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Impact of connection Taludaa 2 mini-hydro power plant on small scale power load

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ABSTRACT

The analysis of the voltage's profile before and after can also evaluate the JTM 20 kV LH.3 Pohe feeder distribution system when it is connected by the substation PLTMH Taludaa 2 with the power of 2300 kW. The method used in this research is the Newton-Raphson method through the simulation by the help of ETAP 12.6.0 software on requiring single line 20 kV Gorontalo system data, generator data, power transformer data, busbar data and line conduct data. The results of the analysis shows that the average improvement in the voltage profile on all buses is 0.991%, while the power losses after connecting PLTMH Taludaa 2 in a system with a load of 80% of the distribution transformer capacity can reduce power losses by 20.6 kW active power and reactive power about 35.9 kVar reactive power.

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1. INTRODUCTION

Gorontalo province is one of the youngest provinces in Indonesia. However, it is rich in agricultural and marine products. In addition, economic growth in Gorontalo province from year to year has been increased by 7 percent [1], [2]. By the increasing of economic growth, electricity needs can contribute the progress of regional development. By the increasing of economic growth [3], the needs for electrical energy will also increase [4]. It is going to affect the ability of electrical energy sources in facilitating the consumer needs [5]. Nowadays, the sustainable energy power plants are one of the options in increasing people's need for electricity which is increasing every year along with the increasing of population and the economic development [6], [7].

One of the alternative energy resources from renewable energy that is starting to be developed is hydroelectric power [8], [9] in this case is micro-hydro and mini-scale MHP [10], [11]. These generators are able to get interconnected with a distribution channel (grid) [12], so that they can become small-scale, scattered or distributed generators. In Bone Bolango District, a mini-scale hydroelectric power plant (PLTMH) has been built in Bone sub-district with a capacity of 2.3 MW with the unit capacity of 1.15 MW each.

The addition of power plants is one of the solutions in overcoming the problem of the electrical energy crisis on small-scale power loads in Gorontalo Province [13], especially on the coast of Bone Bolango Regency [14]. The additional micro hydro power plant with a capacity of 2.3 MW is utilizing the Taludaa waterfall. The PLTMH has been interconnected to a 20 kV network, namely the LH 3 feeder at Pohe connecting substation.

The connection of this new plant will cause changes in power flow [15], [16], especially the voltage's profile of the existing system [17]. Therefore, a power flow analysis is needed to determine the voltage profile in the system [18]. The existing power system's diagram is modeled into the software, then it is simulated and the result is being analyzed.

2. RESEARCH METHOD

The electric power generated by PLTMH Taludaa 2 is injected into the network through a distribution's bus [19]. The new plant will be injected into the power grid of the 20 kV systems via LH feeders.3 Pohe substation at a load of 80% of the capacity of all distribution transformers taking into account power losses and voltage profiles [20].

The addition of the electric power supply will affect the changes of power flow in the system [21], so a load flow analysis is needed to determine the change in the direction of power flow which is useful to find out which buses and channels are capable and which ones are critical [22], so that critical component components can be upgraded. The network which is analyzed is 20 kV intermediate distribution network, that includes the generators, buses and channels, so a load flow analysis is needed using the Newton-Raphson method [23], [24] with the help of ETAP 12.6.0 software for its simulation [25], as shown in Figure 1.

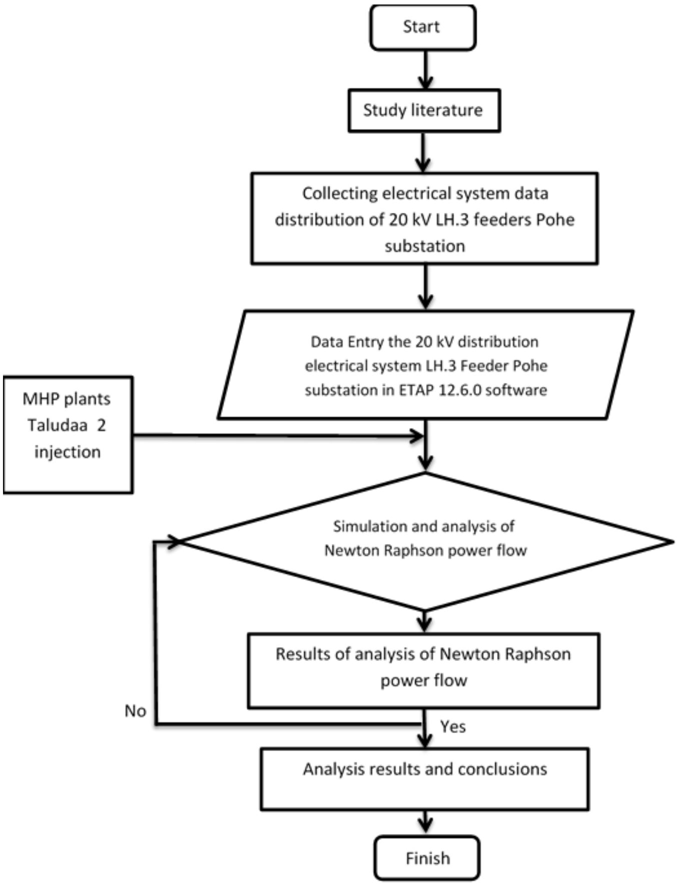

Figure 1. Flowchart research flow

Data which is needed in the study is the existing data on the 20 kV LH.3 Pohe substation feeder distribution system. The data source comes from the Gorontalo distribution control center (DCC) PLN UP2D SULUTTENGGO. The data required in the study are:

- One-line diagram on the 20 kV LH.3 feeder distribution system
- Power plants connected to a 20 kV LH.3 distribution system, the data required are: voltage rating (kV), installed power capacity (kW) and the capable power of each generator
- The transformer installed in LH.3 feeder, the data required are: voltage ratio (kV), power rating (kVA)
- The type and length of using conductor, the data required is the line impedance (R, X, and Y)
- Bus, the data required is a kV rating

The data obtained from the field are still the raw data. Before the simulation is carried out, the data should go through the manual calculation phase to get the system parameter values that will be input into the simulation and the input of data loading, namely the data loading of 80% of the capacity for each transformer installed. Furthermore, the power flow simulation is performed in the LH.3 feeder Pohe substation using the ETAP 12.6.0 program with Newton-Raphson method [26].
The data that are input into the power flow simulation using ETAP 12.6.0 are as follows:
- Busbar name
- Busbar types are reference buses, loading buses and generator buses
- Busbar voltage rating
- Conducting data on distribution channels
- Pseudo power, namely the load connected to the loading bus (kVA)
- Active power in kW on each generator bus
- The basic MVA is 100 MVA and the base kV is 20 kV
- The power factor, namely the generator 0.8 and the load 0.9

The final stage is analyzing the power flow, voltage's profile and power losses in the 20 kV LH.3 feeder distribution system Pohe substation, before and after PLTMH Taludaa 2 is injected into the system.

3. RESULTS AND DISCUSSION

The power system for LH.3 feeders pohe substation as shown in Figure 2 is connected by 3 (three) transformers, namely at GI Botupingge, PLTMH Taludaa 1 and PLTMH Taludaa 2, then 2 (two) mini hydro power plants Taludaa 1 and 2, and there are 4 (four) distribution channels as shown in Table 1, Table 2 and Table 3.

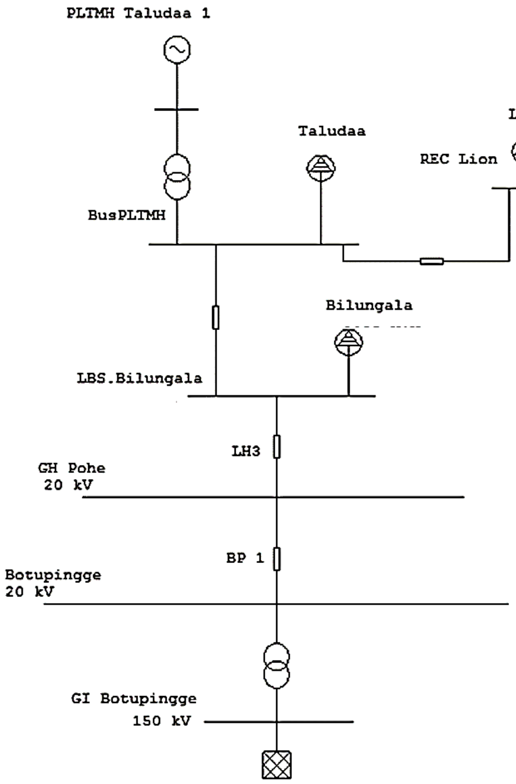

Figure 2. Single line diagram of LH.3 feeder switching of pohe substation

Table 1. Generator data

No	Plant name	Power capacity (kW)
1	PLTMH Taludaa 1	3000
2	PLTMH Taludaa 2	2300

Table 2. Data transformator

No	Transformators name	Type phasa	Capacity (MVA)	Voltage	
				Prim. kV	Sec. kV
1	GI Botupingge	3-Phasa	120	150	20
2	Taludaa 1	3-Phasa	4	6,3	20
3	Taludaa 2	3-Phasa	4	6,3	20

Table 3. Distribution line data

From bus	To bus	Positive sequence	
		R	X
Botupingge 1	GH Pohe	0,201050	0,127000
LH 3, GH Pohe	LBS Bilungala	0,252504	0,131000
LBS Bilungala	PLTMH Taludaa	0,391619	0,137000
PLTMH Taludaa	Recloser Lion	0.391619	0.137000

3.1. Power flow analysis before connecting PLTMH Taludaa 2

From the simulation results of power flow before connecting the PLTMH Taludaa 2 to the 20 kV LH.3 feeder distribution system of Pohe substation, it can be seen in Table 4, that the highest load is on the PLTMH Taludaa bus which is 1731 kW and the lowest load is on REC Lion which is 202 kW.

Table 4. Power flow simulation results

No Bus	Bus Name	Load		Generator	
		kW	kVar	kW	kVar
1	GI Botupingge	0	0	945	-17
2	PLTMH Taludaa	1731	1073	1343	1499
3	GH Pohe	0	0	0,00	0
4	LBS Bilungala	321	199	0,00	0
5	REC Lion	202	125	0,00	0

From Table 5, the voltage is still within the allowable tolerance limits of +5% and -10%. The voltage on the GI Botupingge bus is 100% kV, the PLTMH Taludaa bus is 97.080% kV, the GH Pohe bus is 99.170% kV, the LBS Bilungala bus is 98.112% kV and the lowest voltage is on the REC Lion bus which is 96.993% kV as shown in Figure 3.

Tabel 5. Voltage profile before connecting PLTMH Taludaa 2

No Bus	Name Bus	Voltage kV (%)
1	GI Botupingge	100
2	PLTMH Taludaa	97,080
3	GH Pohe	99,170
4	LBS Bilungala	98,112
5	REC Lion	96,993

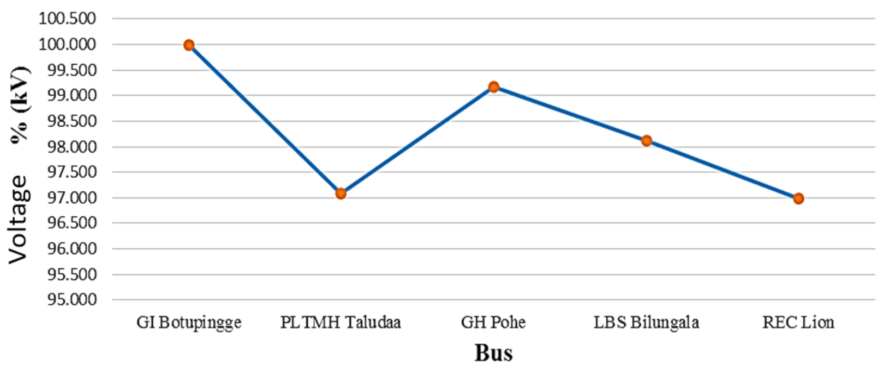

Figure 3. Graphic of voltage’s profile before connecting PLTMH Taludaa 2

The total power losses before connecting the PLTMH Taludaa 2 to the 20 kV LH.3 feeder distribution system of 3 Pohe substation is at active power of 35 kW and reactive power of 86 kVar as shown in Table 6.

Table 6. Power Loss before Connecting PLTMH Taludaa 2

from Bus	to Bus	Active Power (kW)	Reactive Power (kVar)
GI Botupingge	GH Pohe	8	6
GH Pohe	LBS Bilungala	10	5
LBS Bilungala	PLTMH Taludaa	8	3
PLTMH Taludaa	REC Lion	9	72
Total		35	86

3.1.1. Power flow analysis after connecting PLTMH Taludaa 2

From the results of the power flow simulation after the connection of the Taludaa 2 MHP to the 20 kV distribution system of the LH.3 Pohe Substation, it can be seen in Table 7. that the highest load is on the Taludaa MHP bus, which is 1741 kW and the lowest load on REC Lion, which is 203 kW.

Table 7. Power flow simulation results

No bus	Name bus	Load		Generator	
		kW	kVar	kW	kVar
1	GI Botupingge	0	0	576	-18
2	PLTMH Taludaa	1741	1079	1704	1472
3	GH Pohe	0	0	0	0
4	LBS Bilungala	322	199	0	0
5	REC Lion	203	126	0	0

From Table 8, the voltage is still within the allowable tolerance limits of +5% and -10%. The voltage on the GI Botupingge bus is 100% kV, the PLTMH Taludaa bus is 98.525% kV, the GH Pohe bus is 99.499% kV, the LBS Bilungala bus is 98.856% kV and the lowest voltage is on the REC Lion bus which is 98.439% kV as shown in Figure 4.

Table 8. Voltage profile after connection PLTMH Taludaa 2

Bus No	Bus Name	Voltage kV (%)
1	GI Botupingge	100
2	PLTMH Taludaa	98,525
3	GH Pohe	99,499
4	LBS Bilungala	98,856
5	REC Lion	98,439

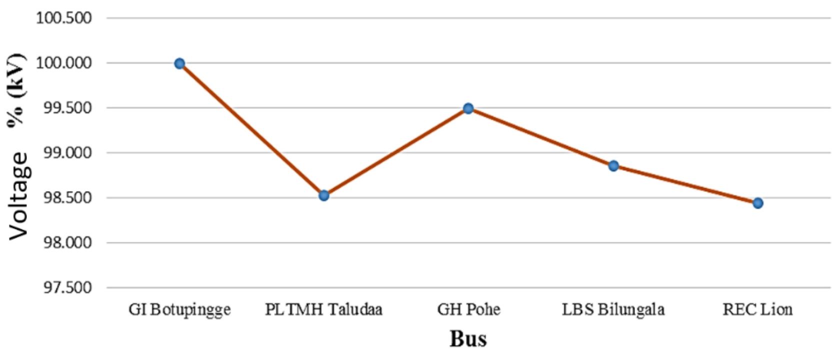

Figure 4. Graphic of voltage's profile after connecting PLTMH Taludaa 2

Total power losses after connecting PLTMH Taludaa 2 to the 20 kV LH.3 feeder distribution system of Pohe Substation is at active power of 14.4 kW and reactive power of 50.1 kVar, as shown in Table 9. The voltage on each bus has increased or experienced an improvement of voltage's profile after connecting PLTMH Taludaa 2, namely the PLTMH Taludaa bus the voltage profile increased by 1.445%, GH Pohe bus by 0.329%, LBS Bilungala bus by 0.744% and REC Lion bus by 1.446%, therefore, the average increase or improvement of the voltage's profile on all buses are equal to 0.991% as shown in Figure 5.

Table 9. Power loss after connection PLTMH Taludaa 2

from bus	To bus	Active power (kW)	Reactive power (kVar)
GI Botupingge	GH Pohe	3	2,2
GH Pohe	LBS Bilungala	3,8	2
LBS Bilungala	PLTMH Taludaa	2,2	0,8
PLTMH Taludaa	REC Lion	5,4	45,1
Total		14,4	50,1

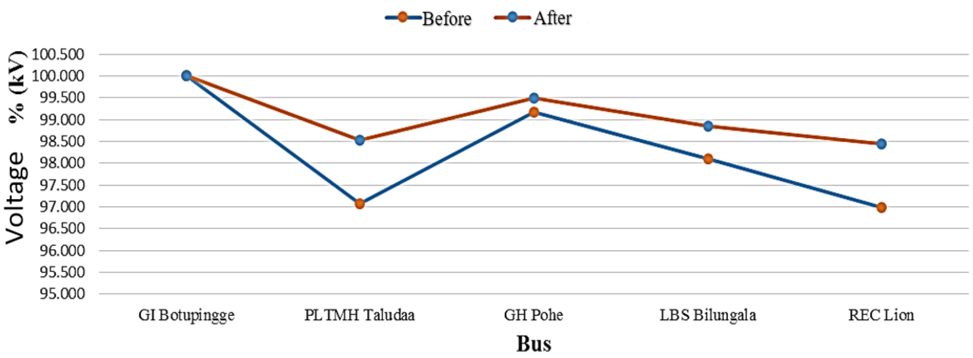

Figure 5. Graphic of voltage profile before and after connecting PLTMH Taludaa 2

4. CONCLUSION

The power connection of PLTMH Taludaa 2 is at the LH.3 feeder of Pohe Substation. The PLTMH Taludaa 2 power connection; besides being able to supply power; can also improve the voltage's rofile with an average increase in all buses of 0.991%, so that it can provide better system of performances. From the results of the analysis before and after the PLTMH Taludaa 2 new power connection at a load of 80% of the distribution transformer capacity, it can reduce the power losses of 20.6 kW of active power and 35.9 kVar of reactive power. The connection of PLTMH Taludaa 2 with a capacity of 2300 kW is able to meet the electricity needs in area of Gorontalo City and Bone Bolango Regency, it can even be distributed to the distribution systems of South Bolaang Mongondow Regency to support the supply of electricity needs.

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