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Simulation And Analysis of Distributed Generation Installation on A 20 kV Distribution System Using Etap 19.0

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ABSTRACT

Conventional power plants are generally designed on a large scale, centralized, and built far from the load center so that they require transmission and distribution networks to distribute electric power. The condition of the distribution channel's length, the high load supplied, and the increasing number of requests for electrical energy each year affect the quality of distribution of electrical energy. From the above problems, simulation and analysis of the installation of distributed generation are carried out. In installing Distributed Generation, three scenarios are used based on the most significant voltage drop point. The installation of Distributed Generation scenario 1 has an average voltage value of 95.16% or 19.81 kV and an average voltage drop of 9.82% or 1.965 kV, and power losses of 946.69 Kw, where losses power loss was reduced by 17.8% or 733.7 kW. The installation of Distributed Generation scenario 2 has an average voltage value of 95.84% or 19.17 kV and an average voltage drop of 4.16% or 0.833 kV, and power losses of 1062.4 Kw, where losses power loss was reduced by 15.8% or 618 kW. The installation of Distributed Generation scenario three does not experience a voltage drop, the average voltage value is 102.4% or 20.38 kV, and power losses are 1062.4 KW, where power losses are reduced by 29.7% or 1114, 6 kW.

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1. INTRODUCTION

Conventional power plants are generally designed on a large scale, centralized, and built far from the load center so that they require transmission and distribution networks to distribute electric power. The conventional electric power system consists of three parts, namely the generation, transmission and distribution systems associated with the load[1][2]. In the current era, population growth in Indonesia is increasing, so the need for electrical energy is also increasing, so the electricity provider will not be able to meet the needs of electrical energy for a long time[3]. For that, start looking for ways to overcome these problems, one of which is by installing Distributed Generation [4].

The Lamno Substation is one of the distribution areas of PT PLN (Persero) Rayon Meulaboh City, which is supplied from the Meulaboh Substation. With a line length of 145 KM, the Lamno Substation is the longest and farthest substation for the PT. PLN (Persero) Rayon Meulaboh City service area which experienced a voltage drop of 18% with the value of the transmit voltage from the substation of 20 kV and the lowest receiving voltage of 16 kV, then based on SPLN no.72 of

1987, namely the voltage drop with a tolerance limit of +5% and -10%, this is outside the set standard [5]. With the condition of the length of distribution channels and the high load supplied as well as the increasing number of requests for electrical energy each year which is in line with economic growth, increasing population, and increasing the number of industrial activities, these are factors that affect the quality of distribution of electrical energy [6].

From the above problems, simulation and analysis of the installation of distributed generation is carried out. Distributed generation is a small-scale power plant (50 kW to 400 MW) distributed, environmentally friendly technology and directly connected to the distribution system [7]. Distributed Generation characteristics limit the construction of a new transmission network because it is built near the load (Close To load) [8][9]. Due to the increasing demand for electrical energy and to reduce unnecessary development costs for transmission and distribution systems [10], Distributed Generation began to be widely applied to electric power systems [11] [12].

The target of this research is to install Distributed Generation, there will be changes in the distribution network so that it will affect the voltage profile and power losses.

2. RESEARCH METHOD

The research methodology is the whole or chronology of a study, from the beginning of the problem until a problem can be answered or solved. The research method is the steps or stages used in doing research. The research approach is a way to achieve the desired research goals and objectives [13]. The method used in this study is a quantitative method. The quantitative aspect of this research is to determine the impact of the installation of Distributed Generation Wind Turbine on the voltage profile and power losses in a 20 kV distribution system. The stages to be carried out in this research are as follows:

2.1 Study Literature

In a research study literature has an important role, because it can be used as a basis for logical thinking in solving problems scientifically. Literature study is done by studying the theories and methods that will be used to achieve the objectives of a research [14].

2.2 Research Procedure

Before conducting the research, the researcher reviewed the distribution network with the longest channel at PT. PLN Persero Rayon Meulaboh The city and location chosen in this study are based on several reasons that have been explained in the previous chapter. After determining the research location, there are further steps as shown in Figure 1 below.

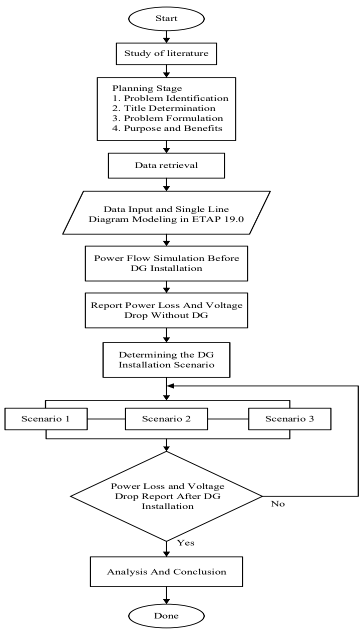

Figure 1. Flowchart research method

3. RESULTS AND DISCUSSION

Based on the Single Line Diagram data of the distribution system from the Meulaboh Substation to the Lamno Substation as shown in Figure 1.1, a load flow simulation was performed using Electrical Power System Analysis (ETAP). The simulation results show the voltage drop and power losses in the system as shown in Table 1.

Table 1. Voltage drop data on distribution system

Bus ID	Nominal kV	Voltage		Voltage Drop	
		(kV)	(%)	(kV)	(%)
Bus GH Teunom	20	19,65	98,25	0,35	1,75
Bus GH Calang	20	17,88	89,41	2,11	10,59
Bus GH Lamno	20	16,57	82,87	3,42	17,13

Table 1 shows the results of the load flow simulation where there are 2 buses that experience a voltage drop value of above 5%, namely the Calang substation bus of 10.59% or 2.11 kV and the Lamno Substation bus of 17.13%. or 3.42 kV.

Of the 3 buses observed in this study, the overall voltage drop in the distribution system from the Meulaboh Substation to the Lamno Substation is 29.47% or 5.895 kV. This condition needs to be improved so that the voltage that will be received by the customer is optimal. The voltage drop data above can be seen in the Figure 2 below.

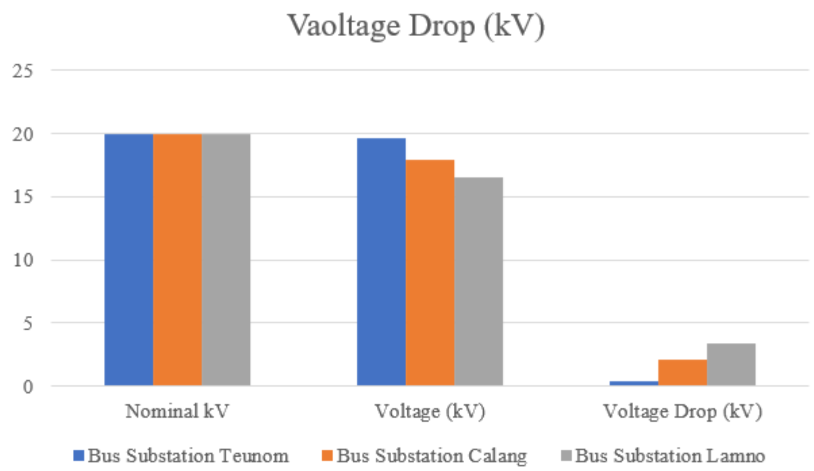

Figure 2. Voltage drop graph in distribution system

In the distribution system from the Meulaboh Substation to the Lamno Substation, apart from a voltage drop, power losses also occur. Power losses data can be seen in Table 2 below.

Table 2. Data losses

Channel	Bus ID		Lenght (KM)	Losses (kW)
	From	To		
1	Bus TD 1	Bus Substation Teunom	47	835,5
2	Bus Substation Teunom	Bus Substation Calang	47	683,2
3	Bus Substation Calang	Bus Substation Lamno	51	161,7
Total			**145**	**1680,4**

Table 2 shows the power loss data from the simulation results that have been carried out, there are 3 channels experiencing power losses above 5%, namely in channel 1 of 835.5 kW, channel 2 of 683.2 kW and channel 3 of 161.7.

The overall power loss in this system is 1680,4 Kw with a line length of 141 KM. Data on power losses on each channel can be seen in Figure 3.

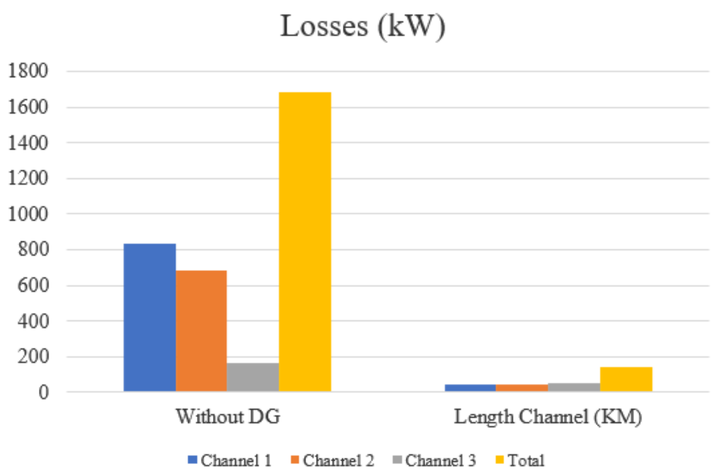

Figure 3. Graph losses

3.2 Distributed Generation Installation Analysis

For the simulation of the Distributed Generation installation, 3 scenarios are used based on the largest voltage drop point which can be seen in Table 3.

Table 3. Distributed Generation installation scenario

Scenario	Location DG	DG Type	DG Power
Scenario 1	Bus Substion Teunom	*Wind Turbine*	1,3 MW
Scenario 2	Bus Substation Calang	*Wind Turbine*	1,3 MW
Scenario 3	Bus Substation Calang and Bus Substation Teunom	*Wind Turbine*	1,3 MW

3.3 Installing Distributed Generation Scenario 1

Installation of Distributed Generation scenario 1 which is connected directly to the distribution system, as shown in Figure 4.

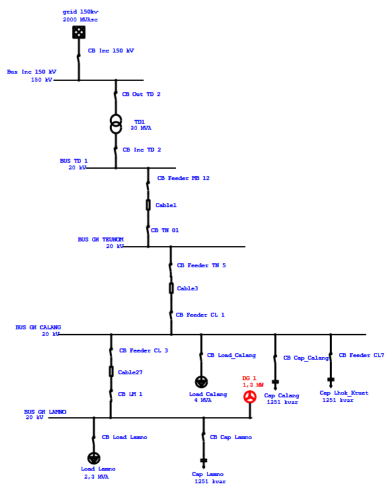

Figure 4. Installing distributed generation scenario 1

The value of the voltage drops after installing Distributed Generation scenario 1, can be seen in Table 4.

Table 4. voltage drop after installation of Distributed Generation scenario 1

Bus ID	Nominal kV	Voltage		Voltage Drop	
		(kV)	(%)	(kV)	(%)
Bus Substation Teunom	20	21,03	102,46	-1,03	-2,46
Bus Substation Calang	20	19,42	97,11	0,58	2,89
Bus Substation Lamno	20	18,98	94,9	1,02	5,10

Table 4 shows the value of the voltage drop after the installation of Distributed Generation scenario 1, it can be seen that there is only one bus experiencing a voltage drop above 5%, namely the Lamno Substation Bus of 5.10% or 1.020 kV.

In the installation of Distributed Generation scenario 1, the voltage on each bus has increased. Where the Teunom Substation Bus increased by 4.21% or 1.382 kV, the Calang Substation Bus experienced an increase of 7.70% or 1.540 kV and the Lamno Substation Bus experienced an increase of 12.03% or 2,407 kV.

The installation of Distributed Generation scenario 1 has an average voltage value of 98.16% or 19.81 kV where the average voltage value has increased by 7.98% or 1.088 kV from the average value of the voltage before the installation of Distributed Generation which is equal to 90.18% or 18.03 kV and the average value of the voltage drop is 9.82% or 1.965 kV. The improvement in voltage drops after the installation of Distributed Generation scenario 1 can be seen in Figure 5.

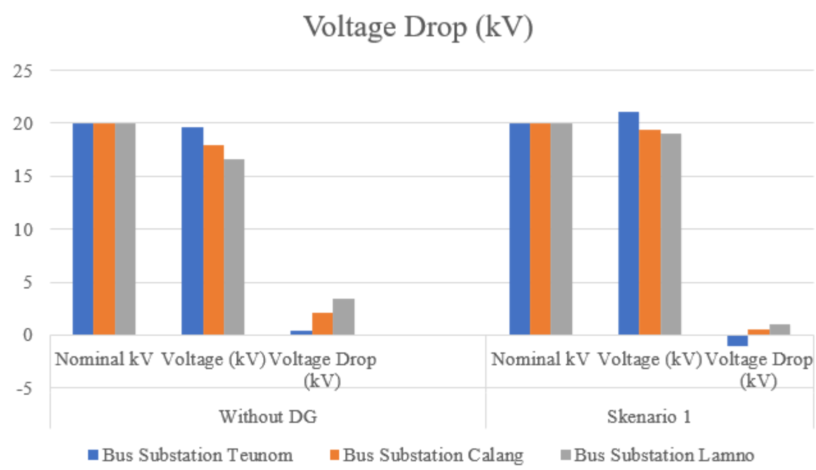

Figure 5. Voltage drops before and after installation of Distributed Generation Scenario 1

Table 5. Losses before and after installation of Distributed Generation Scenario 1

Channel	Bus ID		Length Channel (KM)	Losses (Kw)
	From	To		
1	Bus TD 1	Bus Substation Teunom	47	560,5
2	Bus Substation Teunom	Bus Substation Calang	47	372,4
3	Bus Substation Calang	Bus Substation Lamno	51	13,79
Total			**145**	**946,69**

Table 5 shows the value of power losses after the installation of Distributed Generation scenario 1, the power losses in this system are 946.69 Kw where, the power losses are reduced by 17.8% or 733.7 Kw, this can be seen from reduced power losses in each channel, where on channel

1 by 14.9% or 275 Kw, on channel 2 by 18.3% or 310.8 Kw and on channel 3 by 8.5% or 147.9 Kw. for more details can be seen in the Graph below.

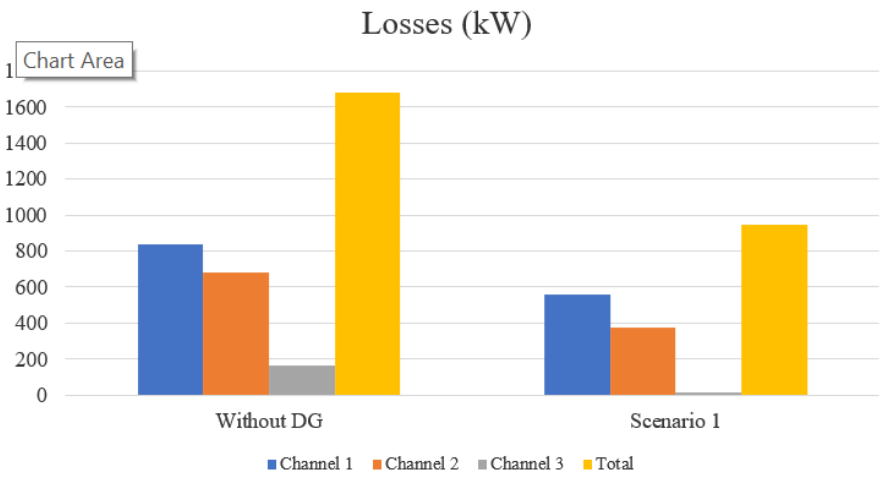

Figure 6. Losses before and after installation of Distributed Generation Scenario 1

3.4 Installing Distributed Generation Scenario 2

Installation of Distributed Generation scenario 2 which is connected directly to the distribution system, as shown in Figure 7.

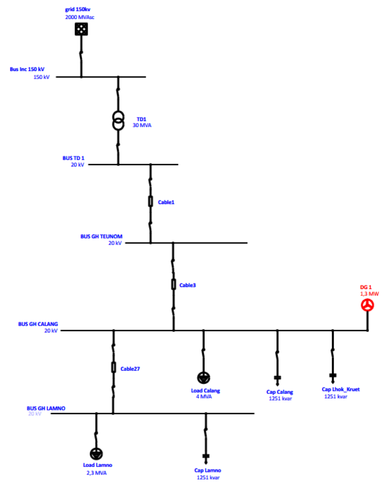

Figure 7. Installing distributed generation scenario 2

The value of the voltage drop after installing Distributed Generation scenario 1, can be seen in Table 6.

Table 6. voltage drop after installation of Distributed Generation scenario 1

Bus ID	Nominal kV	Voltage		Voltage Drop	
		(kV)	(%)	(kV)	(%)
Bus Substation Teunom	20	20,36	101,8	-0,360	-1,80
Bus Substation Calang	20	19,17	95,85	0,831	4,15
Bus Substation Lamno	20	17,97	89,86	2,028	10,14

Table 6 shows the value of the voltage drop after the installation of Distributed Generation scenario 2, it can be seen that there is 1 Bus that experiences a voltage drop above 5%, namely the GH Lamno Bus of 10.14% or 2.028 kV.

In the installation of Distributed Generation scenario 2, the voltage on each bus increases, where at the Teunom Substation Bus it is 3.55% or 0.710 kV, the Calang Substation Bus is 6.44% or 1.287 kV and the Lamno Substation Bus is 6.99% or 1.339 kV.

The installation of Distributed Generation scenario 2 has an average voltage value of 95.84% or 19.17 kV where the average voltage value has increased by 5.66% or 1.132 kV from the average value of the voltage before the installation of Distributed Generation which is equal to 90.18% or 18.03 kV and the average value of the voltage drop is 4.16% or 0.883 kV. The improvement in voltage drop after the installation of Distributed Generation scenario 1 can be seen in the graph below.

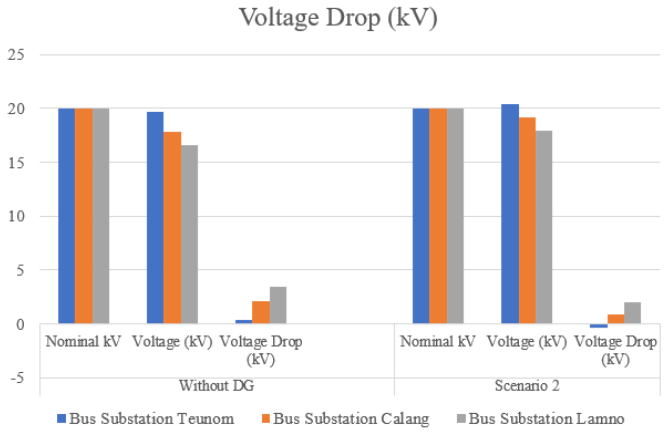

Figure 8. Voltage drops before and after installation of Distributed Generation Scenario 2

Table 7. Losses before and after installation of Distributed Generation Scenario 2

Channel	Bus ID		Length Channel (KM)	Losses (Kw)
	From	To		
1	Bus TD 1	Bus Substation Teunom	47	537,1
2	Bus Substation Teunom	Bus Substation Calang	47	373,2
3	Bus Substation Calang	Bus Substation Lamno	51	152,1
Total			**145**	**1062,4**

Table 7 shows the value of power losses after the installation of Distributed Generation scenario 2, power losses in this system are 1062.4 Kw where, power losses are reduced by 15.8% or 618 Kw, this can be seen from the reduced loss. Power loss on each channel, where on channel 1 it is 15.6% or 298.4 Kw, on channel 2 it is 18.3% or 310 Kw and on channel 3 it is 0.94% or 9.4 Kw. for more details can be seen in the graph below.

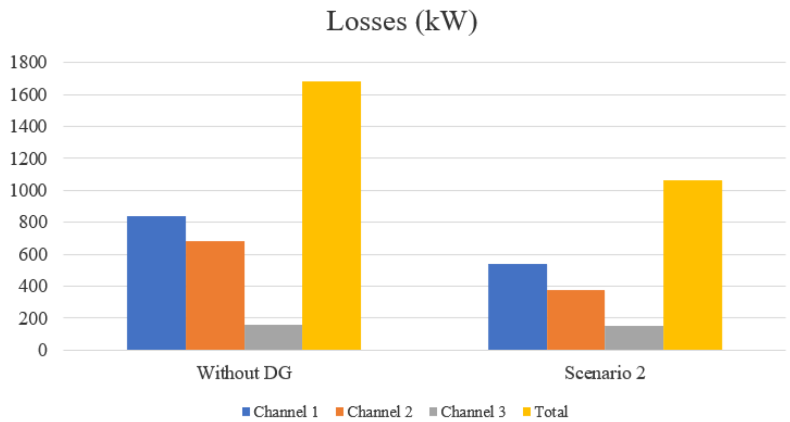

Figure 9. Losses before and after installation of Distributed Generation Scenario 2

3.5 Installing Distributed Generation Scenario 3

Installation of Distributed Generation scenario 3 which is connected directly to the distribution system, as shown in Figure 10.

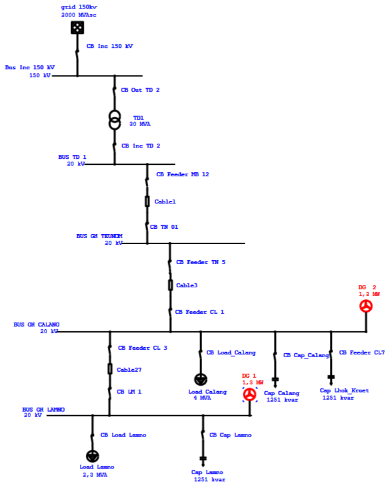

Figure 10. Installing distributed generation scenario 3

The value of the voltage drop after installing Distributed Generation scenario 1, can be seen in Table 8.

Table 8. voltage drop after installation of Distributed Generation scenario 1

Bus ID	Nominal kV	Voltage		Voltage Drop	
		(kV)	(%)	(kV)	(%)
Bus Substation Teunom	20	20,721	105,16	-0,721	-5,16
Bus Substation Calang	20	20,409	102,05	-0,409	-2,05
Bus Substation Lamno	20	20,016	100,08	-0,016	-0,08

Table 10 shows the value of the voltage drop after the installation of Distributed Generation scenario 3, it can be seen that there are no buses experiencing a voltage drop.

In the installation of Distributed Generation scenario 3, the voltage on each bus increases. Where the GH Teunom Bus is 6.91% or 1.071 kV, the Calang GH Bus is 12.64% or 2.527 kV and the GH Lamno Bus is 17.21% or 3,443 kV.

The installation of Distributed Generation scenario 3 has an average voltage value of 102.4% or 20.38 kV where the average value of the voltage has increased by 12.25% or 2.347 kV from the average value of the voltage before the installation of Distributed Generation which is equal to 90.18% or 18.03 kV and the average value of the voltage drop is 9.82% or 1.965 kV. The improvement in voltage drop after the installation of distributed generation scenario 3 can be seen in the graph below.

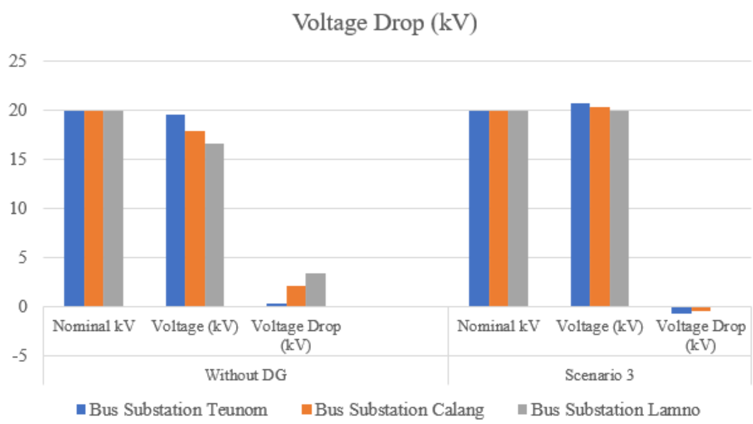

Figure 11. Voltage drop before and after installation of Distributed Generation Scenario 3

Table 9. Losses before and after installation of Distributed Generation Scenario 3

Channel	Bus ID		Length Channel (KM)	Losses (Kw)
	From	To		
1	Bus TD 1	Bus Substation Teunom	47	368,1
2	Bus Substation Teunom	Bus Substation Calang	47	183,6
3	Bus Substation Calang	Bus Substation Lamno	51	14,1
Total			**145**	**565,8**

Table 9 shows the value of power losses after the installation of Distributed Generation scenario 3, the power losses in this system are 565.8 Kw, where the power losses are reduced by 29.7% or 1114.6 kW; this can be seen from reduced power losses in each channel, where on channel 1 by 22.7% or 467.4 Kw, channel 2 by 37.2% or 499.6 kW and on channel 3 by 8.72% or 147.6 kW. For more details can be seen in the graph below.

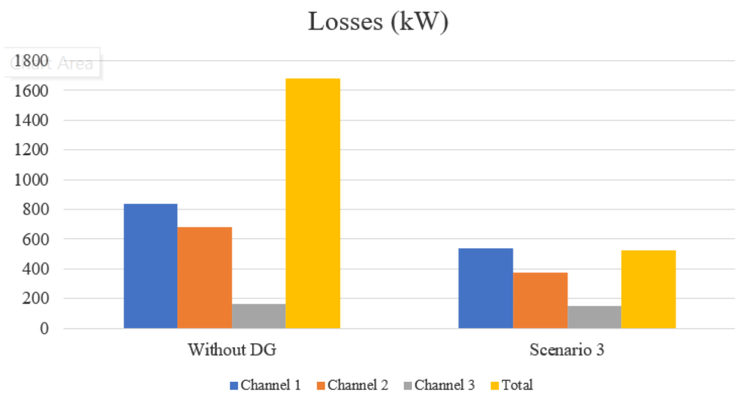

Figure 12. Losses before and after installation of Distributed Generation Scenario 3

3.6 VOLTAGE PROFILE COMPARISON

From the voltage profile data obtained before and after the installation of Distributed Generation with 3 different scenarios, it can be seen in the graph below.

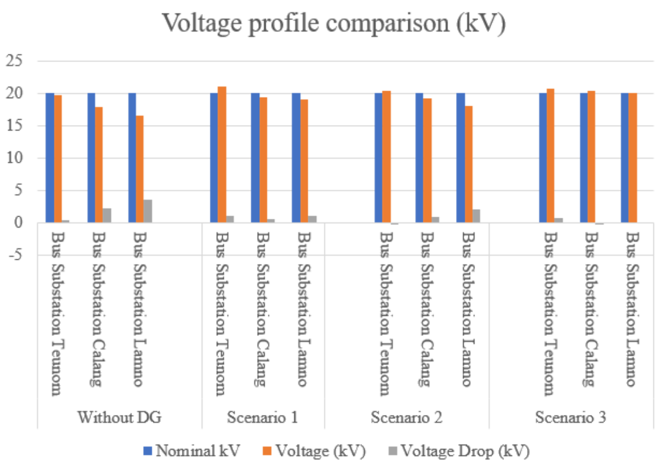

Figure 13. Voltage profile comparison chart

Figure 13 shows that the installation of Distributed Generation can increase the voltage profile. The installation of Distributed Generation scenario 1 has an average voltage value of 98.16% or 19.81 kV where the average voltage value has increased by 7.98% or 1.088 kV from the average value of the voltage before the installation of Distributed Generation which is equal to 90.18% or 18.03 kV and the average value of the voltage drop is 9.82% or 1.965 kV.

The installation of Distributed Generation scenario 2 has an average voltage value of 95.84% or 19.17 kV where the average voltage value has increased by 5.66% or 1.132 kV from the average value of the voltage before the installation of Distributed Generation which is equal to 90.18% or 18.03 kV and the average value of the voltage drop is 4.16% or 0.883 kV.

The installation of Distributed Generation scenario 3 has an average voltage value of 102.4% or 20.38 kV where the average value of the voltage has increased by 12.25% or 2.347 kV from the average value of the voltage before the installation of Distributed Generation which is equal to 90.18% or 18.03 kV and the average value of the voltage drop is 9.82% or 1.965 kV.

From the simulation results of the installation of Distributed Generation scenarios 1,2 and 3 that have been carried out, it can be concluded that the installation of Distributed Generation can improve the voltage profile. Of the 3 scenarios of the Distributed Generation installation carried out, the 3rd scenario is the best choice, because there is no voltage drop in the distribution system and can increase the voltage profile so as to make the distribution system more reliable.

3.7 POWER LOSS COMPARISON

From the data on power losses before and after the installation of Distributed Generation, it can be seen in Figure 14 below.

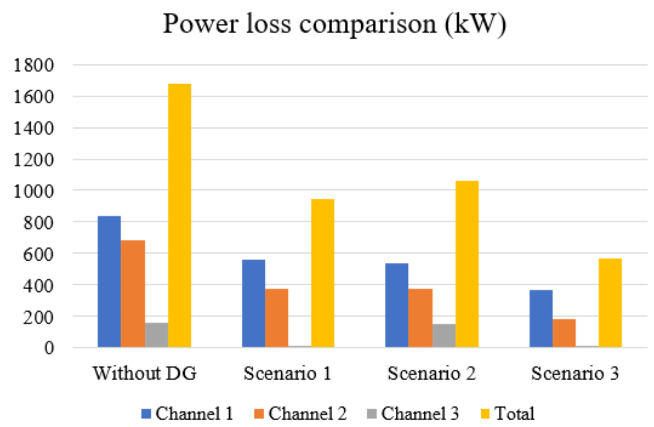

Figure 14. Power loss comparison chart

Figure 14 shows that installing Distributed Generation scenarios 1,2, and 3 can reduce power losses in each channel. The installation of Distributed Generation scenario 1 can reduces power losses in this system by 17.8% or 733.7 kW, this can be seen from before the installation of Distributed Generation the power losses in this system are 1680,4 kW with a total length channel 145 KM.

The installation of Distributed Generation scenario 2 can reduce losses in this system by 15.8% or 618 Kw, this can be seen from before the installation of Distributed Generation the power losses in this system are 1680.4 kW with a total line length of 145 KM.

The installation of Distributed Generation scenario 3 can reduce power losses in this system by 29.7% or 1114.6 kW, this can be seen from before the installation of Distributed Generation the power losses in this system are 1680.4 kW with a total length channel 145 KM.

From the simulation results of the installation of Distributed Generation scenarios 1,2 and 3 that have been carried out, it can be concluded that the installation of Distributed Generation can reduce power losses in this system. Of the 3 scenarios for installing Distributed Generation, the 3rd scenario is the best choice because it can reduce power losses by 29.7% or 1114.6 kW from the value of power losses before installing Distributed Generation, which is 1680,4 kW with a total line length of 145 KM.

4. CONCLUSION

From the simulation results and analysis of the installation of Distributed Generation on a 20 kV distribution system from the Meulaboh Substation (GI) to the Lamno Substation (GH), which was carried out using the ETAP 19.0 software. The conclusions of this study are as follows:

1. Distributed Generation installation locations are carried out in 3 scenarios, based on the most significant voltage drop point.
2. Installation of Distributed Generation scenario 1 has an average voltage value of 95.16% or 19.81 kV and an average voltage drop of 9.82% or 1.965 kV and power losses of 946.69 kW, where power losses are reduced by 17.8% or 733.7 kW.
3. Installation of Distributed Generation scenario 2 has an average voltage value of 95.84% or 19.17 kV and an average voltage drop of 4.16% or 0.833 kV and power losses of 1062.4 Kw, where power losses are reduced by 15.8% or 618 kW.
4. Installation of Distributed Generation scenario 3 does not experience a voltage drop, the average voltage value is 102.4% or 20.38 kV and power losses are 1062.4 kW, where power losses are reduced by 29.7% or 1114.6 kW.
5. Of the 3 scenarios carried out in simulating the installation of Distributed Generation on a 20 kV distribution system, the 3rd scenario is the best choice because there is no voltage drop in the distribution system and can increase the voltage profile and can reduce power losses by 29, 7% or 1114.6 kW with a distribution channel length of 145 KM.
6. A wind turbine with an average wind speed of 2.99 m/s and a power of 1.3 MW can be used to improve this distribution system.

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