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PRECISION IN POWER: A COMPREHENSIVE ANALYSIS OF SOLAR PHOTOVOLTAIC SYSTEM DESIGN WITH PVSOL

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Abstract
The increasing global demand for clean and sustainable energy sources was met with the utilization of solar photovoltaic (PV) systems, which were designed and optimized using PVSOL, a state-of-the-art software tool acknowledged for its accuracy and versatility in solar energy simulation. Acomprehensive analysis of key design parameters, such as system sizing, component selection, shading analysis, and energy yield estimation, was undertaken with a focus on maximizing efficiency and economic viability. Through the integration of PVSOL, valuable insights were provided into the intricate process of solar PV system design, addressing challenges, and offering practical solutions for the effective harnessing of solar energy. The outcomes of this research contribute to the advancement of the understanding of optimal solar PV system configurations, fostering the transition towards a more sustainable and resilient energy future.

Keywords: Sustainable energy, photovoltaic System, PVSOL Software.

I. INTRODUCTION
The escalating global demand for clean and sustainable energy solutions has propelled solar photovoltaic (PV) systems into the forefront of the renewable energy landscape. This research focuses on actively designing and optimizing solar PV systems through the utilization of PVSOL, a cutting-edge software tool renowned for its precision and adaptability in simulating solar energy scenarios. The study encompasses a thorough analysis of crucial design parameters, including system sizing, component selection, shading analysis, and energy yield estimation, with a primary goal of maximizing efficiency and economic feasibility. By integrating PVSOL into the design process, this research aims to provide actionable insights into the complex task of solar PV system design, addressing challenges and presenting practical solutions to enhance the effective harnessing of solar energy. The findings of this study contribute significantly to advancing the understanding of optimal solar PV system configurations, thereby promoting the transition towards a more sustainable and resilient energy future.

II. AIM AND OBJECTIVES OF THE STUDY
The aim of this study is to systematically investigate and optimize the design of solar photovoltaic (PV) systems using the PVSOL software, with the overarching goal of maximizing energy efficiency, economic viability, and contributing to the broader advancement of sustainable and clean energy practices. The objectives of the study are as follows:

1. To conduct a comprehensive review of existing literature on solar PV system design methodologies, software tools, and optimization techniques.
2. To analyse the capabilities and features of PVSOL in simulating solar energy scenarios and assessing their applicability to diverse PV system configurations.

3. To determine optimal sizing parameters for solar PV systems, considering factors such as location, climate, and energy demand.
4. To investigate the impact of shading on PV system performance and develop strategies for effective shading analysis and mitigation using PVSOL.
5. To evaluate the economic feasibility and financial implications of various solar PV system configurations designed with PVSOL.
6. To quantify and compare the energy yield of PVSOL-optimized solar PV systems against traditional design approaches.
7. To provide practical insights and recommendations for industry practitioners and policymakers based on the findings of the study.
8. To contribute to the broader discourse on sustainable energy by advancing knowledge in solar PV system design and optimization using PVSOL

III. LITERATURE REVIEW

Solar energy, one of the most reliable forms of renewable energy worldwide, could be harnessed using Photovoltaic (PV) technology. Generally, two types of PV configurations were in use: on-grid and off-grid systems. The on-grid PV system, a grid-connected array, could convert DC energy to AC energy with the assistance of suitable power conditioning technology and synchronizing the AC energy to the grid. Power was generated during the daytime when sunlight was abundant, ensuring that the average daily PV output matched the utility's peak demand period. A total production of 627 GW was observed globally, combining on-grid and off-grid capacity, which was substantially higher in comparison to the production of the last ten years [1].

In recent years, photovoltaics (PVs) has been the main driver of renewable energy market growth in Poland. The number of photovoltaic installations, most of which were rooftop prosumer systems, was consistently increasing. Therefore, the determination of the applicability and feasibility of photovoltaic systems under different climate conditions was of great significance.This study presented the performance analysis of four prosumer photovoltaic installations situated in the Eastern part of Poland, Lublin Voivodeship. The influence of various tilt angles, ranging from 19° to 40°, and azimuths (south, east, south–east, and east–west) on the final yield was determined under one year of operation (2022). The average yearly final yield was found to be 1022 kWh·kW−1, with the highest value obtained for the installation oriented towards the south, equal to 1079 kWh·kW−1.Subsequently, the PV systems were simulated using four specialized photovoltaic software: DDS-Cad 16, PVGIS 5.2, PVSOL premium 2022, and the PVWatts Calculator 8.2.1 [2].

The design and simulation of a grid-connected solar power system applied for Hyatt Regency Resort and Spa, located in Danang City, Vietnam, were delved into by the authors. An interesting feature of this paper was the usage of the PV*sol software to enhance the effectiveness of the design-and-simulation stage, which partly determined the performance of the implementation stage.During the design procedure, the values of the optimal sizing of all components of the Photovoltaic system, the power exchange with the grid, and the system loss were evidently calculated. Furthermore, the effectiveness of the paper was evaluated by the simulation results [3].

The significance of solar energy in the renewable energy sector was delved into by this research, emphasizing the necessity of utilizing sophisticated analysis and simulation tools for optimal design and optimization of solar photovoltaic (PV) systems. A thorough comparison of three leading software tools: PVSOL Premium, Excel, and PVsyst, was conducted, evaluating their features, accuracy, and suitability for solar energy analysis.

PVSOL Premium was commended for its user-friendly interface and comprehensive capabilities, while Excel offered flexibility despite its general-purpose nature. PVsyst was praised for its accuracy and advanced modelling algorithms [4].

METHODOLOGY

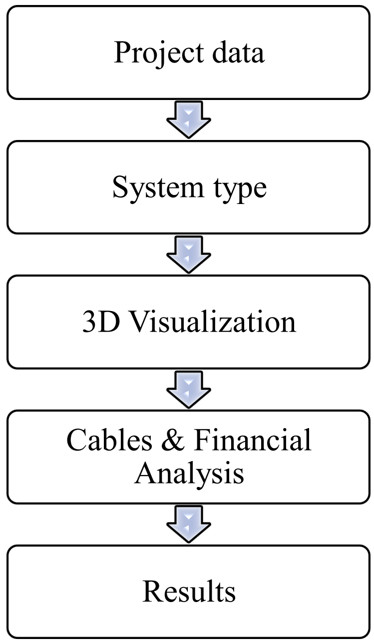

Figure 1. Processing chart of the study

IV. RESULT AND DISCUSSION

The designing and installation of 13 KW solar PV system for residential purpose. It is 3D grid connected solar PV system. In this PVSOL software the designing and installation of the system is distinguished into five parts. The designing starts with the model of the house and the location is allocated with the GPS system; the shading is considered. The solar panels used are silicon polycrystalline ELDORA VSP.60.250.03 with each of its efficiency about 14.92 to 16.24 and the nominal output power is from 240 W to 315 W. The inverter used is of Samsung inverter each of 4 to 6KW. The number of PV modules used is 69 and the number of inverters is 3, the PV generator output is 16.56KWp, the inclination of the panel is 15° and the orientation is of 180° with mounted roof installation type. The output power of the panels after installation is 100%, after a year later the efficiency drops to 5% i.e., 95% and after 10 years the efficiency is 80%.

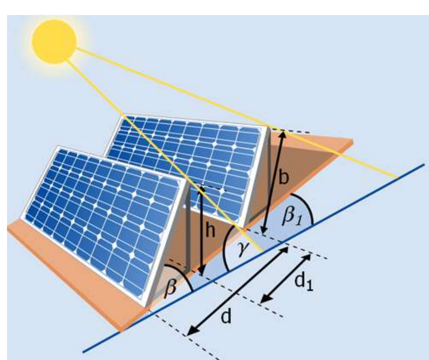

Figure 2

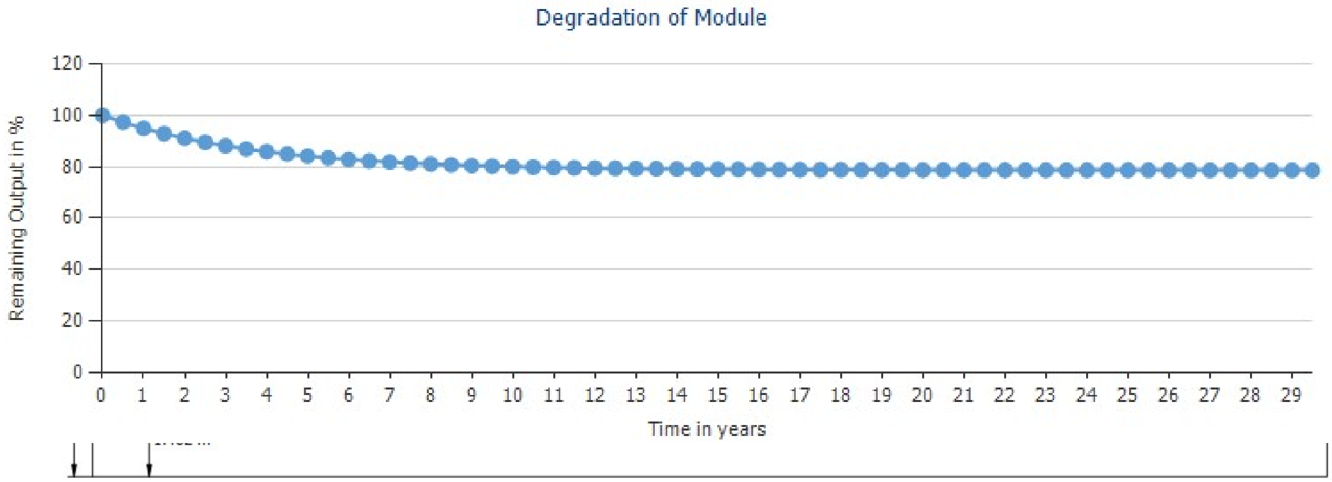

Figure 3. Dimensions of installed panels

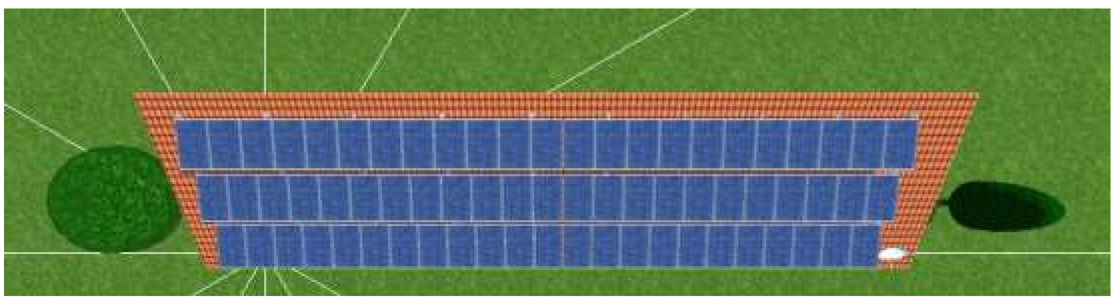

Figure 4. Overview

Figure 5. Deterioration of module

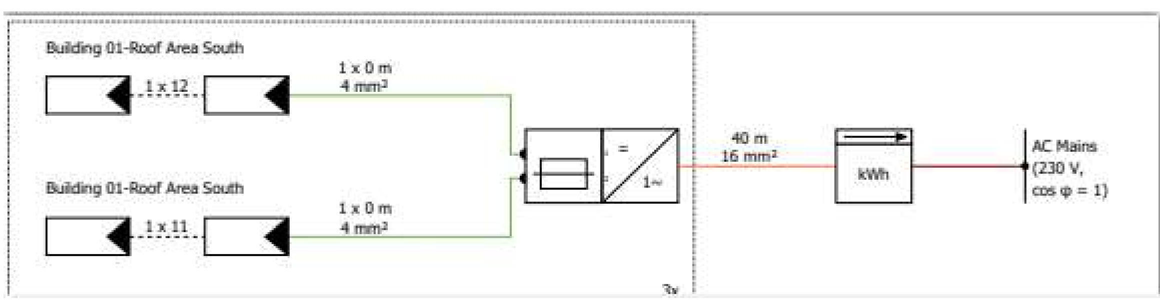

Figure 6. Single line diagram

Hence, PVSOL shows all the minute data of system parameters. In conclusion, PVSOL software provides the data of all the essential parameters which is crucial for designing the ideal PV solar system.

V. BENEFITS OF IMPLEMENTATION

1. Optimized Solar Energy Utilization: The study will provide insights into designing solar photovoltaic (PV) systems using PVSOL, contributing to enhanced energy capture and utilization.

2. Economic Viability: By evaluating economic feasibility, the research aims to assist stakeholders in making informed decisions regarding solar PV system investments, potentially lowering overall costs.
3. Increased Efficiency: The optimization strategies developed in this study have the potential to increase the overall efficiency of solar PV systems, leading to improved energy output.
4. Environmental Impact: The promotion of solar energy aligns with sustainable practices, reducing reliance on non-renewable sources and lowering greenhouse gas emissions, thus contributing to environmental conservation.
5. Knowledge Advancement: The study adds to the body of knowledge in solar PV system design, offering practical insights that can benefit researchers, engineers, and policymakers in the renewable energy sector

VI. FUTURE SCOPE OF THE STUDY

1. Technology Advancements: The study lays the groundwork for adapting to future technological advancements in solar energy and software tools like PVSOL, ensuring the continued relevance and applicability of the findings.
2. Integration with Smart Grids: As smart grid technologies advance, the optimized solar PV systems designed in this study can potentially integrate seamlessly, contributing to a more resilient and efficient energy infrastructure.
3. Policy Implications: The research outcomes may inform future energy policies by providing evidence-based insights into the economic and environmental benefits of PVSOL-optimized solar PV systems.
4. Global Applicability: The study's methodologies can be adapted to various geographic locations, allowing for global applicability and scalability in the design and implementation of solar PV systems.
5. Interdisciplinary Collaboration: Future research could explore interdisciplinary collaborations, incorporating insights from fields such as artificial intelligence, materials science, and energy storage to further enhance solar PV system performance.
6. Market Adoption: The study's recommendations could influence industry standards and encourage the widespread adoption of PVSOL and similar tools in the design and optimization of solar PV systems.

VII. CONCLUSION

In conclusion, this study has delved into the design and optimization of solar photovoltaic (PV) systems using the sophisticated PVSOL software. The exploration of key design parameters, such as system sizing, component selection, shading analysis, and economic feasibility, has yielded valuable insights into maximizing energy efficiency and economic viability.The findings underscore the significance of PVSOL as a powerful tool for simulating solar energy scenarios, enabling precise analysis and optimization of PV system configurations. The study has demonstrated the potential for increased efficiency and economic feasibility in solar PV system design, contributing to the broader goals of sustainable and clean energy.The analysis of shading effects on PV system performance has highlighted the importance of effective shading analysis and mitigation strategies, showcasing the practical utility of PVSOL in addressing real-world challenges. Furthermore, the economic evaluation provides stakeholders with a comprehensive understanding of the financial implications associated with different solar PV system configurations.

As the global transition to renewable energy gains momentum, the insights provided by this study contribute to the collective knowledge in solar PV system design and optimization. The methodologies and recommendations presented here can serve as a foundation for future research, technological advancements, and policy decisions in the renewable energy sector.In essence, the integration of PVSOL into solar PV system design processes offers a pathway towards unlocking the full potential of solar energy, fostering sustainability, and contributing to a cleaner and more resilient energy future. As we move forward, the lessons learned from this study can guide further innovations and advancements in the field, ultimately accelerating the global shift towards a more sustainable and environmentally conscious energy paradigm

VIII. REFERENCES

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