Photovoltaic Project Decisions: Quality, Performance, and Economic Value

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The Technical Report is available for download from the IEA-PVPS website www.iea-pvps.org.

Executive Summary

The report "Photovoltaic Project Decisions: Quality, Performance, and Economic Value" shows that technical and economic decisions across the PV value chain are tightly coupled and must be managed as an integrated system, particularly for centralised (utility-scale) PV systems. The research addresses a fundamental challenge in the rapidly expanding solar industry: the complex interconnections between technical performance and economic outcomes that demand sophisticate decision-making approaches for large-scale solar PV, including key indicators for Agri PV as well as examples and case studies.

Decision Matrix Framework: The report introduces a comprehensive workflow mapping system that visualizes stakeholder interactions across the PV value chain—from banks and investors in development phases to O&M operators during operation. This framework reveals that quality gates implemented early in the value chain provide the greatest cost-effectiveness in pre-venting downstream failures, though significant gaps remain in stakeholder feedback loops.

Economic Impact of Quality Management: Case studies demonstrate that proactive quality management delivers measurable economic benefits far exceeding initial investment costs. Post-shipment testing with mobile laboratories can provide cost savings compared to stationary laboratory testing, while optimized planning and design review for rooftop installations can improve energy yield through better component selection and site assessment.

Application-Specific Strategies: Different PV applications require tailored approaches. Bifacial tracking systems, floating PV, and agrivoltaic installations each present unique challenges demanding specialized risk assessment and mitigation strategies. Geographic factors significantly influence operational approaches, with seasonal failure patterns requiring region-specific maintenance planning.

Climate Risk Management: The increasing frequency and severity of extreme weather events necessitates sophisticated risk assessment beyond traditional models. The report provides compelling evidence that proactive defensive strategies, including tracker stow protocols and appropriate module selection, can prevent catastrophic losses even during 1-in-500-year hail events.

Early-Stage Quality Integration: Implement comprehensive quality gates during development and engineering phases where intervention costs are lowest. This includes mandatory technical due diligence, component testing protocols, and site-specific risk assessments.

Data-Driven Operations: Investment in monitoring systems and analytics platforms enables predictive maintenance and real-time optimization. The transition toward automated corrective and predictive maintenance represents a fundamental shift in asset management, with sea-sonal patterns highlighting the value of proactive resource planning.

Financial Model Evolution: Traditional financial models must incorporate climate-adjusted scenarios and account for fat-tailed distributions of extreme events. The introduction of Probable Maximum Loss and Average Annual Loss frameworks provides tools for quantifying risks, but these require updates reflecting changing environmental conditions.

The frameworks, case studies, and best practices presented represent current industry knowledge but must be continuously updated to reflect technological advances, changing market conditions, and operational experience. The ultimate goal is creating a more resilient, efficient, and profitable solar industry capable of delivering sustainable, cost-effective renewable energy for decades to come. This research provides essential guidance for stakeholders across the PV value chain, emphasizing that quality-driven decisions extend beyond individual projects to influence the bankability and public acceptance of solar PV technology. Overall, the study positions quality-driven, KPI-based and data-enabled decision-making as a central lever for ensuring that PV can reliably serve as a cornerstone of sustainable, secure and economically attractive energy systems worldwide.

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Key Takeaways

- **Integrated Quality Management Delivers Measurable Value**: Proactive quality assurance throughout the PV value chain-especially during early development and engineering phases-significantly reduces downstream failures and delivers economic benefits far exceeding initial investment costs. Early quality gates, technical due diligence, and rigorous component testing are essential.
- **Data-Driven Operations Optimise Performance and Maintenance**: Investment in monitoring systems and analytics platforms enables predictive maintenance and real-time optimisation. Automated, data-enabled corrective and predictive actions are transforming asset management, improving reliability and reducing operational costs.
- **Risk Management Must Evolve with Climate and Market Changes**: Traditional financial and risk models must be updated to account for the increasing frequency and severity of extreme weather events, as well as market factors like curtailment and negative electricity prices. New frameworks for quantifying risks, such as Probable Maximum Loss and Average Annual Loss, are needed to ensure resilient and bankable PV projects.
- **Tailored Approaches for Diverse PV Applications and Regions**: Different PV applications (bifacial tracking, floating PV, agrivoltaics) require specialised strategies for design, operation, and risk mitigation. Geographic and seasonal factors must be considered in maintenance planning and resource allocation, as shown in case studies from Australia and beyond.
- The result of this work is an INTERACTIVE TOOL on *PV Quality & Risk Decisions*, which will be released in June 2026.

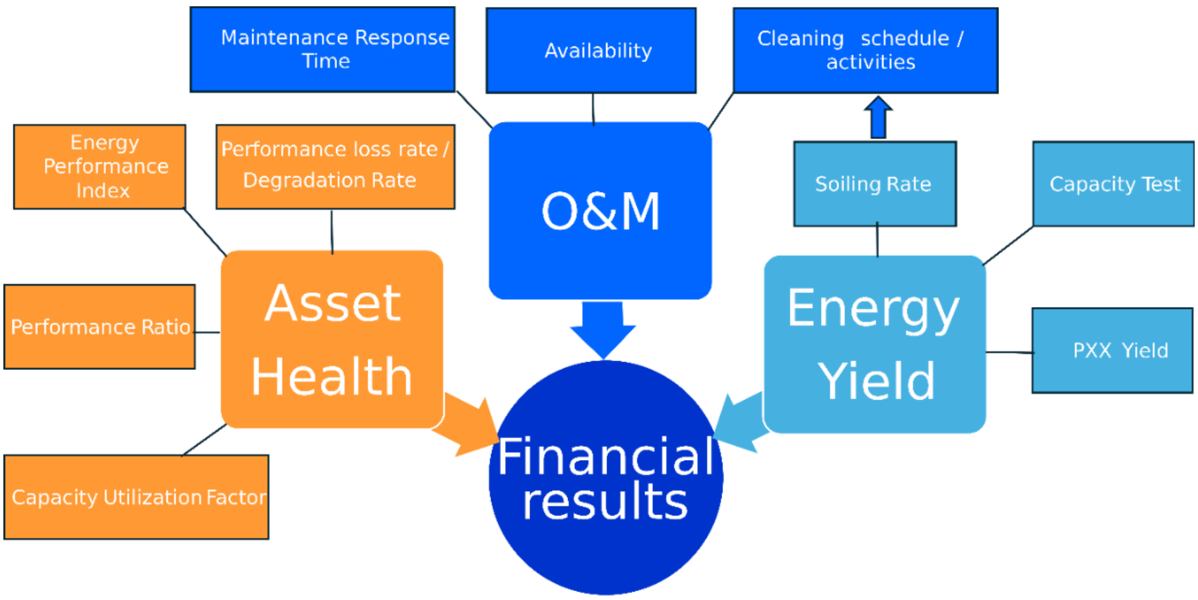

Figure 1: The interlinked nature of technical and economic KPIs from [S. Lindig et al., "Review of Technical Photovoltaic Key Performance Indicators and the Importance of Data Quality Routines," Sol. RRL, vol. 8, no. 24, p. 2400634, 2024, doi: 10.1002/solr.202400634.]

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