Grid Study of Mini Hydro Power Plant (MHPP) of Palangai Hulu 2x4,9 MW South Pesisir

Hidayat[1*2], Cahayahati[1], Arnita[1], *Saiful* Jamaan[2]

[1]Electrical Engineering Department, Bung Hatta University, Padang, Indonesia
[2]PT. Multi Sukses Energi, Padang, Indonesia

Abstract. This paper presents a gridd study of Mini Hydro Power Generation (MHPP) of Palangai Hulu, 2 x 4.9 MW. It is owned by PT. Dempo Sumber Energi (DSE) located at Palangai of South Pesisir Regency. The objective is to fulfill the legal aspects, technical aspects and economic aspects to develop of MHPP. The legal aspect is one of the requirements that must be fulfilled prior to the signing of Power Purchase Agreement (PPA) between DSE and State Electricity Company that called PLN. Technical aspect is to analyze the operational impact of the distribution system after MHPP connecting to the PLN distribution system, while the economic aspect is to analyze how much result energy of MHPP can be absorbed by PLN. Uultimately, it is described the financial feasibility of MHPP. The result is, legal aspect of development of MHPP of Palangai Hulu feasible to be continued to next process to sign contract of PPA. Technically, there is no negative impact of operating the PLN distribution system after the MHPP is connected to the PLN Rayon Balai Selasa system that analyzes using ETAP. Point of Connection (POC) as the selling point of electrical energy by DSE to the most economical PLN is on substation circuit of Balai Selasa. The energy production of MHPP Palangai Hulu can be absorbed 96.4% starting in 2018. The cost of POC is Rp. 11,577,000,000.

1 Introduction

Electricity demand in Indonesia always increases every year. During the five years ago in the period 2010 to 2014 there was an increase in electrical energy sales from 145.7 Tera Watt hours (TWh) to 197.3 TWh, the number of costumers increased from 42.2 million to 57 million and the electrification ratio increased from 66.2 % to 84%. PLN estimates that between 2014 and 2024 electricity consumption will increase to 464 TWh with an average growth of 8.7% per year [1]. The Government's effort to face the condition is to make regulation in the form of Law No. 30 of 2009 on electricity and the launching of acceleration program of 35,000 MW power capacity development [2].

Fulfilling thoses needs will be built power plant by PLN and Independent Power Producer (IPP). Electrical energy that generated by PLN and IPP power plants are integrated into a transmission and distribution network, before the energy gets to customers. The power generation of IPP before it constructed and connected to PLN network system must be done

* Corresponding author: hidayat@bunghatta.ac.id

grid study that undertaken by the electrical developer's. This study aims to determine the point of connection (POC), the amount of power generated IPP that can be absorbed by the PLN without causing negative impact to existing PLN network system, connection facility, equipment capacity upgrade after MHPP connected. PT. PLN has published a guidebook for the Connecting Center for New and Renewable Energy (PLT EBT) to the PLN Distribution System. These are used by PLN and PLT-EBT developers to ascertain and mitigate the risk of disruption to the system due to PLT-EBT connections and the basis for signing the Power Purchase Agreement (PPA) [3]. Development of Palangai Hulu MHPP with capacity of 2x4,9 MW owned by PT. Dempo Hydro Power (DHP) located in South Pesisir Regency of West Sumatera Province is planned to be connected to 20 kV distribution line of GH Balai Selasa [4].

Several studies that required to be done to achieve the objectives of the grid study include (a) load flow analysis in the distribution system; (b) short circuit analysis; (c) breaking capacity analysis (d) protection analysis and coordination set coordination (e) stability analysis, (f) harmonic analysis, using the ETAP 12.00 programming on peak load times (WBP) and out of peak load times (LWBP) in 2014.

2 Modelling of Load Flow Power System

The load flow system study is a very basic and important conducted in the grid study of the MHPP. The parameters are obtained such as voltage, current, power and power factor or reactive power each bus in an electrical network when existing and future condition [5]. The load flow power system model is based on a power system model consisting of 2 buses, although in reality the power system consists of several buses that will be interconnected with each other. The formula of load flow power system can be shown as;
The current formulation entering a bus is expressed by equation (1)

$$I_i = V_i \sum_{j=0}^{n} \mathrm{y_{ij}} - \sum_{j=i}^{n} \mathrm{y_{ij}V_j} \quad , \text{with } \mathrm{j} \neq \mathrm{i} \tag{1}$$

Power in bus,

$$P_i + jQ_i = V_i . I_i^* \tag{2}$$

$$I_i = \frac{P_i - jQ_i}{V_i^*} \tag{3}$$

Substituting equation (3) to (1) is obtained,

$$\frac{P_i - jQ_i}{V_i^*} = V_i \sum_{j=0}^{n} \mathrm{y_{ij}} - \sum_{j=i}^{n} \mathrm{y_{ij}V_j} \tag{4}$$

Based on equation (4) it can be seen that the power flow on the channel is not linear and must be solved by iterative numerical method. Some common methods used to solve the problem of power flow include Newton Rapson method, Fast Decouple, Gaus-Seidel, etc.

3 Grid Study of MHPP Palangai Hulu

3.1 Electrical System of South Pesisir

The Electrical system of South Pesisir district includies in the management of PT. PLN (Persero) West Sumatra Area Padang Rayon Painan and Rayon Balai Selasa. Currently, Electrical system of Rayon Painan and Rayon Balai Selasa got supplies from the 150 kV

interconnection system of Sumbagsel through GI Bungus using two 20 kV feeders along 60 kms. One of the feeder is an xpreess feeder. In GI Bungus, there is a power transformer 30 MVA, 150/20 kV. Based on the review to the field, the quality of the electric voltage at the Painan Rayon is very low, ie at LWBP condition only 17.6 kV and WBP condition 14.8 kV. This condition is caused by voltage drop on the feeder due to the distance and the amount of power that was evacuated from GI Bungus to GH Painan. Therefore, PLN has done the addition of 150 kV substation (GI) Kambang which is still in preparation for operation. The total load of PLN system of Rayon Painan and Rayon Balai Selasa in 2014 amounts to about 25 MW which is partly supplied of PLTD Lunang and PLTD Lakuak. If MHPP Palangai Hulu operate, then PLTD Lakuak is expected stop operation because the cost of renting this diesel is relatively high (Rp. 3.500, - / kWh) [6]. PT. PLN (Persero) of West Sumatera region, that GI Kambang is already operated in 2018, so the PLN of Rayon Painan and Rayon Balai Selasa is supplied from GI Kambang. Therefore GH Painan, GH Lakuak and GH Balai Selasa will enter into GI subsystem. The location of GI Kambang is at GH Lakuak which has one power transformer 30 MVA, 150kV/20kV [1]

3.2 Load Flow Study

One of the studies is needed to connect the Renewable Power Plant to the PLN distribution network i.e. the load flow analysis. This review is based on PLN Directive No.0357.K/DIR/2014 to review the impact of changes in power flow on existing distribution systems due to the inclusion of power plants with power capacity up to 10 MW. Purpose of power flow study as follows;

1. Determine the operating conditions of the electric power system in a steady state
2. To know the operating voltage of the system is the standard range within 5% higher and 10% below the nominal value.
3. To identify power generation requirements, reactive power support requirements (VARs) and the placement of capacitors or reactors in order to maintain the system voltage and power factor (PF) as required 0.9 leading up to 0.8 lagging.
4. To know the technical shrinkage network voltage either branching.
5. For the purposes of controlling the condition of the system.

Load flow analisys of MHPP Palangai Hulu which is planned to be connected to GH Balai Selasa with distance 8.36 kms from MHPP Palangai Hulu. It is assumed that GH Balai Selasa has got supply from main station GI Kambang. Another thing to consider is the inclusion of other MHPP plants that have been previously PPA with PLN and incorporated in Rayon Balai Selasa subsystem [3].

The first step is to determine the bus bar voltage of MHPP Palangai Hulu when it will be parallel to PLN in 2018. It is obtained with simulation of power flow using ETAP application that obtain voltage at the point of connection of MHPP of Palangai Hulu at WBP condition 16,46 kV and LWBP condition 17,96 kV. The voltage values are outside the provisions of PLN to perform parallel, because the voltage drops below 10% of nominal 20 kV. Adjusting of the OLTC transformer in MHPP Palangai Hulu, obtained voltage point connections on the conditions WBP 19.72 kV and LWBP 20.70 kV as Table 1

Table 1 The Condition of MHPP Palangai Hulu Will Just Parallel to Distribution System

Condition	Status Load 2018	Voltage of Bus bar 20 kV MHPP (kV)	Noted	Distribution Line Looses (kW)
MHPP Palangai Hulu Connent to GH Balai Selasa	WBP	19,72	Normally	1020
	LWBP	20,7	Normally	1115

Base on these results, it can be concluded that MHPP Palangai Hulu can parallel with the PLN distribution system on condition of WBP or LWBP 2018 through setting of OLTC type generator transformer

The second step is to determine the power of MHPP generation in 2018 LWBP condition that can be absorbed by PLN without causing adverse impact to the existing system. By generating MHPP power through ETAP simulation we get voltage of 20 kV bus as shown in Fig. 1. The voltage of every bus 20 kV still in standard. Thus it can be seen that the MHPP is able to generate power according to its capacity without causing negative impact on the PLN system. The result of power flow analysis at LWBP condition in 2018, power generation of MHPP of Palangai Hulu can be absorbed by PLN equal to 96,9% without causing worse impact to PLN Rayon Balai Selasa system as shown in Table 2.

Due to LWBP condition of power generation of MHPP can be absorbed according to its capacity, it can be ascertained the same thing also happened in WBP condition. The power generating MHPP in the condition is a limitation of power that can be absorbed by PLN.

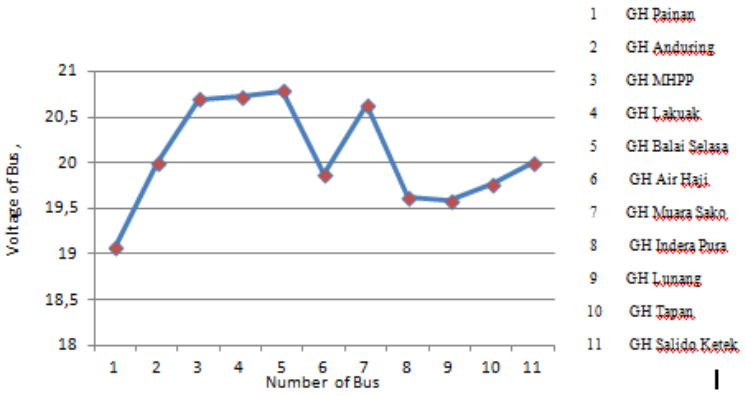

Fig. 1. Voltage of Bus in PLN Sektor Painan After MHPP of Palangai Hulu has been Connected

Table 2. Evacuate Energy of MHPP Palangai Hulu when WBP and LWBP Condition

Load Status in 2018	Energy Generated (GWh)	Energy in POC (GWh)	Losses (%)	Energy Evacuated (%)
LWBP	52.68	51.07	3.1%	96.9%
WBP	52.68	50.53	4.1%	95.9%
Average	52.68	50.80	3.6%	96.4%

3.3 Short Circuit Study

Short circuit study is required to prove that the rated capability of the circuit breaker equipment. The condition of the electrical system in the event of a short circuit taking into account the entry of the MHPP of Palangai Hulu to the distribution line 20 kV at the Rayon Balai Selasa, assuming that the WBP conditions in 2018 because the largest current is obtained at the maximum generation condition. The simulation of the operation pattern of the MHPP Palangai Hulu in WBP condition in 2018 and the short circuit study with 3-phase short circuit, phase and 1-phase short circuit to soil, obtained short circuit current to flow in evacuate distribution line from MHPP to POC as in Fig.2.

The results of the short circuit review wich the greatest short-circuit current of 3-phase noise at busbar location 20 kV in Bus Palangai Hulu is 1.33 kA. Based on distribution power regulation (Distribution Code) in 2009 determined the capacity of short circuit equipment on

the voltage of 20 kV maximum 500 MVA or 14.4 kA. SPLN 118-4-1: 96 has also regulated the breaking capacity of cubicles for nominal voltage 20 kV ie 12.5 kA [7]

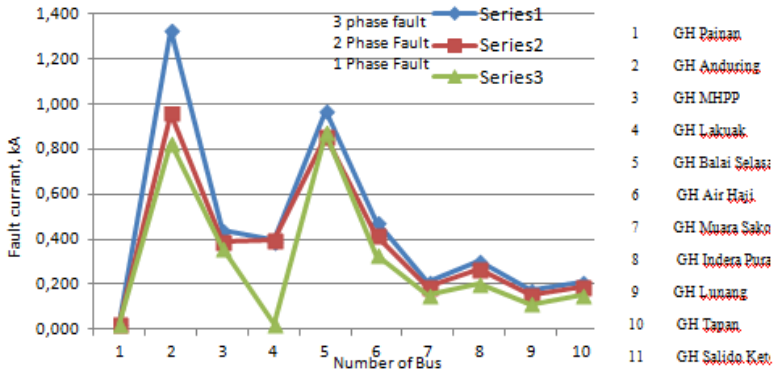

Fig.2. The Current Fault Flows in Evacuate Distribution Line from MHPP to POC

All power breaker equipment on the 20 kV side is required to have at least a breaking capacity of 12.5 kA and generally installed in the GI Kambang has a termination capacity of 25 kA whereas all breaker equipment installed and connectors network distribution has a breaking capacity of 16 kA or 12.5 kA so it can be confirmed with the largest short circuit in GI Kambang of 0.125 kA. The value is still below the circuit breaker capability installed both in the GI Kambang and the distribution network and substation, which means the fixed

4 Conclusion

Technical aspects such as analyzing the operational impact of the distribution system after the connections of MHPP to the PLN distribution system, while the economic aspect is to analyze how much result energy of MHPP can be absorbed by PLN. Ultimately, describe the financial feasibility condition. The result is legal aspect of development of MHPP of Palangai Hulu feasible to be continued to next process that is signing of contract of PPA. Technically, there is no impact on the operation of the PLN distribution system after the MHPP is connected to the PLN Rayon Balai Selasa system. The energy of MHPP Palangai Hulu can be absorbed 96.4% starting in 2018. The cost of POC is Rp. 11,577,000,000.

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