Whitepaper

Technology Transformation in Solar Power Generation

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Executive Summary

Declining costs, supportive policies, and growing energy demand have fueled record solar deployment worldwide, with utility-scale projects emerging as the primary driver of new capacity additions. These projects are expanding solar's role from a supplemental energy source to a major contributor to modern power systems.

In 2025 alone, the world added more than 200 GW of new solar PV capacity, with utility-scale projects accounting for the clear majority.[1] As utilities enter the next phase of scale and maturity, they must transform how solar assets are monitored and managed, moving beyond simple generation to fully optimized, predictable, and resilient solar power systems.

This whitepaper examines the current state of solar markets, the changing dynamics of utility-scale solar generation, the growing complexity of operating and managing solar infrastructure, and the role of integrated technology transformation in enabling the next phase of solar operations.

200+ GW of solar PV was added globally in 2025, with utility-scale projects leading growth and reshaping how solar assets must be managed.

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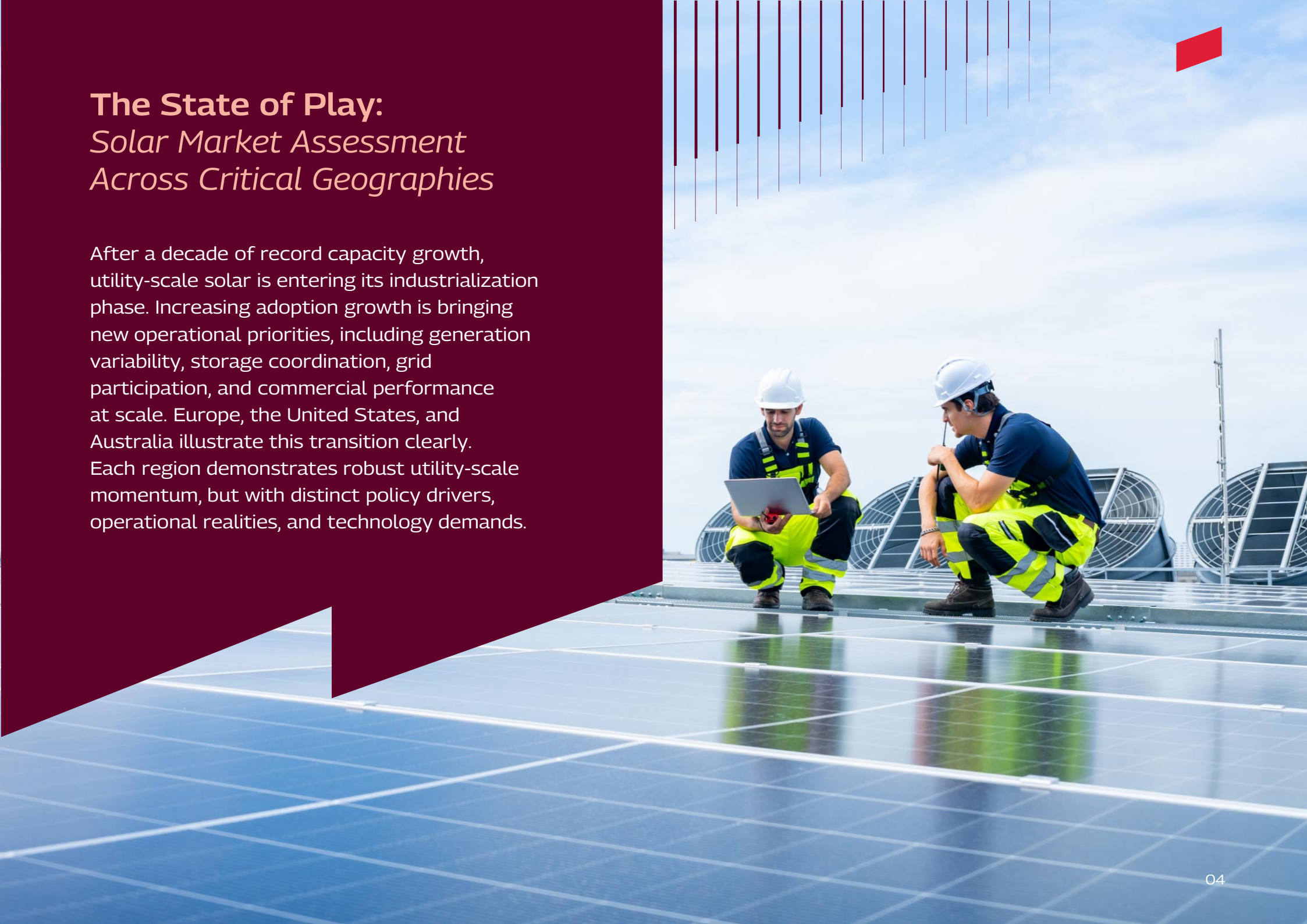
The State of Play:
Solar Market Assessment Across Critical Geographies

After a decade of record capacity growth, utility-scale solar is entering its industrialization phase. Increasing adoption growth is bringing new operational priorities, including generation variability, storage coordination, grid participation, and commercial performance at scale. Europe, the United States, and Australia illustrate this transition clearly. Each region demonstrates robust utility-scale momentum, but with distinct policy drivers, operational realities, and technology demands.



Europe

Europe has established itself as one of the most ambitious solar markets. As a leader in the production and consumption of renewable energy, Europe now sees solar as its fastest-growing power source.[3] Currently, it generates ~13% of its electricity through solar.[4] And in 2025, with strong expansion, the continent installed roughly 400+ GW of PV capacity.[5] This trajectory is on track to reach ~700+ GW by 2030.[3] Key countries in the continent highlight this scale and direction:

Germany	Spain	Italy	France	UK
Installed capacity: >100 GW by end 2024; largest PV fleet in EU	**Installed capacity:** ~50 GW by 2025	**Installed capacity:** ~50 GW by 2026	**Installed capacity:** ~30 GW 2024	**Installed capacity:** ~18-20 GW by 2025
2030 target: 215 GW	**2030 target:** 76 GW	**2030 target:** 79-85 GW	**2030 target:** 48 GW	**2030 target:** 45-50 GW
Solar share: ~12% of electricity today; targeted ~30% by 2030	**Solar share:** 22% of electricity today; ~81% by 2030	**Solar share:** ~17% electricity today; ~69% by 2030	**Solar share:** ~5%	**Solar share:** ~5%

Key Trends

In this dynamic environment, six trends are fundamentally shaping Europe's utility-scale solar market:

- The shift from capacity to integration
- Rising digital and OT relevance
- Cost discipline and commercial innovation through auctioning
- Energy giants entering the utility-scale solar market
- Technological innovation in deployment models
- Strong policy push towards green energy

As a result of these developments, solar has emerged as a core infrastructure asset. It is tightly coupled with storage, modernized grids, digital platforms, and evolving market design.
The market mandate in Europe is clear: operators must move beyond building solar assets to intelligently operating and optimizing them at scale.

The United States

The United States of America is steadily picking up pace in its embrace of solar energy. By 2024, the country had already installed ~236 GW (DC) of solar capacity, supplying ~7% of total electricity generation.[6&7] Additionally, in the same year, it added ~50 GW of new solar capacity, making it one of the fastest-growing solar markets worldwide.[6] To support this growth, it's also expanding its geographic footprint beyond Texas and California. With these shifts in place, it is estimated that by 2030, the US will reach 300-400+ GW of total solar capacity, contributing ~15% of US electricity. [6]

Key Trends

This rapid expansion is paving a clear path to five defining trends.

- The shift from an alternative source to a core pillar of power generation
- Extensively increasing solar capacity build-outs
- Rising digital and OT relevance
- Increasing digitization efforts to support grid resilience
- Technological innovation in deployment models

Despite ongoing geopolitical conflicts, policy constraints, and continued prioritization of traditional energy sources, the United States is still making significant progress in transforming large-scale solar into reliable, grid-ready assets.

Australia

Solar is on the fast track in Australia. As a major world player in large-scale batteries, grid-forming inverters, and virtual power plants (VPPs), Australia is betting big on green energy. The numbers speak for themselves. The country has already installed approximately ~40 GW of total PV capacity, with solar currently supplying ~18% of total electricity generation.[8&9] It is on track to roughly double its installed base by 2030, potentially contributing up to 30% of the nation's electricity.[10] Australia also boasts the highest rooftop solar penetration in the world.

Key Trends

Australia's leadership in solar has brought forward five critical trends that define the market today.

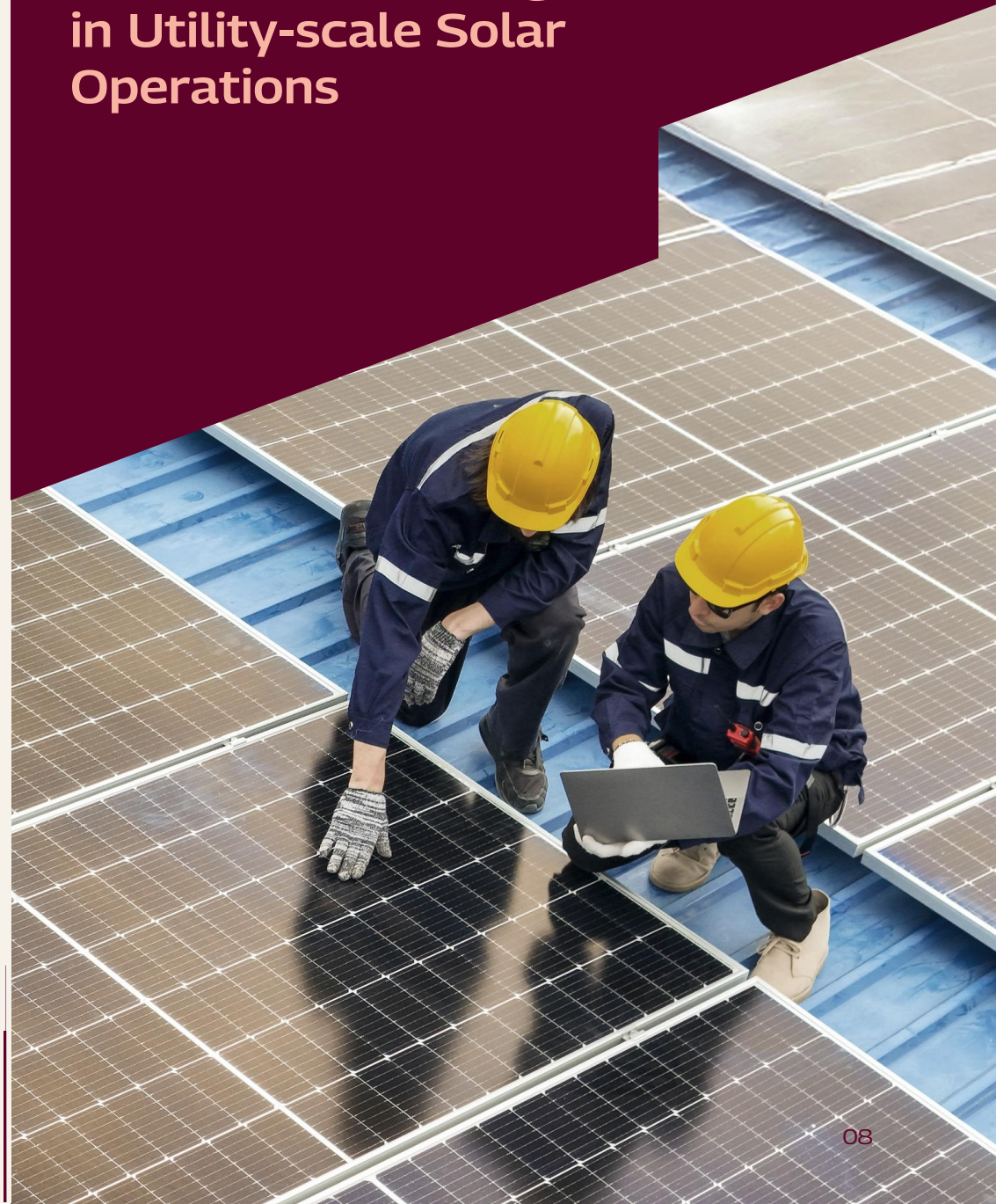
- Effective management of massive distributed solar for seamless power generation
- Rising digital and OT relevance
- Establishment of stable grids with a low level of synchronous generation
- Increasing orchestration efforts and solar storage capacity
- Technological innovation in deployment models

As the world's most advanced solar market, Australia is already ahead not only in its installed capacity but also in operations. To sustain this progress, the country needs solid tech and digital support for grid management, forecasting, market integration, and real-time orchestration.

Structural Challenges in Utility-scale Solar Operations

The global solar market has moved past the early adoption phase. We are now in the industrialization phase, where the challenges have shifted from proving the technology to managing the complexity of the grid. Six major forces converge to constrain modern utility-scale solar operations.

- **Regulatory Volatility:** Constant changes in government policies, such as permits, tariffs, compliance requirements, and prioritization, all compound together to create uncertainty and stall progress in solar energy operations.
- **Intermittency:** Sunlight is not available round the clock. This creates a production issue. Also, the inherent nature of certain geographies limits solar power generation. Without proper storage and hybrid configurations, plants face dire production and distribution issues.



- **Land-related Hurdles:** Constructing and maintaining a utility plant requires the right identification of large-scale land. In addition, its acquisition, which involves negotiation, requires significant time and capital. This prolonged land-related issue impacts utility projects.
- **Technology Obsolescence:** Plants developed in the last decade operate on legacy supervisory control and data acquisition (SCADA) systems, with no AI integration or analytical capabilities. This dated approach to digital infrastructure limits the plant and capabilities in power generation.
- **Performance Degradation:** Plant output eventually declines after 4-5 years. This is due to solar cell degradation and other efficiency issues. Without strategic intervention and modernization, this decrease impacts revenue and yield.
- **Asset Lifecycle Management:** Over time, components in utilities require replacement and retrofitting. Plants operating with legacy and faulty assets incur costs both commercially and operationally.

These challenges rarely occur in isolation. They compound, creating major roadblocks for utilities. The response to overcome it is not through incremental changes but through a total systematic technology transformation.

> ***Solar has entered its industrialization phase. The complexity of managing it at scale demands a fundamental transformation in technology.***

Technology Transformation:
From Passive Power Generation to Intelligent Orchestration

Utilities generally operate in markets with thin margins. Revenue depends on three variables: energy volume sold, price captured per MWh, and operational costs per MWh. Effective technology transformation targets all three. Here's a rundown.

Criteria	How Tech Transformation Helps
Volume	Recovers lost yield due to degradation through operations and maintenance (O&M) optimization.
Price	Forecasting demand and power production supports effective management, especially during peak-price periods.
Cost	Comprehensive monitoring and operational insights reduce downtime and improve performance.

Core Technology Layers for Transformation

Four key layers are the minimum technological requirement for competitive utility-scale solar operations.

Data and Visibility

Intelligent solar operations start with comprehensive data capture and monitoring. Integrating advanced SCADA systems to aggregate real-time data from critical assets such as panel strings, inverters, transformers, weather stations, and grid interface points helps as the operational foundation for optimization.

On a daily basis, utilities generate an extensive amount of data. The challenge for modern plants is not just to collect them but to store, structure, and make them actionable. AI-enabled SCADA systems are progressively enhancing visibility and insight generation capabilities to help plants make sense of their operations.

Intelligence

The performance and reliability of plants can be dramatically improved by integrating AI and ML models to process SCADA data. These AI models are particularly useful for market intelligence, forecasting power generation, predicting asset failures, optimizing performance, managing health across panels and batteries, and planning maintenance.

By embedding intelligence into key operational functions, plants can shift from a reactive to a proactive approach and identify critical issues in real time.

Integration

Traditionally, solar plant operations run in silos. The core systems of plants, operators, and trading desks are often fragmented and work in isolation. Connecting OT and IT at scale solves major challenges and improves visibility. By integrating energy management systems (EMS), advanced distribution management systems (ADMS), and distributed energy resource management systems (DERMS) with key enterprise systems, solar plants gain a unified layer that enables real-time data flow, forecasting, grid interaction, and operational efficiency.

Control

Safety and stability are not afterthoughts; they must be embedded into the core design through technology. Implementing an advanced programmable logic controller (PLC) with real-time orchestration helps monitor asset conditions, automate alerting, trigger corrective actions for deviations, and autonomously initiate shutdowns to minimize damage. This execution at each stage helps utilities decide better under stress.

Tech Mahindra's Integrated Approach to Solar Transformation

Tech Mahindra, in collaboration with Mahindra Teqo, offers end-to-end utility-scale solar transformation through its next-gen solutions and advisory support. Operating with the motto of monitor, measure, improve, and achieve (MMIA), TechM's approach stems from the commitment to sustainability and a dedicated focus on serving solar initiatives.

Tech Mahindra delivers transformation across five critical phases.

Phase	Focus	Solutions
Operations and Maintenance	Day-to-day support for the power generation, including plant monitoring, asset health tracking, workforce coordination, and predictive upkeep.	Digital Twin, Remote Monitoring, Smart Report, AI/ML-based Fault Prediction/Identification, Smart Field Operator, FSM, EAM, Remote Diagnostic Capabilities, Virtual Dexterity Training
Optimization and Performance	Complete streamlining of operations, including forecasting power production, yield recovery, asset tuning, and performance improvement	AI/ML-based Set Point Optimization, Asset Performance Monitoring, Digital Twin, Fuel Quality Monitoring, Water Quality Management, Waste Management, DERs, VPPs, Energy Auditor
Procurement and Supply Chain	End-to-end material management, including component sourcing, inventory control, supplier management, and cost optimization	Inventory Management, Order Management, Supplier Performance Management, Supplier Quotation Sourcing System, BPS Enterprise Back Office, Cognitive Supply Chain Analytics
Financial Planning and HSE	Offers back-office and safety support through capital allocation, demand forecasting, energy trading, worker safety, environmental compliance, and emergency response	ERP System, Demand Forecast, Energy Trading, Renewable Energy Integration, Project Planning, Planned Maintenance, Safety Management System, PPE Monitoring, Emergency Alert System, Emission Monitoring
Transmission and Distribution	Provides transmission and delivery support through grid integration, power evacuation, real-time dispatch, and grid code compliance	AI/ML-based Set Point Optimization, Smart Field Operator, Remote Monitoring, VPPs, DERMS, Digital Twin, Asset Performance Monitoring, AI/ML-based Fault Prediction, Outage Management

TechM's Roadmap for Technology Transformation

TechM initiates the transformation journey by building a Solar + Storage Backbone. This foundation enables key capabilities for the utilities, such as asset performance monitoring, predictive maintenance, and fleet-wide visibility across the plant and its key functions.

Once the backbone is operational, the next priority is breaking down silos between plant-level operational technology and enterprise IT systems. Therefore, TechM enables key integrations of SCADA, EMS/ADMS, and DERMS with enterprise systems. This step provides real-time visibility for planning, forecasting, and dispatch decisions.

Finally, TechM deploys digital operations platforms and enables AI and GenAI applications across the solar value chain. This enables AI-powered capabilities in energy trading, forecasting, market optimization, and risk management, while providing unified analytics and dashboards for further monitoring and management.

Implementation Impact and Value Realization

A digital backbone, AI-driven intelligence, and seamless IT-OT-Grid integration are the new frontiers for modern intelligent solar operations. With this implementation, operators can achieve:

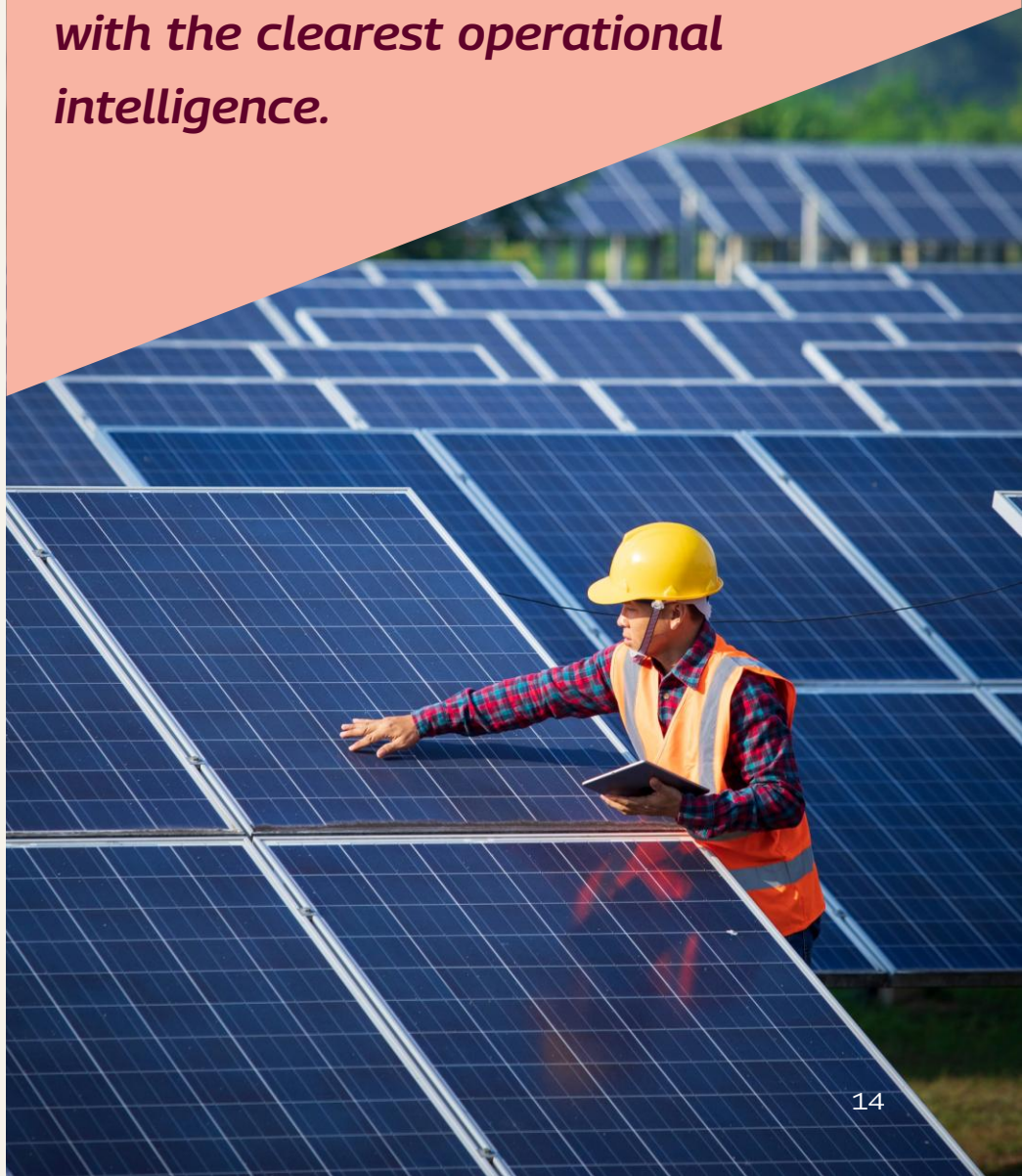
Significant Efficiency Gains through yield and asset optimization, which reduces downtime, extends asset lifespan, and augments productivity.

Cost Optimization by reducing O&M expenses and improving fleet-level efficiency. Shifting from a reactive to a proactive approach can enable plants to save big on maintenance costs and eliminate bottlenecks that drain capital.

Revenue Improvement via accurate forecasting and optimized operations. By allowing operators to capture high market prices and reducing curtailment during negative pricing events, plants can get a substantial revenue uplift.

Enhanced Operational Outcomes with full control and visibility. Plants gain the ability to respond to real-time signals, improve security and safety posture, maintain regulatory compliance, and scale operations without any hassle.

The operators winning in today's solar market are not the ones with the most capacity. They're the ones with the clearest operational intelligence.



The Final Word

As solar power generation drives the next wave of energy market disruption, fueled by volatile conditions, aggressive decarbonization targets, grid complexity, and the rapid shift toward hybrid configurations, embracing intelligent technology transformation becomes imperative.

With TechM's end-to-end support powered by Mahindra Teqo, utility-scale solar operators gain a bird's-eye view of plant and fleet performance, which helps to swiftly translate insights into decisive action and strengthen control in fleeting market conditions.

The mandate is clear: green energy, especially solar, is gaining momentum. But to truly sustain and scale, operators need a smart technology foundation. TechM, with its deep domain expertise, is here to enable the digital shift to power the next phase in solar operations.

The future of utility-scale solar runs on real-time intelligence. Where does your operation stand?

End Notes

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About **Tech Mahindra**

Tech Mahindra (NSE: TECHM) offers technology consulting and digital solutions to global enterprises across industries, enabling transformative scale at unparalleled speed. With 147,000+ professionals across 90+ countries helping 1100+ clients, Tech Mahindra provides a full spectrum of services including consulting, information technology, enterprise applications, business process services, engineering services, network services, customer experience & design, AI & analytics, and cloud & infrastructure services. It is the first Indian company in the world to have been awarded the Sustainable Markets Initiative's Terra Carta Seal, which recognizes global companies that are actively leading the charge to create a climate and nature-positive future. Tech Mahindra is part of the Mahindra Group, founded in 1945, one of the largest and most admired multinational federation of companies. For more information on how TechM can partner with you to meet your Scale at Speed™ imperatives, please visit https://www.techmahindra.com/.

*Figures as per Q4, FY 26.

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