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An Evaluation of Solar Photovoltaic System Depreciation Using PVSOL

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ABSTRACT

This study provides a thorough examination of the design approaches for solar photovoltaic (PV) systems, utilizing the PVSOL software. Given the growing need for renewable energy sources, it is crucial to optimize solar PV installations. An in-depth analysis was conducted to determine the factors that influence the system's performance. These factors include the geographical location, shading effects, and module configurations. PVSOL is used to conduct a thorough analysis of these elements in order to assess their influence on the system's efficiency and amount of energy it produces. The study incorporates both theoretical analysis and practical simulations to offer significant insights into the design process. The results highlight the importance of meticulous design considerations in optimizing energy generation and system performance. This research enhances the development of solar PV technology by providing valuable information on the most effective ways to design optimal systems. This, in turn, helps to promote the shift towards sustainable energy alternatives.

***Keywords*--** PVSOL Software, PV (Photovoltaics), Solar PV System, Solar Modules

I. INTRODUCTION

The global shift towards renewable energy sources has heightened the significance of optimizing solar photovoltaic (PV) system designs to maximize energy output and efficiency. In this context, the utilization of advanced simulation software such as PVSOL has emerged as a crucial tool for engineers and researchers to analyze and refine PV system configurations. This paper presents an in-depth exploration of solar PV system design methodologies, focusing on the extensive utilization of PVSOL for comprehensive analysis. With the increasing complexity of PV system installations and the diverse range of influencing factors, there is a growing need for a systematic approach to design optimization.

By leveraging PVSOL, this study aims to provide valuable insights into the intricate interplay between various design parameters, including geographical location, orientation, shading effects, and module configurations. Through a combination of theoretical analysis and practical simulations, this research endeavors to elucidate the key factors driving system performance and energy generation. By shedding light on the nuances of PV system design employing PVSOL, this study contributes to advancing the understanding and implementation of efficient solar energy solutions in the transition towards a sustainable future.

This paper embarks on a comprehensive exploration of solar PV system design methodologies, with a specific focus on the extensive utilization of PVSOL for meticulous analysis. In an era where the demand for clean energy solutions continues to surge, the need for meticulous design optimization has never been more pressing. Through a blend of theoretical insights and practical simulations, this research aims to offer valuable guidance for engineers and stakeholders navigating the complex terrain of solar PV system design. Ultimately, by illuminating the path towards optimized energy generation through PVSOL-driven analysis, this study seeks to propel the advancement of sustainable energy solutions in the quest for a greener tomorrow.

II. LITERATURE REVIEW

A. Overview

The literature surrounding solar photovoltaic (PV) system design serves as a rich tapestry of insights into the intricate factors influencing system performance and efficiency. Across a diverse array of studies, researchers have delved into various facets of PV system design, emphasizing the pivotal role of meticulous planning and analysis in realizing optimal energy generation. Geographical considerations, including solar irradiance levels and climatic variations, have been highlighting the profound impact of location on PV system output. Moreover, investigations into module configurations have elucidated the significance of factors like orientation, tilt angle, and spacing in maximizing energy yield. This literature review provides a foundation for the present study, which seeks to address this gap by conducting a comprehensive examination of solar PV system design utilizing PVSOL software. By synthesizing insights from existing research and leveraging advanced simulation techniques, this study aims to contribute to the body of knowledge surrounding optimized energy solutions in the renewable energy domain.

B. Literature Survey

M.Pushpavalli [1] In their paper the three PV module areas—one each for a dual axis, single axis, and no axis tracking system—are examined in their research using the PVSOL software. This dual axis tracking device allows for the observation of a PV module's temperature and irradiance. Because of this, that module produces a lot of energy.

Abdullah Al Mehadi [2] this study presents the design, simulation, and analysis of the monofacial photovoltaic module installed on the roof of the residence hall in IUT's North Hall. Three separate pieces of software were used to construct and assess a comprehensive 3D design [3]-[5]. According to a research paper [6], electric vehicle technology is now developing quickly and could eventually supplant conventional autos. It is based on modeling using PVSOL software [7]- [10] To ascertain the technical performance of a 6.4 kW grid-connected rooftop solar PV system for a household to supply power, a simulation study was conducted, and the results are included in their article as a comprehensive case study [11]- [13]. They analyzed several climate zones in their study. The real production data from the power plants in seven different provinces are compared to the production data computed using the PVsyst, PVSOL, and HOMER software. The PV simulation software PVSOL Premium, which is described in this paper, is used to design three-dimensional (3-D) building blocks with solar panels [14]- [16].

III. METHODOLOGY & SYSTEM EVALUATION

A. System Methodology

PVSOL is a widely used software tool for simulating and designing photovoltaic (PV) systems. Developed by Valentin Software, it is utilized by engineers, architects, and solar energy professionals to accurately model and optimize solar power installations for various applications, including residential, commercial, and industrial settings. Users can design PV systems of various complexities using PVSOL. The software enables the specification of PV modules, inverters, batteries (if applicable), and other system components. It allows for the customization of system layouts, including roof-mounted, ground-mounted, and facade-integrated installations. The PVSOL methodology begins with the input of various parameters that define the characteristics of the PV system and its operating environment. These parameters include geographic location (latitude, longitude), system orientation (tilt angle, azimuth), PV module specifications (type, efficiency), inverter specifications (type, efficiency), shading information, weather data, electricity tariffs, and financial parameters.

PVSOL allows users to simulate different system configurations and scenarios to optimize system performance and financial returns. This may involve adjusting parameters such as system size, tilt angle, azimuth, module orientation, inverter sizing, and battery storage options to find the most cost-effective solution. PVSOL has become a widely used software tool in the solar energy industry for designing and evaluating solar PV systems with precision and confidence.

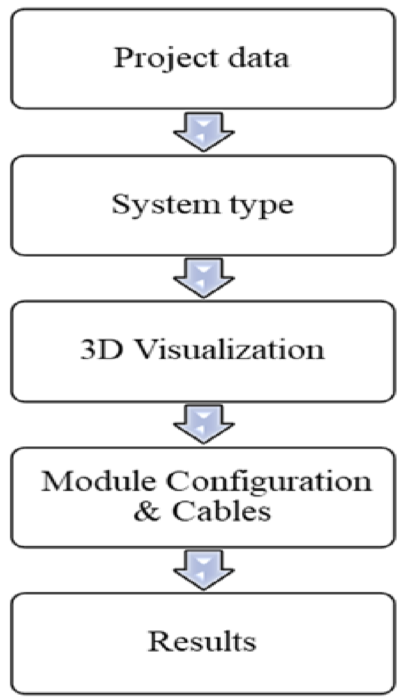

Figure 1: System Methodology

The designing of 13 KW residential solar PV plant involves the systematic process for the simulation. It includes lean of the project date like the name, organization then the system type, climate information, grid connection whether it is on grid or off grid. Next is the 3D Design / Visualization again it focuses on many of the sub parts, the system configuration, selecting of the cables. Thus, after setting up the data, it gives the respective results of the respective simulation of the system.

B. System Evaluation

When inputting project data into PVSOL software, it is essential to ensure accuracy and completeness. Begin by gathering relevant information such as geographical location coordinates, site characteristics, weather data, and electricity consumption patterns. Input these parameters meticulously into the software, specifying factors like tilt angle, azimuth, shading analysis, and system configuration details. By maintaining transparency and integrity in your data input process, you can effectively design and simulate solar PV projects within PVSOL software. The name of the project is Solar PV system, the selected location is Dhule, Maharashtra, India. The latitude is 20.92° and the longitude is 74.78° according to the meteorological data of the location through the GPS system.

In PVSOL software, "System Type" refers to the configuration or setup of the photovoltaic (PV) system being modeled. This includes details such as the type and arrangement of solar panels, inverters, mounting structures, and other components. Different system types may include grid-connected systems, off-grid systems, hybrid systems (combining solar with other energy sources like wind or diesel generators), rooftop installations, ground-mounted installations, etc. Selecting the appropriate system type is crucial for accurately simulating the performance and behavior of the PV system under specific conditions.

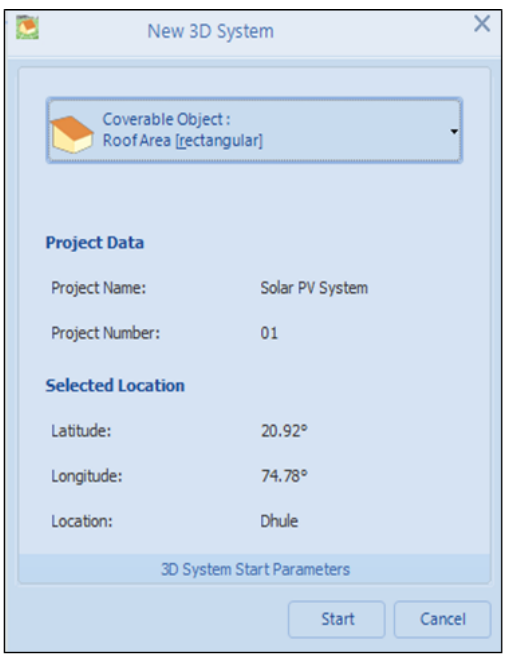

Figure 2: Project data

The "Climate" setting in PVSOL software refers to the local weather conditions and environmental factors at the site where the PV system is installed. This includes parameters such as solar irradiance levels, temperature variations, humidity, wind speed, and precipitation. Accurately modeling the climate conditions is essential for predicting the energy output and performance of the PV system over time. PVSOL software typically provides options to input specific climate data or select from predefined climate profiles based on geographical location.

3D visualization in PVSOL software offers a dynamic way to visualize photovoltaic (PV) systems within their real-world environment. This feature provides a detailed representation of the solar installation, including the solar panels, mounting structures, surrounding buildings, terrain, and other relevant elements. Here is a breakdown of the 3D visualization feature in PVSOL. In PVSOL software, the "Terrain View" feature provides users with a detailed representation of the terrain surrounding the photovoltaic (PV) system installation site. The Terrain View feature allows users to visualize the topography of the installation site. It displays elevation changes, slopes, and contours of the terrain, providing crucial information for assessing the suitability of the site for solar energy production. The Terrain View feature also incorporates shading analysis, considering the terrain's elevation, and surrounding objects such as buildings, trees, or other obstructions.

In PVSOL software, the "Object View" feature provides users with a detailed representation of the photovoltaic (PV) system components within the 3D environment. Overall, the Object View feature in PVSOL software facilitates detailed visualization, design, and optimization of PV system components within the 3D environment. It empowers users to create accurate, visually appealing representations of their solar energy projects and make informed decisions throughout the design process. The parabolic antennas are included on the terrace.

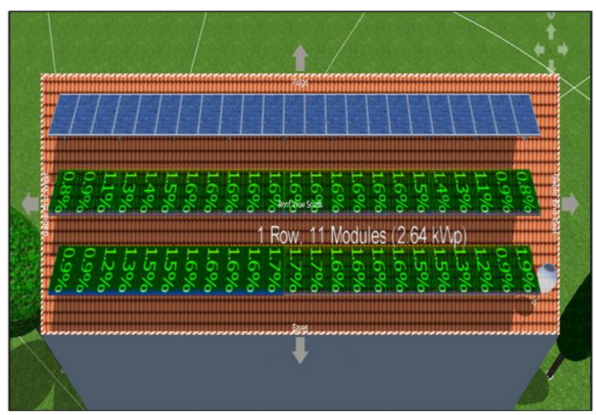

Figure 3: Module mounting

Module coverage refers to the extent to which solar modules (photovoltaic panels) cover or occupy a given area on a rooftop or ground-mounted installation. Module coverage indicates the portion of the available installation area that is covered by solar modules. This can be expressed as a percentage or area measurement. Module coverage in PVSOL software plays a crucial role in optimizing the design, layout, and performance of photovoltaic systems by maximizing the utilization of available space and minimizing shading effects. The solar PV panel is of Eldora Prime 240 (Vikram Solar Pvt. Ltd). Its cell type is of Silicon Polycrystalline with efficiency of each cell is 14.92 %, its nominal output voltage is 240 KW and its MPP voltage in V is 30.6 V and MPP current in A is 7.85 Amp. In total 69 Solar panels are used.

Mounting modules in PVSOL software involves specifying the layout and configuration of solar panels within the software's interface. PVSOL software typically offers various mounting systems like fixed, adjustable, or tracking. Select the appropriate mounting system based on project requirements, site conditions, and budget constraints. There are 11 modules in 1 row and each of 2.64 KWp.

The inverter selected is of Samsung SDI Co. Ltd. The inverter is all in one 4, 6 KW inverter. The total inverters used are 3 i.e., 3*5.52KWp = 16.56 KWp. MPP 1: 1 String x 12 Modules in series. MPP 2: 1 String x 11 Modules in series. The orientation is 180.0° & Inclination is 15.0°.

C. Module Configuration

Within the PVSOL software, users define the configuration of solar modules, including their type, placement, and electrical connections. Users can select from a range of module types such as monocrystalline, polycrystalline, or thin-film, each with unique characteristics affecting energy production. Through the software's interface, modules are positioned on mounting structures, ensuring optimal spacing to minimize shading and maximize sunlight exposure. Electrical configurations, such as series or parallel connections, are specified to achieve the desired voltage and current output for the PV system. Additionally, parameters like module tilt angle and orientation are adjusted to optimize solar irradiance capture based on site-specific conditions.

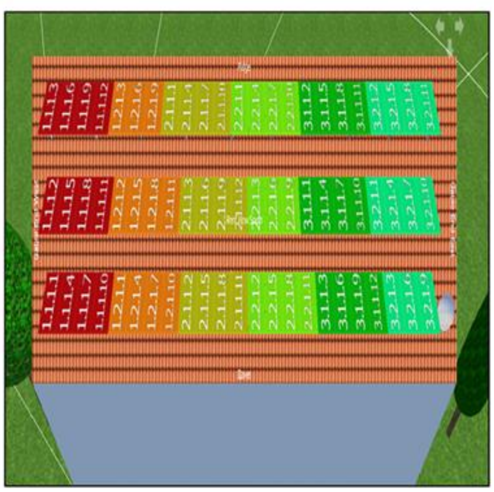

Figure 4: Module configuration

D. Shading Analysis

Shading analysis in PVSOL software involves assessing the impact of obstructions on solar panel performance, such as nearby buildings, trees, or terrain features. The software utilizes advanced algorithms to predict shading patterns throughout the day and across different seasons, considering factors like sun position, object height, and shading geometry. By accurately modeling shading effects, users can identify potential areas of energy loss and adjust the module layout accordingly to mitigate shading-induced performance reductions.

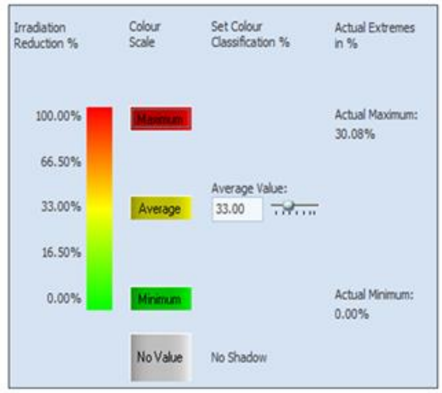

Figure 5: Color classification for shade frequency

E. Cables

Selecting the appropriate cables within PVSOL software is a critical aspect of designing a photovoltaic (PV) system, ensuring efficient energy transmission while maintaining safety and compliance with electrical standards. Users typically begin by specifying the electrical characteristics of the PV array, including the total power output and system voltage. Based on these parameters, the software recommends cables with suitable cross-sectional areas and voltage ratings to handle the expected current and minimize power losses due to resistance. PVSOL software provides access to a database of cables from various manufacturers, each offering a range of options in terms of conductor material, insulation type, and size. Users can filter cables based on criteria such as maximum current carrying capacity, voltage drop, and temperature rating to identify the most suitable options for their specific project requirements.

IV. RESULTS

In PVSOL software, module mounting refers to the process of configuring and positioning solar panels within a photovoltaic (PV) system design. This entails selecting the appropriate mounting structure, whether it be rooftop, ground-mounted, or integrated systems, and placing the modules optimally to maximize energy production. PVSOL offers various mounting options and

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allows users to adjust parameters such as tilt angle, orientation, and spacing between modules to achieve the desired performance. Through accurate module mounting configurations, PVSOL enables users to simulate and analyze the efficiency and output of their solar installations, aiding in the design of cost-effective and reliable PV systems. Below is detailed plan of solar panel installation and its overview.

The outcome of a solar PV plant simulation offers a comprehensive depiction of the system's performance and characteristics. This encompasses a detailed analysis of energy production, considering factors such as irradiance, temperature variations, shading effects, and losses within the system. The software provides insights into both AC and DC energy generation, offering estimates for different time intervals, including daily, monthly, and annual projections. Additionally, PVSOL facilitates a thorough yield analysis, breaking down energy generation by individual components like modules, inverters, and strings, aiding in the identification of potential bottlenecks or areas for optimization.

Module degradation analysis is a crucial aspect of assessing the long-term performance of a solar PV system. This feature allows users to model the gradual decline in the efficiency and output of solar modules over time due to various factors such as exposure to sunlight, temperature variations, and environmental conditions. PVSOL incorporates module degradation models based on empirical data and industry standards to accurately simulate the deterioration of module performance over the system’s lifetime.

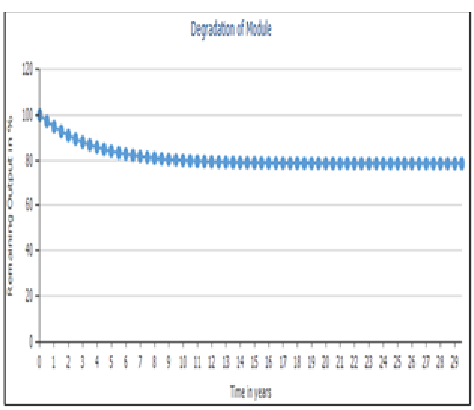

Figure 6: Degradation of module

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 design and installation of the system is distinguished into five parts. The design starts with the house's model 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%. 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. CONCLUSION

In conclusion, this project has delved into designing and optimizing 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.

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