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Injection Analysis of 5 Mwp Photovoltaic Power Plant on 20 Kv Distribution Network In Kupang

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ABSTRACT : A new 5 MWp PLTS or PV has been built in Oelpuah Village, Kupang Tengah. According to PT. PLN NTT,the amount of injected power to the distribution network cannot reach its maximum capability. At the moment, the average value of injected active power is 2 MWp. In this paper, a solution to achieve maximum injected power will be discussed. As a result of the study, the main problem is absence of energy storage. It cause the output power of the PV strongly affected by the weather. Hence a fluctuation of generated power cannot be avoided. The frequency in the distribution network system can be easily increased or decreased. Sudden drop in frequency due to 5 MWp lost, will cause the frequency to decrease beyond the standard value. The under frequency relay trips because it takes a long time to return to the originalvalue. A 5% of droop setting value is not suitable with those conditions. The droop characteristic setting should be reduced to 1% as a proposed solution. So that the response to frequency changes is more sensitive

Keywords: PV, governor, droop, frequency.

I. INTRODUCTION

.According to Pusdatin[1] 87% of electric power generation in Indonesia is still dominated by non-renewable power plants such as fossil-fueled engines, while renewable power plants only 13% of all power plants. Recently, Solar Power (PLTS) or PV is one of renewable energy source that has been implemented on many areas in Indonesia. According to Zhong[2] PLTS is one of the most friendly renewable energy sources because it does not use fossil fuels, hence it does not produce pollution or exhaust emissions. Prakash[3] said thatthe demand for new PV generators is increasing because PV is able to produces electrical energy without damaging the environment by converting solar radiation into electricity. Suyono[4] said that the utilization of PV generation in distribution system has been widely used in various countries.

Currently, a 5 MWp of PV, which is built by PT. LEN Industri Bandung in Oelpuah Village, Kupang Tengah, being the largest PV in Indonesia and the first one built by Independent Power Producer (IPP). The PV is interconnected with the bus at 20 kV medium express buffer. Tamimi[5] said that any PV systems connected to the grid are different from other power plants. The most fundamental difference is the absence of mechanical devices that being used energy conversion process. Marek[6] the network voltage could have been changed due to injected power from PV generation . The voltage changes are dependent on the network system and the amount of injected PV power. Suyono[7] PV power injection can improve the voltage profile and reduce the power loss on the system. Jindrich[8]PV power injection will affect the stability of the distribution system, not only on the particular connection bus, but also has a widespread effects on distribution network. Kundur[9] The stability ofpower system is the ability of the electrical power system to regain initial operating conditions after a system failure occurs. Tamimi[10] The quality of grid-connected PV power generation is determined by the quality of current and voltage output from the PV system itself.

According to information from PT. PLN NTT,those 5 MWp PV power plant cannot achieve its maximum power injection capabilities.At the moment, the amount of injected power only reach 2 MWp. Given the problem,a research has been conducted so that the PV power plant can achieve 5 MWp of injected power value.

II. GOVERNOR SYSTEM

Djiteng[11] governor is an equipment to regulate the amount of fuel in a turbine or diesel engine, to rotate the generator. Fuel addition or reduction arrangements is needed to regulate the active power in the system. By adjusting the active power it is the same thing as adjusting the output frequency on generator. The purpose of the governor is to set the frequency, so that when there is a change of frequency due to any kind of disturbance, the governor is able to return to the normal frequency of 50 Hz.

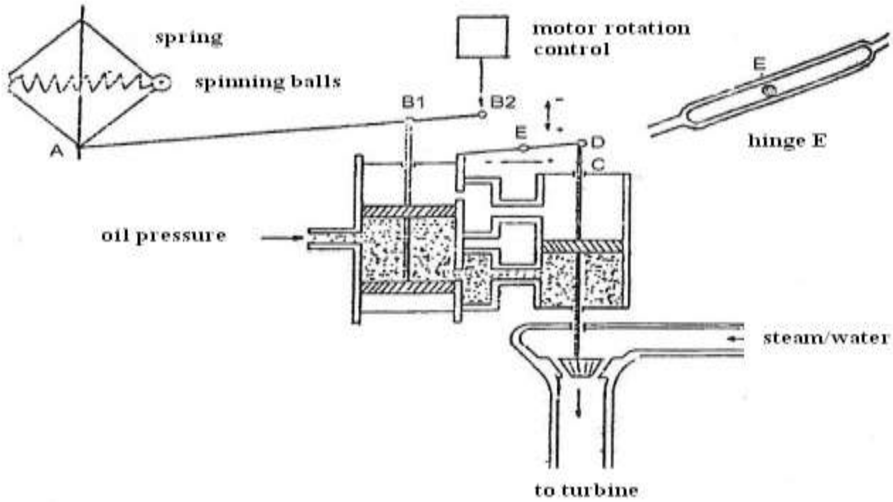

Fig.1. Governor working principle

When there is a change in frequency in the system, the speed of the generator will change. This also causes a change to the spinning balls as the rotating shaft is connected directly through the gear. The point A is also change which further affectsat point B. Given the change in point B, the oil pressure piston will drain the pressurized oil to the main valve. The main valve will be lifted up or down so that the coupled valve to the piston will open or close. By opening and closing the valves the fuel will increase and decrease so that the speed at the generator changes and the frequency of bias is stabilized according to the normal frequency. Speed Droop is a governor characteristic that needs to be considered to regulate the frequency. The smaller the setting value of the speed droop, the more sensitive to changes in frequency or vice versa. The speed droop setting can be done by shifting the hinge E in Figure 1. The closer the distance between point E and point D, then the faster the governor stops its response to the frequency change and resulting a large speed droop. If the distance between point E and point D is farther, then the longer the governor stops its response to the frequency, resulting a small speed droop.

III. EXISTING PV SYSTEM CONDITION

Existing operation scheme on PV power plant in Kupang does not use battery. Currently, the PV array are connected to the inverter to convert the DC power to AC power. Then a step up transformer is used as main interface to inject active power from PV system to distribution network. The PV system only works when there is sufficient amount of sunlight in the area. In other words, the PV system never generate power more than 12 hours in a day. The main reason behind this problem is the absence of energy storage such as battery.Such operating scheme resulting an unstable amount of injected power, because it’s very dependent on the weather condition. When highest sunlight radiation happened, the injected power can reach its maximum capacity of 5 MWp.But sudden changes on weather condition, for example the weather turn to cloudy, the injected power is significantly reduced.At night, the PV is not operating and absorb some energy from network to fulfill its auxiliary load such as lighting.

IV. SIMULATION RESULT

4.1 Existing

Based on existing condition, the PV system cannot reach its maximum power injection capability. The amount of injected power to Kupang distribution network is 2 MWp. Those 2MWpvalue is a standard value chosen by PT. PLN as a main regulator on the network.A field report said that when the injected power value exceeds 2 MWp then the power is lost and the under frequency relay is tripped.The existing operation needs to be evaluated so that the amount of injected power could reach 5MWp. A simulation of existing system with 2MWp of power loss is shown in Fig. 2.

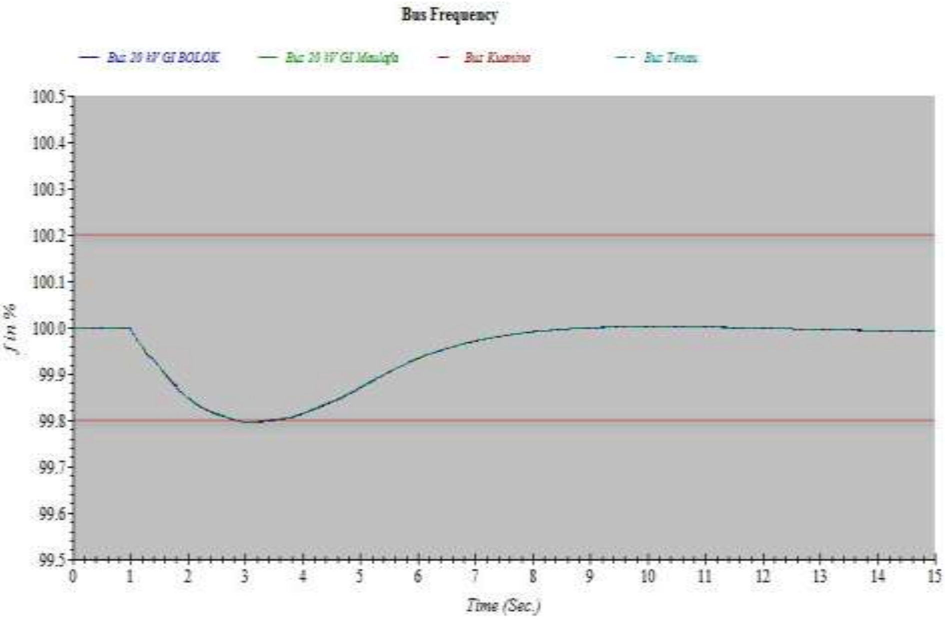

Fig.2. Frequency change due to 2MWp of power loss (existing)

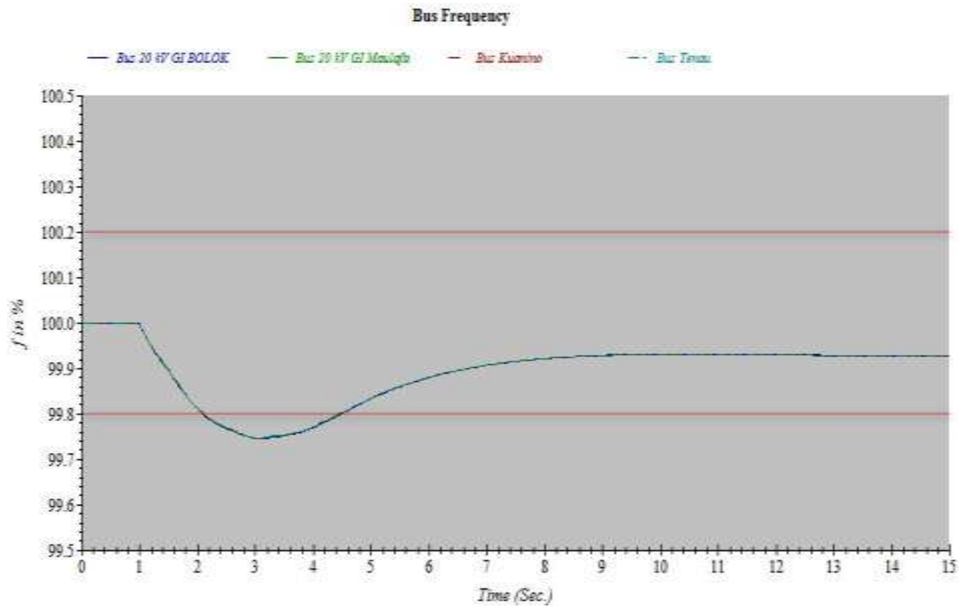

Fig.3. Frequency change due to 2.5 MWp of power loss(existing)

According to Fig. 2 and Fig. 3, lost of PV injected power is occurred on t = 1 s. It can be seen that the system frequency is also affected by the amount of power lost. The frequency value is allowed to swing between 99.8% and 100.2% on normal conditions.But there is another tolerance range between 99.5% and 100.5% in a short time. According to ESDM Ministry 03, 2007 about the rules of the power system network, that the allowable frequency within the normal operating condition is (50 ± 0.2 Hz) unless under short time transition is allowed to (50 ± 0.5 Hz). The result of simulation on Fig. 2 shows that the frequency is still within normal operating limits when the amount of power loss is 2 MWp. On Fig. 3, when the amount of power loss is 2.5 MWp, the frequency decreases beyond the normal operating limit ± 0.2 Hz and returns to normal frequency within 2.2 seconds. Although the frequency is still within the permitted limit i.e. not lower than 99.5% and not higher than 100.5%, however it needs 2.2 seconds to recover the normal frequency condition. The recovery time standard to the normal frequency of 50 ± 0.2 Hzis 200 milliseconds to 300 milliseconds, determined by the Load Control Center. So when the frequency exceeds the limit value, in this case is 2.2 seconds, the under frequency relay is tripped. This is the main reason why PT. PLN choose 2MWp as standard value of injected power from PV power generation.Fig. 4 shows the recovery time is worse when 5 MWp power loss is occurred. In 15 seconds, the system cannot reach the normal operating condition.

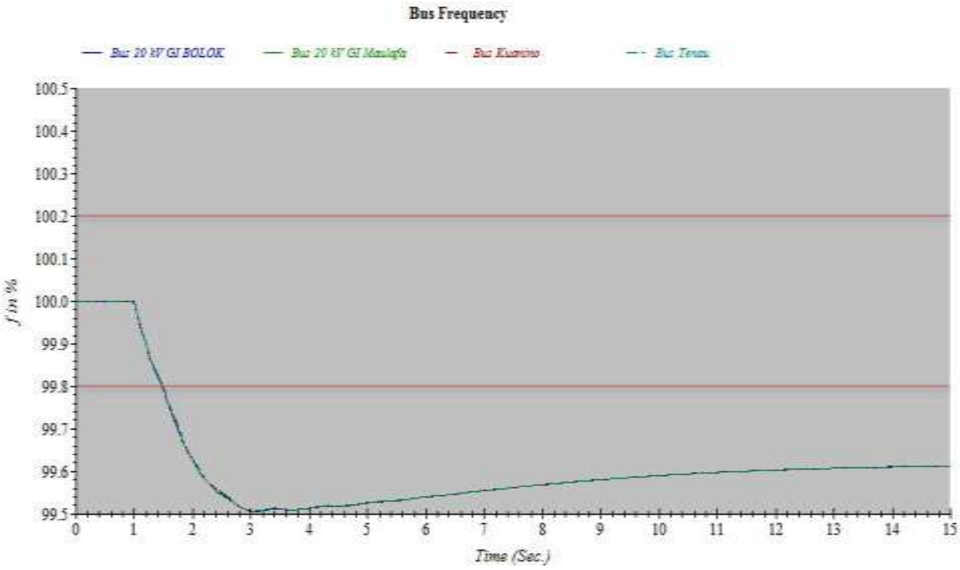

Fig.4. Frequency change due to 5 MWp of power loss(existing)

As a results of simulation, it can be concluded that the absence of energy power affects the injected power significantly. The injected power is highly dependent on sunlight, so when the sunlight is at maximum intensity, the injected power can reach its maximum injected power value. But when the weather turns to cloudy, then output power is decreased rapidly. This causes a significant change of injected power, hence the frequency on Kupang distribution network is affected. According to Djiteng[11] a long recovery time of operating frequency is caused by governor setting. Therefore the proposed solution to this problem is change the speed droop setting on the generator.

4.2 Governor droop setting

On Kupang Distribution network, only certain power plant provide a further adjustment on its governor setting. The power plants that have governor are: PLTU Bolok 1, PLTU Bolok 2, Duta Teknik and Thas Power. The current speed droop setting is 5%. This value is chosen corresponding with ESDM Ministry 03, 2007 which says that all power plants must operate with anunblocked governor unless authorized by the Load Control Center. All power plants should set the droop governor's characteristics at 5% unless allowed by the Load Control Center to set on another level.

Djiteng[11] said that a small value of speed droop characteristic resulting more sensitive to frequency changes, but greater chance to be unstable. Then, changing the speed droop setting to a lower value is proposed as a solution. Based on ESDM Ministry 03, 2007, it is allowed for a certain power plant to set the speed droop setting to another level. The chosen value of speed droop setting is 1%, so that the operating frequency can recover to the normal condition as fast as possible. Fig. 5 shows the frequency response due to 2.5 MWp loss with proposed speed droop setting.

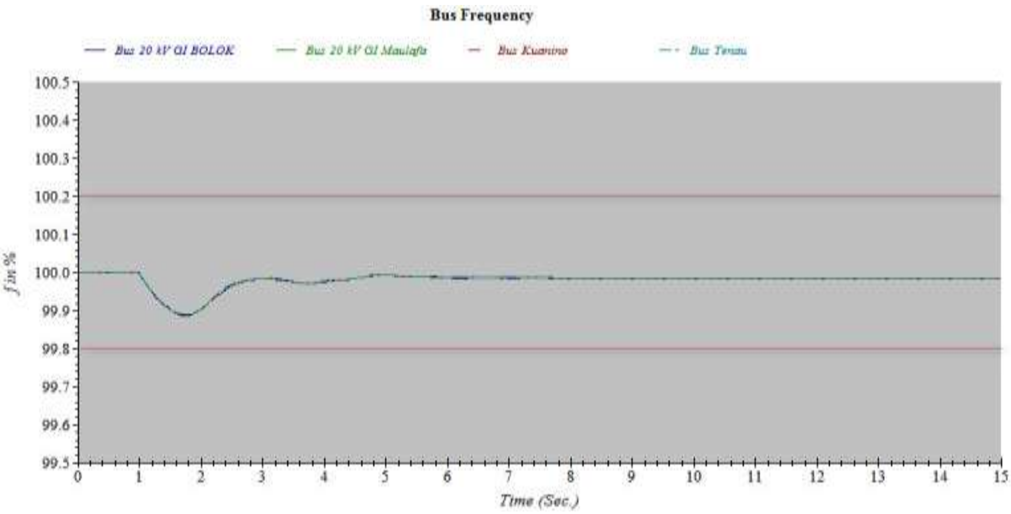

Fig.5. Frequency change due to 2.5 MWp of power loss (proposed solution)

Fig. 5 shows simulation results when a 2.5 MWp power loss is occurred at t=1s. The system frequency experience an oscillation but still able to recover to initial frequency within the limit frequency value of 50± 0.2 Hz. There is a significant recovery time improvement on system frequency, compared to Fig. 3.It can be seen that changing the speed droop setting can affects the recovery time of system frequency due to occurrence of power loss. Fig. 6 shows simulation results when a 5 MWp power loss is occurred at t=1s.When the power loss occurred, the operating frequency is changing without exceeding the allowable range. On t=1.65 s the frequency exceed the allowable range, but it can recover at t=1.9 s. Although it's exceeding the allowable value, the duration is just about 250 ms, which is still allowed by Load Control Center.

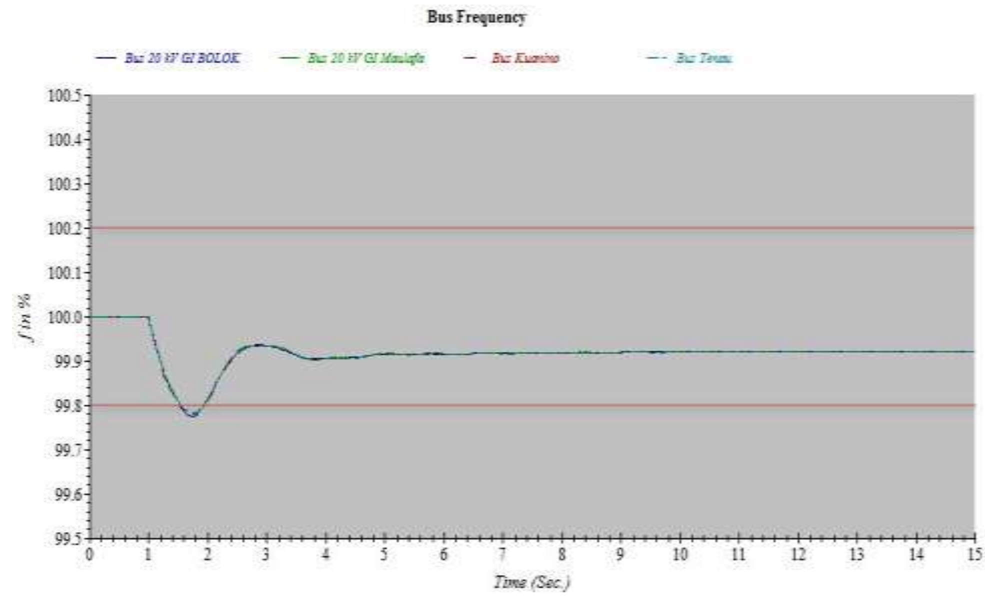

Fig.6. Frequency change due to 5 MWp of power loss (proposed solution)

4.3Generator response

From previous section, it can be concluded that the proposed solution is changing the speed droop setting. Corresponding with the change of speed droop setting, a simulation of generator response is carried out. The simulations results is shown in Fig. 7 and Fig. 8 respectively.

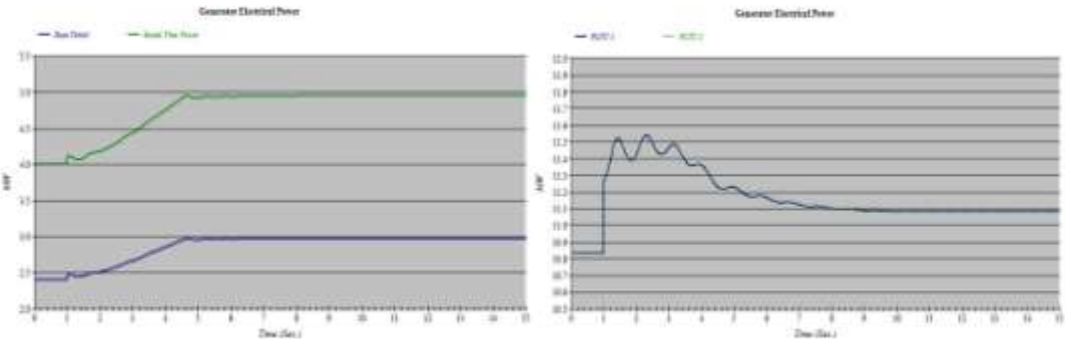

Fig.7. Power graph using 5 % of speed droop setting

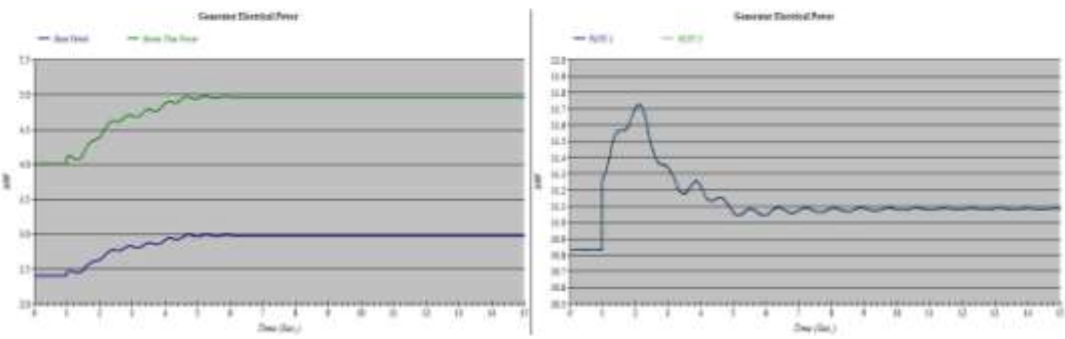

Fig.8. Power graph using 1 % of speed droop setting

It can be seen there some significant differences between Fig. 7 and Fig. 8. Both of them experience increasing amount of output power when the injected PV power is loss. Duta Teknik diesel engine increase its output power by 0.6 MW, Thas Power PLTD by 1 MW, PLTU 1 and PLTU 2 by0.53 MW. The total increase from the four plants is 2.13 MW. The difference between those two figure is the frequencyrecovery time. By using the proposed speed droop characteristic, a better response time when increasing the output power is achieved.

V. CONCLUSION

According to previous analysis, the existing PV system does not have an energy storage such as battery. This is the main reason why the PV system cannot reach its maximum capability of active power injection. After several attempt of simulation, the proposed solution is changing the speed droop setting from 5% to 1%

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