Best Practice Guidelines for the Use of Economic and Technical KPIs

IEA PVPS Task 13, Report IEA-PVPS T13-28:2024, December 2024
ISBN 978-3-907281-69-7

Main Authors:
Sascha Lindig, Univers SAS, Courbevoie, France
Julien Deckx, 3E, Brussels, Belgium
Magnus Herz, TÜV Rheinland, Cologne, Germany
Julián Ascencio Vásquez, Univers SAS, Courbevoie, France
Marios Theristis, Sandia National Laboratories, Albuquerque, USA
Bert Herteleer, KU Leuven, Ghent, Belgium
Kevin Anderson, Sandia National Laboratories, Albuquerque, USA

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

Executive Summary

Key Performance Indicators (KPIs) are an important set of metrics used to assess various aspects of photovoltaic (PV) systems, including their long-term performance, economic viability, and carbon footprint. Technical KPIs support data-driven and informed decision-making when optimizing PV systems and provide a comprehensive overview of how PV systems operate across different conditions and climates. Different KPIs are commonly employed throughout the entire value chain of PV projects and can be categorized into technical, economic and sustainability aspects. In this work, a set of best practices for handling PV system data to reliably calculate relevant KPIs is discussed. The work is divided into three parts, each addressing different aspects of KPIs, data management, and their mapping potential.

A comprehensive overview of key performance indicators (KPIs) that are important across technical, economic, and sustainability domains, highlighting their common definitions and variations, are presented. In addition to this, this work delves into the typical advantages and challenges associated with each KPI, and which variations of each KPI exist. The focus of this report is centred on technical KPIs. It has been demonstrated that the application of all investigated KPIs poses challenges, either in terms of their formulation, interpretation, or due to inherent limitations. This work is based on an extensive literature review and feedback from stakeholder questionnaires across various markets and regions. The objective was to understand which KPIs are widely used within the industry, which have contractual binding, and which are primarily applied in a technical framework. This information is summarized in Table 1.

KPIs that are contractually binding carry direct financial implications, while those used in a technical context serve to support the performance assessment of PV plants, and the associated decision-making by stakeholders. The survey showed additionally that while there are certain KPI usage trends per region, a globalized world and market means that there are no strict differences to be seen. Despite the nominal standardization of contractual KPIs such as the performance ratio and temperature-corrected performance ratio, there are still considerable variations in the data quality routines employed, and consequently, in the calculation of the resulting KPIs.

Table 1: Usage overview of technical KPIs.

KPI	Abbreviation	Private equity / Bank	Project Developer	Asset Owner / Asset Manager	EPC	O&M	Service provider / consultant
Pxx energy yield	**P50 Yield**	T/C	T/C	T/C	T		T/C
Performance ratio	**PR**			T/C	T/C	T/C	T/C
Availability				T/C	T/C	T/C	T/C
Soiling ratio	**SR**	T	T	T	T	T	T
Degradation rate	**Rd**	T	T	T	T	T	T/C
Performance loss rate	**PLR**	T	T	T	T	T	T/C
Energy performance index	**EPI**			T/C	T/C	T	
Capacity test	**CapTest**			T/C	T/C	T	
Capacity utilization factor	**CUF / PLF**				T	T	T
Maintenance response time	**MRT**			C	C	C	C

T – technical, C – contractual binding

The report focuses furthermore on the challenges and best practices in managing PV system and weather data, covering the entire data processing cycle from input data collection to KPI computation. The most important signals, such as power, current, and voltage values from the PV system, as well as climatic variables from weather stations, are discussed. Commonly recorded variables include irradiance, temperature, wind speed, and wind direction. Additionally, the common structure of a PV system, along with its data and command streams, is presented. The quality of the input data directly influences the certainty of the calculated PV system KPIs. Therefore, the data quality and data cleaning steps within the data processing cycle are of utmost importance. Key data quality criteria to consider include accuracy, complete-ness, consistency, timeliness, and reliability. The report also presents the latest findings on imputing, or filling, data gaps in PV system power, irradiance, and temperature time series. However, even the best imputation strategies will inevitably increase uncertainty. In this regard, high-quality data should be viewed as an investment that enables better evidence-based decision-making by ensuring reliable KPI calculations, rather than as a cost that diminishes system profitability.

Finally, a holistic view on the mapping potential of KPIs is presented, emphasizing their applications in various contexts. These include performance ratio mapping of individual PV components to assess system health, as well as global geographical mapping of climate stressors and their impact on PV system performance statistics. The discussion extends to exploitable data resources, including raw time series, aggregated KPIs, geospatial weather data from satellite, geospatial post-processed PV data, aerial images from drones, and static data from cur-rent-voltage tracers. Additionally, five distinct case studies are presented, illustrating how data can be utilized to analyze specific aspects of PV system health. Each case study is broken down into its fundamental concept, required input data, the calculations performed, the data being analyzed, and how the results should be interpreted. This study sets the tone for future work, especially as the increasing availability of PV system data offers greater opportunities for comprehensive mapping and analysis.

By providing a thorough and practical framework, this work aims to enhance the understanding and application of KPIs in the PV industry. It adheres to the three-part IEC 61724 standard, ensuring consistency and compatibility with existing industry standards, and contributes to the improvement and evolution of the current standard by identifying potential areas of enhancement and providing recommendations for more efficient and standardized KPI usage.

This report explores key performance indicators in PV systems, focusing on reliable calculation pathways as well as their use to optimize PV performance. Through a review of current best practices and data management techniques, the report highlights the critical role of KPIs in improving PV operations, contractual transparency, and future PV system designs.

Key Takeaways:

- **KPI Relevance**: KPIs are essential for evaluating PV systems across multiple contexts, including operational efficiency, financial viability, and sustainability metrics, providing a foundation for effective decision-making.
- **Data Quality and Standardization**: The reliability of KPI calculations depends on high-quality data and standardized definitions, which reduce bias, enhance transparency, and ensure fair performance evaluations across projects.
- **Challenges in Data Processing:** Effective data management - from collection to KPI computation - is crucial, with data quality checks and robust filtering procedures identified as key steps for accurate KPI assessment.
- **Mapping and Geospatial Analysis**: Advanced mapping techniques using KPI data allow for a comprehensive assessment of PV performance across regions, supporting tailored operations and early-stage design considerations for new PV projects.

This structured approach enhances understanding and application of KPIs, identifies current shortcomings in the IEC 61724 standards, and sets a foundation for ongoing PV industry improvements.

Task 13 Managers: Ulrike Jahn (ulrike.jahn@imws.fraunhofer.de) and Giosuè Maugeri (giosue.maugeri@rse-web.it)