**ANALYSE THE NUMBER OF SOLAR PANELS NEEDED TO MEET THE ENERGY DEMAND**

**ABSTRACT**

Solar energy has emerged as a promising alternative to traditional sources of energy due to its environmentally friendly nature and abundance. In this study, we aim to analyze the number of solar panels needed to meet the energy demand of a typical household. By evaluating the energy consumption patterns of a household and the efficiency of solar panels, we can estimate the number of panels required to generate the necessary amount of energy. Factors such as location, orientation, and shading of the panels will also be taken into consideration to optimize energy production. Additionally, the study will explore the financial implications of installing solar panels, including initial costs, potential savings on energy bills, and payback period. By providing a comprehensive analysis of the number of solar panels needed to meet energy demand, this research aims to contribute to a better understanding of the feasibility and benefits of transitioning to solar energy. Ultimately, the results of this study can inform homeowners, policymakers, and stakeholders on the practicality and sustainability of adopting solar power as a viable energy solution.

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## CHAPTER 1 INTRODUCTION

**1.1 Overview of Solar Energy**

Solar energy is a renewable and sustainable source of energy that utilizes sunlight to generate electricity through the use of solar panels. These panels consist of photovoltaic cells that convert sunlight into electricity, which can then be used to power homes, businesses, and other devices. In order to determine the number of solar panels needed to meet the energy demand of a particular location, factors such as the amount of sunlight received, the efficiency of the solar panels, and the energy consumption of the location must be taken into consideration. By analyzing these factors, it is possible to calculate the size and number of solar panels required to meet the energy needs of a specific area. This process involves assessing the energy demands of the location, including the amount of electricity used on a daily basis, as well as examining the available sunlight and the efficiency of the solar panels. By conducting a detailed analysis of these factors, it is possible to determine the optimal number of solar panels needed to meet the energy demand of a specific location, making solar energy a viable and cost-effective solution for meeting energy needs in a sustainable manner.

**1.2 Calculation Methodology for Solar Panel Requirement**

The calculation methodology for determining the number of solar panels needed to meet the energy demand involves several steps. The first step is to calculate the daily energy consumption of the household or building in kilowatt-hours (kWh). This can be determined by looking at past energy bills or using energy monitoring devices. The next step is to determine the average daily peak sun hours available at the location where the solar panels will be installed. This information is typically available from solar radiation maps or online databases. Once the daily energy consumption and average daily peak sun hours are known, the total wattage of solar panels needed can be calculated using the formula: Total Wattage = (Daily Energy Consumption)/(Average Daily Peak Sun Hours). This will give an estimate of the total wattage of solar panels needed to meet the energy demand on a daily basis. Finally, the number of solar panels needed can be determined by dividing the total wattage by the wattage of each individual solar panel. It is important to consider factors such as shading, orientation, and tilt angle of the solar panels when calculating the number needed. By following this methodology, a precise estimate of the number of solar panels required to meet the energy demand can be obtained, ensuring the system is properly sized and optimized for maximum efficiency and savings.

**1.3 Factors Affecting Solar Panel Efficiency**

The efficiency of solar panels can be influenced by several factors such as temperature, shading, and orientation. Firstly, the temperature of the solar panels can have a significant impact on their efficiency. Solar panels perform best at cooler temperatures, so excessive heat can reduce their output. This means that it is important to consider the climate of the location where the solar panels will be installed and take measures to prevent overheating. Secondly, shading can also affect the efficiency of solar panels. Even a small amount of shading, such as from a nearby tree or building, can significantly reduce the output of a solar panel system. It is important to consider potential sources of shading when determining the best placement for solar panels. Finally, the orientation of the solar panels plays a crucial role in their efficiency. Solar panels should ideally be facing south in the northern hemisphere or north in the southern hemisphere to receive the maximum amount of sunlight throughout the day. By taking these factors into account, it is possible to determine the optimal number of solar panels needed to meet the energy demand of a particular location. Adjusting for these factors can help ensure that the solar panel system operates at its highest efficiency, ultimately reducing the number of panels needed to meet the desired energy output.

**1.4 Importance of Meeting Energy Demand**

One important aspect of meeting energy demand with solar power is reducing dependence on non-renewable energy sources such as fossil fuels, which are finite and contribute to environmental degradation through greenhouse gas emissions. By utilizing solar power, we can significantly decrease our carbon footprint and work towards a cleaner, more sustainable future for generations to come. Additionally, solar

power can help to stabilize energy costs and reduce the impact of fluctuating fuel prices on consumers. This can provide greater energy security and economic stability, especially in times of geopolitical unrest or natural disasters. Moreover, by investing in solar power, we can create jobs in the renewable energy sector and stimulate economic growth while also enhancing energy independence. To accurately determine the number of solar panels needed to meet a specific energy demand, careful analysis of factors such as location, sunlight exposure, panel efficiency, and energy consumption patterns is essential. By conducting this analysis, we can ensure that the solar power system is properly sized and optimized to meet energy needs effectively and sustainably. With the advancement of technology and the increasing affordability of solar panels, it is becoming increasingly feasible for individuals, communities, and businesses to transition to solar power as a primary source of energy, thus making significant strides towards a more sustainable and resilient energy future.

## CHAPTER 2 LITERATURE SURVEY

## 2.1 REVIEW ON EXISTING SYSTEM

**"Assessing Power Degradation and Temperature Due to Hotspots in Solar PV Panels," by P. Kumar, S. K. Maurya, S. Chowdhury and I. Yadav, in 2024.** Assessing power degradation and temperature due to hotspots in solar photovoltaic (PV) panels is crucial for optimizing solar energy systems efficiency and longevity. Hotspots are localized regions on a solar panel that experience elevated temperatures, often caused by shading, defective cells, or debris accumulation. These anomalies can lead to significant power loss and accelerated degradation of the panel materials. By employing advanced thermal imaging and data analysis techniques, researchers can identify and quantify hotspots, enabling effective mitigation strategies. Understanding the impact of these temperature variations on energy output helps in enhancing the reliability of solar installations. Regular assessment of panel conditions not only maximizes energy harvest but also prolongs the lifespan of the solar systems. This proactive approach supports the transition to renewable energy, ensuring that solar PV technology remains a sustainable and viable option for meeting global energy demands while minimizing environmental impact.

**"SPARK Technology for Condition Monitoring of Solar Power Plants," by A. Garg and M. S. Ballal, in 2023**.

SPARK Technology for Condition Monitoring of Solar Power Plants is an innovative solution designed to enhance the performance and reliability of solar energy systems. Utilizing advanced sensor technology and data analytics, SPARK continuously monitors the operational health of solar panels, inverters, and other critical components. By collecting real-time data on temperature, energy output, and environmental conditions, it provides valuable insights into system performance.   
The technology employs predictive maintenance algorithms, which identify potential issues before they escalate, allowing for timely interventions and minimizing downtime.

**"Study on Characteristics of Discharge Channels Induced by Pulsed Discharge in Water and Its Application in Solar Panel Recycling," by Y. Fan et al., in 2020.**

This study examines the characteristics of discharge channels generated by pulsed electric discharges in water, specifically focusing on their dynamics and interactions. Utilizing advanced diagnostic techniques, researchers analyzed the formation and evolution of these channels, which play a crucial role in various applications, including solar panel recycling. The pulsed discharge process creates high-energy conditions that facilitate the breakdown of materials, making it an innovative method for extracting valuable metals from end-of-life solar panels. By optimizing discharge parameters, the research aims to enhance the efficiency and efficacy of material recovery while minimizing environmental impact. The findings provide insights into the underlying mechanisms of pulsed discharges in aqueous environments, paving the way for more sustainable recycling methods in the renewable energy sector. This study also highlights the potential for developing eco-friendly technologies that contribute to the circular economy by efficiently reclaiming resources from electronic waste, thereby addressing both resource scarcity and waste management challenges.

**"Fuell cell/ Photovoltaic panels/ Wind turbines Hybrid Systems analysed through bibliometric maps," by M. S. Raboaca, N. Bizon, O. V. Grosu, E. Carcadea, C. Filote and L. D. Milici, in 2021.** Hybrid systems that combine fuel cells, photovoltaic (PV) panels, and wind turbines represent an innovative approach to sustainable energy generation. Utilizing bibliometric maps, researchers can systematically analyze the literature surrounding these systems, revealing trends, collaborations, and key contributors in the field. Fuel cells convert chemical energy into electricity, offering high efficiency and low emissions, while PV panels transform sunlight into energy, and wind turbines harness the power of the wind. The integration of these technologies fosters a more resilient and efficient energy system, capable of balancing supply and demand in varying environmental conditions. Bibliometric analysis aids in identifying gaps in research, emerging technologies, and the impact of policies on the adoption of hybrid systems. As the global energy landscape shifts towards renewables, understanding the interplay of these technologies through comprehensive literature analysis not only boosts innovation but also accelerates the transition to cleaner energy solutions, paving the way for a more sustainable future.

**"Improved Packed-U Cell Multilevel Inverter with Asymmetrical Source Management for Grid Connected Solar Energy Conversion System," by M. C. M. Nirmal, V. Sukanya, P. Jayaprakash, O. V. Asokan and B. Singh, in 2020.**

The Improved Packed-U Cell Multilevel Inverter with Asymmetrical Source Management is an advanced solution for grid-connected solar energy conversion systems. Designed to enhance efficiency and performance, this innovative inverter employs a multilevel architecture, allowing for smoother output waveforms and reduced harmonic distortion. The asymmetrical source management feature optimally balances power from multiple input sources, ensuring that energy capture from solar panels is maximized, regardless of varying sunlight conditions. This capability not only increases overall system efficiency but also enhances the reliability and longevity of the inverter. Additionally, the inverter's compact design facilitates easier integration into solar setups, making it suitable for both residential and commercial applications. With its cutting-edge technology, this inverter plays a crucial role in facilitating the transition to renewable energy, contributing to sustainable energy systems while supporting grid stability and reliability. Ideal for eco-conscious consumers and energy investors, this inverter represents a significant advancement in solar energy technology.

**"Recycling Methods for Crystalline Silicon Solar Panels," by P. Sawant, Y. Shinde, P. Patil, S. Gurav, S. Khetree and F. Khan in 2023.**

Recycling methods for crystalline silicon solar panels are essential for promoting sustainability in solar energy production. As these panels gain popularity, the need for efficient recycling processes increases, given their lifespan of 25 years or more. The primary method involves dismantling the panels, where the aluminum frames and junction boxes are removed for recycling. The silicon cells are then processed through mechanical and thermal treatments, allowing for the separation of valuable materials like silicon, silver, and glass. Chemical processes can further enhance recovery rates by dissolving unwanted substances. Innovative technologies, including hydrometallurgical and pyrometallurgical methods, are being developed to improve efficiency and reduce environmental impact. Collaborations between manufacturers, recycling companies, and policymakers are crucial for establishing comprehensive recycling systems. By effectively recycling crystalline silicon solar panels, we can minimize waste, conserve resources, and support the broader transition to renewable energy, ensuring the environmental benefits of solar power extend well beyond their operational lifespan.

**"Numerical study of the hybrid photovoltaic thermal collector with ribs," by A. Khelifa, L. Boutina, K. Touafek, M. T. Baissi and M. Lebbi, in 2020.**

The numerical study of hybrid photovoltaic thermal collectors with ribs focuses on enhancing solar energy conversion efficiency by combining photovoltaic (PV) and thermal technologies. This innovative approach integrates ribbed structures into the collector design to improve heat transfer and optimize airflow over the surface, thereby maximizing energy extraction from sunlight. By employing advanced computational fluid dynamics (CFD) simulations and finite element analysis (FEA), researchers analyze the thermal performance and overall efficiency of these hybrid systems under various environmental conditions. The presence of ribs increases turbulence, which enhances heat exchange between the PV cells and the fluid medium, facilitating better temperature regulation. The study aims to identify optimal rib configurations and materials that contribute to increased energy output, improved thermal management, and overall system performance. This research holds significant implications for the development of sustainable energy solutions, paving the way for more efficient and cost-effective solar energy systems in residential and commercial applications.  
**"Application of Artificial Intelligence in Detecting and Classifying Faults of Solar Panels," by N. T. N. Trinh, D. T. Hung, N. H. T. Dat and P. Q. Dung, in 2022.**

The application of Artificial Intelligence (AI) in detecting and classifying faults in solar panels represents a transformative approach to renewable energy maintenance. Utilizing advanced machine learning algorithms and computer vision techniques, this innovative application can efficiently analyze visual data from solar panel arrays, identifying anomalies such as cracks, soiling, and electrical faults. By processing images captured by drones or stationary cameras, AI systems can discern patterns and categorize issues with remarkable accuracy, enabling rapid response and minimizing downtime. The integration of AI enhances predictive maintenance strategies, allowing operators to address potential failures before they escalate into costly repairs. Furthermore, the application contributes to optimizing energy production and ensuring the longevity of solar installations. With increasing reliance on solar energy, this technology not only boosts operational efficiency but also supports sustainability goals, highlighting AI's vital role in advancing the efficiency and reliability of renewable energy systems.

**"A Flexible and Robust Deep Learning-Based System for Solar Irradiance Forecasting," by I. -I. Prado-Rujas, A. García-Dopico, E. Serrano and M. S. Pérez.**

The flexible and robust deep learning-based system for solar irradiance forecasting represents a significant advancement in the field of renewable energy management. By leveraging advanced machine learning algorithms, this system effectively predicts solar irradiance levels, which are crucial for optimizing the performance of solar energy installations. It integrates various data sources, including weather patterns, geographical information, and historical solar irradiance data, to provide accurate, real-time forecasts. This adaptability allows it to cater to a diverse range of environments and operational conditions, making it suitable for different regions and scales of solar projects. The system's robustness ensures consistent performance even in the presence of incomplete or noisy input data. Ultimately, this innovative approach enhances decision-making for solar energy production, facilitating better energy management, reducing operational costs, and supporting the broader transition towards a sustainable energy future. By improving prediction accuracy, it empowers stakeholders to maximize the benefits of solar technology.

**"Comparative Study to Identify Requirement Issues to Build Low Cost Solar System For Sri Lanka A Review," by H. Fernando and B. Hettige, in 2023.**

This comparative study aims to identify the requirements and challenges in building low-cost solar power systems in Sri Lanka. With the country’s abundant sunlight, harnessing solar energy presents a sustainable solution to address energy shortages and promote environmental conservation. The review analyzes existing solar technologies, materials, and installation methodologies, comparing local and international approaches. It highlights critical issues such as financial constraints, technological gaps, regulatory barriers, and community acceptance. By assessing various case studies and research outcomes, the study seeks to propose cost-effective strategies tailored for the Sri Lankan context. Emphasizing the importance of stakeholder collaboration, it encourages public-private partnerships to facilitate the transition to solar energy. Ultimately, the findings aim to contribute to policy formulation, enhance public awareness, and foster innovative solutions that can lead to a resilient and economically viable solar energy infrastructure in Sri Lanka, enhancing energy security and supporting sustainable development goals.

**2.2 INFERENCE AND CHALLENGES IN EXISTING SYSTEM**

**Lack of accurate data:** Many existing systems do not have precise information on the energy demand of a building, leading to an underestimation or overestimation of the number of solar panels needed

**Inefficient design:** Some systems are designed without considering the optimal orientation, tilt, and shading of the solar panels, resulting in reduced energy generation potential.

**Limited monitoring and maintenance:** Without regular monitoring and maintenance, the efficiency of the solar panels may decrease over time, leading to a decrease in energy output.

**Poor integration with electrical grid:** Some existing systems are not properly connected to the electrical grid, which can lead to inefficiencies in energy distribution and management.

**CHAPTER 3**

**REQUIREMENT ANALYSIS**

## 3.1 NECESSITY & FEASIBILITY OF PROPOSED SYSTEM

**Necessity**

The necessity of analyzing the number of solar panels needed to meet the energy demand arises from the growing need for sustainable and renewable energy sources. With increasing concerns over climate change, energy independence, and rising electricity costs, solar energy has emerged as a viable alternative. Accurately determining the number of solar panels required ensures:

**Optimal Resource Utilization**: Prevents over-installation or under-installation of solar panels, optimizing energy production.

**Cost Efficiency**: Helps in budgeting and cost estimation by calculating the precise number of panels needed.

**Energy Security**: Ensures that the energy needs are met consistently, reducing dependency on non-renewable sources.

**Regulatory Compliance**: Aligns with government policies and incentives for renewable energy adoption.

**Feasibility**

The feasibility of implementing a system to analyze the number of solar panels involves:

**Technical Feasibility**: Utilizes software tools and algorithms to calculate the number of panels based on factors such as location, panel efficiency, and energy consumption.

**Economic Feasibility**: Involves cost-benefit analysis, including installation costs, savings on energy bills, and potential government subsidies.

**Operational Feasibility**: Ensures that the system can be integrated with existing energy management systems and is user-friendly for stakeholders.

## 3.2 HARDWARE AND SOFTWARE REQUIREMENTS

**Hardware Requirements**

* **Solar Panels**: Panels with specifications including wattage, efficiency, and dimensions.
* **Inverters**: Converts DC to AC power; specifications depend on the panel output and energy requirements.
* **Mounting Hardware**: Racks and supports for installing solar panels.
* **Data Acquisition Devices**: Sensors or meters to monitor sunlight intensity and energy production.
* **Computing Hardware**: Servers or computers to run the analysis software and store data.

**Software Requirements**

* **Simulation Software**: Tools like PVsyst or Helioscope for solar panel performance simulation.
* **Energy Management Software**: To track and analyze energy consumption and production.
* **Database Management System**: To store and manage data related to energy demand and solar panel performance.
* **Calculation Algorithms**: Custom or pre-built algorithms for calculating the number of panels required based on input parameters.

## CHAPTER 4

## DESCRIPTION OF PROPOSED SYSTEM

## 4.1 SELECTED METHODOLOGIES

**Load Analysis**: Assessing the energy consumption patterns and peak demand.

**Solar Irradiance Assessment**: Evaluating the amount of solar radiation available at the installation site.

**Panel Efficiency Calculation**: Determining the efficiency of the solar panels being used.

**System Design Algorithms**: Applying algorithms to compute the number of panels needed based on energy demand and solar irradiance.

**Simulation and Optimization**: Running simulations to optimize panel placement and configuration for maximum efficiency.

## 4.2 ARCHITECTURE DIAGRAM

Figure 4.1 Architecture Diagram

## 4.3 DESCRIPTION OF MODULES & WORKFLOW

The inverter converts DC electricity to AC for home use. Its size should match the PV array output:

**Calculate Solar Irradiance:**

Solar irradiance represents the amount of solar power you’ll receive. Use this formula:  
E=H⋅r⋅A

* (E) is the energy generated (in kilowatt-hours, kWh).
* (H) is the annual average solar radiation (in kWh/m²/year).
* (r) is the PV panel efficiency (as a percentage).
* (A) is the area of the PV panel (in square meters).

[For example, if you have a PV panel with an area of 1.6 m², 15% efficiency, and an annual average solar radiation of 1700 kWh/m²/year, it would generate approximately 408 kWh/year1](https://solarplansets.com/learn/59-solar-pv-power-calculations-with-examples-provided/).

**Calculate Energy Demand:**

Determine your household’s power consumption. Use this formula:  
D=P⋅t

* (D) is the total energy demand (in kWh).
* (P) is the power of the appliance (in kilowatts, kW).
* (t) is the usage time (in hours).
* For instance, a 0.5 kW refrigerator used for 6 hours consumes 3 kWh.

**Estimate PV System Size:**

To find the size of the PV system required, use:  
S=365⋅H⋅rD​

* (S) is the PV system size (in kilowatts, kW).
* (D) is the total energy demand (in kWh).
* (H) is the average daily solar radiation (in kWh/m²/day).
* (r) is the PV panel efficiency.
* For a house consuming 20 kWh/day, with 5 kWh/m²/day solar radiation and 15% panel efficiency, the system size would be approximately 7.3 kW.

**Check Structural Load:**

Ensure your roof can support the PV system’s weight. Calculate the load:  
L=AW​

* (L) is the load (in kg/m²).
* (W) is the weight of the PV system (in kg).
* is the area of the PV system.
* For a 7.3 kW PV system weighing 350 kg spread over 45 m², the load is about 7.78 kg/m².

**Evaluate Electrical Current:**

Determine the current flowing through your PV system using Ohm’s law:  
I=VP​

* is the current (in Amperes).
* (P) is the power (in Watts).
* (V) is the voltage (in Volts).
* For a 7.3 kW system operating at 400 V, the current is approximately 18.25 A.

**Calculate Battery Capacity (if applicable):**

If you’re adding a storage system, find the battery capacity:  
C=VD⋅N​

* (C) is the battery capacity (in Ampere-hours, Ah).
* (D) is the daily energy demand (in kWh).
* (N) is the desired autonomy (number of days without sun).
* (V) is the battery voltage.
* For example, with a 5 kWh daily demand and 3 days of autonomy using a 48V battery, the capacity is approximately 0.3125 Ah.

Select Inverter Size:  
I=VP​

* is the inverter size (in kilovolt-amperes, kVA).
* (P) is the peak power from the PV array.

## 4.4 ESTIMATED COST FOR IMPLEMENTATION

Estimating the cost of implementing a solar energy system involves several factors:

* Solar Panels: The cost of solar panels depends on their capacity (measured in watts or kilowatts). High-efficiency panels are more expensive but generate more electricity.
* Inverter: An inverter converts direct current (DC) from solar panels into alternating current (AC) for use in your home. Inverter costs vary based on capacity and type (string inverters, microinverters, etc.).
* Mounting System: The cost of mounting structures (roof or ground) to hold the solar panels.
* Installation Labor: Labor costs for installation, wiring, and connection to the electrical grid.
* Permitting and Inspection Fees: Costs associated with obtaining necessary permits and inspections.
* Overheads: Consider maintenance, insurance, and any additional components (e.g., batteries for energy storage).
* Location: Costs can vary based on your geographical location and local regulations.

For a more accurate estimate, consult a local solar installer or use online solar calculators.

Analyzing the Number of Solar Panels Needed:

To determine the number of solar panels required, follow these steps:

* Calculate Energy Demand: Determine your average daily energy consumption (in kilowatt-hours, kWh). Consider historical bills or use energy monitoring tools.
* Solar Panel Output: Each panel has a rated output (e.g., 300W). Divide your daily energy demand by the panel’s output to find the number of panels needed.
* Account for Efficiency and Location: Adjust for panel efficiency (typically 15-20%) and your location’s solar irradiance (sunlight availability).
* Consider System Size: Decide on the system size (e.g., 5kW, 10kW) based on your budget and available space.
* Consult a Professional: A solar installer can provide a precise assessment based on your specific requirements.

## CHAPTER 5

## CONCLUSION

In conclusion, the number of solar panels needed to meet the energy demand is dependent on a variety of factors including the location, size of the system, and the level of energy consumption. Through the process of analyzing the energy demand and considering these various factors, it is possible to determine the appropriate number of solar panels needed to meet the desired energy output. By conducting a detailed assessment of the energy requirements, it is possible to design a solar panel system that is both cost-effective and efficient in meeting the needs of the user. Additionally, advancements in solar panel technology have made it more feasible to generate enough energy to meet the demand of a household or business. It is important to consider the efficiency and capacity of the solar panels, as well as the orientation and tilt of the panels to maximize energy production. Overall, by carefully analyzing the energy demand and utilizing the appropriate number of solar panels, it is possible to create a renewable energy system that is both sustainable and environmentally friendly. Ultimately, with the right planning and consideration of various factors, it is possible to meet energy demands through the use of solar panels, decreasing reliance on traditional energy sources and reducing the carbon footprint of a home or business.

## REFERENCES

1. A. Garg and M. S. Ballal, "SPARK Technology for Condition Monitoring of Solar Power Plants," 2023 IEEE International Conference on Power Electronics, Smart Grid, and Renewable Energy (PESGRE), Trivandrum, India, 2023, pp. 1-6,doi:10.1109/PESGRE58662.2023.10404111.
2. A. Khelifa, L. Boutina, K. Touafek, M. T. Baissi and M. Lebbi, "Numerical study of the hybrid photovoltaic thermal collector with ribs," 2020 6th International Symposium on New and Renewable Energy (SIENR), Ghadaia, Algeria, 2021, pp.1-4,doi:10.1109/SIENR50924.2021.9631926.
3. H. Fernando and B. Hettige, "Comparative Study to Identify Requirement Issues to Build Low Cost Solar System For Sri Lanka A Review," 2023 5th International Conference on Electrical, Control and Instrumentation Engineering (ICECIE), Malaysia,2023,pp.1-10,doi:10.1109/ICECIE58751.2024.10457377.
4. I. -I. Prado-Rujas, A. García-Dopico, E. Serrano and M. S. Pérez, "A Flexible and Robust Deep Learning-Based System for Solar Irradiance Forecasting," in IEEE Access, vol. 9, pp. 12348-12361, 2021, doi: 10.1109/ ACCESS.2021.3051839
5. M. C. M. Nirmal, V. Sukanya, P. Jayaprakash, O. V. Asokan and B. Singh, "Improved Packed-U Cell Multilevel Inverter with Asymmetrical Source Management for Grid Connected Solar Energy Conversion System," 2020 IEEE 5th International Conference on Computing Communication and Automation (ICCCA), Greater Noida, India, 2020, pp. 542-547, doi: 10.1109/ICCCA49541.2020.9250798.
6. M. S. Raboaca, N. Bizon, O. V. Grosu, E. Carcadea, C. Filote and L. D. Milici, "Fuell cell/ Photovoltaic panels/ Wind turbines Hybrid Systems analysed through bibliometric maps," 2021 13th International Conference on Electronics, Computers and Artificial Intelligence, Pitesti, Romania, 2021, pp. 1-7, doi: 10.1109/ ECAI52376. 2021.9515062
7. N. T. N. Trinh, D. T. Hung, N. H. T. Dat and P. Q. Dung, "Application of Artificial Intelligence in Detecting and Classifying Faults of Solar Panels," 2022 IEEE Ninth International Conference on Communications and Electronics (ICCE), Nha Trang, Vietnam, 2022, pp. 513-518, doi: 10.1109/ICCE55644.2022.9852089.
8. P. Kumar, S. K. Maurya, S. Chowdhury and I. Yadav, "Assessing Power Degradation and Temperature Due to Hotspots in Solar PV Panels," 2024 3rd International conference on Power Electronics and IoT Applications in Renewable Energy and its Control (PARC), Mathura, India, 2024, pp. 500-505, doi:10.1109/PARC59193. 2024. 10486764.
9. P. Sawant, Y. Shinde, P. Patil, S. Gurav, S. Khetree and F. Khan, "Recycling Methods for Crystalline Silicon Solar Panels," 2023 9th International Conference on Advanced Computing and Communication Systems (ICACCS), Coimbatore, India, 2023, pp. 1564-1569, doi: 10.1109/ICACCS57279.2023.10112744.
10. Y. Fan et al., "Study on Characteristics of Discharge Channels Induced by Pulsed Discharge in Water and Its Application in Solar Panel Recycling," 2020 IEEE Electrical Insulation Conference (EIC), Knoxville, TN, USA, 2020, pp. 430-433,doi:10.1109/EIC47619.2020.9158703.