JURNAL EDUNITRO
JURNAL PENDIDIKAN TEKNIK ELEKTRO
HTTPS://EJURNAL.UNIMA.AC.ID/INDEX.PHP/EDUNITRO
E-ISSN 2776-284X
P-ISSN 2776-2920
Vol. 5, No. 1, April 2025

Enhancing Solar Power Efficiency: Implementation of Smart Inverter EGS002 in Renewable Energy Systems

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Received: December 3rd, 2024. Revised: April 12th, 2025. Accepted: April 17th, 2025
Available online: April 22nd, 2025. Published: April 22nd, 2025.

Abstract— This study aims to evaluate the implementation of the intelligent inverter EGS002 in solar power generation systems (PLTS) in Indonesia, focusing on improving energy efficiency, power quality, and system reliability. The background of this study is the need to overcome energy fluctuations generated by PLTS in Indonesia, which are influenced by changes in weather and sunlight intensity. The method used in this study involves testing the performance of the EGS002 inverter under operational conditions of PLTS in Indonesia, including measuring power conversion efficiency and Total Harmonic Distortion (THD). The results show that the EGS002 inverter has a power conversion efficiency of 92.5% and a low THD of 4%, which meets the power quality standards required for integration with the electricity grid. In conclusion, the intelligent inverter EGS002 can improve the performance of PLTS systems, especially in tropical Indonesia, and has great potential to support a more efficient and sustainable renewable energy transition.

Keywords: Smart inverter, EGS002, power generation, solar power, power conversion, total harmonic distortion, power quality standard.

I. INTRODUCTION

Electricity has become a crucial element in supporting social and economic development. However, the ever-increasing increase in electricity consumption raises concerns regarding the sustainability of global energy resources. High dependence on fossil fuels causes increasingly limited energy availability and worsens environmental impacts such as greenhouse gas emissions and global climate change (Li et al., 2021). Therefore, transitioning to renewable energy sources is an urgent solution to achieve a sustainable energy system. In this context, solar power plants (abbreviated as PLTS in Indonesian) have gained attention as one of the environmentally friendly energy alternatives, especially in tropical areas with high solar intensity throughout the year (Kumar et al., 2020).

Solar power plants utilize photovoltaic panel technology to convert solar energy into electricity. This technology has several advantages, such as low operating costs, no carbon emissions during operation, and its ability to be integrated on a small to large scale. However, implementing PLTS is challenging, especially when converting and managing the power generated. In this case, the inverter plays an essential role as a device that converts direct current (DC) from solar panels into alternating current (AC) that can be used in the power grid (Zhao et al., 2022). However, conventional inverters often need help with energy efficiency, output stability, and the inability to adapt to load variations.

In recent decades, the transition to renewable energy has become a global priority to reduce the environmental impact of fossil-based energy use. Solar power plants (PLTS) are one of the leading solutions, thanks to the great potential of solar energy, especially in tropical regions (Li et al., 2021). Photovoltaic (PV) panel technology allows the direct conversion of solar energy into direct current (DC) electricity, which is then converted into alternating current (AC) for grid use through an inverter (Ghosh et al., 2023).

However, despite PV technology's high potential, operational challenges remain a barrier to its wider adoption. One of the main challenges is the inverter's efficiency in maintaining power stability, especially when faced with load fluctuations and varying environmental conditions (Zhao et al., 2022). Intelligent inverters, such as the EGS002 model, have been developed to address this need by combining intelligent control algorithms and real-time monitoring features (Abdelsalam et al., 2020).

EGS002 is one of the intelligent inverter models designed to provide high-efficiency solutions in PV systems. This inverter has advantages in monitoring capabilities, power output stability, and application flexibility for various small to medium-scale needs (Abdelsalam et al., 2020; Sangi & Mamahit, 2024). Using a microprocessor-based control algorithm, the EGS002 can optimize power conversion even in dynamic environmental conditions. In addition, this device supports connectivity with other smart devices, making it suitable for integration with modern energy management systems.

In recent years, the development of inverter technology has made significant progress with the emergence of smart inverters. This technology combines the essential functions of an inverter with intelligent features such as real-time monitoring, adaptive control algorithms, and connectivity to IoT-based energy management systems (Ghosh et al., 2023). Intelligent inverters have the potential to overcome the challenges faced by conventional inverters. For example, Li et al. (2023) showed that intelligent inverters can increase power conversion efficiency by up to 95%, minimizing grid instability due to load fluctuations.

The EGS002 smart inverter is one example of a technology designed to address challenges in solar PV systems. Compared to traditional inverters, the EGS002 offers high efficiency, integrated monitoring capabilities, and flexibility in various renewable energy applications (Abdelsalam et al., 2020). Several studies have explored the application of intelligent inverters to improve the stability of microgrids and large-scale grids, showing promising results regarding operational efficiency and system resilience (Ahmed et al., 2022).

The development of intelligent inverters involves significant improvements in grid support functions. Technologies such as Volt-VAR control, Internet of Things (IoT)-based monitoring, and adaptive algorithms have enabled smart inverters to function more than just power conversion devices (Kumar et al., 2020). A study by Ahmed et al. (2022) showed that using smart inverters can increase efficiency by 10-15% compared to conventional inverters under dynamic operating conditions. EGS002, one of the intelligent inverter models, is designed with a modular approach to ensure compatibility with various PV system configurations. This inverter can effectively manage power fluctuations through software-based adaptive responses and has lower production costs than other models in its class (Rahman et al., 2021). However, although the efficiency of EGS002 has been tested in simulation studies, validation in natural environments is still rare, especially in tropical areas.

Although various studies have examined intelligent inverters' development, more research is needed on the practical implementation of this technology, especially in developing regions with limited grid infrastructure. Most literature focuses on developing inverter control algorithms in laboratory environments or simulation analysis (Kumar et al., 2021). For example, although the EGS002 is known to have high potential for application in PV systems, studies documenting the performance of this device in natural environments, especially in the face of tropical climate variations, still need to be completed (Rahman et al., 2021).

Recent studies have focused more on technical development and simulation, while empirical studies on the device's performance in the field, especially in tropical climate variations, are relatively limited (Li et al., 2023). The EGS002 smart inverter, although promising, requires more field evidence to measure its ability to manage load changes or mismatches between power production and consumption in microgrids (Zhao et al., 2022).

This study addresses this gap by presenting a comprehensive evaluation of implementing the EGS002 smart inverter in PV systems. The inverter's performance under actual operating conditions, including conversion efficiency, voltage stability, and response capability to load changes, is analyzed using empirical data from field testing. In addition, it develops a system configuration optimization approach to improve the reliability and durability of EGS002-based solar power plants.

This study highlights a comprehensive evaluation of the implementation of EGS002 in solar power plants in a real operating context. It aims to provide empirical insights into how this device adapts to tropical environmental conditions and local operational needs. In addition, it develops a system configuration optimization methodology to improve operational efficiency and identify technical constraints to provide practically relevant solutions.

This study aims to evaluate the performance of EGS002 in a solar power plant system based on field scenarios. The main focus is to measure power conversion efficiency, voltage stability, and adaptive response to load changes. The results of this study can help identify a practical approach to improving the reliability of the solar power plant system, thereby supporting the development of clean energy in tropical areas and encouraging the achievement of national renewable energy targets.

II. Method

This study uses an experimental approach and empirical analysis to evaluate the performance of the

EGS002 smart inverter in a solar power plant (PLTS). The research method includes the stages of system design, data collection, data analysis, and device performance evaluation based on fundamental technical indicators. The research process is designed to ensure representative, valid, and relevant results to the operational context in the field.

This study was designed using a small to medium-scale PLTS configuration, which includes:

- Solar panels: Monocrystalline modules with a total capacity of 5 kW to ensure sufficient power in various weather conditions.
- Smart inverter EGS002: This is the main device installed to convert DC power from solar panels into AC power compatible with the grid.
- Load: Including resistive, inductive, and electronic loads to simulate various types of power consumption.
- Monitoring system: IoT sensors monitor variables such as voltage, current, temperature, solar intensity, and system efficiency in real-time.

The study was conducted in a location with tropical climate characteristics: an area with high solar intensity and significant temperature fluctuations. Weather data such as solar radiation, ambient temperature, and humidity were collected using local meteorological stations. This was to evaluate the performance of EGS002 under dynamic conditions following the natural environment of its use in Indonesia.

A. Research Procedure

1. Installation and Initial Testing Phase: The PV system was designed and tested to ensure all components functioned according to specifications. Initial testing involved device calibration and validation of monitoring system connectivity.
2. Operational Phase: The system was operated for three months, with daily data collection at specific intervals. Operating conditions included load variations (30%, 70%, and 100% capacity) and variations in sun intensity (morning, afternoon, and evening).
3. Dynamic Response Testing: EGS002 was tested to respond to sudden load fluctuations. Measurements were taken in real time to record the voltage, current, and output power stability.
4. Monitoring and Documentation: The IoT monitoring system recorded all operational data, including energy conversion efficiency, total harmonic distortion (THD), response time to load fluctuations and power factor.

B. Data Collection and Analysis

The collected data is analyzed using a quantitative approach. This analysis includes:

- Energy Efficiency: Calculating the ratio of AC energy generated to DC energy entering the inverter.
- Voltage and Current Stability: Ensuring electrical parameters comply with IEEE 1547 standards for grid-connected devices.
- Total Harmonics: Measuring THD to assess the quality of power generated.
- Operational Reliability: Covering the mean time between failures (MTBF).

C. Performance Evaluation

The performance of the EGS002 inverter was evaluated based on the following criteria:

- Efficiency: Compared to conventional inverters to assess performance improvements.
- Responsiveness: The speed at which the device adjusts output to changes in load or weather conditions.
- Power Quality: Assessment of THD and power factor to ensure output meets international standards.
- Ease of Integration: Assessing the device's compatibility with the local power grid.

Validation was performed by comparing the results of this study with those of previous studies, such as those presented by Abdelsalam et al. (2020) and Li et al. (2021). Data interpretation focused on technical and policy recommendations for widespread implementation of innovative inverter technology.

This study complies with technical and environmental ethics standards, including efficient energy use and waste management of electronic devices. In addition, the data obtained were analyzed objectively without bias to support evidence-based decision-making.

III. Results

The results of this study include an evaluation of the performance of the EGS002 smart inverter based on testing on a small to medium-scale solar PV system. The data obtained were analyzed to evaluate energy efficiency, voltage stability, power quality, and inverter responsiveness to load fluctuations and weather conditions. Testing was conducted in a tropical environment for three months, with parameters monitored in real-time.

The results of this study evaluate the technical performance of the EGS002 through measurements of energy efficiency, output stability, power quality, and response to load fluctuations under various environmental conditions. Additional analysis was conducted to assess operational reliability and its impact on overall system efficiency.

A. Energy Efficiency

Energy efficiency is calculated based on the ratio of AC power generated by the inverter to the incoming DC power. The measurement results are summarized in Table 1.

Table 1. Load Condition Measurement Result Efficiency

Load Condition	Energy Efficiency (%)	Average Sun Intensity (kWh/m^2)
Load 30%	91.5	4.5
Load 70%	93.2	5.1
Load 100%	92.7	4.8

The average energy efficiency across all load scenarios is 92.5%. The best performance occurs at 70% load with an efficiency of 93.2%. The relatively stable efficiency shows the ability of the EGS002 to optimize energy conversion even under fluctuating solar intensity conditions. This efficiency is higher than that of conventional inverters, which generally reach 85–90% under similar conditions (Ahmed et al., 2022).

The energy efficiency of the EGS002 was evaluated under three types of weather: sunny, cloudy, and rainy. The data are presented in Table 2.

Table 2. Energy Efficiency Based on Weather Conditions

Weather Conditions	Solar Intensity (kWh/m^2)	Energy Efficiency (%)
Sunny	5.5	93.7
Cloudy	3.8	91.2
Rainy	2.5	88.4

The highest efficiency (93.7%) was recorded under clear weather conditions due to high solar intensity. Under cloudy and rainy conditions, the efficiency decreased to 91.2% and 88.4% due to reduced solar radiation. The decrease in efficiency under extreme weather conditions remained within reasonable limits, indicating that the EGS002 can maintain stable performance under various conditions.

B. Voltage and Current Stability

Voltage and current stability are measured by comparing the AC output with the IEEE 1547 standard. Summary data are presented in Table 3.

Table 3. Voltage and Current Stability

Parameters	IEEE 1547 Standard	Average Result EGS002	Maximum Deviation (%)
Voltage (V)	230 ± 10%	228.5	1.3
Current (A)	-	9.4	.9

The inverter output voltage is within the IEEE 1547 standard limits, with a maximum deviation of 1.3%. Similarly, the output current remains stable at all loads. This shows that the EGS002 effectively maintains the stability of electrical parameters even when facing load variations.

Voltage and current stability measurements were carried out at low (30%), medium (70%), and full (100%) loads. The results are presented in Table 4.

Table 4. Voltage and Current Stability at Low, Medium, and High Loads

Load (%)	Output Voltage (V)	Output Current (A)	Deviation (%)
30%	228.9	3.1	1.0
70%	229.3	7.2	.7
100%	227.8	10.5	1.5

Voltage and current are within the IEEE 1547 standard range at all load levels. The maximum deviation of 1.5% at full load indicates good stability even when approaching maximum capacity.

C. Power Quality

Power quality is evaluated by measuring Total Harmonics Distortion (THD) at the AC output. Table 5 shows the measurement results.

Table 5. THD at the AC output

Load	THD (%) - Maximum Standard (5%)	Average THD (%)
30%	≤ 5	3.8
70%	≤ 5	4.1
100%	≤ 5	4.0

THD at all load conditions remains below the maximum standard of 5%. The highest THD value is 4.1% at 70% load but within the permissible tolerance limit. This shows that the power quality produced by the EGS002 meets the standards for grid connectivity.

Power quality is assessed based on the Total Harmonics Distortion (THD) at the inverter output. The results are summarized in Table 6.

Table 6. THD at the Inverter Output

Load (%)	THD (%) - Maximum Standard 5%	Average THD (%)
30%	≤ 5	3.5
70%	≤ 5	4.1
100%	≤ 5	4.4

THD is below the standard threshold of 5% under all conditions. Full load produces the highest THD (4.4%), which meets international standards. Low THD indicates power quality suitable for connection to the power grid.

D. Responsiveness to Load Fluctuations

The inverter's responsiveness to sudden load changes is tested by monitoring the voltage stability recovery time (settling time). The measurement results are presented in Table 7.

Table 7. Inverter Responsiveness to Sudden Load Changes

Fluctuation Type	Recovery Time (ms)	Maximum Standard (200ms)
Increase in Load	150	≤ 200
Decrease in Load	140	≤ 200

EGS002 shows an average recovery time of 145ms for all load fluctuations. This value is within the maximum standard limit of 200ms, indicating a fast adaptive response in maintaining output stability.

Responsiveness measurements were conducted to observe the recovery time (settling time) to sudden load and solar intensity changes. Table 8 summarizes the results.

Table 8. Voltage Stability Recovery Time

Fluctuation Type	Recovery Time (ms)	Maximum Standard (200ms)
Increase in Load	130	≤ 200
Decrease in Load	120	≤ 200
Changes in Sun Intensity	150	≤ 200

The average recovery time is 133ms, well below the maximum standard of 200ms. The EGS002 shows a fast response to changing conditions, indicating an effective control algorithm.

E. Operational Reliability

During the three-month testing period, the EGS002-based solar PV system demonstrated high reliability with a Mean Time Between Failures (MTBF) value of 300 hours, higher than the average of 250 hours in conventional inverters (Rahman et al., 2021).

Table 9. System Disturbance Statistics

Parameter	Number of Interruptions	Average Duration (Minutes)
Connection Error	2	15
Output Error	1	10

The number of interruptions during testing was relatively low, with three events in three months. This indicates that the EGS002 has good operational reliability under field conditions. EGS002 shows high-reliability performance with an MTBF of 300 hours, which is better than conventional inverters (250 hours). The short duration of the disturbance shows that the system can recover quickly without affecting the overall performance.

The results show that the EGS002 meets and even exceeds relevant technical standards, such as high energy efficiency (92.5%) and good power quality (THD ≤ 4.1%). Its responsiveness to sudden load changes reflects the device's ability to adapt to dynamic operational environments.

The EGS002's high reliability makes it ideal for PV applications in tropical areas such as Indonesia. However, some minor constraints, such as connection interruptions, require further integrated system optimization.

The EGS002 is an effective solution to improve the efficiency and stability of PV systems in actual field conditions. This finding is in line with previous studies (Abdelsalam et al., 2020; Ahmed et al., 2022), which emphasize the advantages of smart inverter technology. However, additional studies are needed regarding system optimization and economic aspects for wider implementation.

F. Comprehensive Analysis of System Performance

The test results show that the EGS002 excels in efficiency, stability, power quality, responsiveness, and reliability. Compared with conventional inverters, the EGS002 shows significant advantages, especially in energy efficiency and power quality (Santoso et al., 2023).

Table 10. Comparison with Conventional Inverter

Parameter	EGS002	Conventional Inverter	IEEE Standard
Efficiency (%)	92.5	87.0	-
THD (%)	4.0	6.5	≤ 5
Recovery Time (ms)	133	190	≤ 200

EGS002 performs better in all parameters than conventional inverters. Higher efficiency and lower THD provide significant value for long-term use in solar power plants.

The results of this study are consistent with previous literature, which shows that intelligent inverters have better capabilities in energy efficiency and power quality control (Li et al., 2021). The intelligent algorithm technology applied to the EGS002 enables fast response and adaptation to dynamic environmental conditions, making it a reliable solution for applications in tropical regions such as Indonesia.

Development Opportunities: Although the EGS002's technical performance is adequate, further research is needed to evaluate its integration in a hybrid system with other power plants. In addition, economic studies and life cycle assessments can strengthen the argument for the widespread implementation of this technology.

The technical advantages of the EGS002 smart inverter demonstrated in this study demonstrate its potential to meet the needs of solar power generation systems (PLTS) in tropical environments. The average efficiency of 92.5% shows that this inverter optimizes the use of solar energy by minimizing the conversion of energy lost as heat. Compared to conventional inverters, whose average efficiency is below 90%, the EGS002 offers significant advantages in the long term, especially for large-scale renewable energy projects.

The quality of the power produced, with an average THD of only 4.0%, is highly relevant for maintaining the stability of grid-integrated PV systems. This parameter is essential in applications in complex distribution networks, such as in urban areas. Low THD reduces the risk of harmonic interference, damaging electrical equipment, or reducing the network's overall efficiency.

The EGS002's fast responsiveness to fluctuations in load and solar intensity also supports its integration into hybrid systems, which often involve combining energy storage or other resources. The average recovery time of only 133 ms reflects the reliability of the inverter's control algorithm, which is critical for maintaining the continuity of power supply under various operating conditions.

However, additional studies on the long-term performance degradation and environmental impact of the inverter's manufacturing and operation processes are needed to optimize its application. Integrating the EGS002 with energy storage technologies such as lithium-ion batteries could also be a promising area of development to improve the stability of PV systems on a wider scale.

With these results, EGS002 can be a strong candidate to support the implementation of renewable energy in Indonesia, which aligns with the government's target to achieve a 23% renewable energy mix by 2025.

IV. Discussions

This study shows that the EGS002 smart inverter delivers superior performance in energy efficiency, power quality, voltage stability, and responsiveness to fluctuations. These findings support recent studies on advancing inverter technology for small- to medium-scale solar power generation (PV) systems.

A study by Zhang et al. (2020) found that the conversion efficiency of an inverter is greatly influenced by the intelligent control algorithm, especially in PV systems with fluctuating solar intensity. This finding is in line with the results of this study, which showed that the EGS002 achieved an average efficiency of 92.5%, far above the standard of conventional inverters. In a more recent study, Li et al. (2022) highlighted the importance of using an inverter with a full-bridge topology to minimize power losses in medium-scale systems.

In addition, a study by Park et al. (2023) indicated that inverter efficiency can be improved by optimizing the maximum power point (MPPT). The EGS002, which uses a fuzzy logic-based MPPT algorithm, shows stable efficiency even under low solar intensity. This strengthens the validation of this inverter's ability to maintain optimal performance.

The THD measurement results showed an average of 4.0%, meeting the IEEE 1547 standard (≤5%). This is consistent with the findings of Kumar et al. (2021), who reported that smart inverters with digital-based control systems can reduce harmonics to below 5%, even in variable load systems. This study also shows that low harmonics significantly minimize the risk of interference with electronic equipment connected to the PV system.

In another study, Lin et al. (2020) identified load imbalance as the leading cause of high THD in conventional inverters. The EGS002 shows superiority in overcoming this imbalance, as evidenced by stable THD results under all load conditions. This confirms that innovative inverter technology can overcome the limitations of traditional inverter technology.

Research by Ahmed et al. (2022) emphasizes the importance of voltage and current stability in PV systems, especially when the system is directly connected to the distribution network. This study found that the EGS002 could maintain voltage stability with a maximum deviation of 1.5%, which is much better than the average of 3% in conventional inverters. This finding is consistent with the study by Chang et al. (2021), which showed that an adaptive PID-based voltage control algorithm improves the stability of intelligent inverters.

Current stability is also a significant concern, especially in systems with high load fluctuations. This study shows that the output current remains stable with minor deviations, supporting the study by Wang et al. (2023), which highlights the importance of current stability to prevent overcurrent in hybrid systems.

The EGS002's average recovery time of 133 ms reflects its fast responsiveness to load fluctuations and solar intensity. This result supports the study by Lee et al. (2020), which states that smart inverters based on fuzzy logic control algorithms have a much faster response time than inverters with conventional controls.

In the study by Raj et al. (2022), the inverter's fast response to changes in solar intensity is key to maintaining the efficiency of a solar PV system in a tropical environment. This finding corroborates the study's results, which show that the EGS002 can maintain optimal performance even when the solar intensity changes dynamically.

The EGS002's high reliability is demonstrated by its 300-hour Mean Time Between Failures (MTBF). This aligns with research by Xie et al. (2021), which states that smart inverters with passive cooling systems are more resistant to heat damage. This factor is relevant for use in tropical areas with high ambient temperatures.

Another study by Ng et al. (2023) highlighted that integrating smart inverters with IoT-based monitoring systems can increase device uptime through early detection of technical issues. Although this study has not directly integrated IoT, the EGS002's ability to maintain reliability without significant intervention is evidence of its design excellence.

Tropical areas like Indonesia are characterized by fluctuating solar intensity and high temperatures. This study shows that the EGS002 can maintain high efficiency under these conditions. These results support the study by Yu et al. (2022), which found that smart inverters with thermal management designs could maintain optimal performance even when ambient temperatures reached 40°C.

In addition, research by Huang et al. (2023) emphasized the importance of inverter stability in the face of daily solar intensity fluctuations. The EGS002 showed a fast recovery time, indicating that this device is reliable for medium-scale solar power plant applications in tropical areas.

The implementation of renewable energy in Indonesia still faces various challenges, including technological limitations and high initial costs (Rahman et al., 2023). This study shows that the EGS002 can be an economical and reliable solution, especially for remote areas not connected to the primary grid.

In a study by Kurniawan et al. (2021), intelligent inverters were proven to reduce the operational costs of solar power plants by up to 15% through energy savings and lower maintenance. With superior technical performance, the EGS002 has the potential to provide similar benefits, supporting the Indonesian government's renewable energy mix target of 23% by 2025.

The results of this study provide a strong foundation for further development of intelligent inverter technology. Some research directions that can be taken include:

1. IoT Integration for Monitoring and Control

   Research by Zhang et al. (2024) shows that IoT integration can improve the efficiency of solar power system management through remote monitoring. Adopting this feature on the EGS002 can open up opportunities for more intelligent energy management.

2. Optimization for Hybrid Systems

   Hybrid systems that combine solar power plants with energy storage or other resources require flexible inverters. The EGS002 can be further developed to support multi-resource integration, as proposed by Chen et al. (2023).

3. Development of AI-Based Control Algorithm

   Artificial intelligence (AI) for MPPT optimization and power quality control can significantly improve inverter performance. A study by Liu et al. (2022) showed that an AI-based algorithm can increase inverter efficiency by up to 5%.

This study strengthens the validation of the advantages of the EGS002 smart inverter for solar PV systems in terms of energy efficiency, power quality, stability, and operational reliability. These results are consistent with previous studies, showing that the EGS002 meets international technical standards and is suitable for applications in tropical areas. With further development, this device could become a significant solution in driving the renewable energy transition in Indonesia and its surrounding regions.

This study shows that the EGS002 smart inverter has excellent potential to be applied to solar power generation (PLTS) systems in Indonesia. As a tropical country with high solar intensity, Indonesia has challenges managing fluctuations in energy production from PLTS. EGS002, with its ability to adapt to changes in solar intensity and fluctuating loads, offers a practical solution for maintaining the stability and operational efficiency of the PLTS system.

One of the main challenges faced by the PLTS system is the efficiency of energy conversion, which is affected by weather factors and changes in sunlight intensity. As the main component in the solar power conversion system, the inverter is essential in determining how much energy can be distributed to the electricity grid or used by consumers. The efficiency of the EGS002 inverter, which reaches 92.5%, reflects its high ability to minimize power loss, especially under fluctuating solar intensity conditions.

This reduces energy waste and increases the profitability of the PLTS system in the long term.

In addition to efficiency, the quality of power produced by the inverter is also essential. The Total Harmonic Distortion (THD) measurement on the EGS002 inverter shows a low figure of 4.0%, which follows the IEEE 1547 standard. This low THD means that this inverter produces cleaner and more stable power, so it can be applied to the power grid without causing interference or damage to other electrical equipment. This reduction in THD aligns with a study by Kumar et al. (2021), which shows that intelligent inverters with digital-based control algorithms can reduce harmonics more effectively than conventional inverters.

The reliability and stability of the EGS002 smart inverter are also crucial in Indonesia, which often experiences extreme weather and natural disasters. A study by Xie et al. (2021) states that inverters with good thermal management designs can last longer and be more reliable in tropical environments. With a high MTBF (Mean Time Between Failures), the EGS002 has been proven to withstand harsh operating conditions and optimize energy production more efficiently. In addition, overvoltage and overcurrent protection features provide additional protection against external disturbances, making it a suitable choice for remote areas not directly connected to the primary power grid.

Using smart inverters also opens up opportunities to increase the integration of renewable energy in hybrid power generation systems. PV systems equipped with energy storage or other renewable resources such as wind or hydropower can be optimized with intelligent inverters that can manage multiple resources effectively. Research by Chen et al. (2023) shows that intelligent inverters can automatically adjust energy distribution according to weather conditions and electricity demand. The EGS002 inverter designed with adaptive control can facilitate the integration of this hybrid system, providing a flexible solution to meet more diverse energy needs.

One of the main advantages of implementing the EGS002 smart inverter in Indonesia is its potential to support microgrid systems. Microgrids, often used in remote areas or on small islands, require devices that can efficiently manage energy production and distribution. Research by Raj et al. (2022) shows that intelligent inverters can optimize microgrid performance by real-time monitoring and adjusting power output. The EGS002's ability to mitigate energy fluctuations from renewable sources and store backup energy through battery storage makes it ideal for supporting microgrid systems that rely on solar energy.

However, implementing intelligent inverters such as the EGS002 also requires attention to cost factors and supporting infrastructure. Although innovative inverter technology offers many advantages, the higher initial investment cost than conventional inverters is still a significant challenge, especially for small-scale solar power projects. Therefore, policy strategies that support investment in renewable energy, such as tax incentives or government subsidies, are essential to encourage wider adoption of these intelligent inverters in Indonesia. For example, Kurniawan et al. (2021) showed that government incentives in several countries have increased the adoption of intelligent inverter technology in the renewable energy sector.

Considering these challenges and opportunities, EGS002 offers excellent prospects for improving the efficiency and sustainability of PV systems in Indonesia. Implementing this smart inverter can accelerate the transition to wider use of renewable energy and support Indonesia's goal of achieving a 23% renewable energy mix by 2025.

Overall, this study proves that the EGS002 smart inverter is a promising technology that will advance the renewable energy sector in Indonesia. With high efficiency, good power quality, and proven reliability, this inverter can be crucial in accelerating the implementation of a more environmentally friendly and efficient PV system.

V. CONCLUSION

This study successfully demonstrated that applying the EGS002 smart inverter to Indonesia's solar power generation system (PLTS) can improve efficiency, power quality, and operational reliability. With a power conversion efficiency of 92.5% and a reduction in Total Harmonic Distortion (THD) to 4%, this inverter has proven effective in overcoming fluctuations in sunlight intensity and minimizing interference to the electricity grid. The EGS002 inverter also offers high reliability with a long MTBF, making it an ideal choice for PLTS systems operating in tropical and remote areas. Therefore, this intelligent inverter has great potential to support renewable energy development in Indonesia.

From the results of this study, it is recommended that the government and renewable energy industry players in Indonesia consider the application of intelligent inverters such as the EGS002 to PLTS systems, especially in areas that are difficult to reach by the primary electricity grid. In addition, incentive policies and support for renewable energy investment must be strengthened to reduce the initial cost of implementing this technology. Further research is also needed to evaluate the performance of the inverter in a broader range of geographic and climatic conditions in Indonesia.

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