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Research Article

Technical Analysis of the Impact of High Solar PV Penetration on the Stability of Bali's Power System

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Abstract: The increasing penetration of solar power plants as an alternative clean energy source is an important element in the energy transition process towards Net Zero Emission (NZE). Bali, as a province with high electrical load growth and commitment to green energy development, thus this study aims to assess the impact of high solar PV penetration on the grid system stability of the electrical system operating at 150 kV voltage. The impact analysis was conducted using Digsilent software with high solar PV penetration baseline scenario in 2025 compared to the NZE scenario in 2060. The research includes power flow analysis, short circuit and transient analysis to evaluate the system response to generation fluctuations and systemic disturbances. The results show that a 12% penetration of solar PV leads to an increase in bus voltage, but the value is still within the tolerance limits stipulated in the national grid code. However, in the NZE scenario, a 30.4% increase in solar PV penetration reduces system inertia, which in turn amplifies frequency oscillations and makes the power system more susceptible to major disturbances such as the Jamali submarine cable failure potentially leading to greater instability during such events. This study recommends mitigation strategies by increasing the capacity of the energy storage system and strengthening the interconnection system by improving of the Java-Bali submarine cable line to ensure stability and reliability of the grid system in the future.

Keywords: Net Zero Emission, High Solar PV Penetration, Integration Impact Study

1. Introduction

Most of the world's population believes that climate change is the most serious challenge of the 21st century. Researchers worldwide agree that climate change is one of the impacts of global warming [1]. Global warming arises due to the greenhouse impact caused by human activities related to economic development and prosperous living [1]. To prevent global warming, it is essential to reduce the use of fossil fuels, prevent deforestation, and minimize pollution from the transportation and power generation sectors [1]. The utilization of renewable energy resources to generate clean electricity is one solution to reduce greenhouse gas emissions in the power sector, which is considered a major source of such emissions in many developed and developing countries [2]. Developed countries such as Canada, China, Denmark, Germany, Japan, the

United Kingdom, and the United States have agreed and set large-scale targets for the use of green energy in the power sector [3].

Indonesia has also committed to contributing to the reduction of global warming by starting to use power plants sourced from green energy. In addition, Indonesia has begun planning a "dedieselization" program aimed at retiring diesel power plants and replacing them with green energy-based power plants. All of these plans are outlined in the President Decree of the Republic of Indonesia Number 112 of 2022 concerning the Acceleration of Renewable Energy Development for Electricity Supply, which encourages that by 2030, 40% of the total national electricity sources should come from green energy-based power plants [3]. Bali Island, as an international tourist destination, has business prospects that drive economic growth that requires electricity demand by 6% per year corresponding to 880 MW capacity in 2021 to 1,515 MW in 2030. However, the Bali Clean Energy Program restricts the development of large-scale coal-fired power plants in which the most power plants in Indonesia still rely on coal. As a solution, solar energy has become a promising alternative since Indonesia has significant potential with average sunlight intensity of 4.8 kWh/m^2 per day, a sunlight duration of 10–12 hours with capacity factor ranging from 15% to 20%.

Despite the increasing utilization of solar energy through *Pembangkit Listrik Tenaga Surya* (PLTS), its intermittent nature presents significant operational challenges. A higher share of PLTS in the power grid can adversely affect system stability. As discussed by Markovic *et al.* [4], PLTS generates electricity via direct sunlight conversion without using rotating machinery, and thus contributes no system inertia. Inertia is essential for maintaining system robustness against disturbances and enables quicker frequency recovery, as emphasized by Setiadi *et al.* [5]. The replacement of conventional synchronous generators with PLTS consequently reduces system inertia, as further supported by Setiadi *et al.* [6]. Additionally, PLTS output is inherently uncertain and dependent on environmental factors. As Khasanov, Kamel, Rahmann, Hasanien, and Al-Durra [7] pointed out, PLTS cannot generate electricity consistently, particularly during cloudy conditions, rain, or nighttime. This intermittency becomes critical since peak electricity demand often occurs at night when PLTS is non-operational. To address this imbalance, other dispatchable power sources must compensate, as noted by Krismanto et all [8]. These limitations of PLTS introduce new challenges to power system stability and hinder consistent adherence to grid code requirements.

Rahman *et al.* [9] analyzed the impact of PLTS integration on voltage stability using modified IEEE 14-bus and 30-bus systems. Power flow simulations showed that higher PLTS penetration reduced power losses, improved reactive power transfer, and enhanced voltage profiles, thereby contributing to overall system stability in renewable-rich power networks. The impacts of PLTS penetration on short-circuit current changes in power systems were studied by Tekpeti et al [10]. Fluctuations in solar PV irradiation did not affect fault current changes in the system. However, the connection and disconnection of PV had an impact on the total fault current of the system. Kalloe et al [11] conducted an investigation regarding the impacts of solar PV penetration of the Dutch power system using time-domain simulation. An increase in the solar PV integration capacity into the power system leads to a more significant influence on the system's transient stability . A study on the penetration of PLTS in the Java-Bali power system was published by Putranto et al [12], to determine maximum integration based on the economic dispatch and unit commitment by considering operational efficiency and system readiness. The findings showed that the maximum PLTS capacity that can be integrated into the system is 6.447 MWp (%). Large-scale PLTS integration was deemed feasible starting in 2020, following the installation of automatic generation control (AGC) in several power plants in the Java-Bali region, which allows for automatic power regulation to maintain system stability. The impacts of variability in PLTS generation on the Java-Bali power system have also been studied by Marbun et al [13]. According to them, the integration of variable renewable energy (VRE) sources impacts power system stability, particularly regarding the importance of system inertia, the need for weather forecasting, and solutions to overcome VRE intermittency. However, there has yet to be a comprehensive study examining the impact of high PV penetration on power flow analysis, short-circuit analysis, quasi-dynamics behavior, and transient stability. Furthermore, the development of Bali's power system under the Net Zero Emissions (NZE) Jamali scenario has not been thoroughly explored.

Based on the studies reviewed, a comprehensive analysis of the impact of high solar photovoltaic (PLTS) penetration on Bali's power system particularly in terms of power flow analysis, short-circuit analysis, quasi-dynamics behavior, and transient stability has not yet been conducted. Furthermore, there is a lack of research addressing the future development of Bali’s power system in the context of the Jamali Net Zero Emissions (NZE) scenario and its implications for system performance. Therefore, this study aims to evaluate the technical impacts of high PLTS integration on the stability of Bali’s power system. The findings are expected to support future planning efforts and enhance the reliability and resilience of the region’s electricity grid.

2. Methods

2.1. Bali Electricity System

In this research, the Bali 150 kV electricity system is used for case study. The data of electricity system is directly taken from PT PLN internal data, RUPTL and refer to international journal. Figure 1 shows a Single Line Diagram of the Bali 150 kV electricity system. In this model, the electricity supply from Java is modeled as an external grid, namely the Banyuwangi external grid [20].

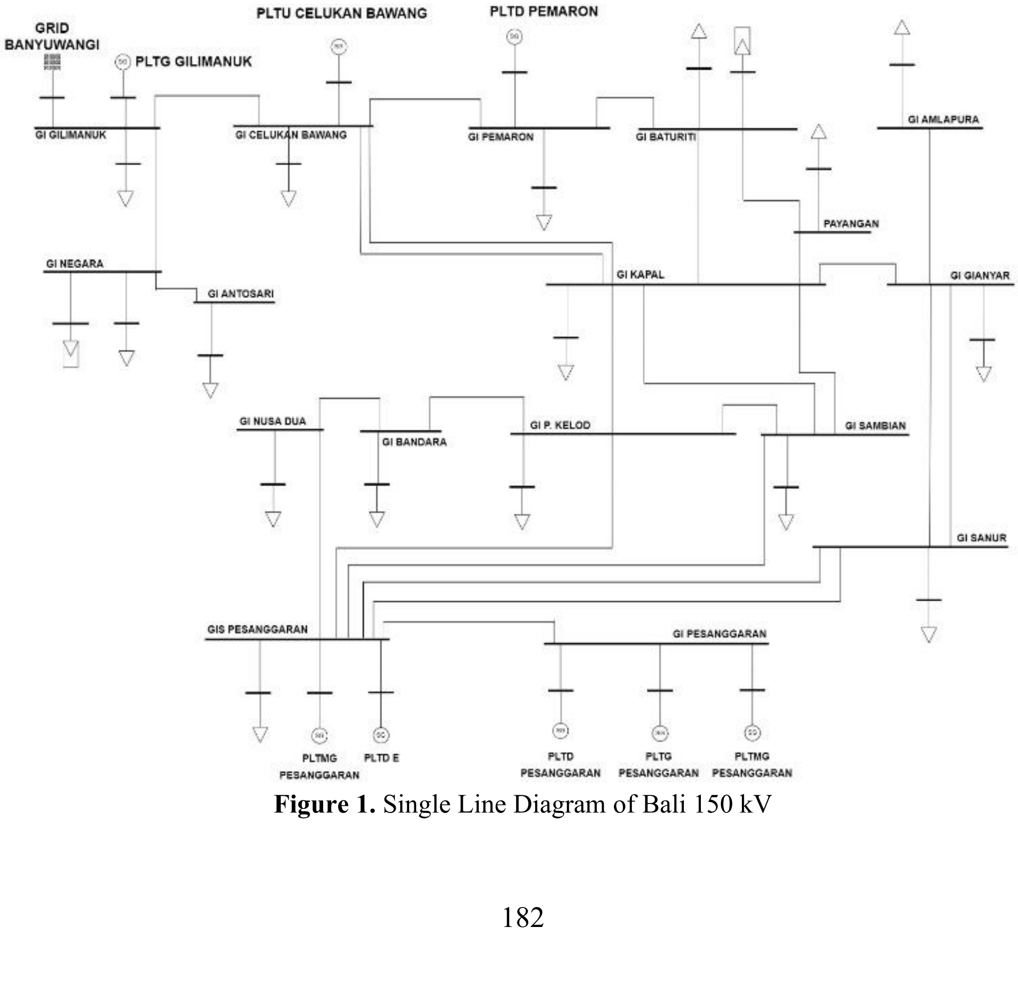
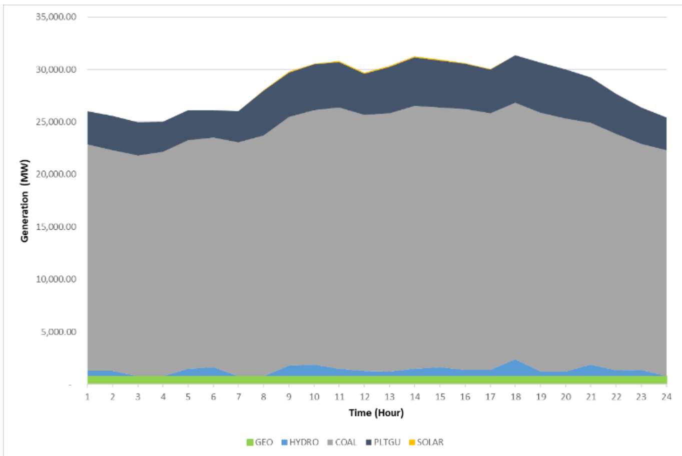


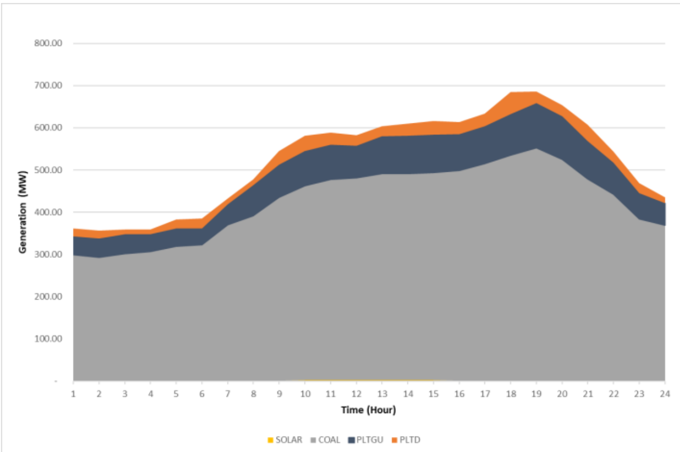
Figure 1. Single Line Diagram of Bali 150 kV

2.2. Dispatch Profile of Jamali and Bali System as Baseline 2025

Data on power plants, networks and others are obtained directly from the field. In addition, the Jamali system dispatch data used is also obtained directly from real data in the field. Jamali dispatch profile data is then processed again to determine the Bali system dispatch profile by considering the percentage of dispatch in each type of generator and seeing the availability of types of generators in the Bali system. It can be seen in Figure 2 (a) that the Jamali system has a Geothermal and Hydro plant dispatch, which type of power plant does not exist in the Bali system which is then adjusted to the type of power plant available in the Bali system such as PLTD.



(a)



(b)

Figure 2. Dispatch Profile as Baseline 2025: **(a)** Jamali System; **(b)** Bali System.

As shown in Figure 2(a), in the Jamali system, geothermal (2.7%) and coal (81.5%) power plants are used as base load, while hydro (2%) and gas (13.6%) power plants serve as peaking units. Meanwhile, in the Bali system as illustrated in Figure 2(b), coal (81.7%) power plants are used as base load, while diesel (4.7%) and gas (13.5%) power plants are utilized as peakers. Solar power plants (PLTS) begin to contribute from around 7:00 AM to approximately 5:00 PM; however, their contribution remains relatively small compared to conventional power plants, indicating that solar energy penetration in 2025 is still limited.

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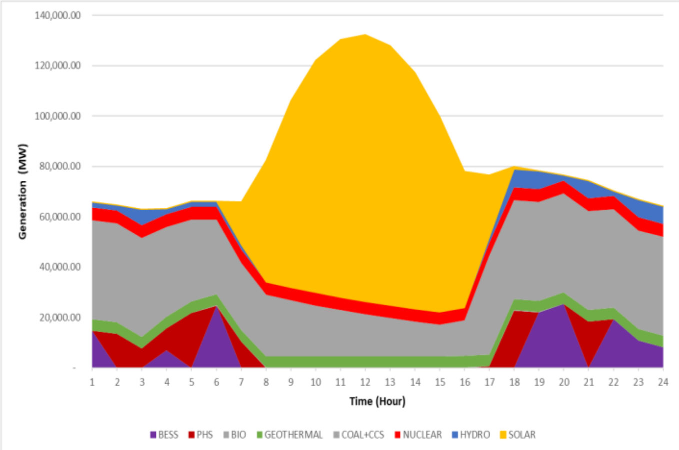
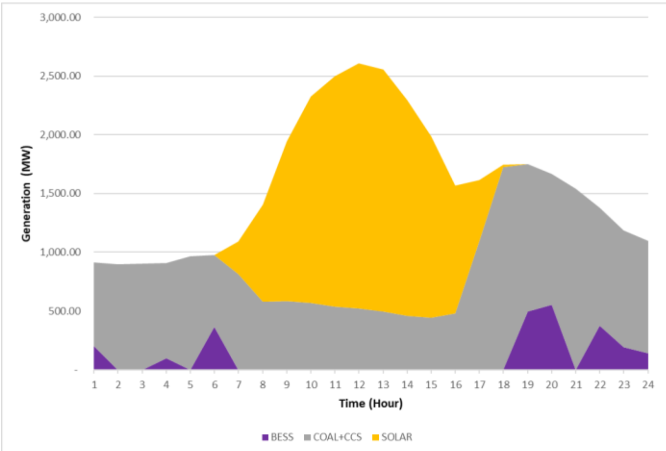
2.3. Dispatch Profile of the Jamali and Bali Systems under NZE 2060

The dispatch scenario development method of Net Zero Emission Jamali in 2060 using TIMES software was carried out by Alif et al (Thesis) which was then used as reference data as input data for dispatch profile using Digsilent software for further analysis in this research. The Jamali NZE system dispatch profile projection data in 2060 in Figure 3 (a), shows that the composition of the plant consists of Coal + CCS (39.7%), Solar (30.4%), Nuclear (6.4%), Geothermal (5.7%) and Hydro (3.6%) and is supported by energy storage in the form of BESS (7.8%) and PHS (6.2%). In this condition, several power plants have been retired such as PLTD, PLTG and conventional PLTU. PLTU with the addition of CCS is an alternative green energy solution in the future, with the presence of 30.4% PLTS penetration, so the system requires an energy storage method to be used at night, therefore BESS and PHS appear as an alternative to storing the energy produced by PLTS.



(a)



(b)

Figure 3. Dispatch Profile under NZE 2060: **(a)** Jamali System; **(b)** Bali System.

After obtaining the Jamali NZE 2060 dispatch projection, the dispatch data of the Bali system was compared with that of the Jamali system. By considering the dispatch percentage of each power plant and taking into account the availability and suitability of the existing power plants in the Bali system, several approaches and data processing methods were applied to obtain the Bali NZE 2060 dispatch profile shown in Figure 3 (b).

As shown in Figure 3(b), the composition of the Bali NZE 2060 system's power plants consists of Coal+CCS (61.8%) and Solar (30.4%), supported by energy storage in the form of BESS (7.8%). Coal-based power plants with Carbon Capture and Storage (COAL+CCS) technology operate as baseload power plants and meet energy needs when solar power plants are not generating energy. Additionally, battery-based energy storage systems (BESS, purple color) play an active role, particularly at night, to balance supply and demand.

2.4. Impact of PLTS Penetration

In this paper, three case studies were analyzed to see how PLTS penetration affects the stability of Bali's electrical system. In this study, simulations were carried out using Digsilent software, which is commonly used by PLN to conduct impact analysis studies at the transmission and distribution levels. The method of analyzing the impact of PLTS penetration is divided into three parts, as described in Table 1.

In this research three different case studies are considered. The first case study focuses on analyzing the steady state operation of Bali 150 kV existing systems (scenario 2025). The second case study focuses on dynamic performance of Bali 150 kV under existing scenario (scenario 2025). The third case study examine the dynamic performance of system Bali 150 kV under NZE scenarios (scenario 2060).

Table 1. List of Case studies

No	Case study	Detailed explanation
1	Steady state analysis of existing system	The first case study analyzes the steady-state performance of Bali's 150 kV power system, focusing on the impact of PLTS (solar PV) integration. Two key analyses were conducted: power flow analysis to assess voltage profiles and identify any voltage stability issues due to PV penetration, and short-circuit analysis to evaluate potential increases in fault currents and ensure they remain within the breaking capacity of existing equipment
2	Baseline 2025 dynamic analysis	A quasi-dynamic analysis was conducted on the Bali power system based on the 2025 baseline scenario to evaluate the system's response to active power fluctuations from solar power plants (SPPs), caused by the intermittent nature of solar energy throughout the day. This simulation examines the system's ability to maintain stability and operational reliability, as well as the potential need for regulatory measures or system reinforcement. In addition, a transient analysis was performed to assess system performance during short-term disturbances.
3	NZE 2060 dynamic analysis	Building on the previous analysis, a projection of Bali's electricity system for 2060 under the Net Zero Emission (NZE) scenario is evaluated. Using a quasi-dynamic analysis, the study examines the system's response to the variability of green energy—particularly solar power—over a 24-hour period. With significantly higher renewable energy penetration than in 2025, this scenario assesses the system's ability to maintain stability and ensure a reliable power supply amid increased fluctuations from intermittent sources. Transient analysis is also conducted to evaluate system performance under short-term disturbances

2.5. Grid Code Standard

A grid code is a set of evolving rules and technical standards designed to ensure the safe, reliable, and efficient operation of the power grid. In Indonesia, the grid code is issued by the Ministry of Energy and Mineral Resources (ESDM) and regulated under ESDM Regulation No. 20 of 2020 [18]. This study references three key standards to assess the impact of solar power plant (PLTS) integration into the Bali 150 kV power system. First, the maximum fault current that equipment can withstand ranges from 20 kA to 40 kA, and the total fault current with PV integration must remain within this limit. Second, voltage levels during steady-state and transient conditions must stay within +5% to -10% of nominal voltage and must not exceed 170 kV [19]. Table 2 shows the grid code standard for voltage variation and maximum voltage.

Table 2. Range Limits of Voltage Variation and Maximum Voltage

Nominal Voltage	Normal Condition	Maximum Voltage
500 kV	+5%, -5%	550 kV
275 kV	+5%, -5%	300 kV
150 kV	+5%, -10%	170 kV
66 kV	+5%, -10%	72.5 kV

Similar to the voltage standard, the nominal frequency during steady state and transient conditions must be maintained during continuous operation. If the frequency of the system drops to the limit set by the grid code, there must be a load shedding scheme, which is not desired by the power system operator. The frequency standard for power systems is described in Table 3 below.

Table 3. Operating Frequency Range Limits

Frequency Range	Operation Time Range
51,50 Hz $< f \leq$ 52,00 Hz	Operates for at least 15 minutes
51,00 Hz $< f \leq$ 51,50 Hz	Operates for at least 90 minutes
49,00 Hz $\leq f \leq$ 51,00 Hz	Operates continuously
47,50 Hz $< f <$ 49,00 Hz	Operates for at least 90 minutes
47,00 Hz $< f <$ 47,50 Hz	Operates for at least 20 seconds

3. Results and discussion

3.1. Steady State Analysis

In the first case study two analyses were conducted, namely stress analysis through power flow calculations and short circuit current analysis. Table 3 shows a comparison of steady state stress before and after the installation of the solar power plant, which had a capacity of 120 MW in this study.

Table 4. Voltage profile on 150 kV bus

Bus name	Before PLTS (kV)	After PLTS (kV)
Amiapura	153.07	153.28
Asari	153.18	153.40
Bandara	152.99	153.21
GI BTRTI	153.20	153.43
GI Gilimanuk	153.25	153.46
GI Pesanggaran	153.01	153.22
GI Pemaron	153.24	153.46
Gianyar	153.08	153.29
GIS Celukan Bawang	153.23	153.44

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GIS Pesanggaran	153.01	153.22
Kapal	153.16	153.38
Ngara	153.21	153.43
Nusa Dua	152.96	153.17
Pbian	153.08	153.29
Pklod	153.07	153.28
Pygan	153.15	153.38
Sanur	153.14	153.27

The results show that there is an increase in the voltage profile on the 150 kV buses in the Bali power system. This voltage increase occurs due to the additional active power supplied by the solar PV. This additional power causes the system to experience a reduction in power losses. As a result. the load can receive power more optimally. However. this increase in the voltage profile does not violate the limits set by national grid code (+5%, -10%).

In this short-circuit analysis. the total short-circuit current on the 150 kV bus after the solar power plant is connected to the existing system will be discussed. For analysis purposes. a three-phase-to-ground short-circuit disturbance was simulated on the Bali system. This type of disturbance was chosen because it has the greatest impact on the power system. The short-circuit current resulting from this disturbance is shown in Table 5.

Table 5. Results of Short Circuit Analysis

Bus Name	**Before interconnection**			**After interconnection**		
	Ik	**Ik"**	**Ip**	**Ik**	**Ik"**	**Ip**
Amiapura	35.19	35.19	81.59	35.19	35.19	81.59
Asari	35.18	35.18	83.83	35.18	35.18	83.83
Bandara	35.15	35.15	81.24	35.15	35.15	81.24
GI BTRTI	35.21	35.21	83.11	35.21	35.21	83.11
GI Gilimanuk	35.37	35.37	85.19	35.37	35.37	85.19
GI Pesanggaran	34.88	34.88	82.69	34.88	34.88	82.69
GI Pemaron	34.97	34.97	83.89	34.97	34.97	83.89
Gianyar	35.32	35.32	83.89	35.32	35.32	83.89
GIS Celukan Bawang	35.42	35.42	85.58	35.42	35.42	85.58
GIS Pesanggaran	34.94	34.94	83.60	34.94	34.94	83.60
Kapal	35.41	35.41	85.43	35.41	35.41	85.43
Ngara	34.72	34.72	83.06	34.72	34.72	83.06
Nusa Dua	35.06	35.06	80.61	35.06	35.06	80.61
Pbian	34.68	34.68	83.16	34.68	34.68	83.16
Pklod	35.22	35.22	84.04	35.22	35.22	84.04
Pygan	35.17	35.17	80.69	35.17	35.17	80.69
Sanur	35.01	35.01	83.02	35.01	35.01	83.02

Based on Table 5, no increase is observed in short-circuit current values, namely the initial short-circuit current (Ik"), peak short-circuit current (Ip), and steady-state short-circuit current, ollowing the integration of the PV system. This is primarily due to the use of a step-up transformer, which connects the PV system to the 150 kV grid and has relatively high impedance. Since PV inverters do not inherently provide impedance, they do not contribute directly to short-circuit currents; instead, any short-circuit contribution originates from the transformer. All measured short-circuit currents remain well below the 150 kV equipment limit of approximately 138 kA, indicating that the PV system does not significantly impact the system’s fault levels. As a result, the integration of the PV system does not necessitate the replacement of existing equipment in the 150 kV Bali electrical network.

3.2. Baseline Scenario 2025

In the second case study (baseline scenario 2025), the dispatch data used is field data. For quasi-dynamic analysis. all power plants in the Bali system are set to dispatch hourly. Figures 4 (red) and 4 (brown) show the dispatch of coal-fired power plants and gas-fired power plants from the Bali system. Meanwhile. Figures 4 (blue) and 4 (green) show the dispatch of diesel-fired power plants and solar power plants in the Bali electricity system.

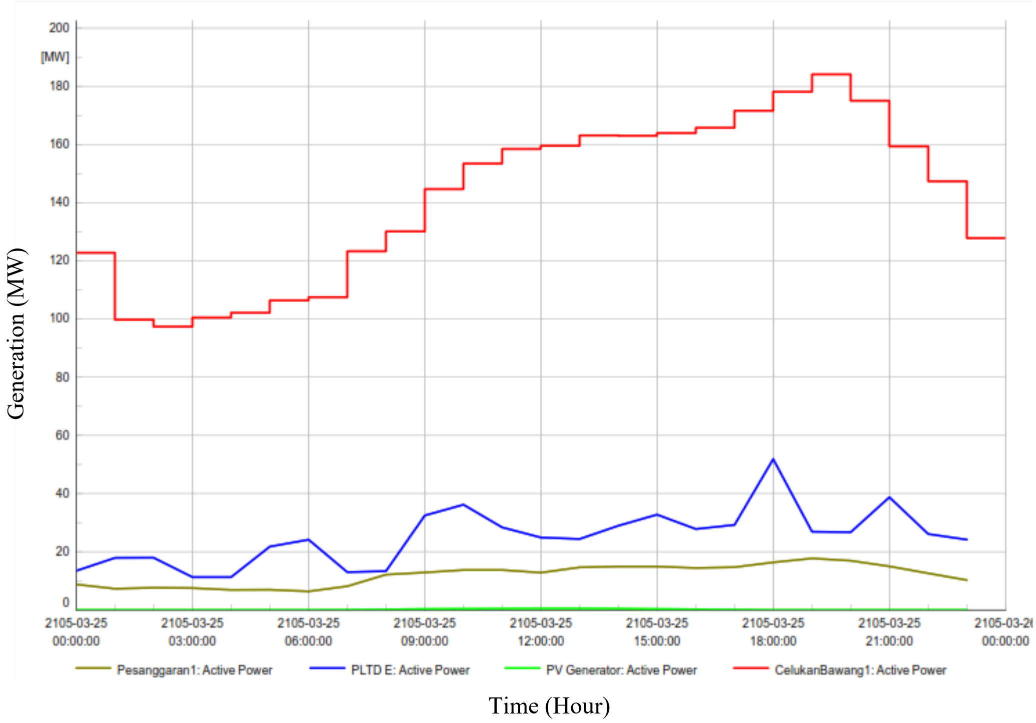

Figure 4. Dispatch profile of each generation unit in the baseline scenario 2025: **(red)** Dispatch of Steam power plant; **(brown)** Dispatch of gas turbine power plants (PLTG); **(blue)** Dispatch of diesel power plants (PLTD); **(green)** Dispatch of solar power plants (PLTS).

The total number of coal-fired power plants (PLTU) in the Bali power system is three. where the dispatch of each PLTU is assumed to be identical to one another. This dispatch is represented by Figure 4 (red). In addition to PLTU. the Bali system has six gas-fired power plants (PLTG). and each PLTG has identical dispatch characteristics as shown in Figure 4 (brown). The Bali system has one diesel-fired power plant (PLTD) with dispatch characteristics as shown in Figure 4 (blue). Finally. there are approximately 4 solar power plants (PLTS) with dispatch characteristics as shown in Figure 4 (green). These dispatch data are used for quasi-dynamic studies. In this study. one bus. Bus Ngara. is used to examine the voltage profile of the Bali system over a 24-hour period. Figure 5 shows the voltage response of the 150 kV system over a 24-hour period.

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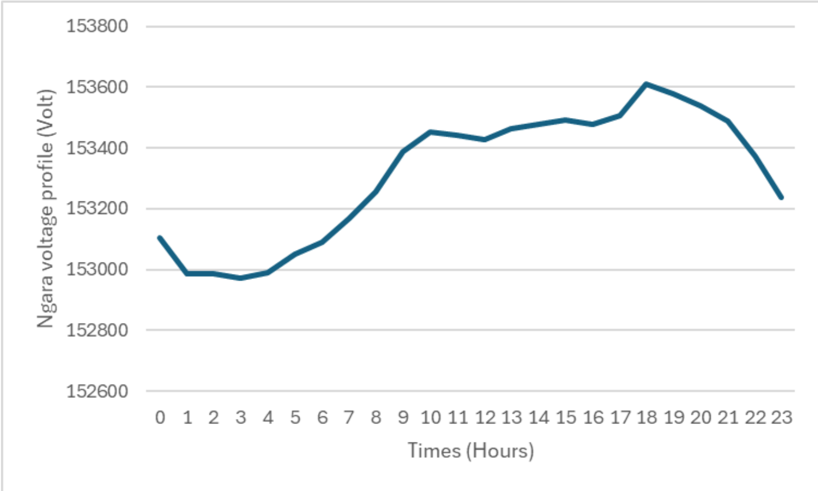

Figure 5. GI Ngara voltage profile baseline scenario 2025

From Figure 5 above. it is observed that the voltage at the GI Ngara bus is quite fluctuating. However. these voltage fluctuations are still within the maximum and minimum limits regulated by the Indonesian grid code. Therefore. the system can be concluded to be in a condition that complies with the grid code requirements. The next study conducted is the transient analysis. which aims to observe the performance of the Bali system in the time-domain during transient conditions.

The transient study is carried out by simulating a increasing load event up to 20%. To observe the extent of the frequency variation. the frequency deviation is plotted and analyzed. Figure 6 shows the frequency deviation response of the 150 kV Bali system.

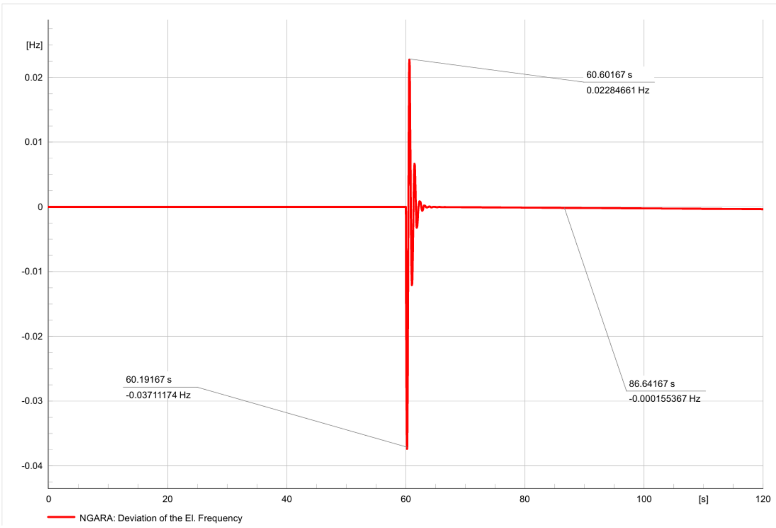

Figure 6. Frequency response baseline scenario 2025

In Figure 6. it can be seen that the system experiences a frequency overshoot of approximately 0.06 Hz. The standard grid code is still far from achieving such a frequency reduction. Additionally. the time required to reach a steady-state condition is relatively quick. Therefore. it can be concluded that the system is stable against transient disturbances.

3.3. NZE Scenario 2060

In this section, the operation of the Bali 150 kV power system under Net Zero Emission conditions projected for the year 2060 is analyzed. As in the 2025 scenario, both quasi-dynamic and transient analyses are employed to evaluate the system's robustness and stability. Figures 7 (red), 7 (green), and 7 (blue) illustrate the dispatch profiles of coal-fired power plants (PLTU), solar power plants (PLTS), and battery energy storage systems (BESS), respectively.

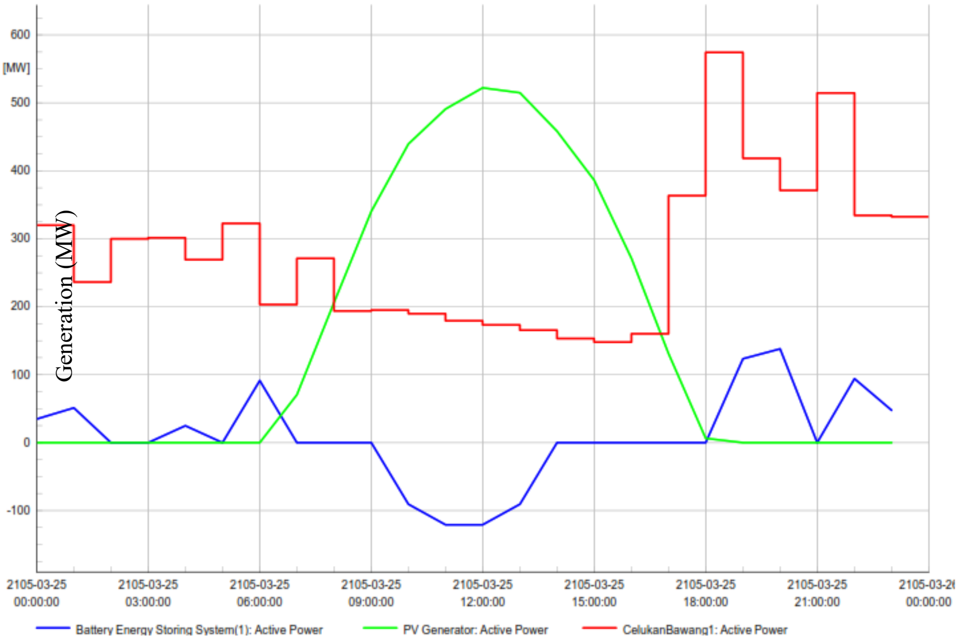

Figure 7. Dispatch profiles of generation units in the NZE scenario 2060: **(red)** Dispatch of Coal-fired power plants with CCS (PLTU); **(green)** Dispatch of solar power plants (PLTS); **(blue)** Dispatch of Battery Energy Storage Systems (BESS).

Figure 7 (red) shows that the dispatch from coal-fired power plants has more than doubled compared to the 2025 baseline. Figure 7 (green) shows that solar power plants (PLTS) experienced the most significant increase. with a rise of more than tenfold. Under the Net Zero Emissions (NZE) scenario. power generation in Bali is dominated by SPPs. Additionally. the dispatch of Battery Energy Storage Systems (BESS) in Figure 7 (blue) is adjusted to follow the fluctuating conditions. Figure 8 illustrates voltage fluctuations at the Ngara bus.

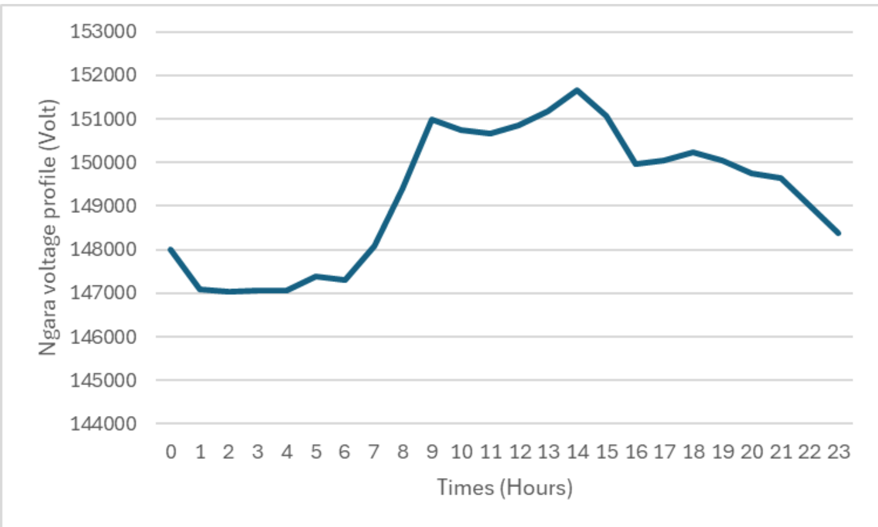

Figure 8. Ngara voltage profile NZE scenario 2060

Figure 8 shows that overall. under NZE conditions. there is a decrease in the voltage profile. The decrease is around 6 volts. However. the voltage decrease that occurs is still within the range specified by the Indonesian grid code. Therefore. from a quasi-dynamic perspective. the voltage conditions in Bali under the NZE scenario can be concluded to be safe. For a more detailed analysis. particularly regarding frequency response changes. a transient study is necessary. Figure 9 shows the frequency response changes caused by a short-circuit current in one of the lines within the Bali system.

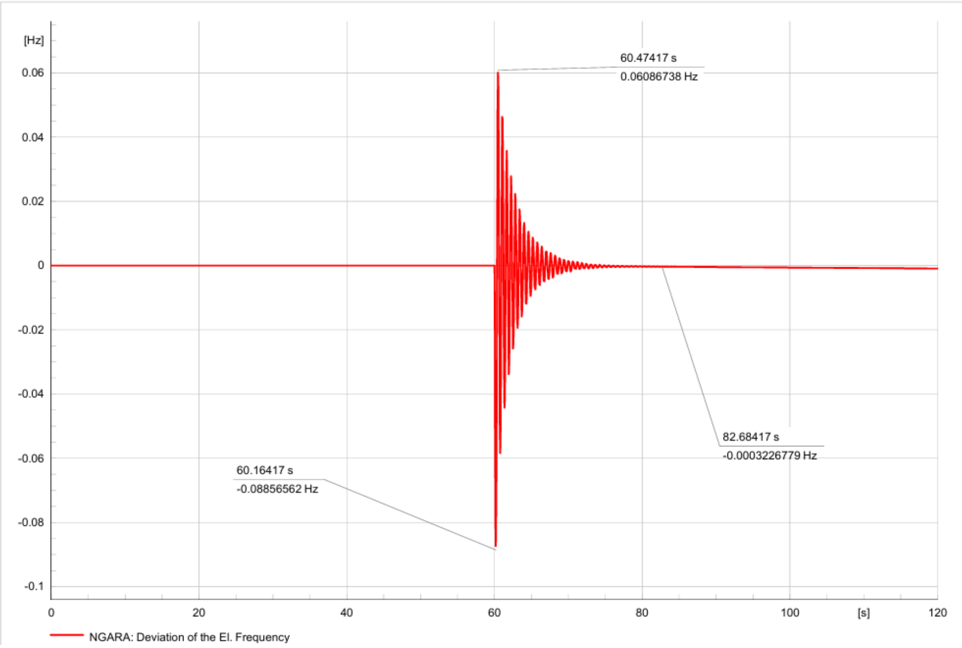

Figure 9. Frequency response NZE scenario 2060

From Figure 9. it can be seen that the frequency changed by 0.09 Hz more than the condition before NZE. which was 0.07 Hz. Although there was such a decrease in frequency. the decrease was still within the safe range according to the grid code. However. what needs to be watched out for is the frequency oscillation that occurred. It can be seen in the NZE scenario that the frequency deviation experienced a longer oscillation. This occurs due to the reduction in the number of power plants with inertia and the increase in inertia-less power plants such as solar power plants. A more in-depth transient analysis was attempted under extreme conditions when a disruption occurred in the Java-Bali undersea cable. Figure 10 shows the frequency change response due to the Jamali undersea cable disruption.

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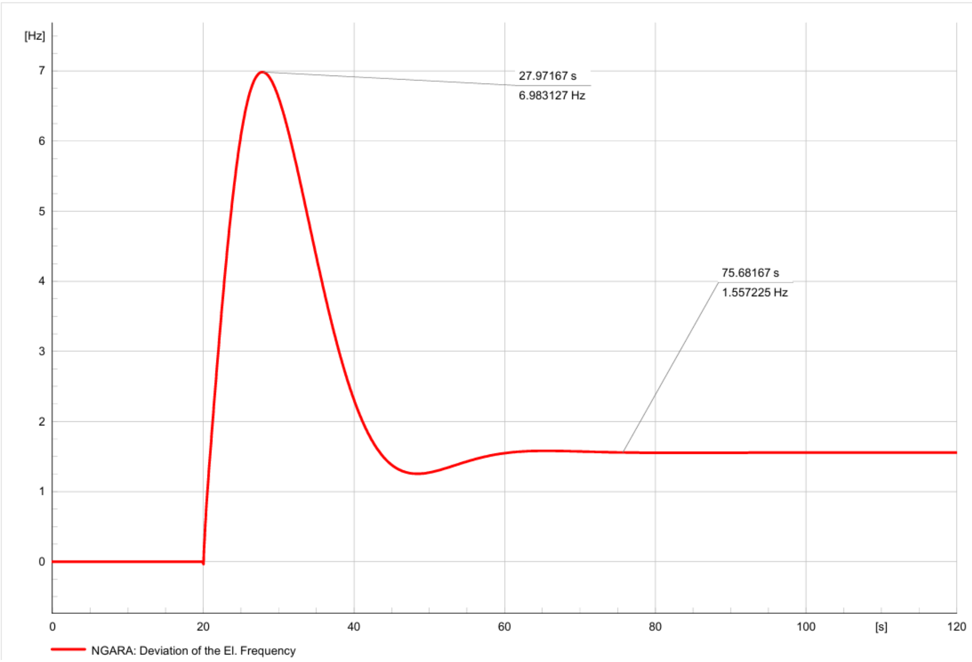

Figure 10. Frequency Response of Jamali Submarine Cable Disturbance

Figure 10 presents the frequency response of the Bali electrical system at the Celukan Bawang bus following a disturbance on the Jamali submarine cable. The disturbance occurred at the 20th second, marked by a sharp frequency drop with a deviation of approximately 6.96 Hz. This significant decline indicates a sudden power imbalance caused by the loss of supply from the Java system.

Following the event, the system tried to stabilize; however, it was only able to recover to a frequency deviation of around 1.57 Hz and failed to return to its nominal frequency. This response suggests that the system lacks sufficient inertia and power reserves necessary for effective frequency stabilization. The inability to restore nominal frequency underscores the need for system reinforcement, particularly in enhancing frequency regulation and inertia support.

Potential solutions include increasing the capacity of Battery Energy Storage Systems (BESS) to provide rapid frequency response, as well as adding an additional Jamali submarine cable to achieve N-1 redundancy. These measures would reduce the risk of blackouts in Bali and enable the system to respond to disturbances more effectively while maintaining frequency stability in line with Grid Code requirements.

4. Conclusion

This study successfully examines the impact of solar power plant penetration on the stability of the Bali electricity system with a comprehensive technical approach. including power flow studies. short circuit analysis. and quasi-dynamic and transient simulations in two time scenarios. namely existing in 2025 and Net Zero Emission (NZE) 2060.

In the 2025 scenario. solar PV power plant integration improves the voltage profile and slightly increases the short circuit current. but all parameters are still within the safe limits according to the Grid Code. The system is able to respond well to transient disturbances. indicating acceptable stability. However. in the NZE scenario in 2060. the dominance of non-inertial generation such as solar power plants increases the challenges of system stability. especially in the form of voltage drops. longer frequency oscillations. and high dependence on the Java-Bali submarine cable. From the frequency perspective the deviation frequency reach -0.089 Hz and the voltage profile are around 147 kV and 153 kV.

The simulation results also show that the system cannot fully recover after major disturbances (the frequency deviation is up to 6.5 Hz and stable on 1.57 Hz). Hence it is important to have clear solution to handle major disturbances such as loss of power from Jawa.

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