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Designing and Evaluating the Performance of Rooftop 83.2 kWp Solar PV- Powered Grid Installed on Technical Institute

Raghvendra Kumar Yadav[1], Dr. Mohammad Atif Siddiqui[2]

[1,2] Electrical Engineering Department, Integral University Lucknow
[1] raghavkni@student.iul.ac.in, [2] atifsiddiqui@iul.ac.in
Orcid Id: 0009-0008-7160-1782, 0000-0001-8143-7025

ABSTRACT: Solar PV cell effectiveness is modulated by both their geographical position and harvesting energy processes. Placed at 30°N latitude, India is fortunate to be in a region that is sun-rich, having approximately 300 days of sunlight annually. The average daily sun insolation in India is 5.00 kWh per m^2, and the nation possesses both fossil fuels and sustainable energy sources. This article employs PVsyst tools to model an 83.2 kWp solar PV system, connected to the power grid and designed for use in an educational setting. It looks at the correlations between a number of variables and system degradation, including system linkages, the ambient temperature, solar irradiation, converter effectiveness, electrical wiring, dust accumulation, power electronic parts, and the grid's reliability. It found that solar PV system PR is 82.44% while the daily mean global horizontal radiation is around 5.05 kWh per m^2. The proposed plant produces an annual energy of about 1,34,339 kWh, which would decrease carbon emissions by 159.4 tCO_2 per year. By comparing the analysis data and the actual data from the PVsyst software, it has been seen that the performance ratio of solar PV has essentially grown in every month of the year. The solar PV system reported the performance ratio of 74% in 2023, compared to the expected performance of ratio 82.44%. After programming was implemented in 2024, the performance ratio increased to 77% in 2025 and subsequently to 78% in 2025.This research may provide some learning for future design and operations of grid-connected systems in India and worldwide.

1. INTRODUCTION

Seeking substitutes is now more important than ever due to the continued exhaustion of fossil fuels and the impacts of climate change. Based on existing research, renewable energy has a lot of potential to assist in fulfilling the global energy demands [1]. India is richly endowed with renewable energy resources, and tapping this potential is indispensable for enhancing the availability, cost-effectiveness, and reliability of the energy supply of the country [2]. The Photovoltaic (PV) systems are still the most popular method of generating electricity from solar power [3]. The demise of conventional sources and a tendency towards higher power demand have caused the solar PV business to flourish rapidly in recent times [4]. With a boost from the government incentives, together with the plummeting costs, the solar industries are rapidly expanding globally as well as on the Indian subcontinent [5]. In order to cope with rising energy needs in numerous locales, which are mainly driven by continuing economic growth and the diminishing reserves of natural resources, experts are still investigating hydroelectricity, wind, solar, and eventually biomass [6]. The emergence of diverse power-generating structures, including solar, wind, hydropower, biomass, and geothermal energies in numerous places has been rendered conceivable by an appropriate energy mix with minimal disruption of accessibility to fossil fuels [7].

Solar-powered production is highly practical due to its ease of installation, accessibility, and affordability [8]. Energy transmission has many efficiency cases, and this way, energy can be stored for several days. Several solar panels are mainly installed on top of buildings to generate power electricity. This article focuses on the design of an 83.2 kWp solar-powered

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system mounted on the educational institution's roof. Fig. 1 illustrates the functional components of the rooftop solar PV-Powered grid-integrated micro grid.

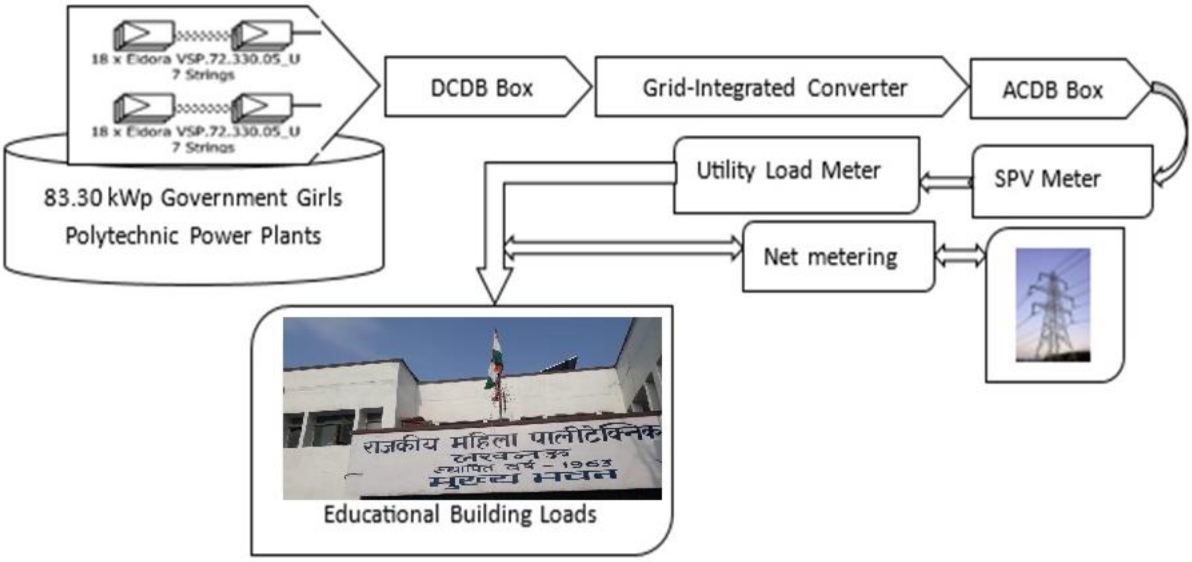

Fig.1: Schematic Representation of an 83.2 kWp Solar PV-Powered Grid-Integrated Micro grid

Plenty of nations have begun solar energy initiatives in an effort to produce more power than the global mean [9]. India is very prospective in generating electricity using solar power. Its geographical location makes it favorable to receive much solar irradiance all year round [10,11]. On average, India's provinces receive 4.70 kWh/m² of solar irradiation daily. An estimated 5,000 trillion kWh of solar power can be absorbed annually by the nation's entire geographical region [12, 13]. With decreasing fall prices of PV modules, photovoltaic systems will likely dominate the electricity generation scenario worldwide in the near future [14,15]. It is used majorly for simulating the efficiency of solar PV-powered grid-integrated micro grid [16,17].

In recent years, several studies on grid-connected rooftop solar-powered plants have been revealed internationally [18]. Several most recent studies of this sort are discussed. In [19], the performance of a 186-kWp solar PV-powered grid-integrated system installed on the rooftop of a building in Northern India for one year has been analyzed. The Performance ratio (PR) for the plant was calculated to be 0.8270, and the total system losses were 27.70%.

Another research paper [20] adopted the IEC-61724 PR standard over 12 months to evaluate the effectiveness of a 6-MW ground-mounted system in Algeria. The results showed average yearly values for 0.7468 PR, 11.39% for the system efficiency, and 21.44% utilization factor. The results demonstrated that PR has a downtrend with increases in the ambient temperature and solar irradiance.

In study [21], investigators monitored the performance of a 462.70-kWp solar PV-powered grid-integrated system over rooftops of 3-educational buildings in India for the course of 3-years. A comparison of real-time data with results from PVsyst software revealed that the 467.2 kWp system had a Performance ratio (PR) of 0.8068 and approximately 15.47% system efficiency.

In another study [22], a 2.25-kWp solar PV-powered grid-integrated plant has been evaluated under IEC standard 61724 in the Algerian desert. The PR of the plant was found to be between 78.00–97.00%.

In study [23] studied a 190-kilowatt solar PV-powered grid-integrated system located in Punjab. Findings of the assessments showed that final-yield (Y_f) ranges from 1.45–2.84 h, reference yield (Y_{ref}) ranges from 2.29–3.53 h, and PR 55–83%. The mean early yield of the plant was 812.76-kWh per kW with an efficiency of 8.30%. Findings from the PVSys tool were contrasted with the insights obtained from the aforementioned system.

The effectiveness of a 13-kW solar PV-powered grid-integrated system erected over the rooftop of an Orissa campus has been assessed. The PV system, Inverter, and overall plant efficiencies ranged between 4.50–9.20%, 3.60–7.80%, and 50.00–87.00%, respectively. The PR varies between 29.00–66.00% [24].

With PVsyst and RETScreen software, a 1 kW solar PV-powered grid-integrated system was reviewed. The observations indicated that the system might be able to serve the major electrical requirements of a house, where an average annual generation of about 1.0-MWh is expected to feed into the grid, with a PR of 72.00% [25].

The effectiveness evaluation of a 40-kW solar PV-powered grid-integrated plant was carried out in a college premises at Agra, India. The facility's effectiveness was monitored using IEC-61724 guidelines. The PV efficiency was found to be 9.36%, while that of inverters was 90.90%. The overall system efficiency was 8.51%. PR and CUF was found to be 63.00% and 0.9, respectively [26].

An article [27] which compared 3-distinct sorts of solar PV-powered grid-integrated systems in Thailand additionally revealed that utility-scale facilities had the cheapest energy costs, at 0.27 US dollar/kWh. Energy costs for ground-mounted roofing solar farms and domestic rooftops SPV plants were 0.29 US dollar/kWh and 0.46 US dollar/kWh, respectively.

The research effort indicates that the IEC 61724 standard and its relevant metrics have been broadly applied in evaluating PV systems' performance. Rooftop PV applications could be implemented in most regions of the world. To compare expected versus actual performance of a plant, cross-validation of software-based simulations must be done against real-world data. As such surveys or studies show, it was revealed that PVsyst simulation software is often employed while making comparison. Economic evaluation also forms an important part of determining whether a PV plant will be viable or not [28–32]. This research work involved to evaluate and analyses of the performance of a grid-dependent SPV system using PVsyst software/tool.

There are four distinct sections in this study. Section 2 has a detailed description of resources and methods applied in solar PV-powered grid-integrated microgrid, with the application of PVsyst software, the process followed in site selection, load profile, and technical specifications of components for the 83.2 kWp solar power plant. In section 3, it shows a detailed discussion along with results of the grid-integrated power plant. Section 4 summarizes and concludes the contributions of the research. This section presents the study's primary objectives:

- The study evaluates the performance of a rooftop solar PV-powered grid-integrated micro grid over a Three-year period based on IEC-61724 guidelines.
- The achievement of the system is measured by some key parameters, like the Y_{ref}, the Y_f, the PR ratio etc.
- The article offers an evaluation of the outcomes created via PVsyst , PLC ,HMI software.
- Lastly, the article discusses how this specific study could potentially be leveraged to assess if constructing substantial solar PV-powered grid-integrated micro grid under diverse meteorological circumstances is conceivable.

2. METHODOLOGY

The primary characteristics of a PV panel include the type of solar cell, cell temperature, and the amount of radiation received in it. The conversion efficiency of energy in a photovoltaic system is one significant parameter that should be considered in the generation of electricity through various technologies [33,34]. This paper has relied on software called PVsyst for conducting a study on the performance of the system.

▪ Tools and Software

PVsyst software designs various applications of solar PV-powered systems, such as DC-grid systems, grid-integrated systems, self-contained systems, and DC-pumping systems. It contains a database of solar modules, batteries, and converters for designing the system. This software can also be joined with location-specific data like NASA-SSE satellite data, Meteo Norm, and RETScreen, which helps a lot in designing. PVsyst assists in optimizing the system design based on load requirements and available area, and it helps analyze the performance of the system at an annual, monthly, and weekly basis [33,35]. This software is intended for architects, engineers, and researchers, hence acting as an educative tool. This provides an extended help menu by way of offering procedures and models, hence acting as an intuitive interface for assisting building projects. Additionally, meteorological information gathered from an assortment of sources, such as user-provided data, could be imported into PVsyst.

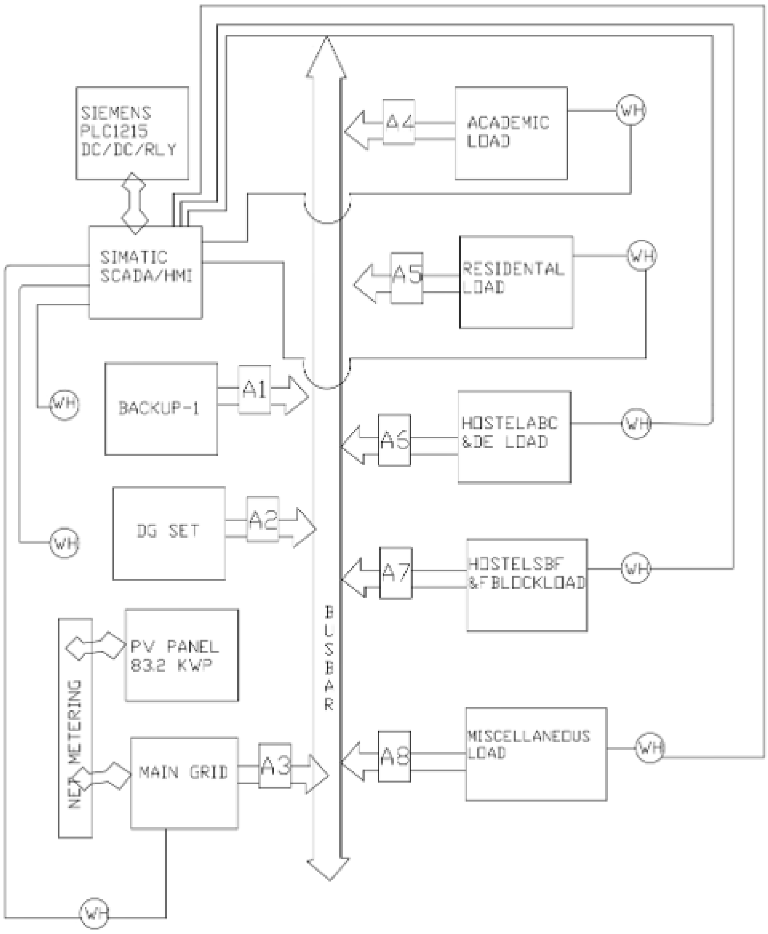

Fig. 2. System architecture.

The model shown in this paper uses Siemens Programming logic control (PLC) 1215 DC / DC / Relay and a Totally Integrated Automation Portal for programming the input Direct current (DC) and output relay type on the PLC The actual demand and supply is being transmitted to the PLC and Human machine interface (HMI) by applying power supply and power demand of each block using hard wire to the PLC and HMI are connected to the Profibus protocol on a dual basis In the self-propelled model, the bus-bar at one end of the power supply is controlled by the main Grid way Department Grid's Through Contractor A3, the Diesel Generator Contractor A2, the backup power is controlled by the PLC at the bus bar through A1 and at the other end of the bus bar, the power demand is met by the Power Load Contractor A4 of the Academic Building, the Power Load Contractor A5 of the Residential Building, the Power Load Contractor A6 of the Hostel ABC and DE Building the Power Load Contractor A7 of the Hostel SBF and F Building and the power load contractor A8 of the miscellaneous load to meet their power demand

- **Site location and Load Profile**

It is installed on the roof of the Government Girls Polytechnic in Lucknow, northern India. Average annual temperature in Lucknow falls between 7°C and 40°C with an annual average rainfall of 670.3 mm. May month has the highest mean temperature (37.50°C), December is the lowest (16.34°C), and July is most precipitous (194.7 mm). With an azimuth of 30° and a tilt of 27°, it is situated at latitudes 26.88°N and longitudinal 81.00°E. The production site is situated in the time zone UTC+5.5, 115-meters above sea-level. Fig.1 depicts the chosen site's solar-powered grid-integrated micro grid location.

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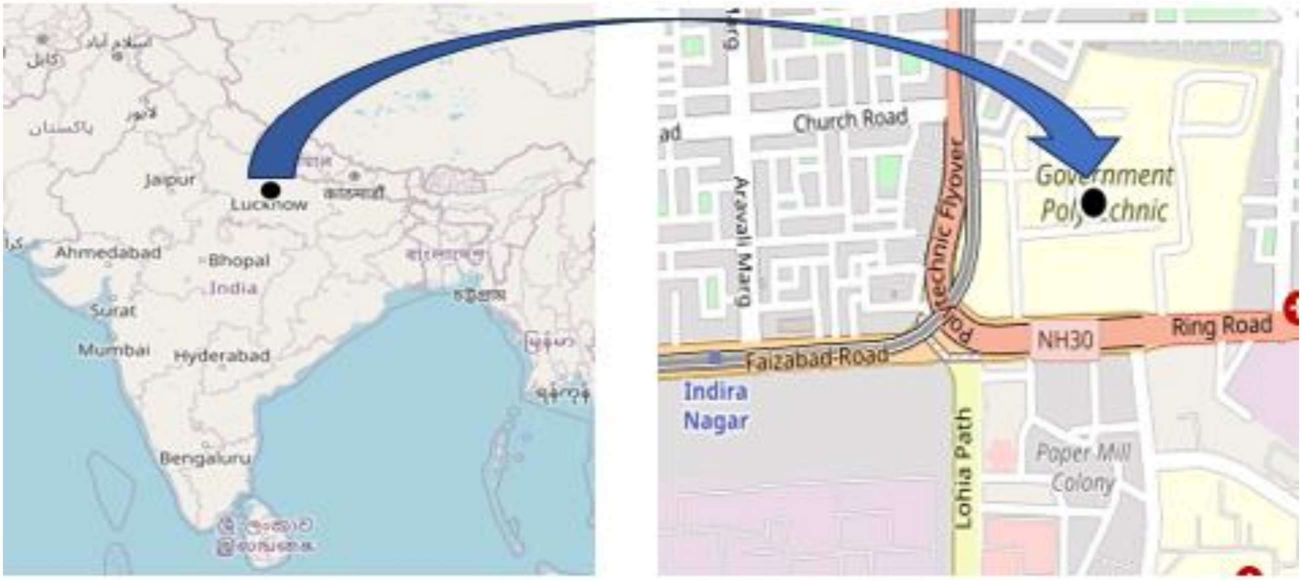

Fig. 3: An 83.2 kWp solar PV-powered grid-integrated micro grid's location

As part of the feasibility study for the PV system, a comprehensive survey was conducted in the area to ascertain load demand as well as the distribution of capacity. The average energy demand is about 370 kWh/day. Consumption is a little lower on the weekdays, mainly on Saturdays, and nothing on Sundays. Peak demand goes up to 97.8 kW. The daily energy requirement for the electrical system exceeds 60 kWh.

- **Technical Specification of Solar Power Plant**

An 83.2-kWp solar PV-powered grid-integrated microgrid was analyzed by using the simulation tool PVsyst, and all power losses in the system were calculated with this software. This system consisted of 83,200-watt Vikram solar PV modules and two 40-kW, 3-phase, 400 V advance energy inverters. Technical details for both the solar PV modules and the inverters are provided in Table-1 and Table-2.

Table 1: Vikram Solar Panel Specifications (330-W)
Eldora VSP.72.330.05-U Solar Module
General Specifications
Nominal Power: 330 Wp
Module Area: 1.937 m²
Cell Area: 1.768 m²
Technology: Silicon Polycrystalline (Si-poly)
Dimensions: 1956 x 992 x 36 mm³
Number of Cells: 72 cells
One-Diode-Model Parameters:
R_{sh}: 350 **Ω**
Io_{Ref}: 0.032 nA
R_{se}: 0.338 **Ω**
Open Circuit Voltage Temperature Coefficient (μ_{Voc}): -148 mV/°C
Power Temperature Coefficient (muPMaxR): -0.38%/°C

Diode Quality Factor (Gamma): 0.950
Results Under Standard Test Condition (STC):
V_{mpp}: 31.3 V.
I_{mpp}: 8.72 A.
P_{mpp}: 330.6 Wp.
μ_{mpp}: -0.37%/°C
Eff_{module}: 17.06%.
Eff_{cells}: 18.70%.
FF: 76.9%
Electrical Parameters:
Reference Temperature: 25 °C
Open Circuit Voltage (V_{oc}): 46.3 V
Reference Irradiance: 1000 W/m²
Short Circuit Current (I_{sc}): 9.240 A
V_{mpp}: 38.0 V
P_{mpp}: 330.6 W
MI_{mpp}: 8.700 A
Short Circuit Current Temperature Coefficient (μ_{Isc}): 5.3 mA/°C
Range: -40 to 85 °C
Reverse Bias Parameters:
(in case of Partial Shading or Mismatch Analysis)
BRev: 3.20 mA/V²
Bypass Diodes/module: 3
Bypass Diode Direct Voltage: -0.7 V

Table 2: Advance Energy Solar Inverter Specifications (40-kW)
Inverter Model: AE 3TL 40 (840) + Connection Box
Commercial Specifications:
Protection Rating: IP65
Dimensions:
Width: 535 mm
Depth: 277 mm
Height: 601 mm
Weight: 41.50 kg
Display: Operational data available
Input Specifications (PV Array Side):

Operating Mode: MPPT
Pnom DC: 41.2 kW
Vmin: 250 V
Pmax DC: 48 kW
Vmax: 900 V
P_thresh: 40 W
Vmax array: 1000 V
Vmin@Pnom: 490 V
Type of Inverter :
(String Inverter with protection feature on the input side and Multi-MPPT Capability)
No. of string input: 7 (02 Nos.)
No. of MPPT inputs: 2
Vmin/Vmax Behavior: Restricted
Pnom Behavior: Restricted
Output Specifications - AC Grid Side
Grid Voltage: 3-phase 400 V
Nominal AC Power: 40 kW
Grid Frequency: 50/60 Hz
Maximum AC Power: 40 kW
Maximum Efficiency: 98.13%
Nominal AC Current: 59 A
Maximum AC Current: 59 A
European Average Efficiency: 97.98%

Figure 4 Illustrated the technical specification of Vikram Solar 330-watt Solar panel and output under standard test condition

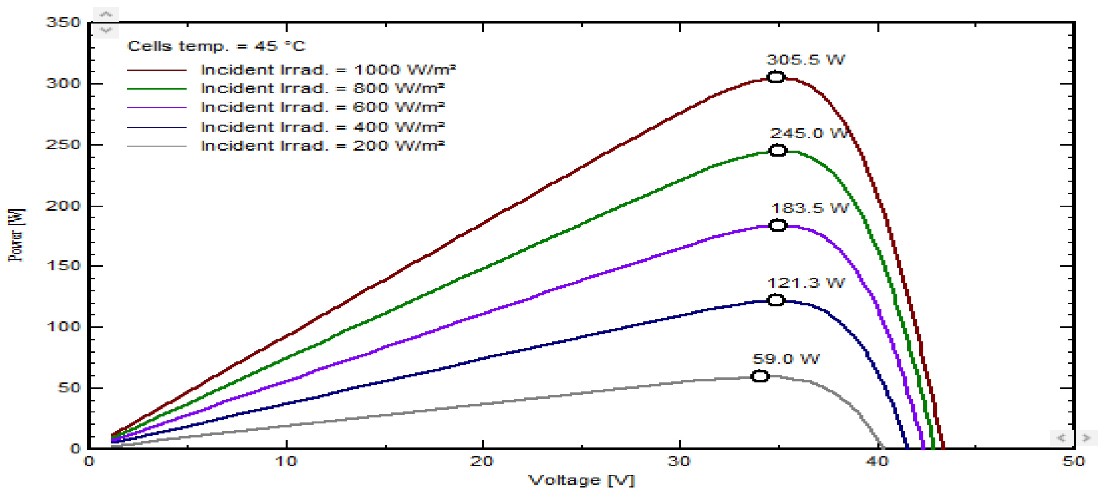

Fig. 4 (a) I_V Features of Solar PV Panel

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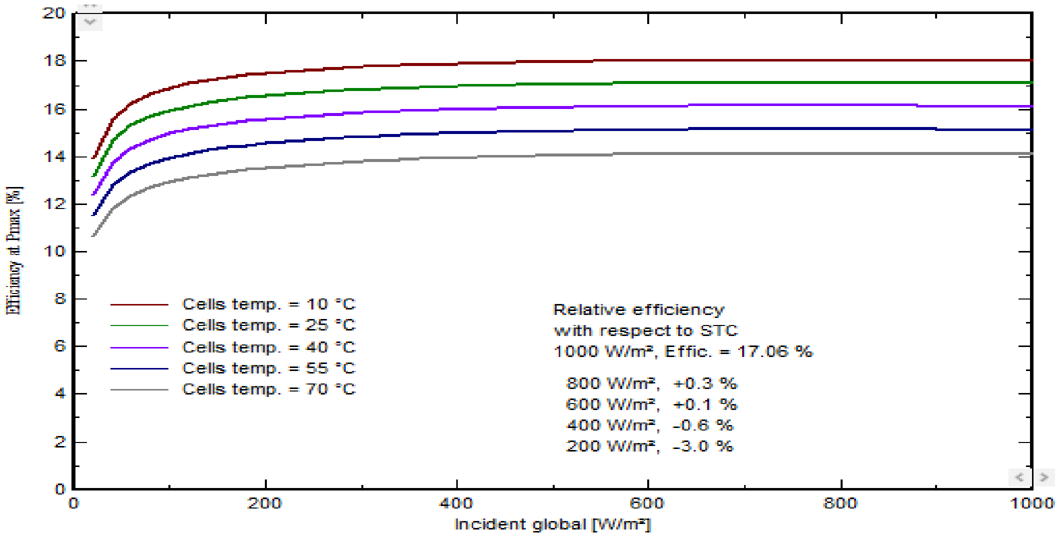

Fig. 4 (b) P_V Features of SPV Panel

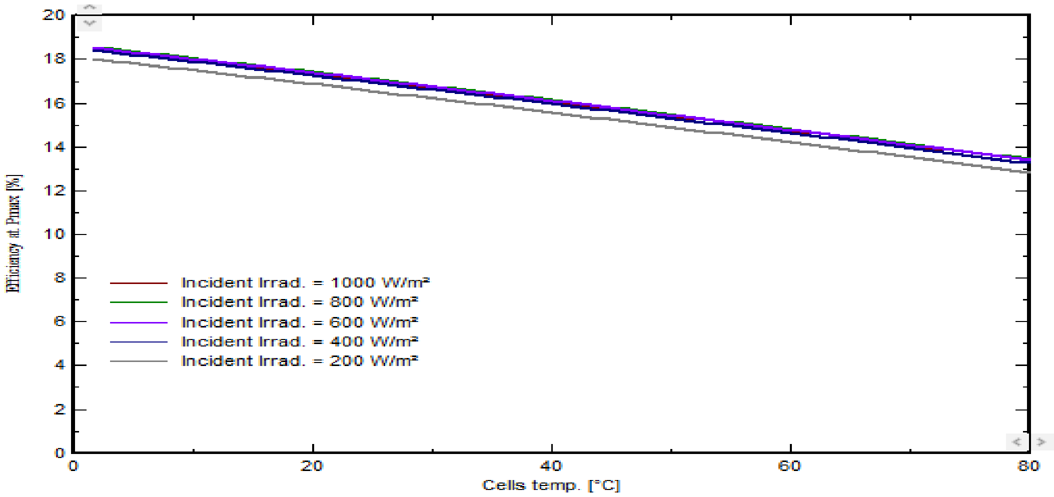

Fig. 4 (c) Efficiency Irradiance Features of SPV Panel

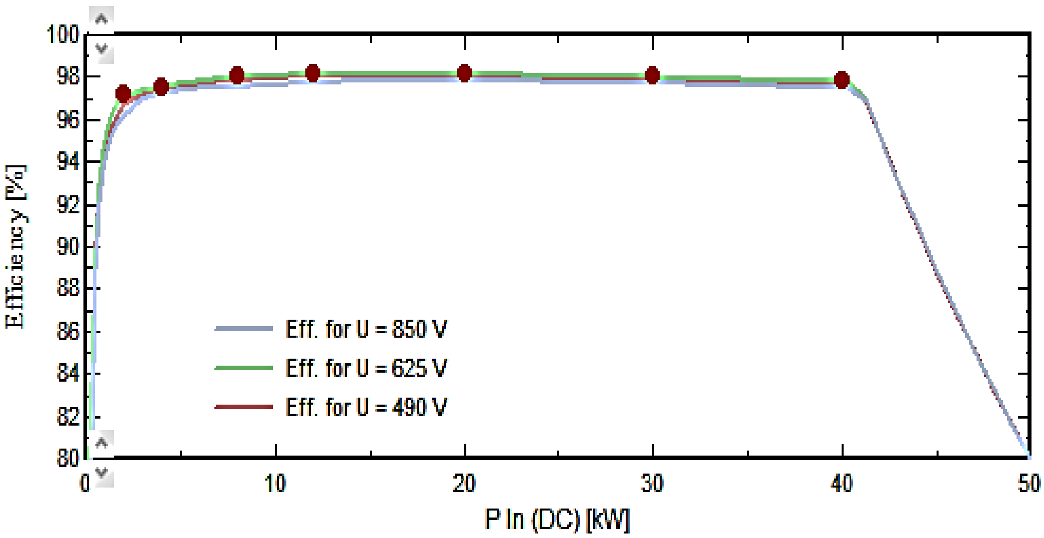

Fig. 4 (d) Efficiency Cell Temperature Features of SPV Panel

Figure 5 illustrates the configuration of the solar PV array. For each module, it was installed at an azimuth and tilt angle of 30° and 27° respectively, that's southward, and doesn't interfere with shading.

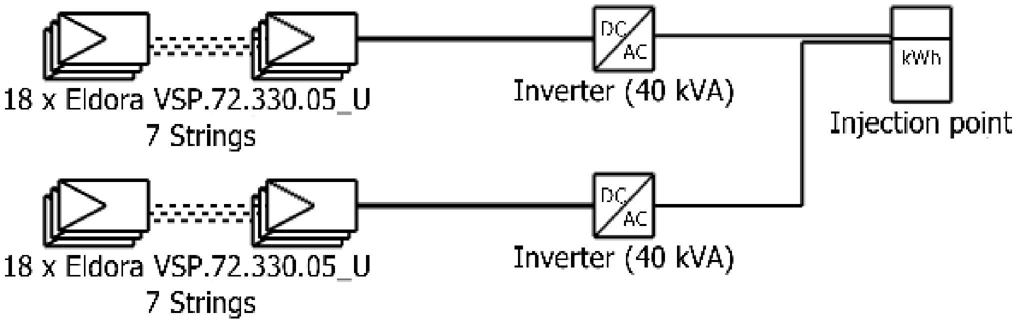

Fig. 5: Configurations of solar PV arrays

The layout contains 252 solar panels, all aligned into 14 strings, with eighteen modules chained together in series. The application uses two 40-kWp inverters, each of which is set with two MPPT units, and the output is connected to the grid.

- **Sun path**

Shading is one of the main influential parameters for overall performance of a solar PV-powered plant. This study explores a solar PV-powered grid-integrated micro grid in which shading has no influence. Figure 6 represents the path chart of sun at the location which shows sun ray throughout the year, and in winter time, it comes up in low altitude, whereas in summer it comes up in high altitude.

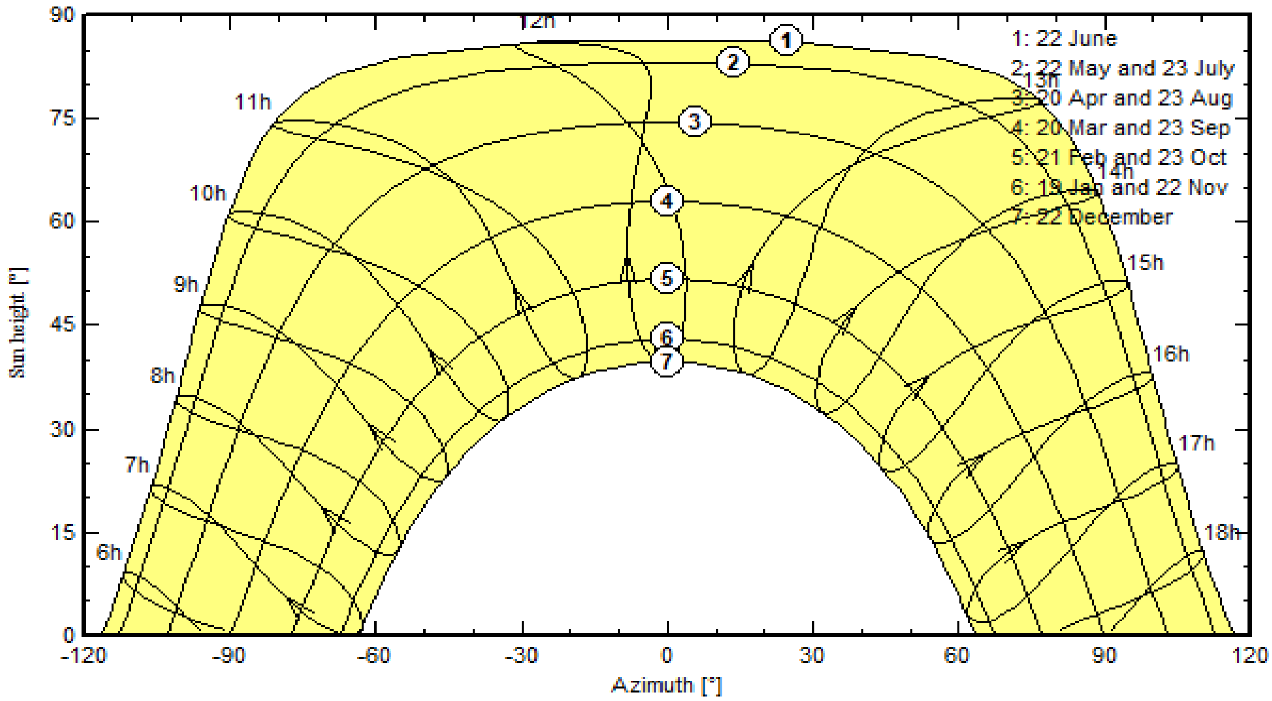

Fig. 6: The height/azimuth plot of sun track in PVsyst

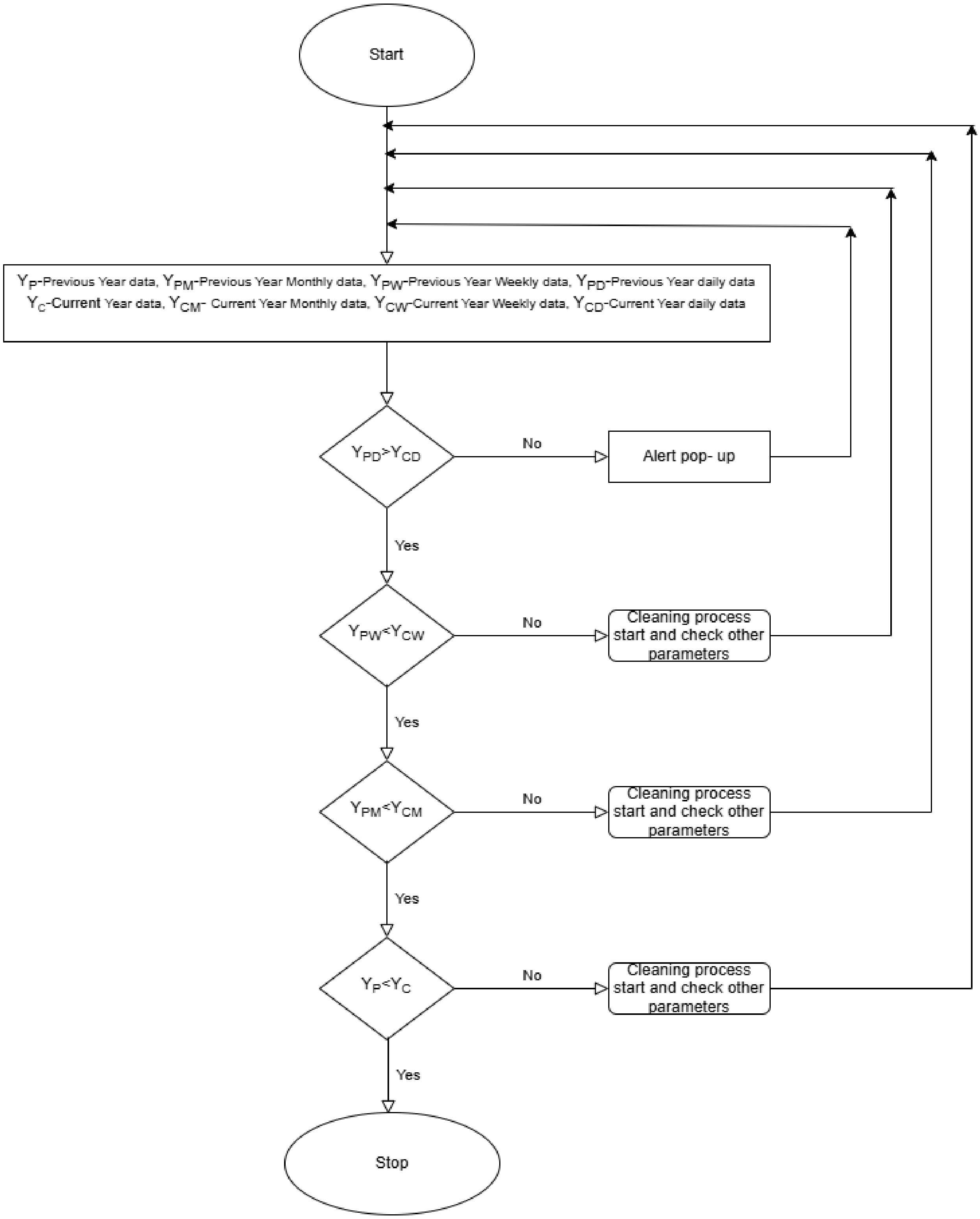

Fig. 7: Flow Chart for Cleaning Strategy

With the help of flow chart, I have to tell about the logic here that by recording and programming the data, the performance ratio of the system is better than before. While doing the study it was found that the performance ratio analysis was less than the performance ratio and the actual performance ratio which was compared with that day of the previous year and that day of the immediate year by the hardware and clean mechanism with the help of programming, if the decrease was recorded and the performance ratio of a consecutive week was found to be less, the performance ratio was increased by the clean strategy.

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3. RESULTS AND DISCUSSION

Table 3 Summarizes balance and critical impact factors on system effectiveness. The average GolbHor is 1843.60-kWh per m², while the average yearly global energy incidence on the collectors, both without optical alterations and with effective global irradiation that contributes to optical losses, is 1874.60-kWh per m² and 1959.50-kWh per m², respectively. The average T Amb is 26.76°C, while the average diffuse radiation is 890.50-kWh per m². With this effective solar radiation, the solar PV-array offers 137.13-MWh of DC energy per year and feeds the utility-grid about 135.11-MWh of AC power. On average, the system's PR is 0.8244.

Table 3: PVsyst software findings for an 83.2 kWp solar PV-powered grid-integrated micro grid

	GlobHor	DiffHor	T_Amb	GlobInc	GlobEff	EArray	E_User	E_Solar	E_Grid	EFrGrid
	kWh/m²	kWh/m²	°C	kWh/m²	kWh/m²	kWh	kWh	kWh	kWh	kWh
January	109.9	56.4	17.35	137.3	131.4	10040	11655	7815	2022	3840
February	130.2	55.1	20.49	155.5	149.1	11078	10360	8201	2649	2159
March	181.1	66.5	26.53	198.5	190.3	13654	11655	9735	3634	1920
April	200.6	82.0	33.17	202.4	193.9	13531	10792	9208	4042	1583
May	204.8	101.0	37.50	194.5	185.9	12908	11655	9485	3161	2170
June	174.1	92.0	34.45	159.6	152.0	10846	11223	7952	2674	3272
July	157.8	90.1	31.01	146.9	140.0	10289	11223	7284	2798	3940
August	157.7	83.8	28.82	153.9	147.1	10876	11655	7904	2752	3751
September	153.9	68.9	27.83	161.3	154.3	11409	10792	8047	3130	2745
October	146.6	73.3	25.50	166.5	159.5	11856	11655	8822	2795	2833
November	120.0	64.5	21.84	146.4	140.3	10565	11223	8047	2308	3177
December	107.0	57.0	16.34	136.6	130.9	10079	11223	7519	2358	3704
Year	1843.6	890.5	26.76	1959.5	1874.6	137131	135111	100017	34322	35093

Legends

GlobHor	Global horizontal irradiation	EArray	Effective energy at the output of the array
DiffHor	Horizontal diffuse irradiation	E_User	Energy supplied to the user
T_Amb	Ambient Temperature	E_Solar	Energy from the sun
GlobInc	Global incident in coll. plane	E_Grid	Energy injected into grid
GlobEff	Effective Global, corr. for IAM and shadings	EFrGrid	Energy from the grid

The PVsyst model clearly shows that the April month has the most produced electricity, while January has the lowest. Figure 8 Summary of Performance Evaluation and Performance Ratio of 83.2-kW Solar PV Plant. In the above graph, the daily captured PV-array loss for the power plant is 0.85 kWh per kWp while the daily system loss is recorded at 0.09 kWh per kWp. The overall daily generated net electricity stands at 4.43 kWh per kWp.

System Production

Produced Energy	134340 kWh/year	Specific production	1615 kWh/kWp/year
Used Energy	135111 kWh/year	Perf. Ratio PR	82.44 %
		Solar Fraction SF	74.03 %

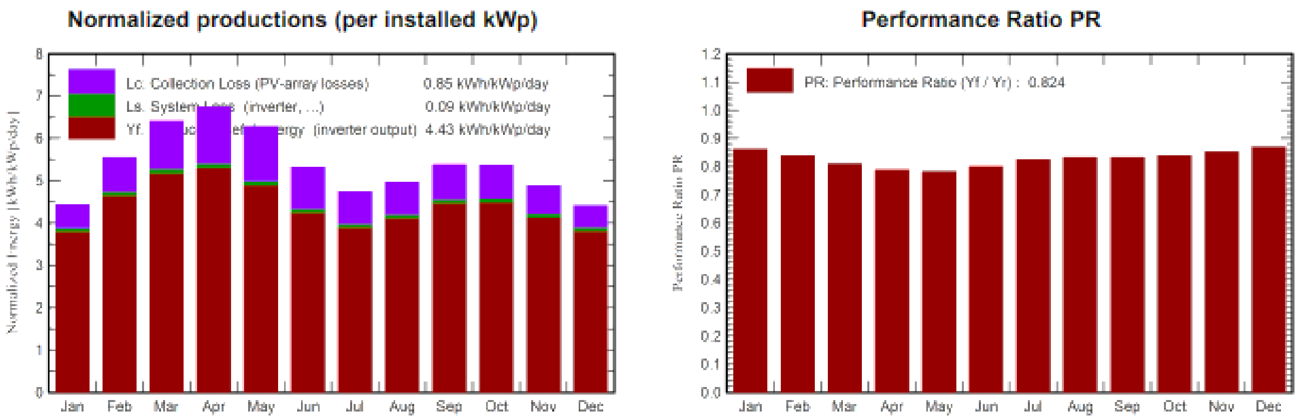

Figure 8: Performance evaluation of an 83.2 KWp solar PV-powered grid-integrated micro grid

An estimated 134,339 kWh of power would be offered to the electrical grid annually by the 83.2-kWp solar PV-powered grid-integrated micro grid. The monthly statistics on the total amount of AC power delivered to the distribution system are provided in Table 3. From the table, it is evident that the plant supplies the lowest generation of electricity in January and its highest in April.

Table 4 Summarizes balance and critical impact factors on system effectiveness. The average Global horizontal irradiation is 1661.99-kWh per m^2, while the average yearly global energy incidence on the collectors, both without optical alterations and with effective global irradiation that contributes to optical losses, is 1595.74-kWh per m^2 and 1774.8-kWh per m^2, respectively. The average T Amb is 26.3°C, while the average diffuse radiation is 590.03-kWh per m^2. With this effective solar radiation, the solar PV-array offers 112.04-MWh of DC energy per year and feeds the utility-grid about 106.78-MWh of AC power. On average, the system's PR is 0.8244

Table 4: Program execution findings for an 83.2 kWp solar PV-powered grid-integrated micro grid

Month	GolbHor kWh/m²	DiffHor kWh/m²	T_Amb °C	GolbInc kWh/m²	GolbEff kWh/m²	EArray kWh	E_User kWh	E_Solar kWh	E_Grid kWh	EFrGrid kWh
January	103.23	35.96	14.1	124.93	112.251	7908	7227	12312	1029	3721
February	127.31	36.83	18.2	147.9	136.764	9035	8703	14061	1110	1999
March	166.78	43.09	23.1	184.76	167.958	11409	11023	18113	1242	1769
April	166.5	31.8	29	182.1	162.03	11514	10870	18091	1239	1439
May	186	45.26	31.7	183.52	162.037	11613	10945	18137	1301	2011
June	167.7	52.2	32.1	162.3	147.09	10544	9432	16021	1284	3446
July	129.27	87.11	29.3	136.4	121.644	8402	8276	13624	887	4541
August	130.2	74.71	28.3	128.34	111.755	8249	7790	12752	1237	3699
September	132.3	62.4	28.1	137.7	123	8520	8102	13120	1173	2667
October	142.6	52.08	25.9	152.21	138.88	9760	9232	15003	841	3049
November	114	34.8	20.3	123	111.36	7989	7644	12332	894	2838
December	96.1	33.79	15.1	111.6	100.967	7098	6934	11022	819	3671
Year	**1661.9**	**590.03**	**26.3**	**1774.8**	**1595.74**	**112041**	**106178**	**174588**	**13056**	**34850**

In the table 4, all the parameters related to solar PV have been recorded under programming, with the help of which we can calculate the data.

Table 5: Grid-fed AC power and PR

	Yr kWh/m²/day	Lc kWh/kWp/day	Ya kWh/kWp/day	Ls kWh/kWp/day	Yf kWh/kWp/day	Lcr ratio	Lsr ratio	PR ratio
January	4.43	0.53	3.89	0.08	3.82	0.121	0.018	0.862
February	5.55	0.80	4.76	0.10	4.66	0.143	0.018	0.839
March	6.40	1.11	5.30	0.11	5.19	0.173	0.017	0.810
April	6.75	1.32	5.42	0.11	5.31	0.196	0.017	0.787
May	6.27	1.27	5.01	0.10	4.91	0.202	0.016	0.782
June	5.32	0.97	4.35	0.09	4.26	0.183	0.017	0.801
July	4.74	0.75	3.99	0.08	3.91	0.158	0.017	0.825
August	4.96	0.75	4.22	0.09	4.13	0.150	0.017	0.833
September	5.38	0.80	4.57	0.09	4.48	0.150	0.017	0.833
October	5.37	0.77	4.60	0.09	4.51	0.144	0.017	0.839
November	4.88	0.65	4.23	0.08	4.15	0.132	0.017	0.850
December	4.41	0.50	3.91	0.08	3.83	0.113	0.018	0.869
Year	5.37	0.85	4.52	0.09	4.43	0.158	0.017	0.824

Figure 9 presents a power loss diagram for the 83.2 kWp solar PV-powered grid-integrated micro grid, showing all losses from cables, soiling, electronic equipment, converter efficacy, climate, radiation, ties, and network accessibility.

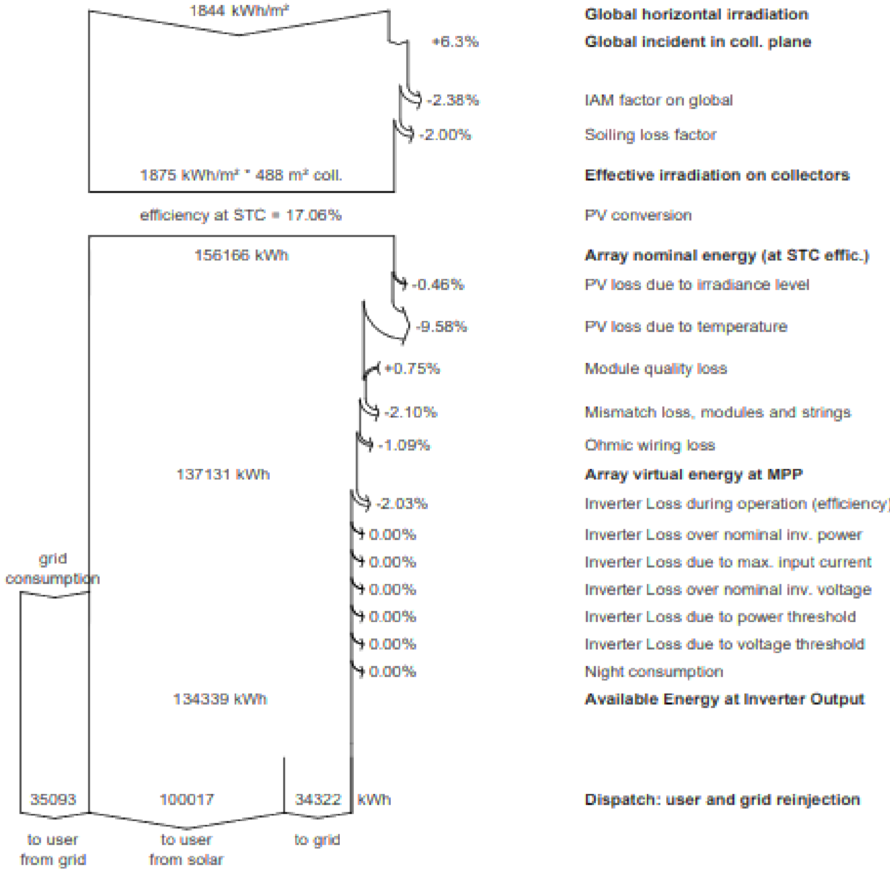

Fig. 9: Diagram of Annual Power loss

The system saw the most energy infusion in April, while January saw the lowest levels. Average horizontal radiation over the year amounts to 1844.00 kWh per m^2and the total incident energy on the collector plane amounts to 1875.00-kWh per m^2.The 83.2-KWp solar PV-powered grid-integrated micro grid reached a yearly average PR of 82.44%.

Table 6: Program execution Grid-fed AC power and PR

Month	Yr kWh/m²	Lc kWh/m²	Ya kWh/m²	Ls kWh/m²	Yf kWh/m²	Lcr ratio	Lsr ratio	Pvsyst PR ratio	Year 2023 PR ratio	Year 2024 PR ratio	Year 2025 PR ratio
January	125.83	28.81	95.43	3	92.4	0.266	0.306	0.9	0.73	0.76	0.77
February	143.56	33.89	109.9	3.6	106.3	0.266	0.306	0.8	0.74	0.76	0.77
March	184.67	42.34	140.98	3.1	137.9	0.266	0.306	0.8	0.75	0.77	0.78
April	182.8	43.12	141.34	3.1	138.2	0.265	0.306	0.8	0.76	0.77	0.79
May	185.07	43.49	138.9	3.3	135.6	0.266	0.306	0.8	0.73	0.76	0.77
June	163.4	38.4	123.6	3.2	120.4	0.266	0.306	0.8	0.74	0.77	0.79
July	137.9	31.83	105.3	3.6	101.7	0.266	0.306	0.8	0.74	0.76	0.78
August	129.9	30.67	99.01	3.9	95.1	0.266	0.306	0.8	0.73	0.78	0.8
September	136.8	33.2	104.6	3.6	101.04	0.266	0.306	0.8	0.74	0.78	0.78
October	154.9	35.4	117.9	3.7	114.2	0.265	0.306	0.8	0.74	0.77	0.79
November	128.9	29.8	96.8	3.6	93.2	0.266	0.306	0.9	0.72	0.75	0.78
December	114.8	27.9	87.9	3	84.9	0.266	0.306	0.9	0.74	0.75	0.77
Yearly	**149.04**	**34.9**	**113.47**	**3.39**	**110.08**	**0.27**	**0.31**	**0.82**	**0.74**	**0.77**	**0.78**

The data shown in the table 6 is presented with the help of programming through which the parameters occurring in the solar PV are observed which are recorded on a day, month and year basis. The data taken by the analysis software is an ideal data before the system is installed. To achieve this, we recorded the data of the year 2023 to rate the performance ratio of the year 2024 and increase the stability of the system. Similarly, in the year 2025, the month-on-month performance ratio was progressively increased with the help of improved programming compared to record data 2024.

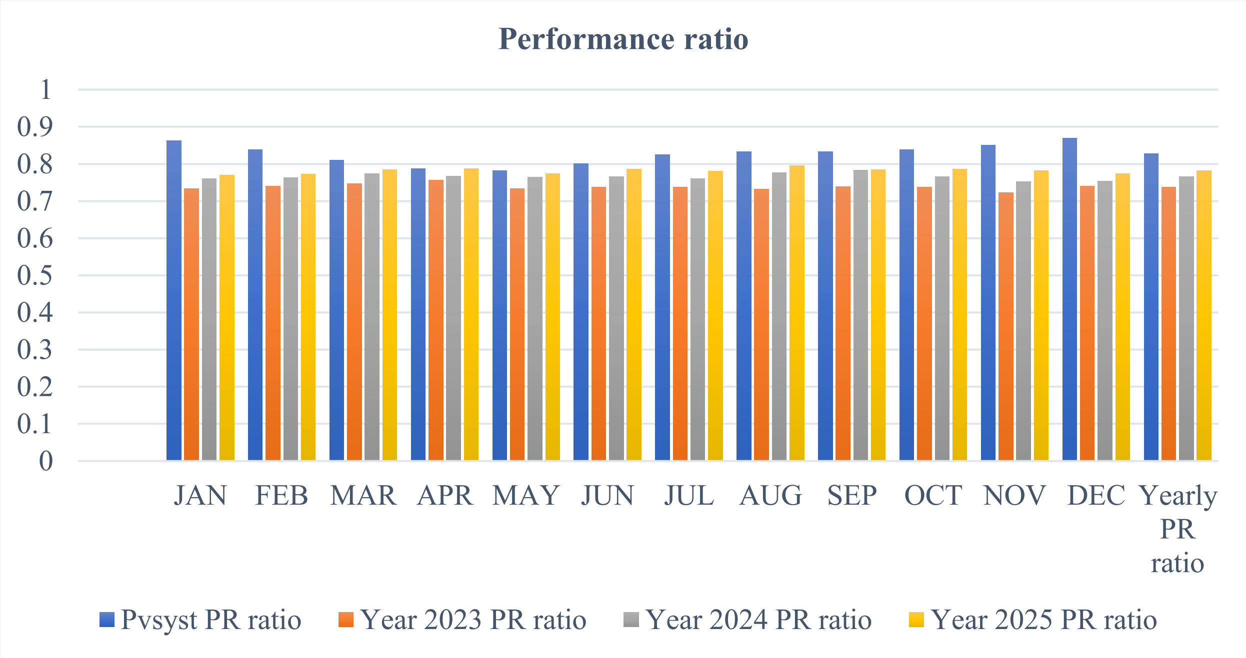

Figure 10: Monthly and Yearly Performance evaluation of an 83.2 KWp solar PV-powered grid-integrated micro grid

In the figure 10, the performance ratio is shown on the basis of month and year, in which the analysis by the PVsyst software and the real data are compared. By looking at the analysis data and the actual data by the PVsyst software every month of every year, the performance ratio of solar PV in every month of every year has been recorded to be practically increased. The analysis software had expected 82.44 percent performance ratio from the system, but in the year 2023, the system has given a performance ratio of 74 percent, after the implementation of programming in 2024, the performance ratio has increased to 77 percent and in the next year 2025, it has increased to 78 percent

4. CONCLUSIONS

The government girl's polytechnic in Lucknow erected an 83.2 KWp solar PV-powered grid-integrated micro grid on the roof of all of its academic buildings. The project was effectively supervised from January 2023 to the end of 2025. Monthly and yearly performance parameters were analyzed accordingly. The micro grid's main conclusions include the plant's yearly average final yield (Y_f) 1616.95 kWh per kWp or 4.43 kWh/kWp/day and PR is 82.44% with a range of 74.20-78.90%. The microgrid exported a total of 134,339 kWh of energy feeded to the utility-grid in its entire monitoring period in ever year and is expected to offset approximately 159.4 tons of CO_2 every year. It has been observed that the performance ratio of solar PV has practically increased in each month of the year by examining the analysis data and the real data by the PVsyst software. The analysis software had anticipated an 82.44 percent performance ratio from the system; however, in 2023, the system reported a performance ratio of 74 percent; following the implementation of programming in 2024 the performance ratio to 77 percent and then to 78 percent in 2025. The research found that each year the performance ratio and system stability showed an improvement over the previous year with an increase in system life. These results suggest the possibility of such large-scale solar installations in the area and also offer insights into using advanced solar technology effectively. A study like this could be informative for the planning and development of solar PV systems in northern India Such an investigation might be beneficial for the design and construction of solar PV systems in India and globally and provide possibilities to perform analyses at other locations in order to compare the results obtained from different software tools. Future work can be carrying out performance measurements of plants in shadings, and it will eventually lead to back up development of DC and AC multi-micro grids in the efficient utilization of PV energy.

Abbreviations- PV: Photovoltaic, IEC: Importer-Exporter Code, DC: Direct Current, AC: Alternating Current, PLC: Programming Logic Control, HMI: Human Machine Interface.

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