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Analysis of Institutional Aspects of Operation and Maintenance of Micro Hydro Power Plant Case Study in Sumba Island - NTT

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Abstract. One strategy is to support the government to increase Electrification Ratio by utilizing Renewable Energy amidst the limitations of The State Electricity Company (PLN – Perusahaan Listrik Negara) to reach outermost and remote rural locations. Sumba Island is one of the areas with the lowest Electrification Ratio but has abundant natural resources for the development of renewable energy power plants. One of the Renewable Energy potentials being developed on Sumba Island is a Micro Hydro Power Plant. Renewable Energy issues are not only in demand supply but also on the sustainability of operation and maintenance. Several villages with electrification programs using Renewable Energy have experienced problems in terms of sustainable operation and maintenance due to the lack of strong institutions that manage the plants that have been built. This research was developed to answer the problems that have been mentioned with the aim of identifying and analysing the aspects that drive the institutional performance of Micro Hydro Power Plant operation and maintenance in Sumba Island, NTT (Nusa Tenggara Timur) Province. The results of the research are important aspects in institutional determination and maintenance that will support the elements of forming a sustainable institutional pattern as input for all stakeholders, especially the government in order to increase the national Electrification Ratio.

Keywords: Institution aspects, maintenance, operational, renewable energy, Sumba

Abbreviations: PLN, NTT.

Running Tittle: Institutional Aspect of Operation and Maintenance

INTRODUCTION

The role of energy is very important to drive the economic activities of a country where electricity is a vital form of energy for human life. The tendency of increasing demand for energy from fossil materials has an impact on decreasing energy reserves. With limited reserves of electrical energy from fossil fuels, it encourages the emergence of new and renewable energy reserves. Renewable energy that is environmentally friendly (pollution free). Renewable energy as alternative energy refers to a form of energy other than conventional fossil energy sources. Among the potential sources of renewable energy are water, sea, wind, geothermal, sunlight, biomass, etc. Several countries, including Indonesia, are starting to use renewable energy for electricity generation. This is based on the importance of alternative energy sources besides fossil energy which face the challenge of decreasing reserves and an impact on climate change due to excessive use of fossil fuels.

The issue of energy is one of the important issues facing Indonesia today where one of the problems is that not all regions have electricity supply. Some of the causes of the obstacles faced by the government in equal distribution of national electricity include the high growth in demand for electricity in line with population growth, inefficient consumption patterns, uneven population distribution, and the characteristics of an archipelagic country that is spread across several outer and remote islands. This is a big obstacle for the state company The State Electricity Company (PLN – Perusahaan Listrik Negara) which is given the task of national electricity supply to reach regions considering the cost of procuring electricity infrastructure is quite expensive.

The issue of energy is one of the important issues facing Indonesia today where one of the problems is that not all regions have electricity supply. Some of the causes of the obstacles faced by the government in equal distribution of national electricity include the high growth in demand for electricity in line with population growth, inefficient consumption patterns, uneven population distribution, and the characteristics of an archipelagic country that is spread across several outer and remote islands. The National Electrification Ratio in 2019 is 98.89% (Decree of MEMR, 2020). However, seen from the electrification ratio, several provinces are below 89%, including NTT - Nusa Tenggara Timur (East Nusa Tenggara) Province at 85%. The performance report of the Ministry of Energy and Mineral Resources in 2019 notes that the primary energy mix is still dominated by coal energy sources of 60.50%.

It is stated in the best practice guidelines which contain the Micro Hydro Power Plant scheme that only a small portion of the potential of hydropower has been utilized by the application of Micro Hydro Power Plant technology in Indonesia. On the other hand, hydropower is the most economical option for providing sustainable village electricity. (Ramussen, 2011) There are several reasons mentioned so that Micro Hydro Power Plant is suitable to be applied to poor and remote villages, including: 1. It does not require a logistical process for collection with energy saving (power sources), 2. The Micro Hydro Power Plant built can last a long time and can even reach a service life of up to 20 years if properly maintained, 3.The electricity generated lasts all day long or does not break like in Solar Power Plant and does not experience large fluctuations except if it is dry season where the flow of flow can be

significantly reduced, 4. Even though it uses sophisticated technology, it is still easy for the community to understand so that the community can be trained to operate and maintain Micro Hydro Power Plant.

MATERIALS AND METHODS

One of the steps taken in order to realize an increase in the Renewable Energy mix and in general to support the reduction of CO_2 gas emissions by building power plants that use Renewable Energy as fuel. In anticipation of the early decline in fossil fuel reserves, the government is promoting the use of Renewable Energy both in big cities to remote and outermost areas that are difficult to reach by energy distribution, especially electricity from power plants that still use fossil fuels (diesel / genset, coal, gas, gas engine, etc.). The availability of electrical energy in remote or outermost islands is needed to improve the economy and community welfare by developing Renewable Energy, one of which is on the island of Sumba. The potential of Renewable Energy that exists makes Sumba Island an icon of Renewable Energy which will be used as an example to be replicated throughout the archipelago and/or the foremost islands in Indonesia.

Sumba Island in East Nusa Tenggara is designated as a Renewable Energy Iconic Island (Sumba Iconic Island - SII) through the Decree of the Minister of Energy and Mineral Resources (MEMR) Number: 3051 K/30/MEM/2015 (Decree of MEMR, 2015). With this stipulation, it is targeted that Sumba Island has 95% (ninety five percent) energy needs to be met through the use of Renewable Energy in 2020. As a vision of the Renewable Energy Iconic Island (Sumba Iconic Island) which is a program on Sumba Island, namely the availability of energy access to the community that comes from renewable energy (Lomi, 2016). Of the total capacity of the Renewable Energy generator on Sumba Island, 74.83% or 4,437 kW is the contribution of Micro Hydro Power Plant (mini and micro hydro).

According to Imam Kholig in his journal (Kholiq, 2015) that apart from Hydroelectric Power Generator, Micro Hydo Power Plant which has a capacity of 200-5,000 kW has a potential of 458.75 MW which is very feasible to be developed to meet the electricity needs of rural areas in remote rural areas or on small islands that have narrow river flows. Micro Hydo Power Plant requires an investment cost that is relatively cheaper than the cost for Hydroelectric Power Generator. One of the reasons is the simplification of construction cost standards that have been adapted to rural conditions. The investment cost required for Micro Hydo Power Plant is approximately 2,000 dollah / kW, and the energy cost for a 20 kW generating capacity (the average used in the village) is Rp. 194 / kWh.

From the environmental side, the effect of using energy in Indonesia has contributed to the contribution of carbon emissions from the energy sector, contributing 30% of carbon emissions (UGM News, 2017). This arises as a result of the effect of energy use in Indonesia which is still dominated by the use of fossil-based energy, especially petroleum fuels and coal. The National Energy General Plan mandates that the target portion of New and Renewable Energy in the national primary energy mix is 23% (perent) in 2025 and 31% (percent) in 2050 (Rahmat MH, 2017). This target is still very far from being realized at this time. Realization of the portion of New and Renewable Energy in the national energy mix by 2017 only reached 8.4% (percent).

The Renewable Energy development strategy is to strengthen coordination between domestic institutions, apply CO2 emissions taxes, provide Renewable Energy investment support, exempt import taxes on renewable energy equipment, implement feed-in rates set by the government, and provide education to the public regarding the application of Renewable Energy in Indonesia. (Adzikri et al., 2017). Some of the challenges in developing Renewable Enegy in Indonesia include: 1. High initial investment, 2. Lack of incentives, 3. Funding mechanisms in favour of Renewable Energy and, 4. There are other business conflicts of interest, including coordination between agencies / ministries that is still weak. Renewable Energy development problems and solutions in Indonesia include the following: 1. Electricity incentives and tariffs are 2 times the conventional tariff prices, 2. Provide incentives for investment in renewable energy plants such as solar energy, 3. Incentives for investment, especially for renewable energy for housing, 4. Utilization of various new renewable energies and bioenergy for electricity generation, and so on. (Notosudjono et al., 2016).

Problem Identifications

As previously explained regarding the trend of using Renewable Energy as a solution to the challenges of limited fossil energy and also realizing clean or environmentally friendly energy, studies related to the use of Renewable Energy sources are urgently needed. Indonesia with the potential of renewable energy sources is still large. However, on the other hand, its application is still very low, requiring an effective strategy to encourage the use of Renewable Energy sources to achieve the government's target of the national primary energy mix of 23% (percent) in 2025 and 31% (percent) in 2050. The constraints faced so far are that aside from financing investment at the time of project initials which are still considered expensive, the biggest problem is that there are still many problems in the continuity of the management of Renewable Energy power plants which have not been handled properly so that from an investment perspective it is not yet attractive. For this reason, a comprehensive feasibility study and an institutional scheme are needed for effective operational and maintenance management.

Problem Formulation

Referring to the preliminary description above, several things that become problems to be followed up with a comprehensive study are as follows:

- What are the aspects that affect the sustainability of the management institutions and Micro Hydro Power Plant that

have been built in Sumba Island, NTT.
- To what extent are the levels of influence of these aspects in the institutional continuity of management and maintenance of the Micro Hydro Power Plant system in Sumba Island, NTT.
- How to model the impact of aspects on the institutional pattern of operational and maintenance management in Sumba Island, NTT Province.

Research Objectives

The objectives of this study are described as follows:
- Identifying the aspects that influence the management and maintenance of the Micro Hydro Power Plant in Sumba Island, NTT Province.
- Analysing the level of influence of the management and maintenance aspects of the Micro Hydro Power Plant system in Sumba Island, NTT Province.
- Develop a model of aspects that influence the institutional pattern of operational management and maintenance of a sustainable Micro Hydro Power Plant.

Research Methodology

The formulation of research questions that will be used is described in several question formulations which will then determine the research method to be used. The formulation of research questions is described as follows: 1. Research Question1 (RQ1): What aspects affect the sustainability of the management and maintenance of MHP in Sumba Island, NTT Province? ; 2. Research Question2 (RQ2): To what extent is the level of influence of these aspects in the institutional continuity of management and maintenance of Micro Hydro Power Plant in Sumba Island, NTT Province? ; 3. Research Question3 (RQ3): How to model the level of influence of aspects on the institutional management and maintenance of Micro Hydro Power Plant in Sumba Island, NTT Province in a sustainable manner.

The regulatory, cognitive and normative aspects have been carried out in previous studies in several regions in several provinces related to marine energy management (Muhartono et al., 2014). Meanwhile, other aspects related to management, financial management and technical management have become important aspects in the scope of duties and functions of the Solar Power Plant management institution (Tetra Tech ES, 2018).

Data Collection

The results of the journal literature study and reports obtained 22 aspects related to the institutional pattern of sustainable Micro Hydro Power Plant management and maintenance on Sumba Island. These aspects are divided into institutional approaches, namely regulatory, cognitive, normative (Muhartono et al., 2014), and functional approaches, namely management, financial management and technical management (Tetra Tech ES, 2018). From this aspect, the variables obtained will be validated by experts through virtual survey methods (Monkey Survey).

All of the indicators for variable X, where there are each by an expert, it does not need to be displayed. However, the other four experts or 80% of the other experts consider that the X variable indicator still needs to be displayed on this research questionnaire. Thus the indicator variable X used in the study is in accordance with the results of expert validation in the table as follows:

Table 1. Indicators of variable X used in the research questionnaire results of expert validation.

Code	Variable X Indicator
A	**Institutional Aspects – Regulation**
X1	Availability of formal rules at the stakeholder and community level related to the management and maintenance of Micro Hydro Power Plant.
X2	The commitment of the stakeholders and the community to comply with the agreed rules for managing and maintaining Micro Hydro Power Plant.
X3	Supervision of the implementation of Micro Hydro Power Plant management and maintenance rules.
X4	Ability to enforce rules by stakeholders.
B	**Institutional Aspects – Cognitive**
X5	Knowledge and expertise (competence) of policy makers / government related to the management and maintenance of Micro Hydro Power Plant.
X6	Knowledge and expertise (competence) of the community regarding the management and maintenance of Micro Hydro Power Plant.
X7	Public knowledge / electricity users in the management and maintenance of Micro Hydro Power Plant.
X8	Capacity building for Micro Hydro Power Plant management and maintenance through training for management, operation and maintenance.
C	**Institutional Aspects – Normative**
X9	The harmony of the Micro Hydro Power Plant development with local social norms and local culture.
X10	Community culture that obeys in paying for electricity usage from Micro Hydro Power Plant.
X11	Public interest to be actively involved in the management of Micro Hydro Power Plant.
X12	Community needs are high for the existence of electricity generated from Micro Hydro Power Plant.
D	**Aspect of Function - Management**
X13	The amount of contribution is determined based on deliberation by the residents / beneficiaries.
X14	Mediate an agreement on monthly payment obligations, as well as sanctions if there are residents who do not pay electricity usage fees from Micro Hydro Power Plant.
X15	The need for regular outreach efforts to grow and strengthen the sense of belonging to the community towards the Micro Hydro Power Plant that has been built.
X16	Looking for supporting sources of funding (other than community contributions) that can ensure the continuity of operation and maintenance of Micro Hydro Power Plant.
X17	Monitoring and evaluating the performance and impact of Micro Hydro Power Plant related to technical, physical, financial and socio-cultural aspects.
E	**Function Aspect – Financial**
X18	Proactive development of a system for collecting and recording fees for Micro Hydro Power Plant electricity users.
X19	Good and correct management of Micro Hydro Power Plant operational funds.
X20	Development of a financial management reporting system by Micro Hydro Power Plant management.
F	**Function Aspect - Engineering Management**
X21	Development of a system for recording data on electricity consumption by residents or other business units.
X22	Scheduling and implementation of the inspection and maintenance cycle (generator panel and distribution network) of Micro Hydro Power Plant.

Pilot Survey Questionnaire

To determine the effectiveness of the questionnaire that will be used first, the questionnaire was tested on a limited number of respondents. It is expected that there will be input and suggestions from at least 10 respondents in the pilot survey where in the end there are 19 respondents who tested the effectiveness of the research questionnaire design. All of respondents who were involved in the pilot survey, there were no difficulties or mistakes in providing responses to the questionnaire questions that we displayed on the questionnaire survey pilot.

RESULT AND DISCUSSION

Respondent Data Collection

The results of distributing questionnaires through online surveys using software from <surveymonkey.com> which we distribute through the WhatsApp application or via e-mail or via email or direct delivery by post or via courier and direct delivery to the addresses of each agency. We distributed the questionnaires to government agencies at the central and local governments. We also involved the University in this survey. We also involved organizations outside the government, including state-owned and private managing cooperatives and state owned or private contractors. There were a total of 42 respondents, 3 of whom were not processed due to incomplete filling of answers and incomplete respondent data. Thus there are a total of 39 respondents which we will further process.

The following is an explanation of the percentage of respondents based on their respective categories, namely institution, latest education and years of work experience. In the category of institution where the central government institution was the largest respondent, namely 10 respondents (26%), then private agencies 8 respondents (20%) and the lowest was from cooperatives with 1 respondent (3%). For details, for the category of institutions from respondents with the following data:

Table 2. Number of Respondents by type of institution.

Type of Institution	Number of Respondents
Regional government	6
Central government	10
Private	8
Lecturer	4
State-owned enterprises BUMN	5
Cooperative	1
NGO	5

The education category is divided into 4 categories according to the category of respondents who have provided responses. Starting from senior high school education, bachelor degree, master degree and doctoral degree. The complete number of respondents for the education category is as follows:

Table 3. Number of Respondents by Education.

Level of education	Number of Respondents
Senior High School	1
Bachelor	15
Master	18
Doctoral	5

Following are the number of respondents according to the category of years of work experience as follows:

Table 4. Number of Respondents Based on Years of Working Experience.

Year of Working Experience	Number of Respondents
5 - 10 years	10
11 - 20 years	10
21 - 30 years	7
31 - 40 years	2
unknown	10

The results of data collection through online surveys for all x variables are presented in the following table:

Tabel 5. Summary of Survey Result.

Code	Variabels	Very Influential		Influential		Netral		Less Influential		No Effect	
		Sample (n)	Percent (%)	Sample (n)	Percent (%)	Sample (n)	Percent (%)	Sample (n)	Percent (%)	Sample (n)	Percent (%)
A	**Institutional Aspects – Regulation**										
X1	Availability of formal rules at the stakeholder and community level related to the management and maintenance of Micro Hydro Power Plant.	27	69,2%	12	30,8%	0	0,0%	0	0,0%	0	0,0%
X2	The commitment of the stakeholders and the community to comply with the agreed rules for managing and maintaining Micro Hydro Power Plant.	27	69,2%	10	25,6%	2	5,1%	0	0,0%	0	0,0%
X3	Supervision of the implementation of Micro Hydro Power Plant management and maintenance rules.	19	48,7%	16	41,0%	3	7,7%	1	2,6%	0	0,0%
X4	Ability to enforce rules by stakeholders.	21	53,8%	15	38,5%	3	7,7%	0	0,0%	0	0,0%
B	**Institutional Aspects – Cognitive**										

X5	Knowledge and expertise (competence) of policy makers / government related to the management and maintenance of Micro Hydro Power Plant.	20	51,3%	17	43,6%	1	2,6%	1	2,6%	0	0,0%
X6	Knowledge and expertise (competence) of the community regarding the management and maintenance of Micro Hydro Power Plant.	21	53,8%	13	33,3%	3	7,7%	2	5,1%	0	0,0%
X7	Public knowledge / electricity users in the management and maintenance of PLTMH.	13	33,3%	17	43,6%	5	12,8%	3	7,7%	1	2,6%
X8	Capacity building for Micro Hydro Power Plant management and maintenance through training for management, operation and maintenance.	27	69,2%	11	28,2%	0	0,0%	1	2,6%	0	0,0%
C	**Institutional Aspects - Normative**										
X9	The harmony of the Micro Hydro Power Plant development with local social norms and local culture.	14	35,9%	16	41,0%	7	17,9%	1	2,6%	1	2,6%
X10	Community culture that obeys in paying for electricity usage from Micro Hydro Power Plant.	20	51,3%	15	38,5%	4	10,3%	0	0,0%	0	0,0%
X11	Public interest to be actively involved in the management of Micro Hydro Power Plant.	10	25,6%	21	53,8%	7	17,9%	1	2,6%	0	0,0%
X12	Community needs are high for the existence of electricity generated from Micro Hydro Power Plant.	24	61,5%	13	33,3%	1	2,6%	0	0,0%	1	2,6%
D	**Function Aspect - Management**										
X13	The amount of contribution is determined based on deliberation by the residents / beneficiaries.	12	30,8%	21	53,8%	5	12,8%	1	2,6%	0	0,0%
X14	Mediate an agreement on monthly payment obligations, as well as sanctions if there are residents who do not pay electricity usage fees from Micro Hydro Power Plant.	14	35,9%	23	59,0%	1	2,6%	1	2,6%	0	0,0%
X15	The need for regular outreach efforts to grow and strengthen the sense of belonging to the community towards the Micro Hydro Power Plant that has been built.	21	53,8%	16	41,0%	2	5,1%	0	0,0%	0	0,0%
X16	Looking for supporting sources of funding (other than community contributions) that can ensure the continuity of operation and maintenance of Micro Hydro Power Plant.	20	51,3%	11	28,2%	7	17,9%	1	2,6%	0	0,0%
X17	Monitoring and evaluating the performance and impact of Micro Hydro Power Plant related to technical, physical, financial and socio-cultural aspects.	20	51,3%	17	43,6%	2	5,1%	0	0,0%	0	0,0%
E	**Function Aspect - Financial**										
X18	Proactive development of a system for collecting and recording fees for Micro Hydro Power Plant electricity users.	17	43,6%	19	48,7%	0	0,0%	3	7,7%	0	0,0%
X19	Good and correct management of Micro Hydro Power Plant operational funds.	27	69,2%	12	30,8%	0	0,0%	0	0,0%	0	0,0%
X20	Development of a financial management reporting system by Micro Hydro Power Plant management.	25	64,1%	0	0,0%	9	23,1%	5	12,8%	0	0,0%
F	**Function Aspect - Technical Management**										
X21	Development of a system for recording data on electricity consumption by residents or other business units.	16	41,0%	19	48,7%	4	10,3%	0	0,0%	0	0,0%
X22	Scheduling and implementation of the inspection and maintenance cycle (generator panel and distribution network) Micro Hydro Power Plant.	22	56,4%	16	41,0%	1	2,6%	0	0,0%	0	0,0%

Discussion

In the institutional aspect – regulation, of all variables X1, X2 and X4, most of the respondents > 50% chose that these three aspects were very influential. For variable X3 where most of the respondents chose that this variable was very influential even though it was chosen by the respondent <50%. In the institutional aspect - cognitive variables X5, X6 and X8 stated by respondents > 50% that these variables are very influential. For variable X7, most of it was chosen by respondents as an influential aspect even though it was chosen by respondents <50%. The next aspect is institutional - normative, consisting of four variables where two variables X10 and X12 are chosen by respondents> 50% that these variables are very influential. For variables X9 (41.0%) and X11 (53.8%) selected by the respondent that these variables have influence.

The function aspect – management, consists of five variables where the variables X15, X16 and X17 are chosen by respondents > 50% that these variables are Very Influential and other variables X13 and X14 also by respondents > 50% choose that the variables are Influential. The next is the function aspect – financial, where the variables X19 and X20 are chosen by > 60% that this aspect is very influential and the X18 variable by the most respondents <50% chooses that this aspect is influential. Functional aspects - technical management where the variable X21 was chosen by the majority of the respondents <50% that the variable is influential and the last variable X22 was chosen by the respondent > 50% that the variable is very influential.

Thus, there are fifteen variables that are very influential and seven variables that are influential. However, it can be said that all twenty-two variables can be considered important as important aspects in the operation and maintenance of Micro Hydro Power Plant.

CONCLUSIONS

Aspects which are variables in the study are aspects that have an influential and are very influential on the management and maintenance of Micro Hydro Power Plant in Sumba Island, NTT. From the results of the opinions collected from all respondents, there are fifteen very influential aspects and seven variables which are influential aspects. All of these aspects are expected to be important aspects recommended by researchers to become aspects that can be used or become aspects that need to be priority references in the implementation and maintenance of Micro Hydro Power Plant in Indonesia.

It is expected that the next research can be continued to find other important aspects in accordance with the dynamics of Micro Hydro Power Plant management and maintenance in Indonesia. The data obtained from the questionnaire survey results still need further statistical tests.

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