Ensuring Minimum CUF of 19% for a Solar Power Plant Over 25 Years: A Guide for Developers under PM-KUSUM Scheme

Executive Summary

PM-KUSUM (Pradhan Mantri Kisan Urja Suraksha evam Utthaan Mahabhiyan) scheme in India aims to promote the use of solar energy among farmers. To ensure the financial viability and operational efficiency of solar power plants under this scheme, a minimum Capacity Utilization Factor (CUF) of 19% over the 25 years lifetime of a plant without deration is required. This whitepaper provides a comprehensive guide for developers on how to achieve this goal with a focus on selecting the correct solar panels.

Figure 1: PM-KUSUM Scheme

Introduction

What is CUF?

Capacity Utilization Factor (CUF) is a measure of how effectively the installed capacity of a solar power plant is utilized. It is defined as the ratio of actual energy generated by the plant over a specific period (typically a year) to the maximum possible energy that could have been generated at continuous full power operation during the same period.

Mathematically, it is: CUF = Plant Output in kWh / (Installed Plant Capacity (AC) in kWh * 365 × 24)

Importance of Meeting CUF Requirements

Meeting the minimum CUF of 19% is crucial for:

- Ensuring financial returns and viability.
- Compliance with PM-KUSUM scheme Component C (Feeder Level Solarization) requirements.
- Sustaining long-term operational efficiency.

Key Factors Influencing CUF

1. Solar Irradiance

Solar irradiance is the power per unit area received from the Sun in the form of electromagnetic radiation. Locations with higher solar irradiance, such as Rajasthan are more favorable for achieving higher CUF.

2. System Losses

System losses include shading, dust, AC and DC wiring losses, inverter losses, array mismatch losses and temperature-related losses. Minimizing these losses is essential for maintaining high CUF.

3. Panel Quality and Degradation

The choice of solar panels directly impacts the Solar Power Plant’s CUF. Solar Panels with lower degradation rates and higher efficiency can maintain performance over the plant's lifetime.

Figure 2: Gautam Solar's Mono PERC Solar Panel

Choosing the Correct Solar Panels

Types of Solar Panels

Polycrystalline Panels: Generally less expensive but also less efficient than monocrystalline panels.

Monocrystalline Panels: Known for their high efficiency and longevity. They perform well in conditions of low solar irradiance and have lower degradation rates. Newer Monocrystalline Panels also incorporate Half-Cut Cell, Multi-Busbar (MBB) and Bifacial Technology to further improve the Panel Performance.

Key Characteristics of Solar Panels

Efficiency: Higher efficiency panels convert more sunlight into electricity, thereby helping achieve higher CUF.

Temperature Coefficient: Panels with a lower temperature coefficient perform better in high-temperature conditions, which is critical in regions with high ambient temperatures.

Degradation Rate: Panels with lower annual degradation rates ensure that the plant maintains its performance over 25 years.

Warranty and Reliability: Long-term warranties and reliable performance are essential for sustaining CUF.

Panel Selection Criteria for KUSUM Scheme

To meet the minimum CUF of 19%, developers should prioritize the following criteria:

High Efficiency: Panels with efficiencies above 20% are recommended. **Gautam Solar's** 550 Wp Mono PERC Panels have maximum efficiency of 21.29%.

Low Degradation Rate: Choose panels with low first year (less than 3%) and annual degradation rates (less than 0.7%). **Gautam Solar's** Mono PERC Panels have 2% first year and 0.55% year 2-25 degradation rates.

Reliable Warranty: While all Solar Panel manufacturers offer at least a 25-year performance warranty, it is recommended to select panels manufactured by a company like **Gautam Solar** which has been in the solar business for at least that much time, to ensure peace of mind.

NOCT and Temperature Coefficient: Opt for panels with a Nominal Operating Cell Temperature (NOCT) below 48°C and Temperature coefficient of -0.4%/°C or better. **Gautam Solar's** Panels have NOCT of 45°C (±2°C) and Temperature Coefficient of Pmax is -0.39%/°C.

Optimized Design using Appropriate Material and Latest Technology: Using Panels manufactured with materials that lower thermal resistance lowers heating losses. Additionally, using technologies like NDC Half-Cutting and Round Ribbon helps ensure optimal performance in regions of high temperatures.

Thermal Tests: Panels used should have undergone various temperature related tests to ensure good performance in high temperature:

- ***Thermal Cycling Test:*** 200 Testing cycles between -40°C to +85°C as per IEC 61215 Standards.
- ***Damp Heat Test:*** 1000 hours testing of Solar Panels at 85°C ± 2°C with relative humidity of 85% ± 5% as per IEC 61215 Standards.
- ***Humidity Freeze Test:*** 10 Testing cycles (of 24 hours) between -40°C to +85°C with rapid rate of temperature change (< 100°C/h) and high humidity (85% ± 5%) at upper limit (+85°C) as per IEC 61215 Standards.

Figure 3: Thermal Cycling Test

Implementation Strategies

Site Assessment

Conduct a thorough site assessment to understand the solar irradiance profile, temperature ranges, and potential shading issues.

Design Optimization

Optimize the plant design to reduce system losses. This includes proper spacing between panels, optimal tilt angles and orientation, and high-quality inverters.

Regular Maintenance

Implement a robust maintenance plan to keep panels clean and free from obstructions, and regularly check and maintain all electrical components.

Performance Monitoring

Use advanced monitoring systems to track the performance of the solar power plant in real-time and identify issues promptly.

Theoretical Case Study

Overview

A theoretical case study of a 1 MW solar power plant implemented under PM-KUSUM scheme demonstrates the practical application of these strategies.

Site Characteristics

- Location: Rajasthan, India
- Solar Irradiance: 5.5 kWh/m^2/day average (varying between 4.36 kWh/m^2/day on cloudy days to 7.57 kWh/m^2/day on sunny days)
- Ambient Temperature: 25°C-45°C

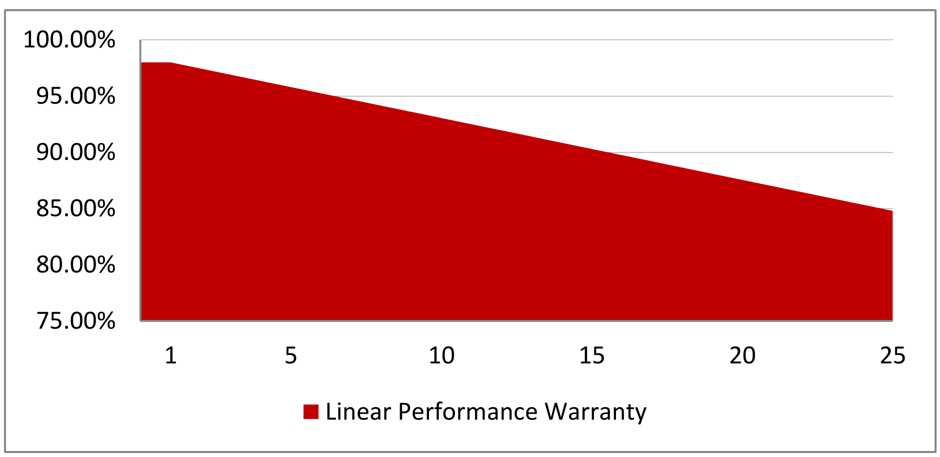

Figure 4: 25 Year Performance Graph of Gautam Solar Panels

Panel Selection

- Make: **Gautam Solar**
- Wattage: 550 Wp
- Type: Monocrystalline PERC Bifacial Glass-to-Backsheet
- Efficiency: 21.29%
- Degradation Rate: 0.55% per year
- Temperature Coefficient: -0.39%/°C

Initial Performance

- Initial CUF: 22.5%

Performance Projection Over 25 Years

Using the first year degradation of 2%, the performance after year 1 can be calculated as follows:

- **After Year 1:** CUF = 22.5% - (2% * 22.5%) = 22.05%

Using annual degradation rate of 0.55%, the performance projection in nth year can be calculated as:

- **After Year n:** CUF ≈ 22.05% * $(1 – 0.55\%)^{(n-1)}$

Performance after 10^{th} and 25^{th} year is calculated as:

- **After Year 10:** CUF ≈ 22.05% * $(1 – 0.55\%)^{(10-1)}$ = 20.982%
- **After Year 25:** CUF ≈ 22.05% * $(1 – 0.55\%)^{(25-1)}$ = 19.316%

Power Plants using **Gautam Solar's** Solar Panels have consistently achieved initial CUF over 22.5%.

Results

Projected CUF: The projected CUF after 25 years is above 19%, meeting the KUSUM scheme requirements.

Assumptions and Mitigations

- **Assumptions:** Consistent maintenance, minimal unexpected downtimes, and favorable weather conditions.
- **Mitigations:** Regular system checks, use of advanced cleaning methods, and preventive maintenance schedules.

Conclusion

Achieving and maintaining a CUF of 19% over 25 years without deration is feasible through careful selection of high-efficiency, low-degradation solar panels (like **Gautam Solar** Mono PERC Panels), and implementing robust design, maintenance, and monitoring strategies. By following the guidelines provided in this whitepaper, developers can ensure compliance with PM-KUSUM scheme and achieve sustainable, long-term performance of their solar power plants.