

Design and Simulation of Grid Connected Solar PV System Using PVsyst And Sketchup

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Abstract—Present work discusses about the design and simulation of a 405kwp solar PV system in Galgotias college of Engineering & Technology. The goal is to evaluate the potential of solar energy to provide sustainable and environmentally friendly electricity in the college which is integrated to grid. This system uses 580W PV module and 380kW inverter. We analyzed the system using PVsyst, solargis and SketchUp. The result showed that SOLARGIS estimated annual energy generation between 550 MWh and 555 MWh. While PVsyst provided a higher estimate of 579.4MWh. This indicates that PVsyst predicts more energy output than the other tools.

Keywords—Photovoltaic, Grid connected, Inverting transformer, Inverter, Sketchup Software, Solargis, PVsyst.

I. INTRODUCTION

In India total 300 days sunny sky in a year make solar energy a fast-growing market with 40% annual growth rate over 15 years [1]. In the literature, solar power has been described as financially viable & flexible. Its integration with other technologies, reliable, and contributory to a country's GDP in the form of job creation and income generation. Various technical barrier present in this type of system like technology, system design, weather effect photovoltaic system efficiency [3-9]. Forecasting of solar generation and optimizes of grid input reduce the costs of system [10]. Simulation tools help analyze performance under various conditions [11]. This study uses PVsyst 7.2 and sketchup to assess solar feasibility.

II. BACKGROUND

Electrical energy is the fundamental driver of economic and social development essential for the provision of services and goods. It is a critical prerequisite for scientific and technological advancements which are vital for improving global living standard of a country, India has a growing economy, and consequently, the power demand is steadily rising. The Indian government has recognized the need for improved energy access and the development of the energy mix for the achievement of developmental goals. On the other hand, many educational institutions, such as the Galgotias College of Engineering & Technology (GCET), face issues with respect to the stable and sustainable provision of power, in the light of the rising concerns for environmental sustainability. The need for alternative energy forms has therefore been incorporated into the economies of both the urban and rural settings. The incorporation of the solar power arrangement seeks to address the electricity requirement of the institution.

The development schedule of solar power technology is broken down into four phases:

- Phase A: This phase would include the plans for the initial stages of implementing a renewable energy system at the college.

- Phase B: In this phase, a solar power system supplying a total capacity of 579 MWh would be installed. This would include solar panels, inverters, and more. The aim would be to provide renewable power to the campus.
- Phase C: The solar energy project will be expanded in order to satisfy the increased demand for electricity as the campus develops.
- Phase D: This phase is focused on optimizing the solar system to ensure energy efficiency. The objective is to ensure all energy needs of the college are met through renewable energy.

The commissioning of this solar energy system could help lessen the college's reliance on foreign energy sources and support the stated Indian goals of increasing the overall use of renewable energy resources [12-14]. Such a project is also part of the overall focus found in India to decentralize energy sources and satisfy energy demands within urban cities.

III. SYSTEM CONFIGURATION

Greater Noida, in the state of Uttar Pradesh, in India, has been found to possess considerable potential in the form of renewable resources, especially solar energy, because of its favourable climate and geographic location. The area receives high solar radiation, averaging 300 days in a year, with values between 5.5 and 6 kWh/m²/day, as indicated in Fig. 1 & Fig. 2. This makes it an optimum site for utilizing photovoltaic systems [15-19] on both off-grid and on-grid systems. The use of solar energy in Greater Noida helps India to switch to cleaner and more environmentally stable energy resources. The use of solar energy available in Greater Noida complements the country's vision to produce 300 GW of solar by 2030. Being one of the key players in the success of this vision, Uttar Pradesh is making good use of its potential to establish large-scale solar plants. This fits well with the institute's plan to establish a 579 MWh solar energy project with the intention of using local solar energy to meet all its electricity needs. This helps the institution to reduce its reliance on grid electricity.

The estimated total solar power potential available in Uttar Pradesh is 11,000 MW, and Greater Noida has the potential to harness this resource. The expected mean annual energy output from a photovoltaic cell of 1kWp in this area is estimated to be between 1,900 and 2,000 kWh, and this is equivalent to similar territories that get optimum levels of solar radiation. This reflects the viability of the solar power project at GCET, which aims to take advantage of the same. It is all the more significant as the country is trying to meet the demands for energy as well as taking into account the implications related to climate changes, along with the achievement of the defined targets. The solar power venture that cumulatively has the potential of 579 MWh will also serve as an example for other educational bodies in the country, showcasing the benefits that can be derived for the achievement of their energy demands using renewable solutions. By promoting sustainability and clean energy practices. In conclusion, the solar energy potential in Greater Noida, Uttar Pradesh, combined with solar power project.

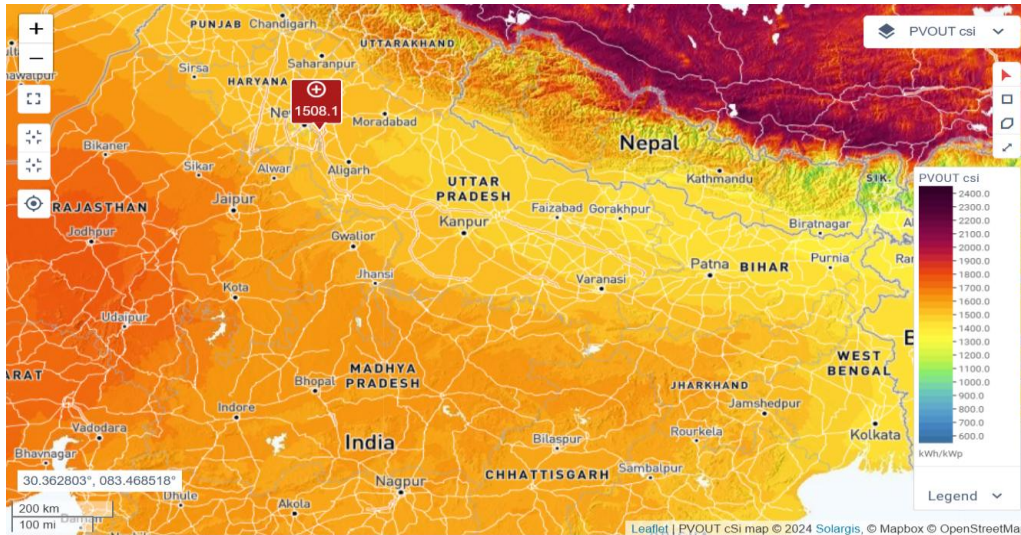


Fig.1. Uttar Pradesh global horizontal radiation atlas

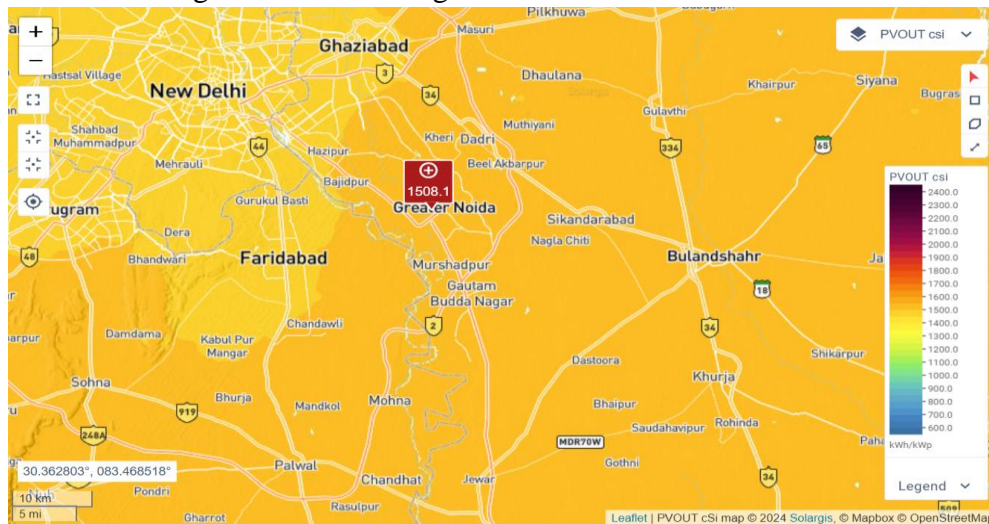


Fig.2. Greater Noida global horizontal radiation atlas

Inputs required: This study investigates the feasible design and generation capacity of a 579 MWh PV system at College, Greater Noida, Uttar Pradesh, India. The system design, simulation, and analysis were performed using PVsyst and SketchUp software and also considering the parameters such as latitude: 28.50°N , azimuth: $-39\ 10/-13^{\circ}$, tilt angle: 10° .

Solar PV Module: Mechanical characteristics of solar PV module are Name of manufacturer: Jinko solar, cell type: N type Monocrystalline, Maximum power: 580 Wp Maximum power voltage: 42.37 V, Maximum power current: 13.69A, Open circuit voltage: 51.02 V, Short circuit voltage: 14.47 A, Module efficiency STC: 22.45%, Operating temperature: $-40^{\circ} \sim +85^{\circ}$ Physical characteristics of PV module are Selected: JINKO:JKM580M-72HL4-V , Length: 1500mm , Width: 1000mm, Thickness: 40mm, Power: 230W, Weight: 28Kg [20].

Inverter: Inverter specifications Input (DC) (Max. PV input voltage: 1500V, MPP voltage range: 500V-1500V, Max. DC short-circuit current 50A*12) Output (AC) (Max. PV input voltage: 180.5A, Nominal grid frequency / Grid frequency range: 50 Hz / 45 – 55 Hz, 60 Hz / 55 – 65 Hz, Max. efficiency: 99.00%) [21].

Software Used: SketchUp is a software for three-dimensional modeling and generally employed for architectural and engineering designs and visualizations. While using this study, SketchUp was used for spellbindingly creating a detailed 3D model for the solar PV system layout at Galgotias College. The software will allow precise placement and orientation of the PV panels, thereby achieving an optimal layout for maximum solar energy capture all with it. Furthermore, SketchUp was also used for estimating the solar horizon, shading, and spatial arrangement of the PV array to ensure that the solar panels would be well exposed to sunlight all throughout the day without any obstruction. Plus, it created an easy way of showing the project. It is also pretty well understood and communicated with through the system design shown in Fig. 3.

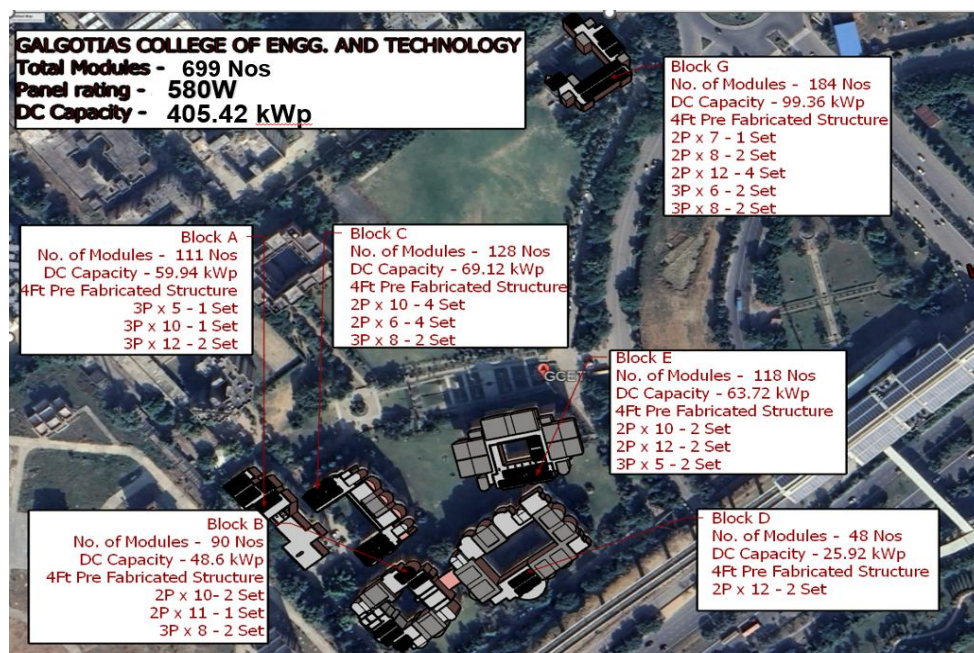


Fig.3. Galgotias college Sketchup design.

PVsyst: PVsyst is a specialized simulation software used for the design and analysis of photovoltaic (PV) systems. It allows users to model the performance of PV systems based on geographical location, solar radiation, system configuration, and technical specifications. PVsyst provides detailed system performance analysis results, such as energy generation and losses due to shading, converter efficiency, and more. The results can be obtained on an hourly, daily, or monthly basis, depending on the requirements of the analysis. This software tool is very helpful for evaluating energy and overall system performance for large-scale PV systems like the one at GCET. It also aids in optimizing parameters like tilt, azimuth, and arrangement of the system for higher energy output, as shown in Fig. 4.

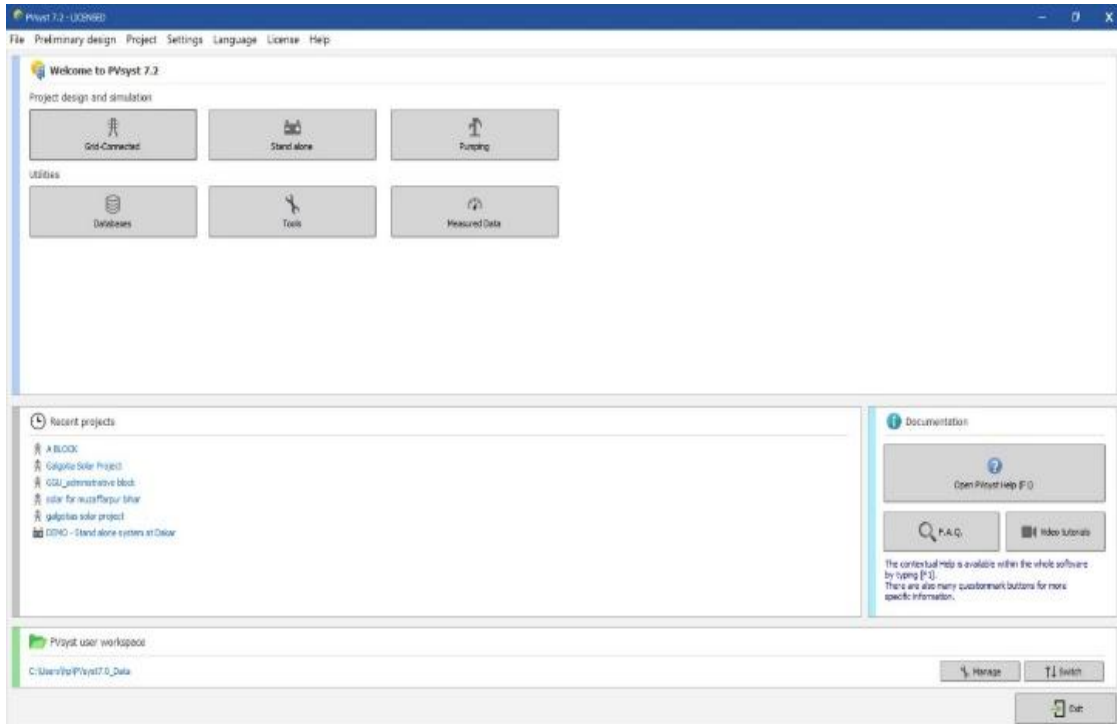


Fig.4. PVsyst

System Location: Installation of a 579 MWh PV system has been projected for the Galgotias campus, which is situated in Greater Noida, Uttar Pradesh, India. The location, which is about 8 kilometres away from the urban area at 28°31'N, 77°30'E, has been identified as having sufficient space for the installation of the PV system outside the identified heritage area. The location has been selected due to the unobstructed availability of sunlight for maximum power generation as a result of optimal energy capture. Additionally, the location has been identified as having sufficient space for optimal orientation of the PV system, as indicated in Fig. 5.



Fig.5. Galgotias college google earth view

Solar Horizon of the Site: These areas receive complete, unshaded sunlight without any shading effects, either from surrounding structures or vegetation. The solar horizon mapping process in

SketchUp illustrates how the whole area is exposed to sunlight. The absence of shading barriers is necessary for optimizing the overall energy production in a year. The solar horizon is depicted in Fig. 6 to identify areas where solar panels can be installed.

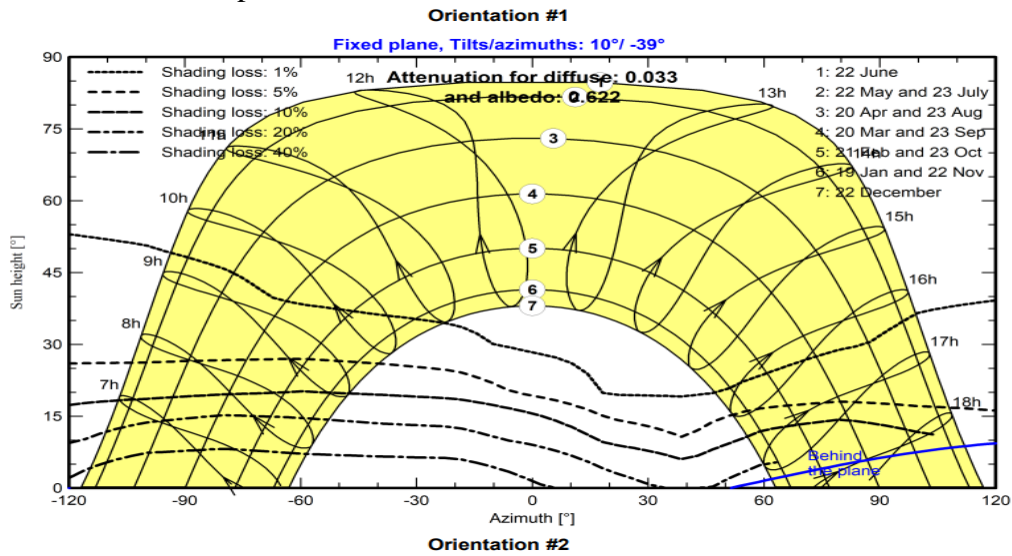


Fig.6. Sun path

Orientation: The solar panels are facing the southern direction with an azimuth angle of zero degrees (true south); this is the best direction considering the region. Its tilt angle is also fixed at 10°, considering the region's latitude. This will ensure the summer months (April to September) and the winter months (October to March) receive optimal sunlight. Every detail of the energy optimization in a year has been considered in the design of the setup, as shown in Fig. 7.

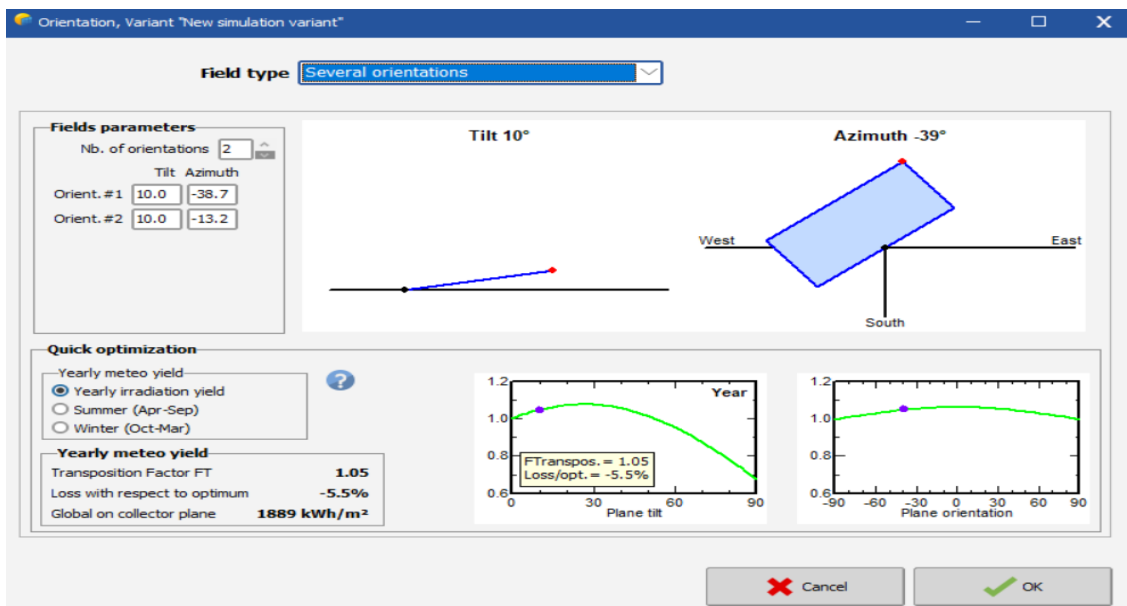


Fig.7. Module several orientations

PV System Configuration: The 579 MWh PV system consists of 580 Wp monocrystalline silicon PV modules. The system uses a total of 699 PV modules, with 18 modules connected in series to form strings. The total number of strings is 39. This configuration ensures that the voltage and current levels are optimized for the inverters. The system is equipped with 6 inverters, each having a capacity of 100 kW, for a total inverter capacity of 500 kW. These inverters convert the DC power generated by the

PV panels into AC power, which is then fed into the electrical grid of the campus. The inverters operate within the voltage range of 500V-1500V and PV system parameter are Nominal PV power 405 KWp, Maximum PV power 387 KWDC, Nominal AC power 385KWAC shown in Fig. 8.

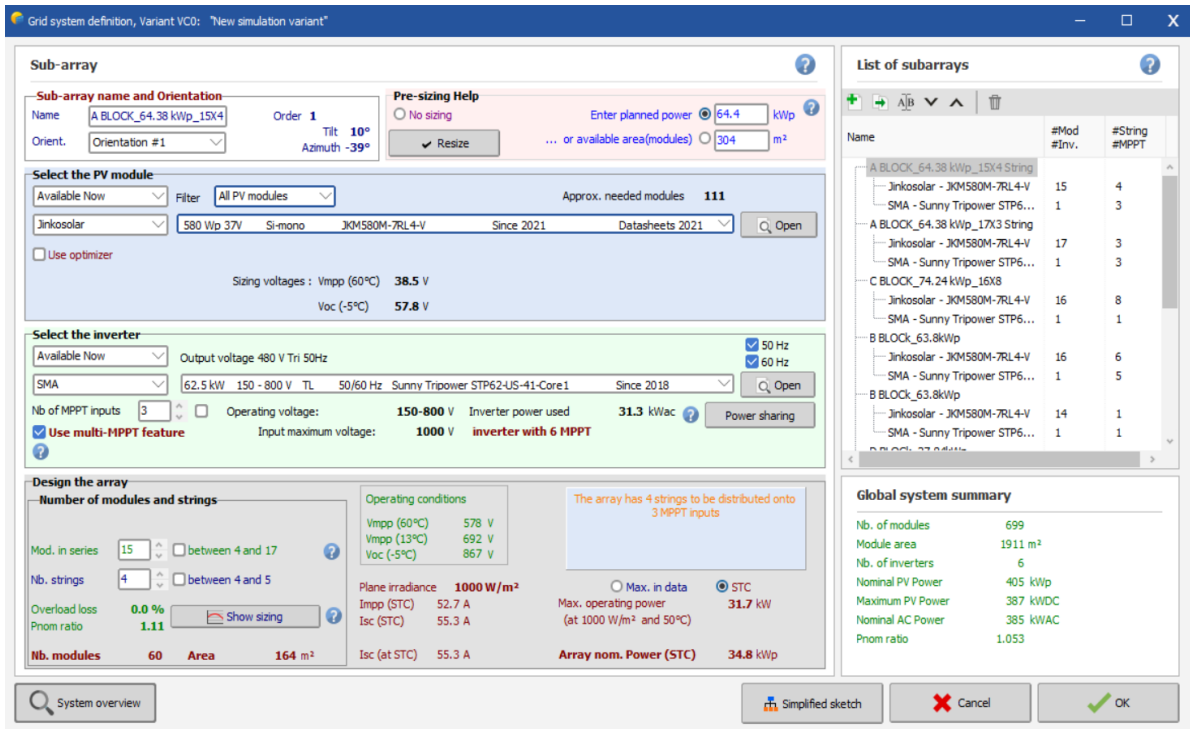


Fig.8. PV system design parameters

IV. RESULT AND DISCUSSION

The configuration of the PV array is designed to optimize the energy yield while keeping the system as cost-effective as possible, ensuring that the system can supply a stable and sustainable source of solar energy shown in Fig. 9. normalized productions with near shading parameters are Lc(collection loss): 1.08KWh/KWp/day, Ls(system loss):0.15KWh/KWp/day, Yf(produce use full energy): 3.92KWh/KWp/day.

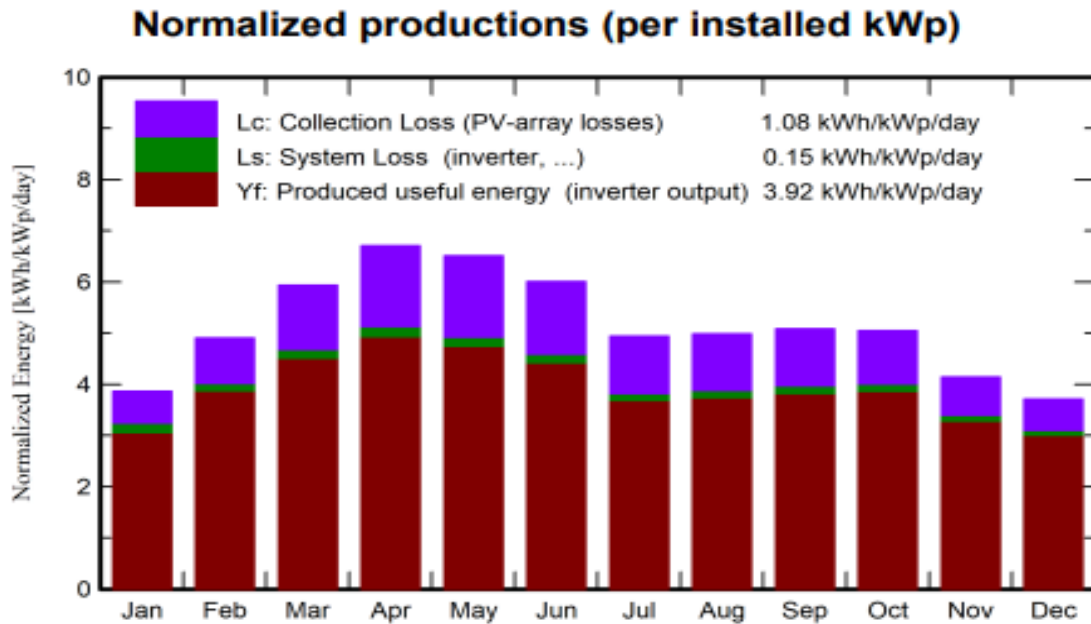


Fig.9. normalized production fixed tilt with near shading

Normalized productions without near shading parameter parameters are Lc(collection loss): 0.99KWh/KWp/day, Ls(system loss):0.16KWh/KWp/day, Yf(produce use full energy): 4KWh/KWp/day shown in Fig. 10. The monthly generated energy of the system is analyzed by PVsyst [9]. The annual energy produced by the system is calculated to be approximately 579,370 kWh (or 579.4 MWh). Monthly energy generation results for the system are presented in simulated energy yield comparison shown in Fig. 11 where Horizontal irradiation (GlobHor), Ambient temperature (T_Amb), horizontal diffuse irradiation (DiffHor), Global incident in coll. Plane (GlobInc), Effective energy at the output of the array (E_Array), Effective global, corr. For IAM shadings (GlobEff).

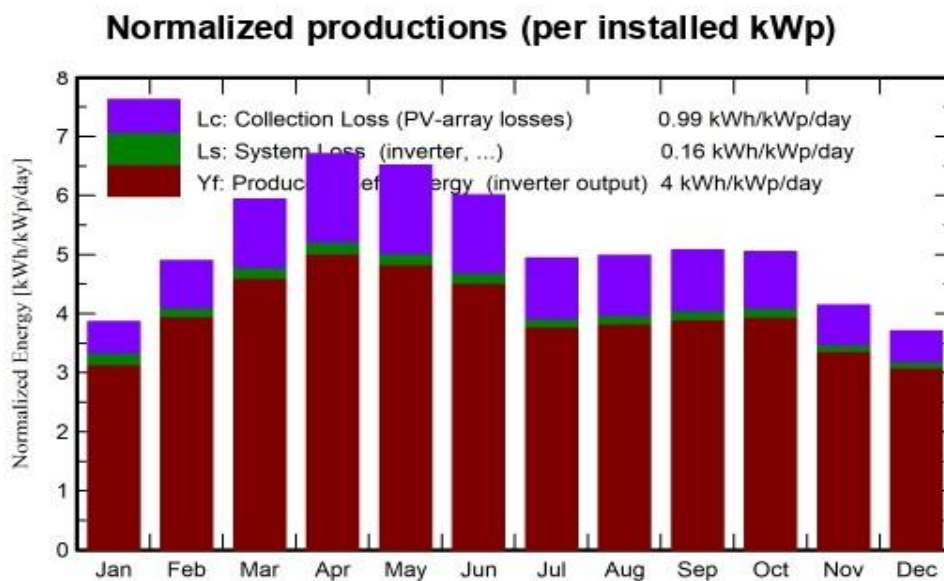


Fig.10. normalized production fixed tilt without near shading

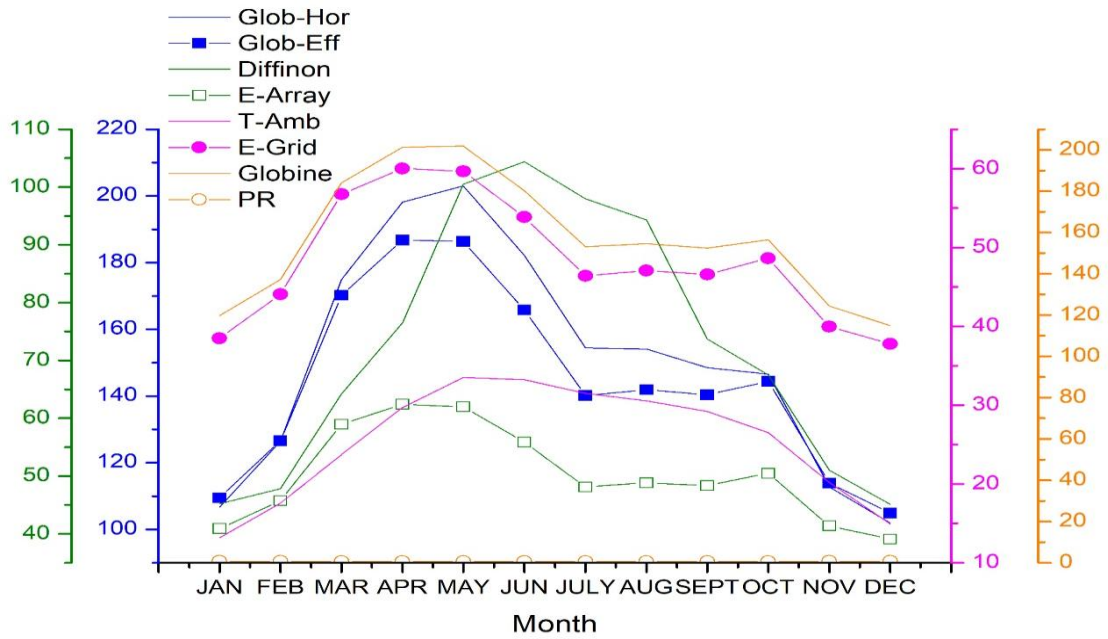


Fig.11. Simulated energy yield comparison

We were comparing fixed tilt with shading and Fixed tilt without shading shown in Figure 12. We can also see the difference in costs due to different structures to represent areas available for solar panel installation and performance ratio of the system.

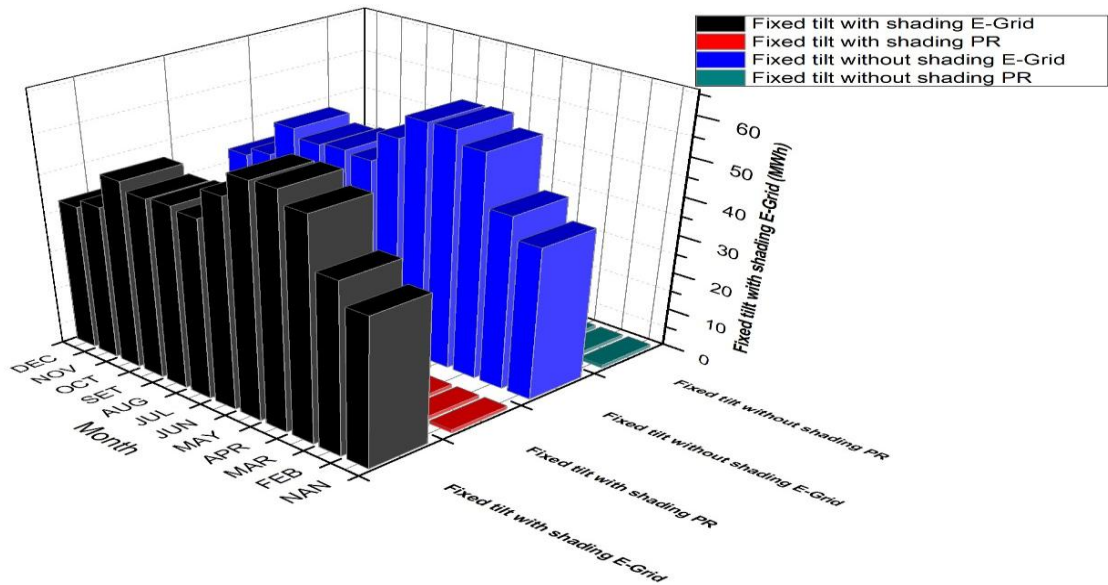


Fig. 12. Shading and non-shading result analysis

V. CONCLUSION

A system loss of 23.43% indeed lies in the range that might be expected for systems doing so under normal environmental conditions. This means that the energy generated by the PV system annually is 1,429 kWh/kW/year, signifying that a reasonable amount can be generated and that it can sustain energy requirements in GCET. Meanwhile, useful energy per day by the system of 3.91 kWh/KWp shows that the system works well with regards to even losses occurring. Given that the grid-connected PV power plant at GCET is expected to produce 579.4 MWh of energy annually, this system is well-suited for meeting the college's energy needs.

REFERENCES

- [1] Kumar, Laveet, Md Shouquat Hossain, Mamdouh El Haj Assad, and Mansoor Urf Manoo. "Technological advancements and challenges of geothermal energy systems: a comprehensive review." *Energies* 15, no. 23 (2022): 9058.
- [2] Vashishtha, Vineet Kumar, Apurv Yadav, Ashok Kumar, and Vinod Kumar Shukla. "An overview of software tools for the photovoltaic industry." *Materials Today: Proceedings* 64 (2022): 1450-1454.
- [3] Kumar K, Tanya Aggrawal, Vishal Verma, Suraj Singh, Shivendra Singh, Dr. Lokesh Varshney, "Modeling and Simulation of Hybrid System", *IJAST*, vol. 29, no. 4s, pp. 2857 - 2867, Jun. 2020.
- [4] Kumar K, Varshney L, Ambikapathy A, Saket RK, Mekhilef S. Solar tracker transcript—A review. *Int Trans Electr Energ Syst*. 2021;31(12):e13250. doi:10.1002/2050-7038.13250.
- [5] Kumar K, Varshney L, Ambikapathy, Vrinda, Sachin, Prashant, Namya. Soft Computing and IoT based Solar Tracker. *International Journal of Power Electronics and Drive System (IJPEDS)*. Vol 12, No 3: September 2021. doi.org/10.11591/ijpeds. v12.i3. pp1880-1889.
- [6] Kumar K, Varshney L, Ambikapathy, Inayat, Ashish, Anant, Sajal. Vision based solar tracking system for efficient energy harvesting. *International Journal of Power Electronics and Drive System (IJPEDS)*. Vol 12, No 3: September 2021. doi.org/10.11591/ijpeds. v12.i3.pp1431-1438.
- [7] Varshney, Lokesh, Kanhaiya Kumar, Snigdha Sharma, and Dinesh Singh. "Real-time iot-based online analysis to improve performance of pv solar system for medical emergencies." In *Machine Learning, Deep Learning, Big Data, and Internet of Things for Healthcare*, pp. 77-92. Chapman and Hall/CRC, 2022.
- [8] V. K. Mishra, L. Varshney, G. S. Dohare and Kumar K, "Comparison and Performance analysis of Solar PV Panel Configurations," 2022 2nd International Conference on Advance Computing and Innovative Technologies in Engineering (ICACITE), 2022, pp. 2249-2253, doi: 10.1109/ICACITE53722.2022.9823561.
- [9] Seme, Sebastijan, Bojan Štumberger, Miralem Hadžiselimović, and Klemen Srednšek. "Solar photovoltaic tracking systems for electricity generation: A review." *Energies* 13, no. 16 (2020): 4224.
- [10] Artanto, Dian, Andreas Prasetyadi, Doddy Purwadiana, and Rusdi Sambada. "Design of a GPS-based solar tracker system for a vertical solar still." In *2016 International Conference on Smart Green Technology in Electrical and Information Systems (ICSGTEIS)*, pp. 140-143. IEEE, 2016.
- [11] Abdullah, A. Z., M. H. Amlus, N. Azizan, I. M. Sali, and M. H. Rahim. "Performance analysis of different type PV module for 3kW residential roof top PV system using PVsyst simulation tool." In *Journal of Physics: Conference Series*, vol. 2312, no. 1, p. 012042. IOP Publishing, 2022.
- [12] Khan, Akhlaque Ahmad, Ahmad Faiz Minai, Rupendra Kumar Pachauri, and Hasmat Malik. "Optimal sizing, control, and management strategies for hybrid renewable energy systems: A comprehensive review." *Energies* 15, no. 17 (2022): 6249.

- [13] Krishna, Yathin, M. F. Fauzan, and N. B. Muhammad Nurhisham Gan. "Design and simulation of a rooftop PV System in Taylor's University Lakeside Campus." In *Journal of Physics: Conference Series*, vol. 2120, no. 1, p. 012035. IOP Publishing, 2021.
- [14] Nassar, Yasser F., Samer Y. Alsadi, Hala J. El-Khozondar, Mohamoud S. Ismail, Maher Al-Maghalseh, Tamer Khatib, Jaser A. Sa'ed, Mohammed H. Mushtaha, and Tarek Djerafi. "Design of an isolated renewable hybrid energy system: a case study." *Materials for Renewable and Sustainable Energy* 11, no. 3 (2022): 225-240.
- [15] Tunçer, Berk, and S. Sazak. "Simulation and Analysis of a Grid Connected Photovoltaic System using PVsyst Software." Istanbul, Turkey: International Graduate Research Symposium: IGRS'22, 2022.
- [16] Iqbal, Md Jahed, Md Kawsher Hamid, Raihan Chowdhury, Abu Shufian, and Rashidul Islam. "Enhanced Optimum Design and Performance Evaluation for Grid-Connected Solar PV Rooftop Systems: A Case Study for Bangladesh." In *2022 International Conference on Recent Progresses in Science, Engineering and Technology (ICRPSET)*, pp. 1-6. IEEE, 2022.
- [17] Plachta, Kamil. "Autonomous tracking controller for photovoltaic systems using global positioning system." In *2018 IEEE International Conference on Environment and Electrical Engineering and 2018 IEEE Industrial and Commercial Power Systems Europe (EEEIC/I&CPS Europe)*, pp. 1-5. IEEE, 2018.
- [18] Krishna, Yathin, M. F. Fauzan, and N. B. Muhammad Nurhisham Gan. "Design and simulation of a rooftop PV System in Taylor's University Lakeside Campus." In *Journal of Physics: Conference Series*, vol. 2120, no. 1, p. 012035. IOP Publishing, 2021.
- [19] Kader, Kazi Abdul, Florina Rahman, N. Islam Nahid, Zahid Abedin, and M. Abdul Mannan. "Design and analysis of an on-grid solar system using Pvsyst software for commercial application." *Int. J. Sci. Eng. Res* 12, no. 9 (2021): 8.
- [20] <https://mysolar.en.made-in-china.com/product/qmXrpzVyZYWF/China-Jinko-Tiger-Neo-N-Type-Jkm580n-72h14-V-585W-580W-575W-570W-Watt-Mono-Facial-Modules-Solar-Panel-Price-Cells-PV-Photovoltaic-Ja-Longi-Mysolar-Trina-Wholesale.html>.
- [21] https://en.sungrowpower.com/upload/file/20210108/DS_20201121_SG250HX%20Datasheet_V1.5.4_EN.pdf.pdf