Operation Management Scenarios of Medium Voltage Distribution 20 kV with PV Rooftop Penetration

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Abstract -The availability of renewable energy in various sectors certainly needs to be improved, one of which is Solar Power Plant or PV. The province of Bali has a Solar Power Plant (PV) development target of 108 MW by 2025. The Solar Power Plant target has been stated in the RUEN (National Energy General Plan) policy. Efforts made by the Province of Bali to support and to realize the RUEN target are in the Bali Governor Regulation (Pergub) No. 45 of 2019 concerning "Clean Energy Bali". One of the areas in Bali that can be developed as a PV development is Nusa Dua area. In this area, the integration of conventional grid systems and renewable energy (PV Rooftop) can be carried out. In this journal, the author proposes several scenarios that are expected to be considered in planning the integration of a 20 kV grid system with renewable energy power plants. Some of these ideas are the integration of 25%, 50%, and 100% of PLTS capacity in meeting electrical energy needs. The purpose of the scenario is to find out the direction of the flow supplied by the PV, and to know whether the grid will remain stable or not if disturbance occurs.

***Index Terms*— Solar Power Plant, PV, Integration, Grid, Energy**

I. INTRODUCTION

Renewable energy is one of the solutions to overcome fossil energy which is becoming less in its supply day by day. The availability of new renewable energy in various sectors certainly needs to be improved. This is in line with government regulations as stated in Article 20 paragraph 4 of Law No. 30 of 2007. In addition, in accordance with KEN (National Energy Policy), Indonesia has a target for the spread of new and renewable energy in 2025 and in 2050. In 2025, the desired target is 23%; while in 2050, it is 31%[1]. Renewable energy sources can be obtained from various sources, such as water, wind, and sun or solar. Solar power or sunlight is a form of renewable energy that has been and will be developed as a clean and sustainable energy solution for Indonesia. Sunlight (solar) emitted can be converted into a power plant called Solar Power Plant (PV).

Based on the RUEN (General National Energy Plan), Indonesia's solar power potential reaches 208 GW. This encourages Indonesia to have a PV development target of 6500 MW in 2025 and an increase of 45000 MW in 2050[1].

The policies set out in the RUEN are intended for various regions in Indonesia, one of which is the Province of Bali. The province of Bali itself has a PV development target of 108 MW by 2025. The efforts made by the Province of Bali to support and realize the RUEN target are in the stipulation of Bali Governor Regulation No. 45 of 2019. The regulation describes “Clean Energy Bali”. This clean energy is based on the principles of benefit, independence, environmental sustainability, economy, sustainability, resilience, security and safety, fairness and healthy business. This is all to meet energy needs independently, environmentally friendly, sustainable, equitable by using clean energy. In the presrnt, the need for energy in the province of Bali is still mostly supplied by conventional energy, namely fossil energy. Therefore, Governor Regulation of Bali No.45 also explains the rules for several groups of consumers of electrical energy to switch to using PV. There are several types of PV applications, such as PV Rooftop, ground mounted PV, floating PV, etc. What is expected from the Bali Governor Regulation is that buildings that include commercial, industrial, social, and household buildings with a floor area of more than 500 m2 are recommended to install a rooftop solar system or a roof of at least 20% (percent) of the installed capacity or roof area. Meanwhile, buildings with a roof area of more than 1000 m2, buildings with a land area of more than 3000 m2 and 4-star hotel buildings and above can receive special rates or green tariffs if the building uses electricity with clean energy sources[2]. One of the areas in Bali Province that can be developed as a PV development area is Nusa Dua area.

In this journal, the Nusa Dua area is one of the author interests in carrying out several proposals or ideas, especially in the development of electricity in the Province of Bali by utilizing clean energy and renewable energy. The Nusa Dua area can contribute to the development of electricity by utilizing the PV Rooftop model on several existing buildings in the area. The buildings in the area are hotels, villas, museums, restaurants, etc. The proposed Solar Power Plant modelling is PV Rooftop with on-grid system. The intended on-grid system is integrated into one with the existing conventional network or PT PLN's 20 kV distribution network. An integration model of a conventional network system with a renewable energy system requires a network operation management system, namely by taking into account the electrical energy needs of an area, the supply of electrical power from conventional and renewable energy sources, as well as the flow of power in the area. The integration of renewable power plants with a 20 kV network system has integration guidelines, one of which is the State Electricity Enterprise Standard Of PLN (SPLN). This is done so that the system can work properly and optimally. In this journal, the author proposes several scenarios that are expected to be considered in planning the integration of a 20 kV network with renewable energy power plants. Examples of case studies that the author uses are in several areas located on the 20 kV Nusa Dua Substation network.

II. LITERATURE REVIEW

A. Solar Power Plant (PV)

The generation of electrical energy by utilizing sun power as a source of generation can be called Solar Power Plant (PV). Based on the Solar Power Plant installation system, the modeling can be divided into on-grid Solar Power Plant, off-grid Solar Power Plant, and hybrid Solar Power Plant[3]. Off-grid Solar Power Plant is Solar Power Plant that is not connected to the PLN network. On-grid Solar Power Plant is Solar Power Plant that is connected to the conventional PLN network. On-grid Solar Power Plant will work during the day and if the electricity network from PLN operates normally (no blackouts). If PLN does not operate due to interference or maintenance, then on-grid Solar Power Plant will also not operate unless it is designed to operate in islanding mode or isolated mode from the PLN network. Based on the place of installation, on-grid Solar Power Plant are grouped into four, namely: (1) PV ground mounted, (2) floating PV or water surface Solar Power Plant, 3) building integrated PV or Solar Power Plant integrated in buildings, and 4) Rooftop Solar Power Plant. The electrical energy produced by a Solar Power Plant is influenced by several factors, including: the potential of the sun, the Solar Power Plant technology used, as well as the operation and maintenance of the Solar Power Plant.

Fig 1. PV Off-grid and On-Grid

B. Technical Requirements for Renewable Energy Power Plant Integration

The technical requirements for the integration of renewable energy power plants are based on the PT PLN standard, where this requirement is carried out to ensure that the parallel integration and operation of renewable energy power plants with the PLN distribution system will not have an adverse impact on the safety, reliability and power quality of the PLN distribution system. Some of these technical requirements are [4]:

a. The installed capacity of renewable energy power plants does not exceed 10 MW.
b. Setting the maximum clearing time from -50% to 135% of normal voltage.
c. Setting the maximum clearing time from 47.5 Hz to 51.0 Hz specifically for PLTB and PV mini-grid, the frequency range of 49 Hz to 51 Hz refers to SPLN No. D3.022-2-2-2012.
d. Stopping energizing the network within 2 seconds if a fault is detected.
e. Stopping energizing the network within 2 seconds of forming unintended islanding.
f. Does not cause voltage fluctuations at the connection point > +/- 5%.
g. Re-integration to the network at least 5 minutes after the network voltage and frequency return to normal.
h. Parallel equipment has a resistance of 220% of the nominal voltage of the splicing system.
i. Harmonic distortion (<3% individual, & <5% total harmonic voltage distortion, and <total current harmonic distortion.
j. Flicker, IEC standard (Pst = 1.0, Plt = 0.8)
k. Power Factor at 0.9 leading and 0.85 lagging.
l. Maximum voltage drop of 5% at the junction.
m. DC Injection (for inverter) limit +0.5% of nominal output of inverter.

III. RESEARCH METHODOLOGY

The sources of this research data is by using a research method of literature study secondary data which includes single line data distribution network 20 kV Nusa Dua feeder, electricity load data from PT PLN (Persero) Nusa Dua feeder, PV Rooftop potential data. The simulation that will be carried out is load flow from several areas in the Nusa Dua area. In this journal, the authors propose several scenarios for simulation. The scenarios are the existing condition of a grid 20 kV Nusa Dua, and grid integration simulation with PV capacity 100%, 50%, 25% of transformer capacity.

IV. RESULT AND DISCUSSION

In this journal, the author uses several sources of research literature that can provide input and concepts to support the author in proposing the ideas outlined in this journal. Some of these journals have the following abstracts:

Based on a research article entitled "Data-driven Modeling of Solar-Powered Urban Microgrid" by Arda Halu in 2016, it shows that the modeling of medium-voltage and low-voltage electricity networks uses the concept of a microgrid with a source of electrical energy from solar panels. This modeling considers various aspects, namely spatial networks, percolation theory, DC electric power flow, developments in the use of real data for microgrids. The network topology used in this journal uses a radial or open-close loop type. In this study, two scenarios of power flow are used, namely by using diesel as a source of electrical energy, and without diesel as a source of electrical energy, and using cost considerations. The results of this research microgrid simulation show that there is an optimization of the total flow and cost[5].

Based on a research article entitled "Optimal Interconnection Planning Of Community Microgrids with Renewable Energy Sources" by Liang Che in 2015, it shows that power generation planning with microgrids is influenced by various factors such as economy, reliability, variability of renewable energy, network and reliable implementation. The method used for generation planning with the microgrid concept is a data collection method in a microgrid network that is implemented as many as 6 microgrid operating systems on an island mode network. Some of the discussions in this journal are (1) new research directions for optimal planning and operation of multi-microgrids; (2) Optimal microgrid interconnection planning by considering grouping methods to represent the use of renewable energy variables; and (3) A reliability-based interconnection system solution that uses the Minimal Cut-Set (MCS) method for optimal probabilistic microgrid planning. The results of this research simulation suggest the installation of three interconnection paths to ensure each microgrid will maximize reliability with limited capital costs. Numerical results have shown that the proposed interconnection planning methodology is capable of becoming an interconnection alternative with reliability and optimal and efficient interconnection planning[6].

Based on a research article entitled “A Power management and Control Strategy with grid-ancillary services for a microgrid based on DC Bus” by G. Barone in 2014, it shows that an energy management control strategy with additional grid services for a new microgrid configuration, defined by the author as a Smart User Network, which is characterized by various types of micro-sources and storage systems that are interconnected with conventional networks, which is proposed using a DC bus. Several simulations have been carried out by using the Smart User Network model implemented with Matlab/Simulink[7].

Based on a research article entitled "Energy Management System for PV-Battery Microgrid based on Model Predictive Control" by M. Reyasudin Basir Khan in 2019, it reveals that the microgrid model with Energy Management System (EMS) is based on Model Predictive Control (MPC). The microgrid consists of PV, and a battery storage system. The goal of EMS is to produce reliable and optimal generation of multiple microgrid sources. In addition, MPC will also provide battery charge control for smooth PV output. The model is simulated based on the actual load profile and renewable resources such as solar radiation. Several disturbances such as load variation, PV generation and shading have been simulated to measure EMS performance. The results illustrate that the system is able to show reliable performance in various conditions[8].

In this journal, the author proposes several scenarios to see how the power flow and operation management of the conventional 20 kV network integration in the Nusa Dua area with renewable energy power plants, namely PLTS. The author proposes several scenarios for simulation with the assistance of simulation software, namely as follows: :

1. The first scenario :

Simulation on the 20 kV network in the Nusa Dua area. In this simulation, scenarios will be carried out without combined generation with Solar Power Plant. Therefore, it will be seen how the condition of the conventional 20 kV grid power flow with transformer data input and existing load data. The expected simulation results are the voltage and current that enter the PLN operating standard.

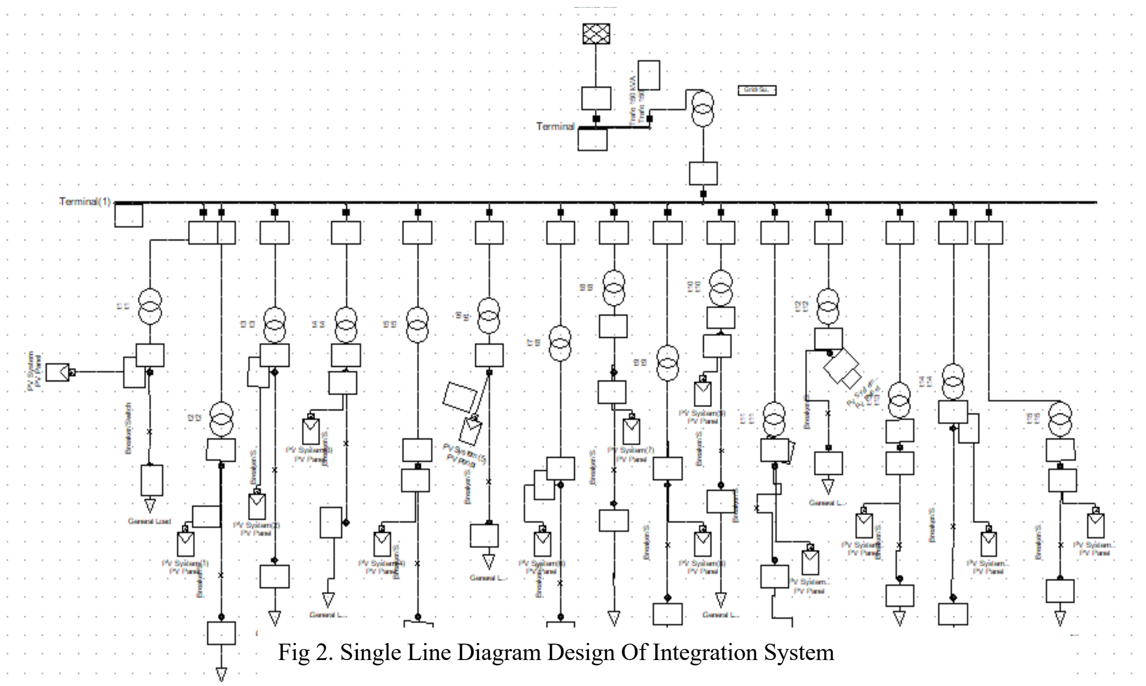

Fig 2. Single Line Diagram Design Of Integration System

2. The Second Scenario:

Simulation of 20 kV grid integration system and Solar Power Plant with maximum capacity equal to transformer power.In this simulation, the 20 kV grid system that was previously made will be added to the Solar Power Plant system for each feeder in the Nusa Dua area. Each feeder has a distribution transformer. In this simulation, the Solar Power Plant capacity is expected to generate power equal to the maximum power of the transformer and Solar Power Plant can fully supply the load requirements. The expected simulation output if there is an excess of generating power, the excess will not inject into the transmission network.

3. The Third scenario :

Simulation of 20 kV grid integration system and Solar Power Plant with a capacity of 50% of the transformer power.In this simulation, the integration of a 20 kV grid system with a Solar Power Plant system with a capacity of 50% of the maximum transformer power will be carried out. The simulation output is expected if there is an excess of generating power, the excess will not inject into the transmission network, and if at some points the feeder is disturbed how the Solar Power Plant system and the transformer supply the load needs.

4. The fourth scenario

Simulation of 20 kV grid integration system and Solar Power Plant with a capacity of 25% of transformer power.This fourth scenario is the same as the third scenario that has been proposed, but there are differences in the capacity of the Solar Power Plant to be installed. In this simulation, the integration of a 20 kV grid system with a Solar Power Plant system with a capacity of 25% of the transformer's maximum power will be carried out. The simulation output is expected if there is an excess of generating power, the excess will not inject into the transmission network, and if at some points the feeder is disturbed how the Solar Power Plant system and the transformer supply the load needs.

5. The Fifth Scenario

In this scenario, the Solar Power Plant to be installed on the grid is Solar Power Plant with various capacities, 100%, 50%, 25% and even 0% of the installed transformer power. The expected output is the 20 kV grid will remain stable in the event of a disturbance at some point.

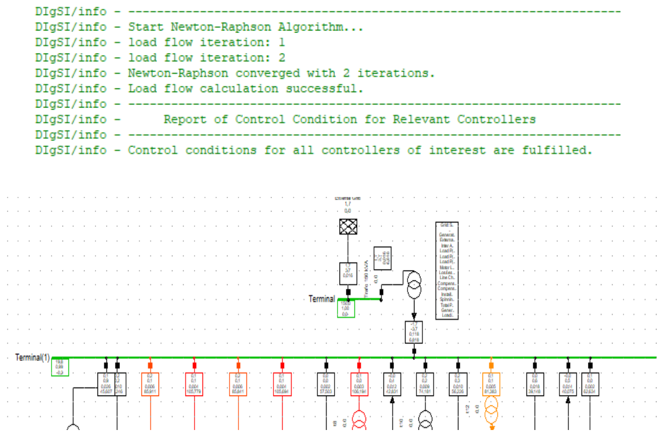

Fig 3. The Indicator Simulation Running Well

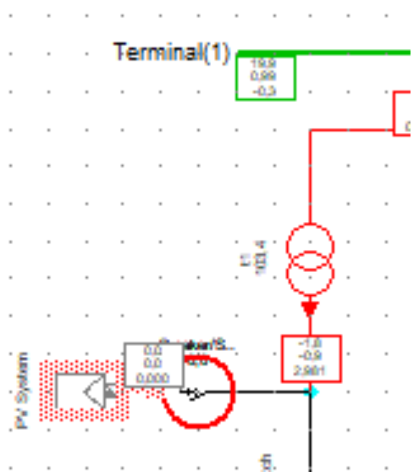

Fig 4. Event in Some Point

V. Conclusion

Based on several scenarios that have been prepared, the expected result of the author is to know where the supply flow from Solar Power Plant (PV) to the system that has been made. The purpose of these scenarios is to see how much Solar Power Plant capacity must be generated on the grid so that it can meet the load and there is no injection to the transmission network. The events (interference) provided on the grid is used to see whether the network can still survive in accordance with the standards set in the SPLN or not.

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