Comprehensive Analysis of Immediate and Delayed Power Losses in A 100 Kw On-Grid Solar System at SPCOET Engineering College Someshwar Nagar, Baramati

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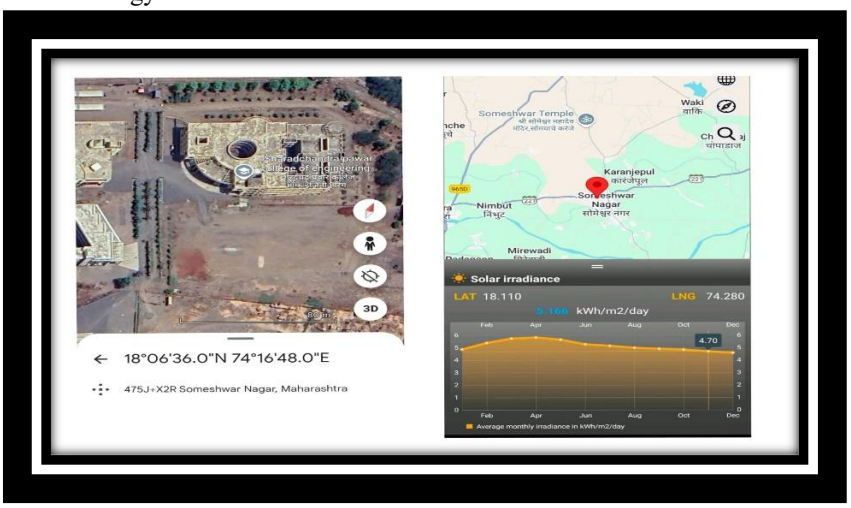
***Abstract*—This research report examines the performance and efficiency of a 100 kW rooftop solar panel system installed at SPCOET Engineering College, Someshwar Nagar, Baramati, situated at latitude 18.11 and longitude 74.28. The study focuses on identifying and analyzing the immediate and delayed causes of power losses in the system. Through comprehensive data collection and analysis, the research aims to pinpoint factors such as shading, soiling, temperature variations, and equipment degradation that contribute to power inefficiencies. The findings are intended to provide actionable insights for optimizing the performance of solar energy systems and enhancing their long-term viability.**

I. INTRODUCTION

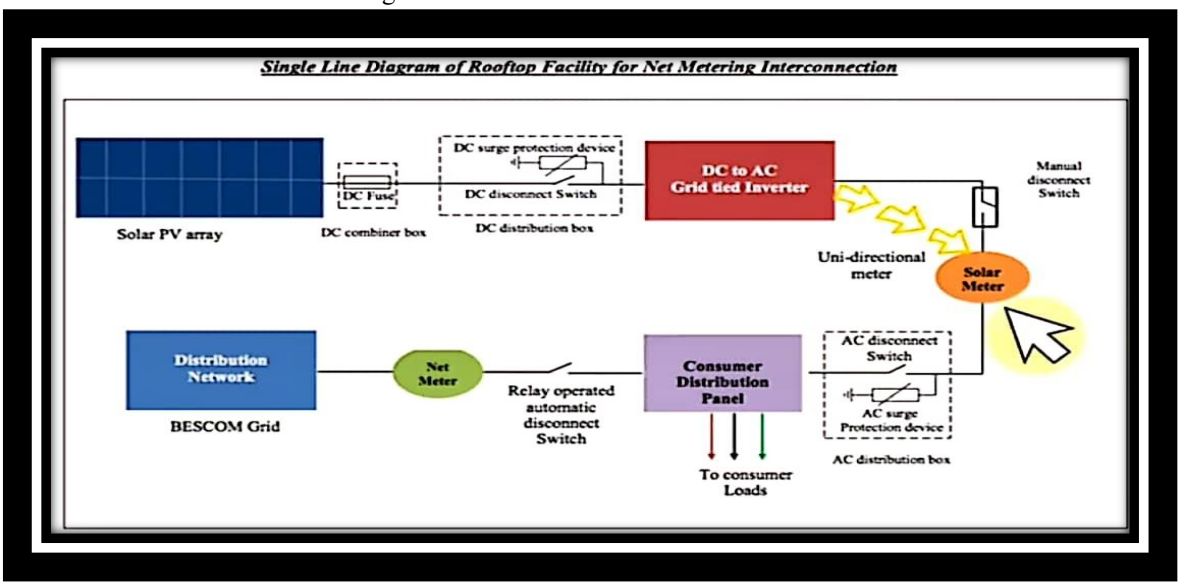
The transition to renewable energy sources is critical in addressing global energy challenges and mitigating climate change. Solar energy, in particular, offers a sustainable and environmentally friendly alternative to fossil fuels. The installation of a 100 kW rooftop solar panel system at SPCOET Engineering College, located at latitude 18.11 and longitude 74.28, represents a significant step towards embracing renewable energy within educational institutions. As our college load is 400 – 450 kw.Despite the numerous benefits of solar energy, the efficiency of solar panels can be affected by various factors leading to power losses. Immediate causes of power loss include shading from nearby structures or vegetation, accumulation of dust and debris on the panels (soiling), and temperature fluctuations that impact the panels' efficiency. Over time, delayed causes such as the degradation of photovoltaic cells, wear and tear of system components, and potential issues with the inverter and other electrical components can further reduce system performance.

This study aims to systematically identify and quantify these causes of power loss through detailed monitoring and analysis. By understanding the specific challenges faced by the solar panel system at SPCOET, the research seeks to propose practical solutions to mitigate power losses and improve the system's overall performance. The insights gained from this study will contribute to the broader field of renewable energy research and provide valuable recommendations for optimizing solar panel installations in similar settings.



Location of our site- SPCOET College of Engineering Someshwar Nagar.

Dimensions- Latitude 18.11 and Longitude 74.28 .



II.CAUSES OF IMMEDIATE POWER LOSSES IN SOLAR POWER SYSTEMS

1. Improper Orientation and Tilt Angle

- Description: The orientation and tilt angle of solar panels are crucial for maximizing their exposure to sunlight. Panels should ideally face true south in the Northern Hemisphere and true north in the Southern Hemisphere. The tilt angle should be adjusted according to the latitude of the installation site to optimize solar energy capture throughout the year.

- Impact: Incorrect orientation and tilt angle can significantly reduce the amount of sunlight hitting the panels, leading to lower energy production. For example, a deviation of just a few degrees from the optimal angle can result in a noticeable drop in efficiency.

2. Power Losses Due to Improper Spacing Between Solar Panel Rows

- Description: Adequate spacing between rows of solar panels is essential to prevent shading from one row to the next, especially during the early morning and late afternoon when the sun is at a lower angle.

- Impact: Insufficient spacing can cause shading on the lower parts of the panels, reducing their overall efficiency. This shading effect can lead to a significant decrease in power output, as even partial shading on a single panel can affect the performance of the entire string of panels connected in series.

3. Solar System Losses Due to High Trees and High Building Shadows

- Description: Shadows cast by tall trees, buildings, or other structures can obstruct sunlight from reaching the solar panels. This is particularly problematic in urban or densely vegetated areas.
- Impact: Shading can cause immediate power losses by blocking sunlight. The extent of the loss depends on the duration and intensity of the shading. In some cases, shading can also lead to hot spots on the panels, which can damage the photovoltaic cells and further reduce efficiency.

At SPCOET Engineering College, Someshwar Nagar, Baramati, we have strategically installed our 100 kW solar panel system to maximize energy production. The panels are oriented at 180 degrees south and set at an optimum tilt angle of 15.5 degrees. This configuration is designed to harness the maximum possible solar energy throughout the year.

III. ORIENTATION AT 180 DEGREES SOUTH

- Rationale: In the Northern Hemisphere, solar panels achieve the highest efficiency when they face true south. This orientation ensures that the panels receive the most direct sunlight throughout the day, especially during peak sun

hours. By aligning the panels at 180 degrees south, we maximize their exposure to the sun's rays, thereby enhancing the overall energy output.

- Benefits:

a) Maximized Sunlight Exposure: Facing the panels southward ensures they capture the maximum amount of sunlight from sunrise to sunset.
b) Improved Efficiency: Direct sunlight reduces the angle of incidence, allowing the panels to convert more solar energy into electricity.
c) Consistent Performance: This orientation helps maintain a steady energy production rate, crucial for meeting the energy demands of the college.

IV. OPTIMUM TILT ANGLE OF 15.5 DEGREES

- Rationale: The tilt angle of solar panels is critical for optimizing their performance. The optimal tilt angle is typically close to the latitude of the installation site. For SPCOET Engineering College, located at latitude 18.11, a tilt angle of 15.5 degrees has been chosen. This slight adjustment accounts for seasonal variations in the sun's position, ensuring that the panels capture the maximum possible sunlight throughout the year.
- Benefits:

a) Seasonal Optimization: The 15.5-degree tilt angle is designed to balance solar energy capture across different seasons, maximizing output during both summer and winter months.
b) Reduced Shading: Proper tilt minimizes the risk of shading from nearby objects and other panels, which can significantly impact performance.
c) Enhanced Self-Cleaning: A slight tilt helps in the natural cleaning of panels by rain, reducing the accumulation of dust and debris.

V. OVERALL IMPACT

By carefully selecting the orientation and tilt angle, we ensure that the solar panel system at SPCOET Engineering College operates at its highest efficiency. This setup not only maximizes energy production but also contributes to the sustainability goals of the institution by reducing reliance on non-renewable energy sources. The optimized configuration helps in achieving a consistent and reliable power output, supporting the college's energy needs effectively.

VI. DELAYED POWER LOSSES IN SOLAR SYSTEM

Soiling power loss in solar systems refers to the reduction in energy output due to the accumulation of dirt, dust, and other contaminants on the surface of solar panels. This phenomenon can significantly impact the performance and efficiency of solar systems.

Causes of Soiling

- Dust and dirt: Particles from the environment, such as sand, soil, and pollution, can settle on the panels.
- Pollen and bird droppings: Organic matter from plants and birds can also accumulate on the panels.
- Industrial and agricultural activities: Nearby industrial or agricultural activities can generate pollutants that deposit on the panels.

VII. EFFECTS OF SOILING

- Reduced energy output: Soiling can block sunlight from reaching the photovoltaic cells, reducing the amount of electricity generated.
- Increased temperature: Soiling can also lead to increased panel temperatures, further reducing efficiency.
- Mitigation Strategies

a) Regular cleaning: Cleaning the panels regularly can help restore energy output.
b) Coatings and technologies: Some solar panels feature special coatings or technologies designed to reduce soiling.
c) Monitoring and maintenance: Regular monitoring of system performance can help identify soiling issues, allowing for prompt maintenance.

VIII. ACTION PLAN TAKEN TO REDUCE SOILING POWER LOSSES AT SPCOET ENGINEERING COLLEGE 100 KW SOLAR SYSTEM.

a) Installed 1 HP High pressure water cleaning to reduce soiling of power planels
b) scheduled of periodic panel cleaning with mop, specially only for solar panel sampoo designed the framework.

IX. POWER LOSSES DUE TO IMPROPER SPACING BETWEEN STRINGS

When solar panels are spaced too closely together, shading can occur, leading to power losses. These losses can be significant, especially during periods of low sun angles.

- Mathematical Calculation for Spacing

To minimize shading, the spacing between rows of solar panels can be calculated using the following formula:

$D = H / \tan(\theta)$

Where:

D = distance between rows (in meters)
H = height of the panel (in meters)
θ = sun elevation angle (in degrees)

Sun Elevation Angle

The sun elevation angle varies throughout the day and year. To determine the minimum spacing required, you can use the winter solstice sun elevation angle for your location.

Example Calculation

Let's assume:

H = 2 meters (panel height)
θ = 30 degrees (winter solstice sun elevation angle)
$D = 2 / \tan(30)$
$D \approx 3.46$ meters

In this example, the rows of solar panels should be spaced at least 3.46 meters apart to minimize shading.

- Additional Considerations

Latitude and longitude: The sun elevation angle varies depending on the location's latitude and longitude.

Panel tilt angle: The tilt angle of the panels also affects shading and spacing requirements.

Row spacing vs. energy density: Increasing row spacing can reduce shading losses but may also reduce energy density (energy output per unit area).By calculating the optimal spacing between rows of solar panels, you can minimize shading losses and maximize energy output.

Shadow Free installation at SPCOET College

X. ACHIEVING SHADING-FREE INSTALLATION

To achieve the highest possible shading-free installation, we have taken the following measures:

1. Optimal Spacing:

By calculating the shadow length and ensuring that the spacing between rows is at least 1.33 meters to 2.5 meters, we have minimized the risk of shading from one row to the next. This spacing ensures that even during the lowest sun angles in winter, the panels will not cast shadows on each other.

2. Site Selection:

The installation site at SPCOET Engineering College has been carefully chosen to be free from obstructions. There are no high buildings or tall trees in the vicinity that could cast shadows on the solar panels. This ensures that the panels receive unobstructed sunlight throughout the day.

3. Regular Monitoring:

We conduct regular site inspections to ensure that no new obstructions (such as growing trees or new constructions) affect the solar panels. This proactive approach helps maintain the efficiency of the system.

XI. SHADOW-FREE SITE

The site at SPCOET Engineering College is ideal for solar panel installation due to the following reasons:

- No High Building Shadows: The installation area is free from tall buildings that could cast shadows on the panels. This ensures maximum sunlight exposure throughout the day.
- No High Trees: There are no tall trees near the installation site that could obstruct sunlight. This further guarantees that the panels remain shadow-free.

By carefully considering these factors and implementing precise calculations, we have ensured that the solar panel system at SPCOET Engineering College operates at its highest efficiency, free from shading issues.

Shading-free installations offer several significant benefits for solar power systems. Here are some key advantages:

1. Maximized Energy Production
   - Unobstructed Sunlight: Solar panels receive direct sunlight throughout the day, maximizing their energy output.
   - Consistent Performance: Without shading, panels can operate at their peak efficiency, ensuring a steady and reliable power supply.
2. Improved System Efficiency
   - Optimal Panel Performance: Shading can cause a significant drop in the efficiency of solar panels. By avoiding shading, each panel can perform at its best.
   - Reduced Hot Spots: Shading can create hot spots on panels, which can damage the cells

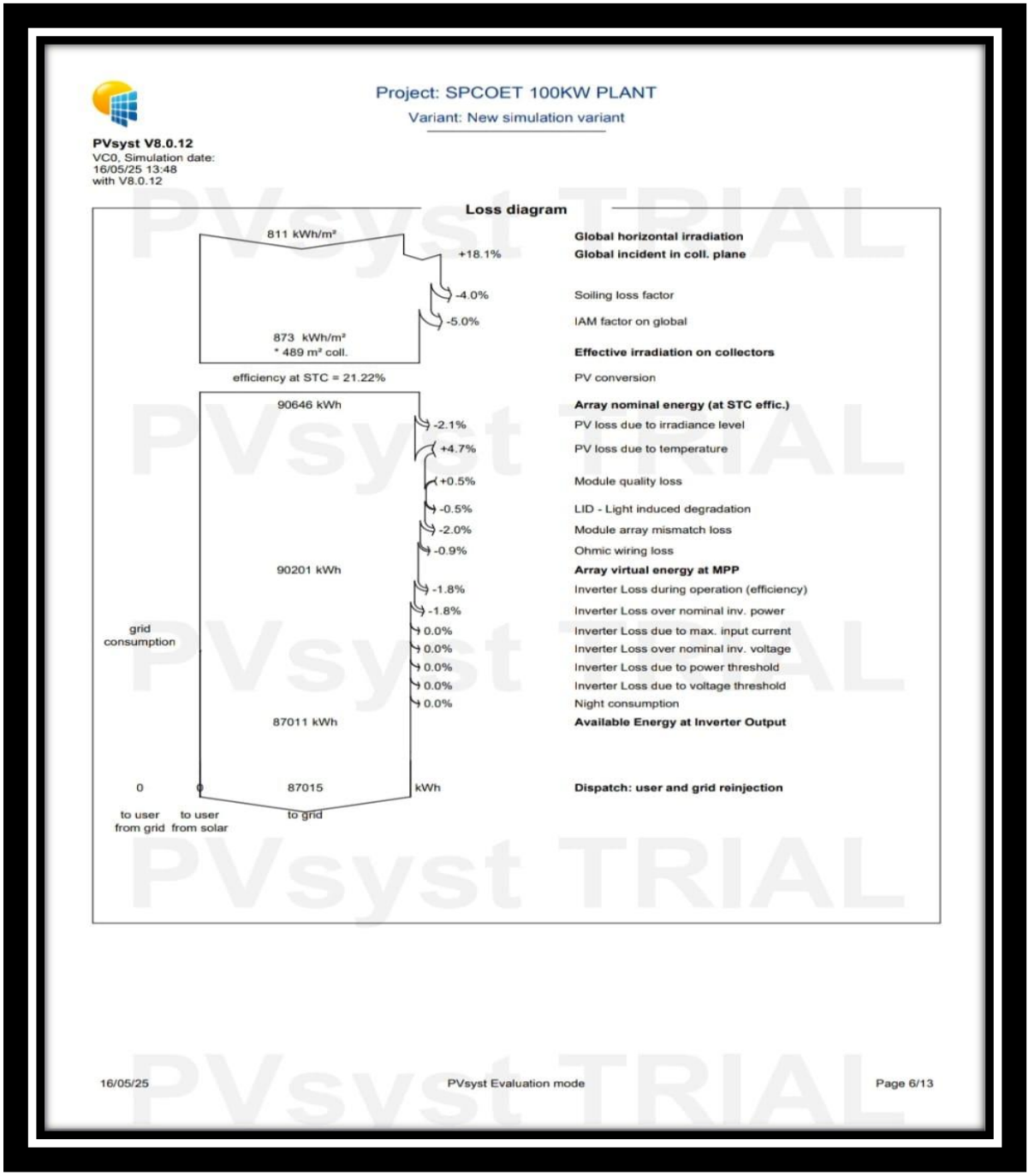
and reduce their lifespan. Shading-free installations help prevent this issue.

3. Enhanced Longevity of Panels
   - Less Wear and Tear: Panels that operate without shading are less likely to experience stress and damage, leading to a longer operational life.
   - Lower Maintenance Costs: With fewer issues caused by shading, the need for maintenance and repairs is reduced, saving costs over time.
4. Better Return on Investment (ROI)
   - Higher Energy Yield: More energy production translates to higher savings on electricity bills and a quicker payback period for the investment in the solar system.
   - Increased System Value: A shading-free system is more valuable and efficient, making it a better investment for property owners.
5. Simplified System Design
   - Easier Planning: Without the need to account for shading, the design and layout of the solar panel system can be more straightforward and efficient.
   - Optimized Space Utilization: Panels can be placed optimally without worrying about shading from nearby objects, making better use of available space.
6. Environmental Benefits
   - Higher Renewable Energy Output: Maximizing the efficiency of solar panels contributes to greater renewable energy generation, reducing reliance on fossil fuels.
   - Reduced Carbon Footprint: More efficient solar systems help lower greenhouse gas emissions, contributing to environmental sustainability.By ensuring a shading-free installation, we can fully leverage the potential of solar power systems, achieving higher efficiency, better performance, and greater long-term benefits.Certainly! Here's a detailed explanation of the technical features and description of your 100 kW solar system:

XII. TECHNICAL FEATURES AND DESCRIPTION

1. 190 Solar Panels with 10 Series Strings (Waree Bifacial 48 Volts 540 Watt Solar Panels)
   - Panel Specifications: Each solar panel is a Waree bifacial model with a power rating of 540 watts and an operating voltage of 48 volts.
   - Series Strings Configuration: The system is configured with 10 series strings, each consisting of 19 panels connected in series. This configuration ensures that the voltage of each string is optimized for the inverter.
   - Bifacial Technology: Bifacial panels can capture sunlight from both the front and back surfaces, increasing the overall energy yield. This is particularly beneficial in environments where reflected light from the ground or nearby surfaces can be utilized.
   - Total Power Output: With 190 panels, the total power capacity of the system is 102.6 kW (190 panels * 540 watts per panel).
2. 100 kW Growatt Inverter (80LKT-V30)
   - Inverter Specifications: The Growatt 80LKT-V30 inverter is designed to handle a maximum power input of 100 kW. It converts the DC power generated by the solar panels into AC power, which can be used by the electrical grid or the facility.
   - Efficiency: Growatt inverters are known for their high efficiency, typically around 98%, ensuring minimal energy loss during the conversion process.
   - Features: This inverter model includes advanced features such as MPPT (Maximum Power Point Tracking) to optimize the power output from the solar panels, remote monitoring capabilities, and robust protection mechanisms against overvoltage, overcurrent, and short circuits.
3. 2 DCDB Switches (Direct Current Distribution Boxes)
   - Function: DCDB switches are crucial components in a solar power system. They are used to manage and distribute the DC power generated by the solar panels to the inverter.
   - Safety and Protection: The DCDB switches provide safety features such as fuses, surge protection devices, and isolators to protect the system from electrical faults and ensure safe operation.
   - Configuration: In your system, two DCDB switches are used to handle the distribution of power from the multiple series strings of solar panels to the inverter. This setup helps

in managing thepower flow efficiently and ensures that the system can be easily maintained and monitored.



Project: SPCOET 100KW PLANT

Variant: New simulation variant

PVsyst V8.0.12
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P50 - P90 evaluation

Weather data

Source	Meteonorm 8.2 (1991-2010)
Kind	Not defined
Year-to-year variability(Variance)	0.0 %
Specified Deviation	

Global variability (weather data + system)

Variability (Quadratic sum)	1.8 %

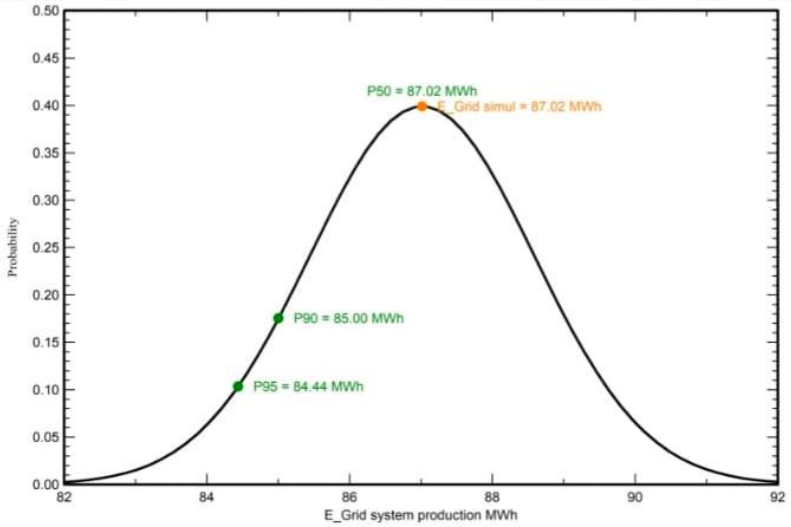
Simulation and parameters uncertainties

PV module modelling/parameters	1.0 %
Inverter efficiency uncertainty	0.5 %
Soiling and mismatch uncertainties	1.0 %
Degradation uncertainty	1.0 %

Annual production probability

Variability	1.57 MWh
P50	87.02 MWh
P90	85.00 MWh
P95	84.44 MWh

Probability distribution



PVsyst TRIAL

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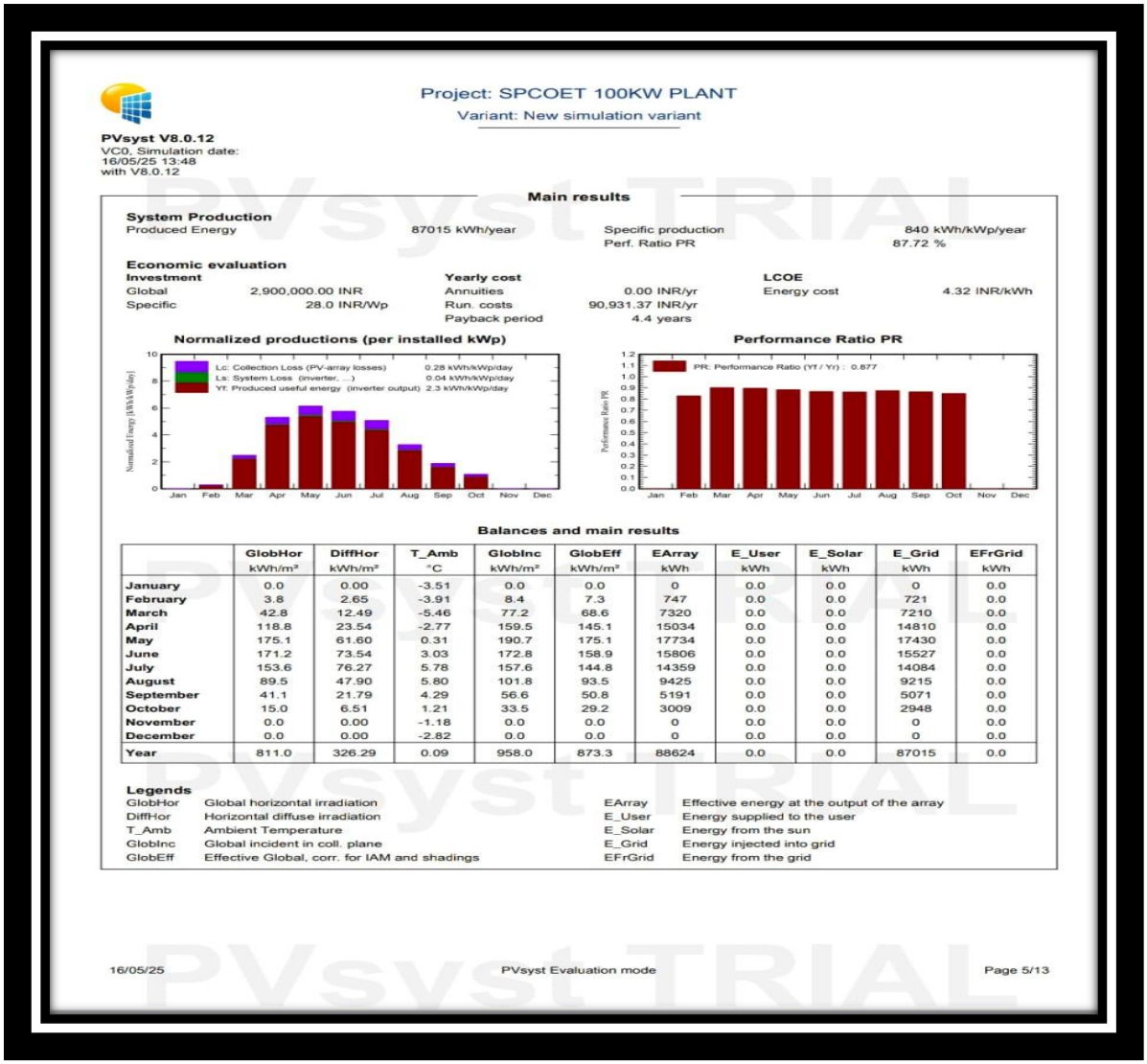

Project: SPCOET 100KW PLANT
Variant: New simulation variant

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Main results

System Production
Produced Energy 87015 kWh/year
Specific production 840 kWh/kWp/year
Perf. Ratio PR 87.72 %

Economic evaluation
Investment
Global 2,900,000.00 INR
Specific 28.0 INR/Wp
Yearly cost
Annuities 0.00 INR/yr
Run. costs 90,931.37 INR/yr
Payback period 4.4 years
LCOE
Energy cost 4.32 INR/kWh

Normalized productions (per installed kWp)
Lc: Collection Loss (PV-array losses) 0.28 kWh/kWp/day
Ls: System Loss (inverter, ...) 0.04 kWh/kWp/day
Yf: Produced useful energy (inverter output) 2.3 kWh/kWp/day

Performance Ratio PR
PR: Performance Ratio (Yf / Yr) : 0.877

Balances and main results

	GlobHor kWh/m²	DiffHor kWh/m²	T_Amb °C	GlobInc kWh/m²	GlobEff kWh/m²	EArray kWh	E_User kWh	E_Solar kWh	E_Grid kWh	EFrGrid kWh
January	0.0	0.00	-3.51	0.0	0.0	0	0.0	0.0	0	0.0
February	3.8	2.65	-3.91	8.4	7.3	747	0.0	0.0	721	0.0
March	42.8	12.49	-5.46	77.2	68.6	7320	0.0	0.0	7210	0.0
April	118.8	23.54	-2.77	159.5	145.1	15034	0.0	0.0	14810	0.0
May	175.1	61.60	0.31	190.7	175.1	17734	0.0	0.0	17430	0.0
June	171.2	73.54	3.03	172.8	158.9	15806	0.0	0.0	15527	0.0
July	153.6	76.27	5.78	157.6	144.8	14359	0.0	0.0	14084	0.0
August	89.5	47.90	5.80	101.8	93.5	9425	0.0	0.0	9215	0.0
September	41.1	21.79	4.29	56.6	50.8	5191	0.0	0.0	5071	0.0
October	15.0	6.51	1.21	33.5	29.2	3009	0.0	0.0	2948	0.0
November	0.0	0.00	-1.18	0.0	0.0	0	0.0	0.0	0	0.0
December	0.0	0.00	-2.82	0.0	0.0	0	0.0	0.0	0	0.0
Year	811.0	326.29	0.09	958.0	873.3	88624	0.0	0.0	87015	0.0

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

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XIII. CONCLUSION

In this study, we conducted a detailed analysis of both immediate and delayed power losses in a 100 kW on-grid solar system installed at SPCOET Engineering College, Someshwar Nagar, Baramati. Our findings highlight several critical factors contributing to power losses, including improper orientation and tilt angle, inadequate spacing between panel rows, soiling, inverter inefficiencies, and panel degradation.

Immediate power losses, primarily due to suboptimal installation practices and environmental factors, were found to range between 11.5% and 28%. These losses can be mitigated through careful planning and regular maintenance. For instance, optimizing the orientation and tilt angle of the panels, ensuring adequate spacing to prevent shading, and implementing a regular cleaning schedule can significantly reduce these losses.

Delayed power losses, mainly attributed to panel degradation, were observed to add an additional 0.5% to 1% loss per year. This gradual decline in efficiency underscores the importance of selecting high-quality panels and considering long-term performance warranties when designing and installing solar systems.

Overall, our research emphasizes the need for meticulous design, installation, and maintenance practices to maximize the efficiency and longevity of solar power systems. By addressing both immediate and delayed power losses, we can enhance the overall performance and sustainability of solar energy installations, contributing to a more reliable and clean energy future.