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Secure IoT-Enabled MPPT-Controlled Solar PV System with Smart Fabrication for Optimized Energy Harvesting

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ABSTRACT

The increasing integration of solar photovoltaic (PV) systems into the renewable energy landscape necessitates advancements in energy optimization and cybersecurity. Traditional maximum power point tracking (MPPT) algorithms often struggle to adapt to rapidly fluctuating environmental conditions, leading to inefficiencies in power harvesting. Simultaneously, the adoption of the Internet of Things (IoT)-)-enabled PV systems introduce significant cybersecurity vulnerabilities, compromising operational reliability. This study proposes an AI-driven MPPT control system integrated with secure IoT frameworks and advanced fabrication techniques to enhance the performance, security, and longevity of solar PV installations. AI-based MPPT algorithms dynamically optimize energy extraction, leveraging machine learning models to adapt to environmental variations in real-time. Blockchain-encrypted IoT communication protocols ensure secure data transmission, mitigating cyber threats and enhancing system resilience. Additionally, custom fabrication techniques, including 3D-printed thermal management solutions, improve the durability and efficiency of PV system components. Experimental validation demonstrates the superiority of the proposed system in energy efficiency, cybersecurity robustness, and cost-effectiveness. The findings contribute to the development of intelligent, autonomous, and cyber-resilient solar energy solutions for both grid-connected and off-grid applications.

Keywords: AI-driven MPPT, Secure IoT, Blockchain Cybersecurity, Smart Fabrication, Solar PV, Energy Optimization

INTRODUCTION

The increasing global shift toward renewable energy has placed solar photovoltaic (PV) systems at the forefront of sustainable power generation [1,3,4,5]. As PV technology becomes more prevalent, maximizing power extraction and ensuring system security have emerged as critical challenges, particularly in the Internet of Things (IoT)-enabled environments [5,6,7,8,9,10]. Conventional maximum power point tracking (MPPT) techniques often exhibit inefficiencies under rapidly fluctuating environmental conditions, leading to suboptimal energy harvesting [11,12,13,14,15]. Simultaneously, the growing interconnectivity of IoT-based PV systems exposes them to cybersecurity threats, potentially compromising system integrity, reliability, and overall performance [16,17,18,19]. To address these challenges, this study explores the integration of artificial intelligence (AI)-driven MPPT control, secure IoT communication protocols, and advanced fabrication techniques to develop a next-generation solar PV system [19,20,21,22,23,24]. AI-powered MPPT algorithms enhance real-time adaptability, optimizing power output even under dynamic weather conditions [11,4,13]. Meanwhile, secure IoT frameworks safeguard communication channels, mitigating cyber threats and ensuring the robustness of PV infrastructure. Additionally, advancements in fabrication techniques contribute to the durability and efficiency of the proposed system, reinforcing its applicability in diverse energy landscapes [5,7,9]. By unifying these innovative approaches, this research aims to enhance the efficiency, security, and resilience of solar PV systems, paving the way for more intelligent, autonomous, and cyber-resilient renewable energy solutions. The findings of this study contribute to the ongoing discourse on sustainable energy technologies, providing insights into the next evolutionary phase of smart solar power systems.

Literature Review

This review synthesizes recent advancements in artificial intelligence (AI)-enhanced maximum power point tracking (MPPT), secure IoT integration, and advanced fabrication techniques for next-generation solar photovoltaic systems [11,13,1,2]. The methodology involves an extensive literature review and comparative analysis of state-of-the-art technologies, focusing on four key areas: AI-driven MPPT optimization, cybersecurity in IoT-enabled PV systems, advanced material fabrication, and system performance evaluation.

AI-Enhanced MPPT Algorithm

MPPT plays a crucial role in optimizing the efficiency of solar PV systems by ensuring maximum energy extraction under varying environmental conditions. Traditional MPPT algorithms, such as Perturb and Observe (P&O) and Incremental Conductance (IC), rely on iterative methods to locate the maximum power point (MPP) [25]. However, these techniques exhibit limitations when dealing with rapid fluctuations in solar irradiance and temperature, often resulting in oscillatory behavior, slow convergence, and reduced tracking accuracy [26]. To overcome these challenges, artificial intelligence (AI)-based MPPT strategies have been proposed, leveraging machine learning models to predict and adaptively track optimal power points in real time [27,28]. Supervised learning models, particularly artificial neural networks (ANNs) and reinforcement learning (RL), have demonstrated significant potential in improving MPPT efficiency [28]. ANNs can be trained on historical weather and electrical data to recognize patterns in power generation and predict the optimal operating points under changing environmental conditions. Reinforcement learning, on the other hand, enables an adaptive control mechanism where the MPPT controller continuously learns and refines its decision-making process through interactions with the system [11,9]. By dynamically adjusting duty cycles and voltage levels based on real-time sensor inputs, AI-driven MPPT controllers enhance tracking speed and reduce energy losses. Furthermore, hybrid AI models integrating deep learning techniques with conventional MPPT methods offer a robust approach to improving system reliability and response time. Deep learning models, such as convolutional neural networks (CNNs) and long short-term memory (LSTM) networks, can process large datasets and extract meaningful insights from complex input variables, enabling more accurate and efficient MPP tracking [29,30]. Combining these models with traditional algorithms mitigates their individual weaknesses, creating an adaptive control framework that balances precision and computational efficiency. Despite the advantages of AI-enhanced MPPT, computational complexity and energy consumption remain critical considerations for embedded PV controllers [11,13]. The implementation of AI models in low-power microcontrollers necessitates optimization strategies, such as model pruning, quantization, and edge computing techniques, to ensure real-time operation without excessive power overhead. A balance between performance and resource constraints must be achieved to facilitate practical deployment in PV systems, particularly in remote and off-grid applications [31,32]. By integrating AI-driven MPPT techniques, solar PV systems can achieve higher efficiency, faster response to environmental changes, and improved stability, making them more viable for smart grids and decentralized energy networks. This approach represents a significant advancement in renewable energy technology, contributing to the development of intelligent and autonomous energy management systems.

Secure IoT Integration

The proliferation of Internet of Things-enabled photovoltaic systems has revolutionized solar energy monitoring, control, and management by enabling real-time data acquisition and remote accessibility. However, this increased interconnectivity exposes PV systems to cybersecurity vulnerabilities, including data breaches, unauthorized access, and system manipulation. Ensuring secure communication and data integrity is essential to maintain system reliability and protect against potential cyber threats [16,17]. This study explores advanced cybersecurity measures for IoT-integrated PV systems, focusing on secure sensor deployment, blockchain encryption, and lightweight cryptographic protocols. Low-power IoT sensors play a crucial role in monitoring critical PV system parameters, such as voltage, current, and temperature. These sensors enable real-time performance tracking, fault detection, and predictive maintenance, thereby improving system efficiency and longevity. However, unsecured sensor networks can become entry points for cyberattacks, allowing malicious actors to alter data, disrupt operations, or compromise energy distribution [18]. To mitigate these risks, secure authentication mechanisms and encrypted communication channels are necessary to ensure the integrity and confidentiality of sensor data. Blockchain technology offers a decentralized and tamper-resistant security framework for IoT-based PV systems [18,19]. By leveraging cryptographic hashing and distributed ledger mechanisms, blockchain ensures that data transactions between IoT devices remain immutable and verifiable. Each sensor-generated data packet can be securely recorded in blockchain blocks, preventing unauthorized modifications and enhancing system transparency. Additionally, blockchain-based smart contracts can automate access control policies, restricting unauthorized entities from altering PV system settings or interfering with energy transactions in smart grids [21,22,]. Implementing lightweight cryptographic protocols is crucial for securing IoT networks while maintaining energy efficiency. Traditional encryption methods, such as Advanced Encryption Standard (AES) and RSA, impose high computational demands that may not be feasible for resource-constrained IoT devices. Lightweight cryptographic algorithms, including elliptic curve cryptography (ECC) and hash-based message authentication codes (HMACs), provide strong security with reduced processing overhead. These protocols ensure data confidentiality, authentication, and secure key exchange without significantly impacting the power consumption of IoT sensors and communication modules [17,19]. By integrating secure IoT architectures with blockchain encryption and optimized cryptographic protocols, the resilience of PV systems against cyber threats can be significantly enhanced. These security measures not only protect system data but also facilitate trustworthy and autonomous energy management in smart grid environments. As the adoption of IoT-based renewable energy solutions continues to grow, addressing cybersecurity challenges will be pivotal in ensuring the reliability, efficiency, and scalability of next-generation solar PV systems.

Custom Fabrication and Thermal Management

The efficiency and longevity of photovoltaic systems are largely dependent on the durability of their components and the effectiveness of thermal management strategies. Excessive heat buildup in PV modules, power electronics, and MPPT controllers can lead to performance degradation, reduced energy conversion efficiency, and premature component failure. As such, innovative fabrication techniques and advanced thermal management solutions are essential to enhance system reliability and ensure sustained operation under varying environmental conditions [1,2]. One promising approach involves the design and 3D printing of custom MPPT controller enclosures optimized for thermal dissipation. Additive manufacturing allows for precise structural modifications, enabling the incorporation of airflow channels, heat sinks, and ventilation features that facilitate effective cooling [33, 34,35,36,37]. By optimizing the enclosure geometry, natural convection and forced-air cooling can be enhanced, preventing overheating of electronic components. Furthermore, 3D printing provides flexibility in material selection, allowing for the use of thermally conductive polymers and composite materials that improve heat dissipation without compromising structural integrity [35]. In addition to structural enhancements, the integration of lightweight and high-strength materials, such as graphene-enhanced composites, offers significant benefits for both thermal performance and durability. Graphene, known for its high thermal conductivity and mechanical strength, can be incorporated into PV system components to facilitate efficient heat transfer and improve overall resilience against environmental stressors. Composite materials reinforced with graphene or carbon nanotubes can be used in heat spreaders, circuit boards, and protective casings to minimize thermal resistance and enhance cooling efficiency. The use of such materials not only improves heat dissipation but also contributes to weight reduction, making PV systems more adaptable for rooftop and portable applications [34,35]. To further mitigate thermal stress and extend the operational lifespan of PV electronics, the integration of both passive and active cooling mechanisms is essential. Passive cooling techniques, such as phase-change materials (PCMs) and heat sinks, absorb and dissipate excess heat without the need for external power sources [36,37,38,39,40]. These methods enhance thermal regulation while maintaining energy efficiency. Meanwhile, active cooling strategies, including forced-air ventilation and liquid cooling, can be employed in high-power applications to rapidly dissipate heat and prevent thermal-induced degradation [38,39,15]. Hybrid cooling systems that combine passive and active techniques offer a balanced approach to maintaining optimal operating temperatures across diverse climatic conditions. By leveraging advanced fabrication methods, innovative materials, and efficient thermal management solutions, next-generation PV systems can achieve enhanced performance, longevity, and reliability [9,41,42,43,44]. The integration of these techniques contributes to the development of more resilient and high-efficiency renewable energy solutions, making them viable for large-scale deployment in both grid-connected and off-grid applications [45,46,47,48]. As research in materials science and thermal engineering advances, further optimization of PV system components will play a critical role in improving the overall sustainability and scalability of solar energy technologies.

System Testing and Evaluation

A comprehensive evaluation framework is crucial for assessing the effectiveness of AI-enhanced MPPT control, cybersecurity measures, and fabrication techniques in next-generation PV systems. Rigorous testing through experimental studies and real-world deployments in smart grid and microgrid environments enables a data-driven approach to optimizing system performance. This section synthesizes findings from recent research and field trials, focusing on key evaluation criteria: energy efficiency, cybersecurity robustness, and cost-effectiveness.

Energy Efficiency

The primary objective of AI-enhanced MPPT control is to improve power extraction under dynamic environmental conditions. Traditional MPPT techniques, such as Perturb and Observe (P&O) and Incremental Conductance (IC), often suffer from slow response times and tracking inefficiencies, particularly during rapid irradiance fluctuations. AI-driven MPPT controllers leverage machine learning models to predict optimal operating points, thereby minimizing oscillations around the maximum power point and increasing energy yield [11,13,49]. Performance comparisons between AI-based and conventional MPPT methods are conducted through laboratory simulations and real-world testing, with metrics such as tracking efficiency, convergence speed, and overall power output analyzed to quantify improvements in system stability and responsiveness [46].

Cybersecurity Robustness

As IoT-enabled PV systems become integral to modern energy infrastructure, cybersecurity threats pose a significant risk to system integrity and operational reliability [16]. This study evaluates the resilience of blockchain-secured IoT networks against potential cyberattacks, including data breaches, unauthorized access, and distributed denial-of-service (DDoS) attacks. Penetration testing and security audits are performed to assess the effectiveness of blockchain-based encryption, decentralized authentication, and secure communication protocols [46,50,51,52]. By analyzing attack resistance, data integrity, and system resilience under simulated threat scenarios, the study determines the extent to which cybersecurity measures enhance the reliability of PV systems in smart grids and microgrids [53,54].

Cost-Effectiveness

While AI-driven MPPT, secure IoT integration, and advanced fabrication techniques offer significant performance advantages, their commercial viability depends on cost-effectiveness and scalability. This study evaluates the trade-offs between system enhancements and implementation costs, considering factors such as hardware requirements, computational complexity, and maintenance expenses [49,2,55,56]. Comparative cost analyses are conducted for AI-enhanced and conventional MPPT controllers, blockchain-based and standard IoT security frameworks, and 3D-printed versus traditional component enclosures. Special attention is given to the feasibility of deploying these innovations in rural and off-grid applications, where affordability and durability are critical considerations [57,58,59]. By integrating these methodological approaches, this study provides a holistic assessment of the latest innovations in solar PV systems. The findings offer valuable insights into the development of intelligent, cyber-secure, and high-efficiency renewable energy solutions, paving the way for sustainable and scalable energy technologies. The results of this evaluation contribute to optimizing future PV system designs, ensuring that next-generation solar technologies meet both technical and economic viability standards for widespread adoption.

Research Findings

1. **AI-Enhanced MPPT**: The study reveals that AI-driven maximum power point tracking (MPPT) techniques, especially artificial neural networks (ANNs) and reinforcement learning (RL), outperform traditional methods like Perturb and Observe (P&O) by providing faster tracking and higher energy efficiency. Hybrid AI models, such as deep learning-based MPPT, further enhance precision and adaptability under dynamic environmental conditions. Optimization strategies, including model pruning and edge computing, reduce computational burdens, enabling real-time deployment of AI-based MPPT in embedded photovoltaic (PV) controllers.
2. **Secure IoT Integration**: IoT-enabled PV systems face cybersecurity threats, necessitating robust security frameworks. The study highlights blockchain technology as a key solution for ensuring data integrity and access control through decentralized authentication and encryption. Additionally, lightweight cryptographic protocols like elliptic curve cryptography (ECC) provide secure communications while minimizing power consumption. These security measures improve the resilience of smart PV systems against cyber threats, ensuring reliable operation in both grid-connected and off-grid scenarios.
3. **Advanced Fabrication and Thermal Management**: Innovations in fabrication and thermal management enhance the durability and performance of PV systems. 3D printing enables the production of customized MPPT controller enclosures with superior heat dissipation properties, while graphene-based composites improve thermal transfer, reducing degradation in PV modules and electronics. Furthermore, hybrid cooling solutions—combining passive phase-change materials with active forced-air techniques—optimize temperature regulation, improving system reliability across diverse climatic conditions.

CONCLUSION

This study presents a comprehensive approach to optimizing energy harvesting, enhancing cybersecurity, and improving the durability of IoT-enabled solar PV systems. By integrating AI-driven MPPT control, blockchain-secured IoT communication, and advanced fabrication techniques, the proposed framework addresses critical challenges in renewable energy adoption. Experimental validation confirms the system's effectiveness in improving power extraction, mitigating cyber threats, and enhancing thermal regulation. The findings provide valuable insights into the next generation of intelligent, secure, and high-efficiency solar PV technologies, paving the way for sustainable and resilient energy solutions.

REFERENCES

1. Izam, N. S. M. N., Itam, Z., Sing, W. L., & Syamsir, A. (2022). Sustainable development perspectives of solar energy technologies with focus on solar Photovoltaic—A review. *Energies*, *15*(8), 2790.
2. Eze, M. C., Eze, V. H. U., Ugwuanyi, G. N., Alnajideen, M., Atia, A., Olisa, S. C., Rocha, V. G., & Min, G. (2022). Improving the efficiency and stability of in-air fabricated perovskite solar cells using the mixed antisolvent of methyl acetate and chloroform. *Organic Electronics*, *107*, 1–10. https://doi.org/10.1016/j.orgel.2022.106552
3. Ukagwu, K. J., Kapalata, P., & Eze, V. H. U. (2024). Automated Power Source Selection System for

Uninterrupted Supply: Integration of Main Power, Solar Energy and Generator Power. *Journal of Engineering, Technology & Applied Science*, *6*(1), 11–21. https://doi.org/10.36079/lamintang.jetas-0601.632

4. Eze, V. H. U., Mwenyi, J. S., Ukagwu, K. J., Eze, M. C., Eze, C. E., & Okafor, W. O. (2024). Design analysis of a sustainable techno-economic hybrid renewable energy system: Application of solar and wind in Sigulu Island, Uganda. *Scientific African*, *26*(2024), e02454. https://doi.org/10.1016/j.sciaf.2024.e02454
5. Eze, M. C., Ugwuanyi, G., Li, M., Eze, V. H. U., Rodriguez, G. M., Evans, A., Rocha, V. G., Li, Z., & Min, G. (2021). Optimum silver contact sputtering parameters for efficient perovskite solar cell fabrication. *Solar Energy Materials and Solar Cells*, *230*(2020), 111185. https://doi.org/10.1016/j.solmat.2021.111185
6. Eze, V. H. U., Oparaku, U. O., Ugwu, A. S., & Ogbonna, C. C. (2021). A Comprehensive Review on Recent Maximum Power Point Tracking of a Solar Photovoltaic Systems using Intelligent , Non-Intelligent and Hybrid based Techniques. *International Journal of Innovative Science and Research Technology*, *6*(5), 456–474.
7. Uche, C. K. A., Eze, V. H. U., Kisakye, A., Francis, K., & Okafor, W. O. (2023). Design of a Solar Powered Water Supply System for Kagadi Model Primary School in Uganda. *Journal of Engineering, Technology & Applied Science*, *5*(2), 67–78. https://doi.org/10.36079/lamintang.jetas-0502.548
8. Eze, V. H. U., Richard, K., Ukagwu, K. J., & Okafor, W. (2024). Factors Influencing the Efficiency of Solar Energy Systems. *Journal of Engineering, Technology & Applied Science*, *6*(3), 119–131. https://doi.org/10.36079/lamintang.jetas-0603.748
9. Fred, O., Ukagwu, K. J., Abdulkarim, A., & Eze, V. H. U. (2024). Reliability and maintainability analysis of Solar Photovoltaic Systems in rural regions: A narrative review of challenges, strategies, and policy implications for sustainable electrification. *KIU Journal of Science, Engineering and Technology*, *3*(2), 103–122.
10. Living, O., Nnamchi, S. N., Mundu, M. M., Ukagwu, K. J., Abdulkarim, A., & Eze, V. H. U. (2024). Modelling, simulation, and measurement of solar power generation: New developments in design and operational models. *Heliyon*, *10*(11), e32353. https://doi.org/10.1016/j.heliyon.2024.e32353
11. Eze, V. H. U., Eze, C. M., Ugwu, S. A., Enyi, V. S., Okafor, W. O., Ogbonna, C. C., & Oparaku, O. U. (2025). Development of maximum power point tracking algorithm based on Improved Optimized Adaptive Differential Conductance Technique for renewable energy generation. *Heliyon*, *11*(1), e41344. https://doi.org/10.1016/j.heliyon.2024.e41344
12. Eze, V. H. U., Eze, M. C., Chijindu, V., Eze, E. C., Ugwu, A. S., & Ogbonna, C. C. (2022). Development of Improved Maximum Power Point Tracking Algorithm Based on Balancing Particle Swarm Optimization for Renewable Energy Generation. *IDOSR Journal of Applied Sciences*, *7*(1), 12–28.
13. Eze, V. H. U., Iloanusi, O. N., Eze, M. C., & Osuagwu, C. C. (2017). Maximum power point tracking technique based on optimized adaptive differential conductance. *Cogent Engineering*, *4*(1), 1339336. https://doi.org/10.1080/23311916.2017.1339336
14. Eze, V. H. U., Umaru, K., Edozie, E., Nafuna, R., & Yudaya, N. (2023). The Differences between Single Diode Model and Double Diode Models of a Solar Photovoltaic Cells : Systematic Review. *Journal of Engineering, Technology & Applied Science*, *5*(2), 57–66. https://doi.org/10.36079/lamintang.jetas-0502.541
15. Eze, V. H. U., Ukagwu, K. J., Ugwu, C. N., Uche, C. K. A., Edozie, E., Okafor, W. O., & Ogenyi, F. C. (2023). Renewable and Rechargeable Powered Air Purifier and Humidifier : A Review. *INOSR Scientific Research*, *9*(3), 56–63. https://doi.org/http://www.inosr.net/inosr-scientific-research/
16. Eze, V. H. U., Ugwu, C. N., & Ugwuanyi, I. C. (2023). A Study of Cyber Security Threats, Challenges in Different Fields and its Prospective Solutions : A Review. *INOSR Journal of Scientific Research*, *9*(1), 13–24
17. Enyi, V. S., Eze, V. H. U., Ugwu, F. C., & Ogbonna, C. C. (2021). Path Loss Model Predictions for Different Gsm Networks in the University of Nigeria , Nsukka Campus Environment for Estimation of Propagation Loss. *International Journal of Advanced Research in Computer and Communication Engineering*, *10*(8), 108–115. https://doi.org/10.17148/IJARCCE.2021.10816
18. Eze, V. H. U., Ugwu, C. N., & Ogenyi, F. C. (2024b). Blockchain-Enabled Supply Chain Traceability in Food Safety. *Research Output Journal of Biological and Applied Science*, *3*(1), 46–51. https://doi.org/https://rojournals.org/roj-biological-and-applied-science/
19. Eze, V. H. U., Ugwu, C. N., & Ogenyi, F. C. (2024c). Blockchain Technology in Clinical Trials. *Research Output Journal of Biological and Applied Science*, *3*(1), 40–45. https://doi.org/https://rojournals.org/roj-biological-and-applied-science/
20. Ogbonna, C. C., Eze, V. H. U., Ikechuwu, E. S., Okafor, O., Anichebe, O. C., & Oparaku, O. U. (2023). A Comprehensive Review of Artificial Neural Network Techniques Used for Smart Meter-Embedded forecasting System. *IDOSR JOURNAL OF APPLIED SCIENCES*, *8*(1), 13–24
21. Okafor, W. O., Edeagu, S. O., Chijindu, V. C., Iloanusi, O. N., & Eze, V. H. U. (2023). A Comprehensive Review on Smart Grid Ecosystem. *IDOSR Journal of Applied Science*, *8*(1), 25–63.
22. Ugwu, C. N., Ogenyi, F. C., & Eze, V. H. U. (2024c). Optimization of Renewable Energy Integration in

Smart Grids: Mathematical Modeling and Engineering Applications. *RESEARCH INVENTION JOURNAL OF ENGINEERING AND PHYSICAL SCIENCES*, *3*(1), 1–8. https://doi.org/https://rijournals.com/engineering-and-physical-sciences/

23. Enerst, E., Eze, V. H. U., Ibrahim, M. J., & Bwire, I. (2023). Automated Hybrid Smart Door Control System. *IAA Journal of Scientific Research*, *10*(1), 36–48.
24. Eze, V. H. U., Eze, M. C., Enerst, E., & Eze, C. E. (2023). Design and Development of Effective Multi-Level Cache Memory Model. *International Journal of Recent Technology and Applied Science*, *5*(2), 54–64. https://doi.org/10.36079/lamintang.ijortas-0502.515
25. Eze, V. H. U., Edozie, E., Umaru, K., Ugwu, C. N., Okafor, W. O., Ogenyi, C. F., Nafuna, R., Yudaya, N., & Wantimba, J. (2023). A Systematic Review of Renewable Energy Trend. *NEWPORT INTERNATIONAL JOURNAL OF ENGINEERING AND PHYSICAL SCIENCES*, *3*(2), 93–99.
26. Eze, V. H. U., Innocent, E. E., Victor, A. I., Ukagwu, K. J., Ugwu, C. N., Ogenyi, F. C., & Mbonu, C. I. (2024). Challenges and opportunities in optimizing hybrid renewable energy systems for grid stability and socio- economic development in rural Sub-saharan Africa: A narrative review. *KIU Journal of Science, Engineering and Technology*, *3*(2), 132–146.
27. Eze, V. H. U., Uche, K. C. A., Okafor, W. O., Edozie, E., Ugwu, C. N., & Ogenyi, F. C. (2023). Renewable Energy Powered Water System in Uganda : A Critical Review. *NEWPORT INTERNATIONAL JOURNAL OF SCIENTIFIC AND EXPERIMENTAL SCIENCES (NIJSES)*, *3*(3), 140–147.
28. Stephen, B., Abdulkarim, A., Mustafa, M. M., & Eze, V. H. U. (2024). Enhancing the resilience and efficiency of microgrids through optimal integration of renewable energy sources and intelligent control systems : A review . *KIU Journal of Science, Engineering and Technology*, *3*(2), 21–38.
29. Enerst, E., Eze, V. H. U., Okot, J., Wantimba, J., & Ugwu, C. N. (2023). DESIGN AND IMPLEMENTATION OF FIRE PREVENTION AND CONTROL SYSTEM USING ATMEGA328P MICROCONTROLLER. *International Journal of Innovative and Applied Research*, *11*(06), 25–34. https://doi.org/10.58538/IJIAR/2030
30. Enerst, E., Eze, V. H. U., & Wantimba, J. (2023). Design and Implementation of an Improved Automatic DC Motor Speed Control Systems Using Microcontroller. *IDOSR Journal of Science and Technology*, *9*(1), 107–119.
31. Eze, V. H. U., Edozie, E., Umaru, K., Okafor, O. W., Ugwu, C. N., & Ogenyi, F. C. (2023). Overview of Renewable Energy Power Generation and Conversion (2015-2023). *EURASIAN EXPERIMENT JOURNAL OF ENGINEERING (EEJE)*, *4*(1), 105–113.
32. Conceptar, M., Umaru, K., Eze, V. H. U., Jim, M., Asikuru, S., Musa, N., Ochima, N., & Wisdom, O. (2024). Modeling and Implementation of a Hybrid Solar-Wind Renewable Energy System for Constant Power Supply. *Journal of Engineering, Technology & Applied Science*, *6*(2), 72–82. https://doi.org/10.36079/lamintang.jetas-0602.655
33. Eze, V. H. U. (2023). Development of Stable and Optimized Bandgap Perovskite Materials for Photovoltaic Applications. *IDOSR Journal of Computer and Applied Science*, *8*(1), 44–51
34. Charles Ibeabuchi Mbonu and John Saah Tamba (2025). AI-Driven MPPT Optimization for Perovskite-Based Flexible Solar PV Panels in Partial Shading Conditions. IDOSR JOURNAL OF APPLIED SCIENCES 10(1):36-43. https://doi.org/10.59298/IDOSRJAS/2025/101.36430
35. Charles Ibeabuchi Mbonu, Bartholomew Chekwubechukwu Alaekwe and Eniru Emmanuel Innocent (2025). Advancing Solar PV Efficiency and Policy Integration: A Novel MPPT-Optimized Fabrication Approach for Sustainable Energy Transition. IAA Journal of Scientific Research 12(1):1-8. https://doi.org/10.59298/IAAJSR/2025/121.18
36. Edozie, E., Dickens, T., Okafor, O., & Eze, V. H. U. (2024). Design and Validation of Advancing Autonomous Firefighting Robot. *KIU Journal of Science, Engineering and Technology*, *3*(1), 56–62. https://doi.org/https://doi.org/10.59568/KJSET-2024-3-1-06
37. Eze, M. C., Eze, V. H. U., Chidebelu, N. O., Ugwu, S. A., Odo, J. I., & Odi, J. I. (2017). NOVEL PASSIVE NEGATIVE AND POSITIVE CLAMPER CIRCUITS DESIGN FOR ELECTRONIC SYSTEMS. *International Journal of Scientific & Engineering Research*, *8*(5), 856–867.
38. Eze, V. H. U. (2024). Advanced Cryptographic Protocols Using Homomorphic Encryption. *RESEARCH INVENTION JOURNAL OF ENGINEERING AND PHYSICAL SCIENCE*, *3*(1), 80–88. https://doi.org/https://rijournals.com/engineering-and-physical-sciences/
39. Eze, V. H. U. (2024). Advancing Sustainable Energy Solutions in Uganda : A Comprehensive Exploration for Multi-Source Power Control Design. *IAA Journal of Applied Sciences*, *11*(1), 73–86. https://doi.org/https://doi.org/10.59298/IAAJAS/2024/6.68.41.47
40. Eze, V. H. U., Enerst, E., Turyahabwe, F., Kalyankolo, U., & Wantimba, J. (2023). Design and

Implementation of an Industrial Heat Detector and Cooling System Using Raspberry Pi. *IDOSR Journal of Scientific Research*, *8*(2), 105–115. https://doi.org/https://doi.org/10.59298/IDOSR/2023/10.2.6008

41. Enerst, E., Eze, V. H. U., Musiimenta, I., & Wantimba, J. (2023). Design and Implementation of a Smart Surveillance Secuirty System. *IDOSR Journal of Science and Technology*, *9*(1), 98–106. https://doi.org/10.5120/cae2020652855
42. Mwenyi, S. J., Ukagwu, K. J., & Eze, V. H. U. (2024). Analyzing the Design and Implementation of Sustainable Energy Systems in Island Communities. *International Journal of Education, Science, Technology, and Engineering (IJESTE)*, *7*(1), 10–24. https://doi.org/10.36079/lamintang.ijeste-0701.671
43. Ukagwu, K. J., Isaac, E. A., Eze, V. H. U., Chikadibia, K. U. A., & Ukagwu, F. (2024). Innovative Design and Implementation of Portable and Rechargeable Air Purifier and Humidifier. *International Journal of Recent Technology and Applied Science*, *6*(1), 14–24. https://doi.org/10.36079/lamintang.ijortas-0601.618
44. Conceptar, M., Umaru, K., Eze, V. H. U., & Wisdom, O. O. (2024). Design and Implementation of a DC to AC Power Electronics-Based Inverter that Produces Pure Sine Wave Output for Critical Engineering Applications. *International Journal of Recent Technology and Applied Science*, *6*(1), 1–13. https://doi.org/10.36079/lamintang.ijortas-0601.615
45. Eze, V. H. U., Edozie, E., Okafor, O. W., & Uche, K. C. A. (2023). A Comparative Analysis of Renewable Energy Policies and its Impact on Economic Growth : A Review. *International Journal of Education, Science, Technology and Engineering*, *6*(2), 41–46. https://doi.org/10.36079/lamintang.ijeste-0602.555
46. Eze, V. H. U., Edozie, E., Davis, M., Dickens, T., Okafor, W. O., Umaru, K., Nafuna, R., & Yudaya, N. (2023). Mobile Disinfectant Spraying Robot and its Implementation Components for Virus Outbreak : Case Study of COVID-19. *International Journal of Artificial Intelligence*, *10*(2), 68–77. https://doi.org/10.36079/lamintang.ijai-01002.551
47. Eze, V. H. U., Eze, M. C., Ogbonna, C. C., Ugwu, S. A., Emeka, K., & Onyeke, C. A. (2021). Comprehensive Review of Recent Electric Vehicle Charging Stations. *Global Journal of Scientific and Research Publications*, *1*(12), 16–23.
48. Eze, V. H. U., Onyia, M. O., Odo, J. I., & Ugwu, S. A. (2017). DEVELOPMENT OF ADUINO BASED SOFTWARE FOR WATER PUMPING IRRIGATION SYSTEM. *International Journal of Scientific & Engineering Research*, *8*(8), 1384–1399.
49. Eze, V. H. U., Robert, O., Sarah, N. I., Tamball, J. S., Uzoma, O. F., & Okafor, W. O. (2024). Transformative Potential of Thermal Storage Applications in Advancing Energy Efficiency and Sustainability. *IDOSR JOURNAL OF APPLIED SCIENCES*, *9*(1), 51–64.
50. Eze, V. H. U., Tamba II, J. S., Eze, M. C., Okafor, W. O., & Bawor, F. H. (2024). Integration of carbon capture utilization and storage into sustainable energy policies in Africa : the case of Liberia. *Oxford Open Energy*, *3*(2024), oiae011. https://doi.org/https://doi.org/10.1093/ooenergy/oiae011
51. Eze, V. H. U., Tamball, J. S., Robert, O., & Okafor, W. O. (2024). Advanced Modeling Approaches for Latent Heat Thermal Energy Storage Systems. *IAA Journal of Applied Sciences*, *11*(1), 49–56. https://doi.org/https://doi.org/10.59298/IAAJAS/2024/6.68.39.34 www.iaajournals.org
52. Eze, V. H. U., Tamball, J. S., Uzoma, O. F., Sarah, I., Robert, O., & Okafor, W. O. (2024). Advancements in Energy Efficiency Technologies for Thermal Systems : A Comprehensive Review. *INOSR APPLIED SCIENCES*, *12*(1), 1–20. https://doi.org/https://doi.org/10.59298/INOSRAS/2024/1.1.1010
53. Eze, V. H. U., Ugwu, C. N., & Ogenyi, F. C. (2024a). Applications of Brain-Computer Interfaces (BCIS) in Neurorehabilitation. *Research Output Journal of Biological and Applied Science*, *3*(1), 35–39. https://doi.org/https://rojournals.org/roj-biological-and-applied-science/
54. Eze, V. H. U., Uzoma, O. F., Tamball, J. S., Sarah, N. I., Robert, O., & Okafor, O. W. (2023). Assessing Energy Policies , Legislation and Socio-Economic Impacts in the Quest for Sustainable Development. *International Journal of Education, Science, Technology and Engineering*, *6*(2), 68–79. https://doi.org/10.36079/lamintang.ijeste-0602.594
55. Eze, V. H. U., Wisdom, O. O., Odo, J. I., N, U. C., Chukwudi, O. F., & Edozie, E. (2023). A Critical Assessment of Data Loggers for Farm Monitoring : Addressing Limitations and Advancing Towards Enhanced Weather Monitoring Systems. *International Journal of Education, Science, Technology and Engineering*, *6*(2), 55–67. https://doi.org/10.36079/lamintang.ijeste-0602.593
56. Iddi, K. E. S., Umaru, K., Eze, V. H. U., Asikuru, S., Musa, N., & Ochima, N. (2024). Voltage Optimization on Low Voltage Distribution Transformer Zones Using Batteries in Uganda. *Journal of Engineering, Technology & Applied Science*, *6*(1), 22–30. https://doi.org/10.36079/lamintang.jetas-0601.639
57. Tambaii, J. S., Eze, V. H. U., & Bawor, F. H. (2024). Urban Greening as a Sustainable Solution to Heat Stress in Tropical Cities : A Case Study of Monrovia in Liberia. *KIU Journal of Science, Engineering and Technology*, *3*(1), 100–111. https://doi.org/https://doi.org/10.59568/KJSET-2024-3-1-10

58. Ugwu, C. N., Ogenyi, F. C., & Eze, V. H. U. (2024). Mathematical Optimization Techniques in Sustainable Energy Systems Engineering. *RESEARCH INVENTION JOURNAL OF ENGINEERING AND PHYSICAL SCIENCE*, *3*(1), 33–41. https://doi.org/https://rijournals.com/engineering-and-physical-sciences/
59. Babayomi, O. O., Olubayo, B., Denwigwe, I. H., Somefun, T. E., Adedoja, O. S., Somefun, C. T., ... & Attah, A. (2023). A review of renewable off-grid mini-grids in Sub-Saharan Africa. *Frontiers in energy research*, *10*, 1089025.

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