examples of human resources. The examples of organization resources are capabilities to organise resources, access to resources of others such as information, loan, technical support and management system to generate a superior product.

The scarcity of critical resources may be short-lived because it is inherently imitable or a temporary phenomenon due to limitation in the replication in rapidly changing conditions or longer-lasting due to barriers to imitation and substitution in stable environment. Competitive resources are capable of using scarce resources to generate and retain valuable revenue for a long time (durable). Some sources of competitive advantages are 1). Imperfect mobility, natural restrictions of resources capable of generating products with more economic value such as patent, permit, ownership of material, process and systems (Peteraf, 1993; Collis and Montgomery, 2008, Hart, 1995), 2). Productivity, cost, quality and service leadership in the production process, 3). Favourable revenue.

The sustainability analysis is carried out to see whether a business model has reliable inputs, productive process and favourable profitability for a long time either lowering cost and or improving benefits (Peteraf and Barney, 2003; Newbert, 2008; Yuwono et al., 2019). Iddrissu and Bhattacharyya (2015) propose five indicators for sustainability namely technical, social, environment, economic and institutional. Technical indicator captures the reliability and efficiency of resources such as raw materials, infrastructures of facilities. Social indicator captures public support and distribution of the benefit. Environment indicator captures environmental issues and mitigation of environmental risks. Economic indicator captures cost, profitability and the potential of growth of the business. Institutional indicators capture the capability of an organisation in managing resources, controlling cost and maximising result. Social, environment and economics indicators are also used in sustainability analysis, see International Atomic Energy Agency (2005). The on-grid mini hydro business involves a lot of technical and management aspects. Therefore, the indicators proposed by Iddrissu and Bhattacharyya (2015) is considered more suitable for the research.

Mini-hydro power plant is a system that converts the flow rate of water coming from a certain height (head) into electricity. Schematic diagram a general hydropower plant is provided on figure 1.

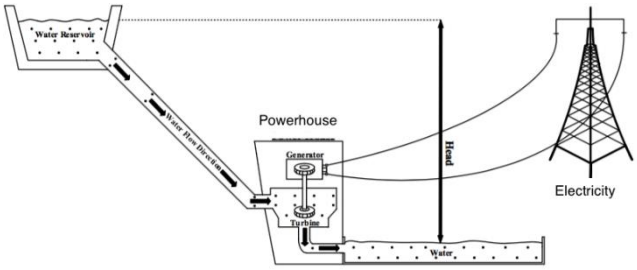

Figure 1. Schematic diagram of converting water flow rate coming from a certain head into electricity using a turbine and a generator.

Project design, construction, operation, maintenance and electrical generation productivity of a mini-hydropower plant has influence on overall electricity generation cost. The cost leadership in electricity production and favourable profitability determine the business performance level. The sustainable competitive advantage of a mini hydropower plant is characterized by value, rareness and reliability of the installation as well as the capability in generating durable profitability.

The roles of government in the on-grid renewable electricity business are: 1) providing a reliable and affordable supply of electricity, 2) providing opportunity and threat to the mini hydro business. The government protects the public interest by regulating feed-in-tariff through long-term power purchase agreement (PPA), providing incentive to attract investment in the renewable energy business and setting standards on safety, technical reliability, environment and social (Noor, 2015; Samuelson and Nordhaus, 2002). The government is part of the external factors that provide opportunity and threat to the mini hydro business and it acts independently from a company. In line with the stakeholder theory, the positive interaction between both competitive advantage and government policy in business determines the profitability and sustainability of mini-hydropower plant business. The value chain of a mini-hydropower plant business is provided on figure 2.

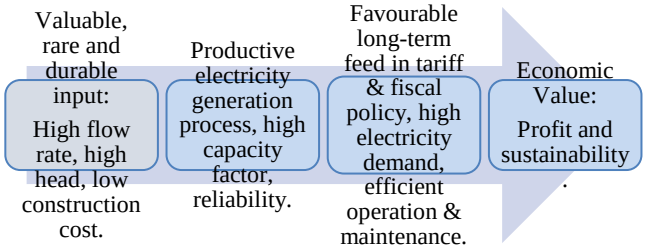

Figure 2. The value creation process, business performance and sustainability of on-grid mini hydropower plant business.

3. METHODOLOGY

This paper uses a qualitative method for analyzing the business performance and the sustainability of on-grid mini hydropower plants with capacity up to 10 MW. Panel data were captured from 12 mini-hydropower plants that have been in commercial operation for more than 1 year. The data were collected in 2018 from the owners, directors and managers of the mini hydropower plant installations. Descriptions of the mini hydropower plants studied were provided on table 1 as follows:

Table 1. Descriptions of the 12 mini-hydropower plants studied

Location	**Capacity**	**Capacity factor**	**Respondent**
Sumatera : 8 Java : 1 Bali : 1 Sulawesi : 2	< 1 MW : 1 1 – 4 MW : 3 4 – 6 MW : 4 > 6 MW : 4	45 – 85% **Operation Period** 1 – 3 years: 7 > 4 years : 5	Shareholders: 8 Directors : 7 Managers : 12

Each on-grid mini-hydropower plant has its own characteristics related to its competitive advantage, tariff and incentive from the government, economic performance and business sustainability. Interviews with mini hydro owners, directors and managers were conducted on the competitive advantage of resources, government roles related to tariff and incentive, economic performance and business sustainability. Five indicators of sustainability proposed by Iddrissu and Bhattacharyya (2015) were used to capture the level of competitive advantage and business sustainability. The technical, social, environment, economic, and institutional indicators were taken into consideration when analysing competitive advantage and the sustainability of each mini-hydropower plant.

In a mini-hydropower plant, the technical indicators capture productivity, reliability of civil, mechanical and electricity distribution of the facility. The social indicators capture the quality of the relationship between the company to the society around the mini-hydropower plant, job creation and economic growth in the area. The environment indicators capture catchment area conservation. The economic indicators capture the construction or acquisition cost of the plant and access to financing. The institutional indicators capture the operational management competence, skill, business experience of the management and shareholders and openness towards innovation or new ideas to improve productivity.

The indicators used to capture roles of the government in the renewable energy business are tariff and fiscal incentives, environment protection and openness of the government to feedback from the stakeholders. Every mini-hydropower plant may have different electricity tariff and incentives depending on the applicable regulation during the power purchase agreement. The indicators used to capture the business performance in the renewable energy business are regular payment from the electricity buyer, profitability, cash flow and market share. The business

performance represents the profitability level of the mini-hydropower plant business.

The on-grid mini-hydro business normally has fifteen to twenty five years of the power purchase agreement (PPA). The sustainability indicators capture the capability of the mini-hydropower plant business to deliver the expected profitability throughout the PPA.

This paper assumes that the mini-hydropower plant business has been considered profitable throughout the PPA when the investment decision was made. To capture the business performance and sustainability of the twelve mini-hydropower plants were evaluated after the construction has been completed and in commercial operation for more than 1 year. The respondents were asked to give their opinions on indicators statements related to the competitive advantage of their operational mini-hydropower plants, roles of the government, performance of the business and the business sustainability. The respondents are assumed knowledgeable about the technical, social, environment, financial of the mini hydropower plant. The level of agreement and disagreement were differentiated into 1) strongly disagree, 2) disagree, 3) slightly disagree, 4) slightly agree, 5) agree, 6) strongly agree.

4. RESULT

Out of the 12 mini hydropower plants participating in the survey, there were 27 eligible respondents. All those 12 mini hydropower plants secure a long-term PPA. Each mini hydropower plant has specific electricity output and capacity factor depending on the site quality and the electricity demand of the grid. The capacity factor shows the percentage of the electricity delivered to the grid concerning the power generation capability in supplying the grid.

The feed-in-tariff is determined based on applicable government policy, and each power plant may have different feed-in-tariff. The total revenue of each power plant depends on the quantity of electricity sold to the grid in kilowatt-hour and the applicable feed-in-tariff per kilowatt-hour (IDR/kWh). The revenue derived from selling the electricity will be used to cover investment cost, operation and maintenance cost and dividend. The investor expects profit from the mini hydro business. The most productive power plants are the ones that capable of generating the least cost of electricity and deliver electricity to the grid at an interesting profit.

The survey has indicated that seven mini hydropower plants have both problems of cost overrun and access to financing. Two suffer from cost overrun. So, in total, nine mini hydropower plants have problems with cost overrun. Only three mini hydropower plants were built at the right cost. Overall, ten mini hydropower plants have problem to access the loan. Only one mini hydropower plant agrees that the government provides the right policy support on tariff and incentive to the mini hydro business and ten mini hydropower plants only slightly agree on the statement.

Throughout operation, only one installation has agreed that the profit meets the expectation. Ten installations slightly agree and one installation disagrees on the statement that the mini hydropower plant delivers the expected profit. Three installations have cash flow problems. Five installations agreed and seven installations slightly agreed on the statement of good sustainability of the mini hydro business. The results of the research on business performance and sustainability of the mini hydropower plants were summarised on Table 2.

Table 2. Results of the research of the mini-hydro system competitive advantage, government support, business performance and business sustainability

No	Installed Capacity, location & operational duration	Capacity factor	Good Competitive Advantage	Good Government Support	Good Business Performance	Good Sustainability
1	8 MW, Sumatera, > 4 years	70%	Agree	Slightly agree	Slightly agree	Slightly agree
Problems: cost overrun, financing access from banks, less profitability.						
2	5 MW, Sumatera, > 4 years	65%	Agree	Slightly agree	Slightly agree	Slightly agree
Problems: cost overrun, financing access from banks, less profitability, cash flow.						
3	4 MW, Sumatera, 1 - 3 years	50%	Slightly agree	Slightly agree	Slightly agree	Agree
Problems: cost overrun, financing access from banks, less profitability.						
4	5.3 MW, Sulawesi, > 4 years	52%	Slightly agree	Slightly disagree	Slightly agree	Slightly agree
Problems: cost overrun, less profitability. Agree to easy access to financing and good interest.						

5	3 MW, Sumatera, 1 - 3 years	45%	Agree	Slightly disagree	Slightly agree	Slightly agree
Problems: cost overrun, financing access from banks, less profitability, cash flow.						
6	2.3 MW, Bali, 1 - 3 years	55%	Agree	Slightly disagree	Slightly agree	Agree
Problems: financing access from banks and less profitability.						
7	6 MW, Sumatera, 1 - 3 years	65%	Slightly agree	Slightly agree	Slightly agree	Slightly agree
Problem of cost overrun. Profitability is slightly less than the expectation. Slightly agree to easy access to financing and good interest.						
8	10 MW, Sumatera, 1 - 3 years	76%	Agree	Slightly disagree	Slightly agree	Agree
Problem of financing access from banks. The government is considered not so supportive. Profitability is slightly less than the expectation.						
9	3 MW, Sulawesi, > 4 years	78%	Agree	Agree	Agree	Agree
Problems: financing access from banks, less reliable grid. The profitability is as the expectation.						
10	9 MW, Sumatera, > 4 years	75%	Agree	Slightly agree	Slightly agree	Slightly agree
Problems: cost overrun, financing access from banks. Slightly less profitability than the expectation.						
11	7 MW, Sumatera, 1 - 3 years	80%	Agree	Slightly disagree	Slightly agree	Agree
Problems: cost overrun, financing access from banks. Slightly less profitability than the expectation.						
12	0.7 MW, Java, 1 - 3 years	60%	Slightly agree	Slightly agree	Disagree	Slightly agree
Problems: cost overrun, financing access from banks, less profitability, cash flow.						

5. DISCUSSION

The potentially productive and profitable locations of on-grid mini hydropower plants are rare or scarce. When constructions of on-grid mini hydropower plants were started, the investors believe that the investment will deliver expected profit over the power purchase agreement (PPA) period, which is about 15 to 25 years long. The PPA sets the selling price of electricity generated in kilowatt-hour (kWh) into the grid. An on-grid mini hydropower plant has a competitive advantage if it generates expected profitability. If the profit is maintained throughout PPA, then the installation has a sustainable competitive advantage. The costs of project development, construction, operation, and maintenance have an impact on the profitability and sustainability of the mini-hydro installation. Operation and profitability track record will help in securing financing from lenders.

The construction cost overrun has been experienced by the most mini hydropower plants. The facts that only three mini hydropower plants were built at the right cost and most installations have difficulty to access financing from lender, it indicates that most mini hydro installations were not planned properly and lenders consider that the business is either risky or unknown. Although all mini hydropower plants studied are confident on the ability to continue the business throughout PPA, the cost overrun in the construction of the mini hydropower plant explains why most mini hydropower plants have less profitability. A more precise project planning, costing, risk management and

more supporting policy will help in improving the business performance and sustainability. Mini hydropower plants experiencing a lot of costs overrun and less energy generation will find feed-in-tariff not enough to provide expected profitability. Resources that are unable to exploit business opportunities, minimising weaknesses and threat are not competitive.

Based on the available data, the profitability of on-grid mini hydropower plants have been influenced by productivity of the mini hydro installation, cost of construction, cost of operation and maintenance and revenue. In line with the resource-based theory (RBT), the level of resources and internal capabilities of each installation differentiate the competitive advantage of each mini hydropower plant. Many resources, capabilities and stakeholders are involved in the on-grid mini hydro business. The precision of the business plan in forecasting construction, operation and revenue will minimise the deviation of the business performance from the business plan. The level of competitive advantage of the resources and the profit durability over the period PPA of on-grid mini hydropower plants is reflected after the installation is operational. In-depth study, analysis and value creation steps such as productive project design, construction, operation and maintenance, sales of product involved in transforming potential hydropower plant site into profitable and sustainable on-grid mini hydropower plants business. Business owners, vendors, contractors, employees expect favourable revenue for the investment, products and services delivered. Customers expect reliable and affordable electricity. Lenders expect getting their loan back with interest. Government protects public orders by setting standards, issuing policies for encouraging and discouraging certain economic activities. The synergy among stakeholders is the key to fulfill the interest of each party and successful mini hydro business.

The research of on-grid mini hydropower plants business performance and sustainability has been found consistent with the resource-based theory and stakeholder theory. The choice on indicators and the conformance of indicators to resource-based theory logic may contribute to the consistency of the theories with the research results. The sustained competitive advantage of the mini hydro power business requires a good fit among resources and stakeholders involved in the business in the long run. Finding the respondents who understand the overall conditions of the mini hydropower plants and willing to fill the questionnaires was barriers of the research. More operational on-grid mini hydropower plants participating in the survey will give more precise performance and sustainability information of the business.

6. CONCLUSION

The sustainability of on-grid mini hydropower plant business is dependent on the cost, the durability of the inputs, productive electricity generation and distribution, favorable government policy on feed-in-tariff and fiscal policy, the quantity of electrical energy consumption and efficient revenue collection. At a certain feed-in-tariff for the mini hydro, having the precise project feasibility study, the right cost of electricity production, reliable electricity supply and the right quantity of electricity sales to the grid are keys for achieving good business profitability and sustainability. Adjustment of the government policy on the feed-in-tariff and the fiscal policy are required to attract investment and maintain the sustainability of the renewable energy business. The competitive advantage of the resources and the synergy of the internal factors and the external factors are the determinant of the profitability and the sustainability of the mini hydropower plant business in Indonesia.

The qualitative research on the business performance and the sustainability of the mini hydropower plants has been supported by the theory of stakeholder and the resource-based theory. Measuring the influence of resources, roles of government to the business performance and sustainability of mini hydropower plants are interesting subjects for future quantitative research. Further research on mini hydro business financing issues is also useful for improving the effectiveness of government policy and the sustainability of the renewable energy business in Indonesia. In addition to mini hydropower plant business, other on-grid renewable energy businesses utilising renewable resources such as biomass, biogas, solar energy, geothermal are also interesting for further research to understand the business and sustainability characteristics of each type of renewable energy power generation.

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