JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

Optimizing Solar Photovoltaic Systems An Analysis of PV*SOL Premium, Excel, and PVsyst

[1] Tejpal Singh Dara, [2]Ms. Indu , Ms. Kalpana Meena

[1]M. Tech Scholar, [2,3]Assistant Professor

[1,2]Department of Electronics and Communication Engineering.(VLSI Design), College Name, Jaipur, Rajasthan

Abstract: This research delves into the significance of solar energy in the renewable energy sector and highlights the necessity of utilizing sophisticated analysis and simulation tools for optimal design and optimization of solar photovoltaic (PV) systems. It conducts a thorough comparison of three leading software tools: PVSOL Premium, Excel, and PVsyst, evaluating their features, accuracy, and suitability for solar energy analysis. PVSOL Premium is commended for its user-friendly interface and comprehensive capabilities, while Excel offers flexibility despite its general-purpose nature. PVsyst is praised for its accuracy and advanced modeling algorithms. The abstract emphasizes the importance of this comparative analysis in aiding stakeholders to choose the most suitable tool for their needs, enhancing efficiency in PV system design processes and informing policy decisions to accelerate the adoption of solar energy and achieve renewable energy goals.

***Index Terms* - Solar energy, renewable energy, analysis tools, simulation tools, photovoltaic systems, PV*SOL Premium, Excel, PVsyst.**

I. Introduction

The increasing global emphasis on renewable energy sources has propelled solar energy to the forefront of the transition away from fossil fuels. Solar photovoltaic (PV) systems, in particular, have garnered significant attention due to their scalability, versatility, and environmental benefits. As countries and industries strive to meet ambitious sustainability targets, optimizing the performance of solar PV systems has become imperative [1]. Central to the design and optimization of solar PV systems are analysis and simulation tools that enable engineers, researchers, and policymakers to assess various parameters and configurations. These tools not only facilitate the evaluation of energy generation potential but also aid in the identification of optimal system designs, layouts, and components. Among the multitude of software solutions available, three prominent tools stand out: PV*SOL Premium, Excel, and PVsyst [2].

PV*SOL Premium is renowned for its comprehensive features and intuitive interface, providing users with the ability to model and simulate complex solar PV systems with ease. Its sophisticated algorithms enable accurate prediction of energy yields under different environmental conditions, making it a preferred choice for professionals in the solar energy industry [3]. While not specifically designed for solar analysis, Excel offers unparalleled flexibility and widespread usability. Its familiar spreadsheet interface allows users to customize calculations and models to suit their unique requirements. Despite its versatility, Excel may require additional effort and manual intervention for complex solar energy analysis tasks [4].

In contrast, PVsyst is celebrated for its advanced modeling capabilities and precise simulation algorithms. Widely used for detailed feasibility studies and optimization of PV systems, PVsyst offers unmatched accuracy in predicting energy generation and system performance [5]. This paper embarks on a comprehensive comparative analysis of these three software tools, aiming to evaluate their features, accuracy, and suitability for solar energy analysis and PV system optimization. By scrutinizing their strengths and limitations, this study seeks to empower stakeholders with the knowledge necessary to make informed decisions regarding the selection and utilization of these tools [6].

Furthermore, the insights derived from this comparative analysis have broader implications beyond individual system design. Informed decision-making enabled by this research can guide policy initiatives, investments, and strategic planning efforts aimed at accelerating the adoption of solar energy and fostering sustainable energy transitions. In conclusion, this paper sets out to explore the intricate landscape of solar energy analysis tools, providing a foundation for enhanced efficiency, innovation, and progress in the field of solar PV system design and implementation [7].

1.1 Scope of Research:

This research focuses on comparing and evaluating three prominent software tools - PV*SOL Premium, Excel, and PVsyst - used for solar energy analysis and optimization of photovoltaic (PV) systems. The scope encompasses an in-depth examination of the features, accuracy, and suitability of each tool for various applications related to solar energy generation and system design. The comparison includes aspects such as user interface, modeling capabilities, simulation accuracy, and flexibility, with the aim of providing valuable insights to stakeholders involved in solar energy projects [8].

1.2 Problem Statement:

The optimization of solar PV systems requires the selection of appropriate analysis and simulation tools that can accurately assess energy generation potential and facilitate efficient system design. However, the wide array of available software options makes it challenging for stakeholders to identify the most suitable tool for their specific needs. Consequently, there is a need for comprehensive research to compare and evaluate leading software tools in the field of solar energy analysis, thereby assisting stakeholders in making informed decisions regarding tool selection and utilization [8].

1.3 Objective of Research:

The primary objective of this research is to conduct a comparative analysis of PV*SOL Premium, Excel, and PVsyst to assess their features, accuracy, and suitability for solar energy analysis and PV system optimization. Specific objectives include:

- Evaluate the user interface and usability of each software tool for solar energy analysis tasks.
- Assess the modeling capabilities and simulation accuracy of the software tools in predicting energy generation from PV systems.
- Compare the flexibility and customization options offered by each tool for adapting to diverse project requirements.
- Identify the strengths and limitations of PV*SOL Premium, Excel, and PVsyst for different applications in solar energy analysis and system optimization.
- Provide recommendations and insights to stakeholders, including engineers, researchers, and policymakers, to aid in the selection and utilization of solar energy analysis tools for efficient PV system design and implementation.

II. Literature Review

O. Younis, et al [9]present a computer platform designed for automated analysis of associations among solar events. Leveraging association algorithms, the platform scrutinizes extensive solar catalog data spanning solar flares, eruptive filaments, and Coronal Mass Ejections (CMEs). Its goal is to amalgamate disparate solar data catalogues into a dynamic space weather database for comprehensive solar activity analysis. This tool identifies association patterns and furnishes numerical representations suitable for machine learning algorithms and real-time prediction systems.

Limodio, G., et al. (2022)focus on conducting a Life Cycle Assessment (LCA) of thin-film solar panels manufactured in the Netherlands. Utilizing real data from the factory floor, they estimate the environmental footprint of various manufacturing stages. Their assessment evaluates the influence of technological advancements, such as enhanced efficiency and differing deposition rates, alongside considerations of large-scale utilities and location specifics.

P. Gupta., et al. [10] present the design and performance analysis of a three-axis solar tracker system aimed at optimizing solar panel alignment throughout the day. By dynamically adjusting the panel's height to track the sun's movement and mitigate shading from obstructions like buildings and trees, the system significantly enhances power output compared to static panels and dual-axis trackers.

M. Umer, et al. [11]investigate the efficacy of a solar thermal-based domestic hot water system using TRNSYS modeling. Their simulation, based in Lahore, Pakistan, incorporates a flat plate solar collector and a 0.6 m3 tank. An auxiliary electric heater supplements hot water demand during low-sunlight periods, resulting in an average solar fraction of 80% annually, ensuring hot water availability even in winter.

A. R. Kalair, et al. [12] model and analyze a solar heat and light stimulated trigeneration system tailored for residential and commercial applications in Melbourne, Australia. Integrating active and passive solar electro-thermal technologies, their design aims to meet energy requirements with minimal reliance on auxiliary or grid energy, potentially enhancing overall performance and space utilization in buildings.

III. Methodology

The methodology for conducting a comparative analysis of solar energy analysis tools—PV*SOL Premium, Excel, and PVsyst—involves several systematic steps to ensure a thorough evaluation and effective utilization of each software. Here's a suggested methodology:

Step 1: Familiarization

Begin by gaining a comprehensive understanding of each software tool. Explore their features, user interfaces, and available documentation or tutorials provided by the respective developers.

Step 2: System Requirements

Verify that your computer meets the system requirements for installing and running the software tools. Check compatibility with your operating system, available memory, and any additional hardware or software dependencies.

Step 3: Data Collection

Gather the necessary data for solar energy analysis, including location-specific weather data (solar radiation, temperature, wind speed), site characteristics, module and inverter specifications, electrical components, and any other relevant information required by the software tools.

Step 4: PVSOL Premium

a. Install and launch PVSOL Premium.

b. Input project parameters such as location, roof or site layout, orientation, tilt angle, shading objects, module technologies, and system losses.

c. Utilize the software's simulation capabilities to predict PV system energy production based on the input data.

d. Explore different design scenarios, optimize system configurations, and assess the impact of various factors on energy yield.

Step 5: Excel

a. Create a spreadsheet in Excel for custom calculations and models for solar energy analysis.

b. Input collected data, such as solar irradiation, temperature, system losses, and other relevant parameters.

c. Utilize Excel's formulas and functions to calculate solar panel output, system performance, financial metrics, or any other desired analysis.

d. Generate charts, graphs, or tables to visualize results and facilitate data interpretation.

Step 6: PVsyst

a. Install and open PVsyst.

b. Enter project-specific data, including geographical location, weather data, system configuration, and component specifications.

c. Utilize PVsyst's simulation capabilities to analyze PV system performance considering shading effects, module behavior, electrical losses, and other factors.

d. Generate energy yield predictions, performance reports, and financial analysis using the software's comprehensive features.

Step 7: Comparison and Integration

a. Compare results obtained from PV*SOL Premium, Excel, and PVsyst to validate accuracy and consistency of the analysis.

b. Identify any discrepancies or differences in outputs and investigate potential reasons.

c. Integrate results from different software tools to gain a comprehensive understanding of solar energy analysis, considering both technical and financial aspects.

Step 8: Analysis and Interpretation

a. Analyze generated results and interpret findings.

b. Evaluate PV system performance in terms of energy production, system losses, financial metrics, and other relevant parameters.

c. Assess feasibility, viability, and potential improvements of the solar installation based on analysis conducted with software tools.

Step 9: Documentation and Reporting

a. Document methodology, input data, software settings, and analysis results for future reference and reproducibility.

b. Prepare clear, concise reports or presentations summarizing the solar energy analysis process and outcomes.

c. Communicate findings effectively to stakeholders involved in the solar energy project.

Note: Adapt the methodology as needed based on project requirements and user preferences.

IV. RESULT ANALYSIS

4.1 Dataset

The NASA Surface Meteorology and Solar Energy (SSE) Release 6.0 Data Set provides a comprehensive compilation of solar energy and surface meteorological conditions spanning a period of 22 years from July 1983 to June 2005. Its primary focus is on "Insolation Incident On A Horizontal Surface," which quantifies the solar radiation energy received on a horizontal surface at specific Earth locations, expressed in kilowatt-hours per square meter per day (kWh/m^2/day). This dataset offers both monthly and annual averages of insolation data, accessible to interested researchers and analysts through the provided URL. Organized based on geographical coordinates, with each region representing a 1x1 degree area on Earth's surface, the dataset presents regional averages rather than point-specific information. Users can access additional details regarding the methodology and accuracy of the SSE dataset online. In summary, the NASA SSE Release 6.0 Data Set serves as a valuable resource for researchers and organizations engaged in solar energy and meteorological research, offering extensive insolation data for analysis and research endeavors.

4.2 Results

latitude	40
longitude	-74

parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	dec
S_H	3.23	3.91	5.11	6.28	6.99	7.69	7.33	6.85	5.86	4.48	3.45	3
Latitude	30	30	30	30	30	30	30	30	30	30	30	30
Longiude	31	31	31	31	31	31	31	31	31	31	31	31
Day Number	21	52	80	111	141	172	202	233	264	294	325	355
Declanation	-20.155463	-11.2022	-0.3453	11.66	20.2163	23.5	20.446	11.706	-0.291	-11.9	-20.5	-23.5
Alpha	39.844537	48.79782	59.6547	71.66	80.2163	83.5	80.446	71.706	59.709	48.14	39.47	36.501
Beta (calcuations)	53.499104	53.4991	53.4991	53.499	53.4991	53.4991	53.499	53.499	53.499	53.5	53.5	53.499
beta(desing)	60	60	60	60	60	60	60	60	60	60	60	60
Sm	4.9648055	4.91683	5.14195	4.938	4.53304	4.5972	4.7273	5.3809	5.8903	5.713	5.351	5.0089
Sm(mini)	4.533037112											
Sm(max)	5.890252732											
P.S.H	5.096971311											

Fig 4.1 Excel Calculation

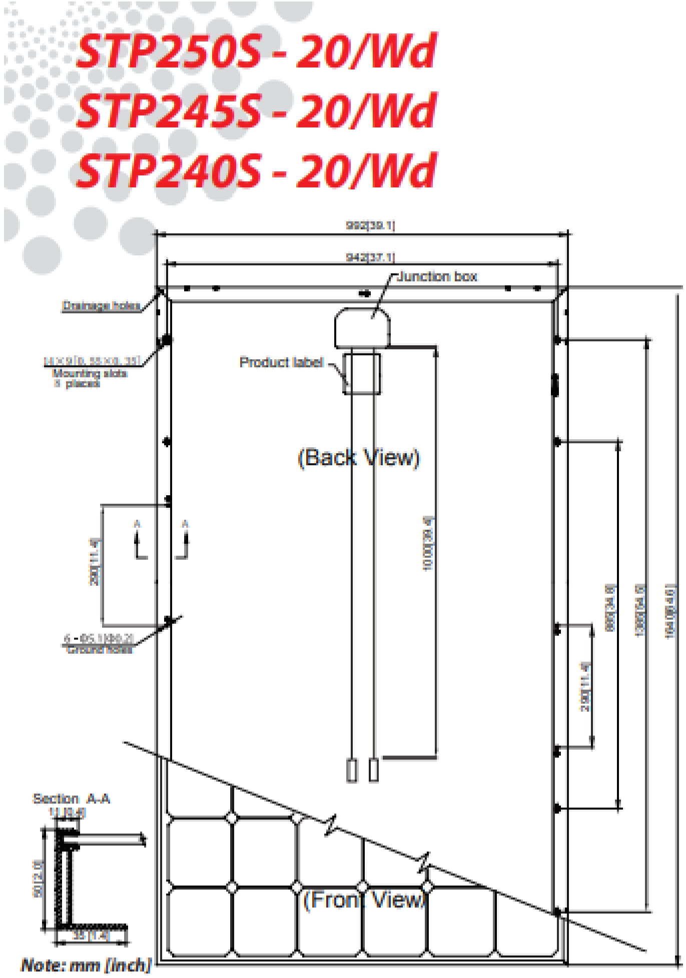

Fig 4.2 Solar Panels in Consideration

The solar panel specifications provided include three models: STP250S-20/Wd, STP245S-20/Wd, and STP240S-20/Wd.

For each model:

- The prefix "STP" likely represents the manufacturer's brand or a specific product line.
- The numerical value following "STP" denotes the power output of the solar panel in watts (W). For example, STP250S-20/Wd has a power output of 250 watts.
- The letter "S" may indicate a particular series or model within the manufacturer's product lineup.
- The number following the power output represents the voltage rating of the panel. For instance, "20" suggests an operating voltage of around 20 volts (V).
- The significance of "Wd" is less clear and may refer to a specific variant or feature of the panel, but further information from the manufacturer is needed to determine its exact meaning.

In summary, these solar panels vary in power output (ranging from 240 to 250 watts) and likely share similar characteristics such as operating voltage and series designation. However, the exact interpretation of the "Wd" designation requires additional context from the manufacturer.

NOCT	STP250S-20/ Wd	STP245S-20/ Wd	STP240S-20/ Wd
Maximum Power at NOCT (Pmax)	183 W	180 W	177 W
Optimum Operating Voltage (Vmp)	27.9 V	27.8 V	27.7 V
Optimum Operating Current (Imp)	6.55 A	6.46 A	6.39 A
Open Circuit Voltage (Voc)	34.4 V	34.3 V	34.2 V
Short Circuit Current (Isc)	6.96 A	6.89 A	6.81 A

NOCT: Irradiance 800 W/m², ambient temperature 20 °C, AM=1.5, wind speed 1 m/s;
Best in Class AAA solar simulator (IEC 60904-9) used, power measurement uncertainty is within +/- 3%

Fig 4.4 NOCT

Table 4.1 On-Grid Solar Calculations

Paramters	Jan	Feb	March	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
S_H	1.8	2.71	3.85	4.62	5.82	6.53	6.91	5.99	4.47	2.91	1.8
Latitude	41.902782	41.902782	41.902782	41.9028	41.9028	41.9028	41.9028	41.902782	41.9028	41.9028	41.902
Longitude	12.496365	12.496365	12.496365	12.4964	12.4964	12.4964	12.4964	12.496365	12.4964	12.4964	12.496
Day Number	21	52	80	111	141	172	202	233	264	294	32
Num.(days)	31	28	31	30	31	30	31	31	30	31	3
Declination	-20.15546	-11.20218	-0.3452533	11.6596	20.2163	23.5	20.4462	11.706265	-0.29149	-11.861	-20.53
Elevation	27.941755	36.895036	47.7519647	59.7568	68.3135	71.5972	68.5434	59.803483	47.8057	36.2367	27.563
Beta(calculations)	41.902782	41.902782	41.902782	41.9028	41.9028	41.9028	41.9028	41.902782	41.9028	41.9028	41.902
Beta(desing)	45	45	45	45	45	45	45	45	45	45	4
Sm	3.6734322	4.4704198	5.19720758	5.17433	5.7558	6.15814	6.81112	6.7040897	6.02875	4.86696	3.7946

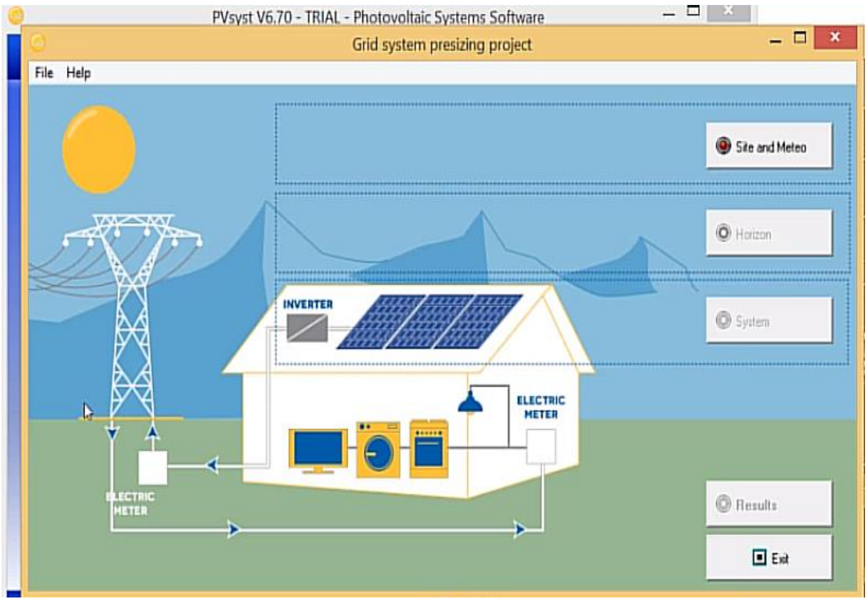

Fig 4.5 Site Design

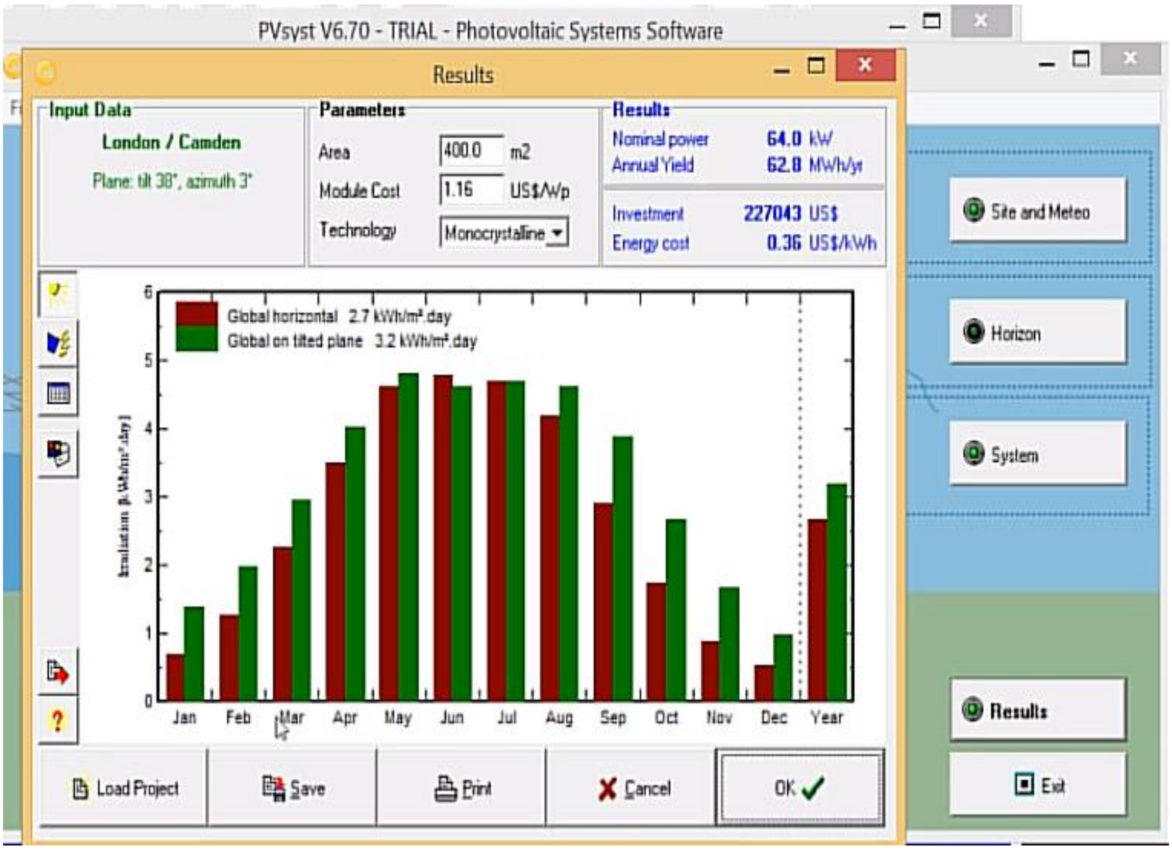

Fig 4.6 Power Yield

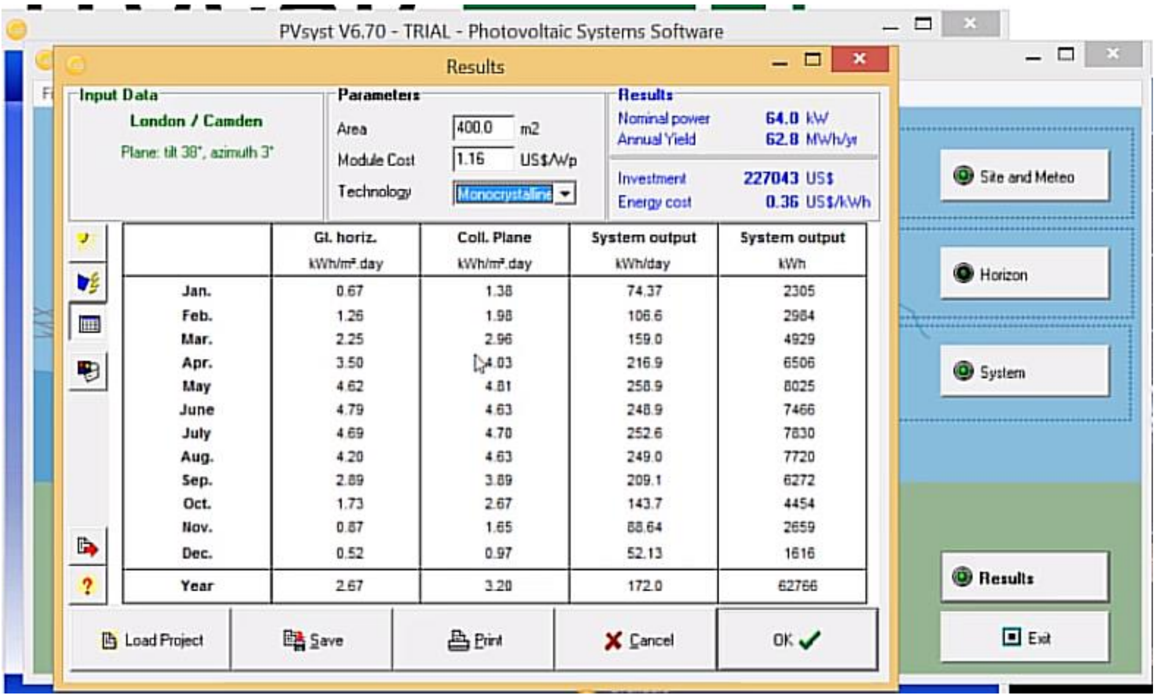

Fig 4.7 System Output

V. CONCLUSION

In summary, this research has provided comprehensive insights into the comparative analysis of three prominent software tools for solar energy analysis: PVSOL Premium, Excel, and PVsyst. Through meticulous evaluation of their capabilities, accuracy, and suitability for solar photovoltaic (PV) system design and implementation, several key conclusions have emerged. Firstly, each tool caters to diverse application scenarios, with PVSOL Premium offering user-friendly features for quick studies, Excel providing flexibility albeit with more manual effort, and PVsyst serving as a specialized, comprehensive tool for in-depth analysis. Secondly, PVsyst exhibited superior accuracy and precision in simulating solar energy generation due to its robust algorithms and comprehensive parameter consideration. Thirdly, PVSOL Premium stood out for its ease of use and intuitive interface, making it accessible to a broader audience, while Excel requires a deeper understanding of solar energy concepts. Lastly, considerations of cost and accessibility highlight PVSOL Premium and Excel as more cost-effective and accessible options compared to the specialized and investment-intensive PVsyst. Overall, stakeholders should weigh these factors carefully to select the most suitable software tool based on their specific needs and budget constraints.

REFERENCES

1. A. Shubham and K. Padmanabh, "Solar power prediction using deduced feature of visibility index and artificial neural network", 2017 International Conference on Advances in Computing Communications and Informatics (ICACCI), pp. 97-102, 2017.
2. A. Tuohy, "Solar Forecasting: Methods Challenges and Performance", IEEE Power and Energy Magazine, vol. 13, no. 6, pp. 50-59, Nov.Dec. 2015. S. Jose and R. L. Itagi, "Data Analytics in Solar Photovoltaics Power Forecasting for Smart Grid Applications," *2021 International Conference on Intelligent Technologies (CONIT)*, Hubli, India, 2021, pp. 1-5, doi:
3. M. Zhang, Z. Miao and L. Fan, "Data Analytics of Real-World PV/Battery Systems", 2019 IEEE Power & Energy Society General Meeting (PESGM), pp. 1-5, 2019.
4. B. E. Meyers, E. Apostolaki-Iosifidou and L. T. Schelhas, "Solar Data Tools: Automatic Solar Data Processing Pipeline", 2020 47th IEEE Photovoltaic Specialists Conference (PVSC), pp. 0655-0656, 2020.
5. E. Geraldi, F. Romano and E. Ricciardelli, "An Advanced Model for the Estimation of the Surface Solar Irradiance Under All Atmospheric Conditions Using MSG/SEVIRI Data", IEEE Transactions on Geoscience and Remote Sensing, vol. 50, no. 8, pp. 2934-2953, Aug. 2012.
6. W. F. Holmgren, A. T. Lorenzo and C. Hansen, "A Comparison of PV Power Forecasts Using PVLib-Python", 2017 IEEE 44th Photovoltaic Specialist Conference (PVSC), pp. 1127-1131, 2017.
7. W. F. Holmgren and D. G. Groenendyk, "An open source solar power forecasting tool using PVLIB-Python", 2016 IEEE 43rd Photovoltaic Specialists Conference (PVSC), pp. 0972-0975, 2016.
8. G. Limodio, S. Makhlouf, E. Hamers and A. Smets, "Life Cycle Assessment analysis of thin-film, flexible solar panels produced in the Netherlands," *2022 IEEE 49th Photovoltaics Specialists Conference (PVSC)*, Philadelphia, PA, USA, 2022, pp. 0606-0606.
9. O. Younis, Y. Tashtoush, M. Alomari and O. Darwish, "A Platform for Automated Solar Data Analysis Using Machine Learning," *2022 Ninth International Conference on Social Networks Analysis, Management and Security (SNAMS)*, Milan, Italy, 2022, pp. 1-4.
10. P. Gupta, V. Gupta, M. Sharma, R. K. Pachauri and J. Akhtar, "Design and Performance Analysis of Three axis Solar Tracking System," *2022 7th Asia Conference on Power and Electrical Engineering (ACPEE)*, Hangzhou, China, 2022, pp. 1876-1880.
11. M. Umer, S. Dilshad, A. Akbar and N. Abas, "Simulation Analysis of Solar Thermal Water Heating System for Climate of Lahore," *2022 International Conference on Emerging Trends in Electrical, Control, and Telecommunication Engineering (ETECTE)*, Lahore, Pakistan, 2022, pp. 1-6.
12. A. R. Kalair, M. Seyedmahmoudian, S. Mekhilef and A. Stojcevski, "Dynamic Analysis of Solar Heat Stimulated Residential Absorption Cooling with Integrated Thermal Wall for Space Heating," *2022 7th International Conference on Smart and Sustainable Technologies (SpliTech)*, Split / Bol, Croatia, 2022, pp. 1-5.
13. A. K. Prasad and M. K. Singh, "Design and analysis of different types of solar collector for solar air dryer: A review," *2022 1st IEEE International Conference on Industrial Electronics: Developments & Applications (ICIDeA)*, Bhubaneswar, India, 2022, pp. 169-174.

14. S. A. Ntlela and I. E. Davidson, "Solar Irradiation Forecasting for the City of Durban Using Time Series Analysis," *2022 30th Southern African Universities Power Engineering Conference (SAUPEC)*, Durban, South Africa, 2022, pp. 1-5.