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TECHNICAL SPECIFICATION

colour inside

Photovoltaic power systems (PVPS) – Information model for availability

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PHOTOVOLTAIC POWER SYSTEMS (PVPS) – INFORMATION MODEL FOR AVAILABILITY

FOREWORD

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Technical Specifications are subject to review within three years of publication to decide whether they can be transformed into International Standards.

IEC TS 63019, which is a Technical Specification, has been prepared by IEC technical committee 82: Solar photovoltaic energy systems.

The text of this International Standard is based on the following documents:

DTS	Report on voting
82/1447/DTS	82/1505A/RVDTS

Full information on the voting for the approval of this Technical Specification can be found in the report on voting indicated in the above table.

This document has been drafted in accordance with the ISO/IEC Directives, Part 2.

Information model categories are written in capital letters.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under "http://webstore.iec.ch" in the data related to the specific document. At this date, the document will be

- transformed into an International standard,
- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

A bilingual version of this publication may be issued at a later date.

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INTRODUCTION

This technical specification (TS) defines a common basis for the exchange of information on photovoltaic power system (PVPS) availability metrics among owners, utilities, lenders, operators, manufacturers, engineer/procure/construction firms, specifiers/designers, consultants, regulatory bodies, certification bodies, insurance companies, and other stakeholders. From this diverse group of stakeholders, external and internal interfaces arise in the operation and delivery of power. Although these are mostly power- and energy-related, some are informational or for power system control. The intention is for information exchange on capability- and energy-related data to form a nucleus for separate information needed by stakeholders, as illustrated in Figure 1.

It identifies external and internal elements related to the capability, health, and condition of components, subsystems, and the system itself, as well as energy production, plant operation, and asset management, which also benefit from a defined set of terms. This is achieved by providing an information model specifying how (PVPS) time designations shall be assigned by information categories. An information model facilitates how the unavailability of time of components, subsystems, and systems, as well as the lost power and other capabilities affect the PVPS. The ability to estimate the resulting lost energy and/or loss of PVPS capability forms the basis for how to allocate time for reporting availability metrics or, more directly, unavailability.

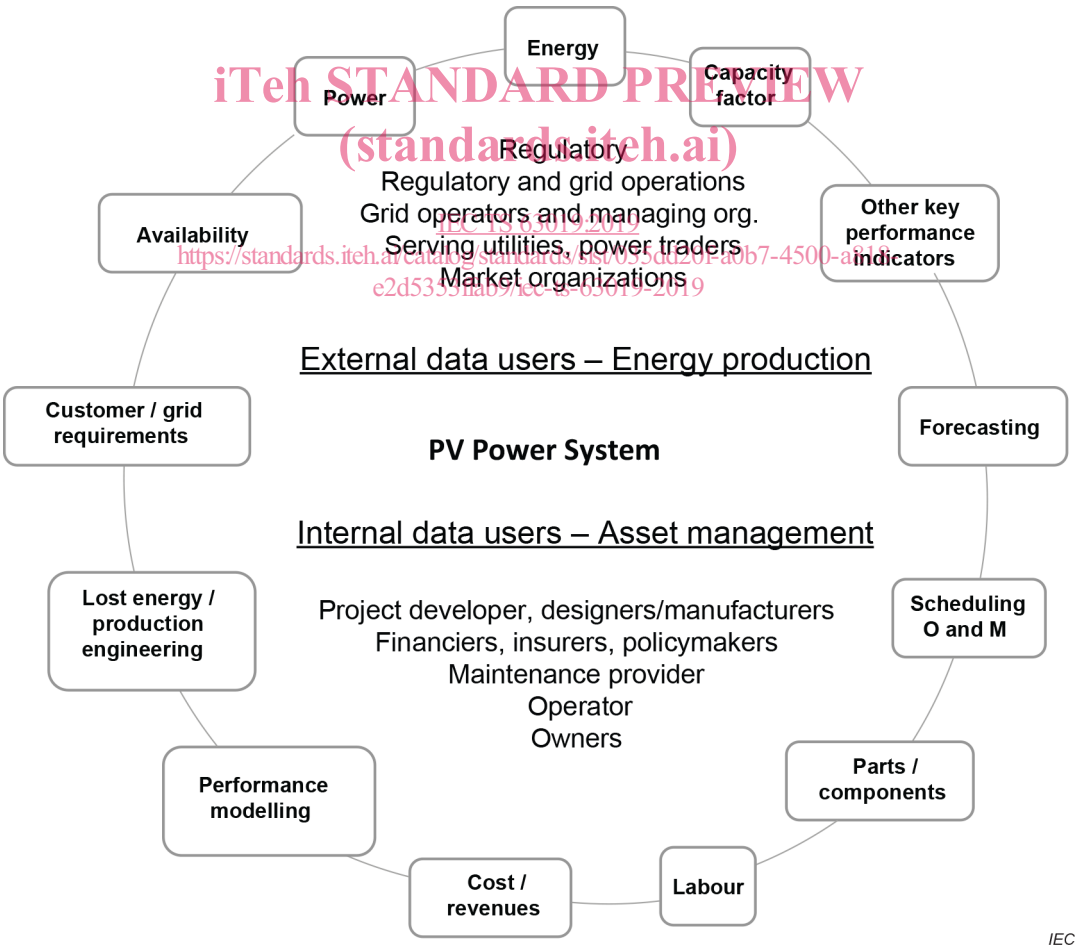

Figure 1 – Data stakeholders for a PVPS

PHOTOVOLTAIC POWER SYSTEMS (PVPS) – INFORMATION MODEL FOR AVAILABILITY

1 Scope

A common basis of understanding results from defined metrics that can be useful to the stakeholders, populated by data collected in the operation of the PVPS:

a) To provide a standarized approach to characterize availablity and unavailablity for a PVPS.

b) To provide standard methodologies for determining the appropriate forms of availability of the PVPS during varying time periods, including real-time capability assessment or longer, for reporting availablity metrics to stakeholders.

Table 1 – Stakeholder roles and objectives for reliability and maintenance data

Roles	Objective
Owner	Decision support for investments
Operator	Reporting performance indicators
	Determining availability and weaknesses
	Identifying maintenance strategies
Service provider	Maintenance optimization
	Optimizing keeping stock of spare parts
Original equipment manufacturers/ supplier	Design optimization
Financier/insurer	Risk assessment
Grid operator	Highly reliable and stable bulk power system
Source: International Energy Agency (IEA)	

This document provides a framework from which the availability metrics of a PVPS can be derived and reported. It describes how data are categorized and defines generic information categories to which time can be assigned for a PVPS considering internal and external conditions based on fraction of time, system health, and condition by specifying the following:

- generic information categories of a PVPS considering availability and production.
- information category priority to discriminate between concurrent categories.
- entry and exit point for each information category to allocate designation of time.

The PVPS comprises all photovoltaic (PV) modules, inverters, DC and AC collection systems, grid interconnection equipment, the site, its infrastructure, and all functional service elements. This is further explained in 6.3 and 6.4.

Formulas in this document provide normative guidance for standardization. Beyond that, it is not the intention of this document to specify exactly how other undefined, time-based availability metrics shall be calculated. The annexes are examples and guiding principles for developing methods for calculation and estimation of availability metrics, subject to the knowledge and concurrence for use by the involved stakeholders. Estimates and calculations also have recommendations on how they are to be used as part of the informative function.

It is not within the scope of this document to determine the method of information acquisition. Relevant IEC documents on data collection and information acquisition are included in the following normative references. IEC 61724-1 has requirements and IEC TS 61724-3:2016, 6.2.5, specifically identifies measured data on this topic.

Data generated during the operation of a PVPS are valuable, establishing who owns the monitoring data and who will have access to the data and for what purpose should be established. Different stakeholders will have different needs, as summarized in Table 1 (IEA). In Annex E, the monitoring systems are addressed in greater detail.

Availability metrics cannot be derived without important outage information. Questions can require the PVPS operation to properly collect the requisite data, such as what equipment or portion of the plant is failing, how long, how often, and how much energy is being lost and categorized by the information model. Asset management questions include the source of the outage (i.e., Whose clock is it on? Was the outage due to internal or external forces? What power and energy was generated? And, what was expected?).

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC TS 61724-3:2016, *Photovoltaic system performance – Part 3: Energy evaluation method*

IEEE Std 762™-2006, *IEEE Standard definitions for use in reporting electric generating unit reliability, availability, and productivity*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

The International Organization for Standardization (ISO) and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO online browsing platform: available at http://www.iso.org/obp

3.1
availability
where the PVPS, a subsystem, or a component is capable of providing service, regardless of whether it is actually in service and regardless of the capacity level that can be provided

Note 1 to entry: Specific definitions and characterizations are provided on availability and related terms throughout the annexes.

[SOURCE: IEEE 762:2006, 4.1.1, modified – Expansion of the term "unit" to more general applications for PVPS, subsystems and components.]

3.2
capability
degree to which the component, system, or subsystem is operative and functioning according to design specifications and control logic with no technical restrictions or limitations beyond the ones included in the specifications

3.3
constrained operation
mode of operation of a PVPS in which the outputs of all inverters are limited by the capability of the equipment rather than by the output from the PV array

[SOURCE: IEC TS 61724-2:2016, 3.1, modified – Definition tailored to the case of PVPS and references to DC and AC ratings omitted.]

3.4
curtailed operation
mode of operation of a PVPS in which the output is limited for an external reason, e.g., inability of the local grid to receive the power per contractual agreement

3.5
degradation
decrease in equipment operating characteristics or ability to perform due to physical- or chemical-related reduction in performance

3.6
derating
redefinition of capability due to external commands or constraints

3.7
downtime
total time that the equipment is not capable of operating per specification when it would otherwise be expected to do so

3.8
energy availability
energy generation of a PV system that is calculated with the same assumptions as those used in the predicted energy model using actual weather data collected at the site during operation of the system for the year in question

3.9
energy unavailability
metric that quantifies the energy lost when the system is not operating (as judged by an automatic indication of functionality, such as the inverter status flag indicating that the inverter is actively converting DC to AC electricity or not)

[SOURCE: IEC TS 61724-3:2016, 3.2. modified – The second sentence of the definition, on energy availability has been omitted, along with the note to entry.]

3.10
expected energy
energy of a PVPS that is calculated with the same specific performance model or approved equal with same assumptions, losses, and formulas as those used in the predicted energy model using actual weather data collected at the site during operation of the system (for the period in question)

[SOURCE: IEC TS 61724-3:2016, 3.5, modified – inclusion of assumptions, losses, and formulas if the original model is not readily available; deletion of Notes 1 and 2 to entry.]

3.11
failure
loss of ability to perform as required

[SOURCE: IEC 60050-192:2015, 192-03-01, modified – The domain and Notes 1 to 3 to entry have been omitted.]

3.12
masking
PVPS condition and situation where unidentified and/or not easily discernible deficiencies cause performance to diminish despite the appearance that the PVPS is operating as it was designed to operate

3.13
PVPS AC capacity
rated output of a PVPS, or, alternatively, its contractually obligated maximum, under specific designated conditions

3.14
photovoltaic power system
PVPS
electric power generating system, which uses the PV effect to convert solar power into electricity

3.15
rating
set of rated values and operating conditions

[SOURCE: IEC 60050-151:2001, 151-16-11]

3.16
reliability

probability that an item (component, assembly, or system) can perform its intended function for a specified interval under stated conditions

3.17
service

provision delivered by the PVPS

3.18
system
composite of equipment, skills, and techniques capable of performing or supporting an operational role or both

3.19
time
fundamental element used in developing the concept of availability, also used in many measures of reliability and maintainability (for unavailability)

3.20
unavailability
operational state when the equipment is not capable of operation because of operational or equipment failures, external restrictions, testing, work being performed, or some adverse condition

[SOURCE: IEEE 762:2006, 4.1.2, modified – use of the term "equipment" rather than "unit".]

3.21
uptime
amount of time that the system or component is operating during a defined period of time

Note 1 to entry: Other and more specific definitions are contained in the information categories as well as the annexes. Reliability, availability, maintainability (RAM) metrics have many specified availability definitions based on specific applications and are further explained in Annex C.

4 Overview

4.1 Understanding the use of this document

This document defines generic terms of PV systems and environmental constraints in describing PVPS operation and availabilities, restoration, time, and optional energy accounting criteria for operation and maintenance (O&M) and asset management. This document defines terminology and generic terms for reporting availability measurements. A PVPS includes all equipment up to the point of common coupling (interconnection point) to a grid or network that is buying the energy produced; however, PVPS availability can and often is affected by the grid and grid quality. Measurements are concerned with units of time affected; involved components, systems, and subsystems; and site and PVPS O&M. Unavailability measurements are also instrumental for measurement and/or estimation techniques for determining PVPS capabilities or, more specifically, capability loss.

The conditions – environmental and other site aspects – are considered for reporting the station condition and the impact those conditions have on the PVPS, including subsystems and components. Environmental aspects include solar irradiance and other weather and location-specific conditions at the site. System operating constraints due to differential site or as-built characteristics, which might affect or eventually affect energy system performance (typically energy production), are included in the energy calculus (e.g., availability model and energy reporting). This document defines terms for reporting fundamental availability metrics. Formulas and application methods are included in Clause 6 and Annex A and Annex B. The categories can apply to the whole system (with the grid interface also affecting it) or to subsystems and components, wherever the outages or reduced capability occur. It is observed that the more robust and granular data systems are, the better the knowledge of the issues affecting capabilities.

More generally, although this document is written to be applied to utility-scale PVPS, stakeholders will find that many of the document's elements have application to smaller systems, subsystems, or components. Residential and small commercial systems will also need enough data collection and maintenance logs in their operational phases to determine and document necessary uptime metrics and who should be receiving the data.

Multiple aspects of PVPS availability depend on the system quality and characteristics, system health, condition, and operational states. Therefore, it is essential to have clear knowledge and awareness of the operating and outage status of the power system's components. This is important for O&M and reliability as well as for financial and insurance purposes. As such, the data are collected for use. Performance, environmental, failure and outage, time-based O&M, and electrical parameters are included in the types of data that may be included in various aspects of the PVPS availability assessments. Levels of systems and consequential data needs are described in the informative annexes. Information management is addressed specifically in Annex E.

Night-time generation shutdown is not expected by definition; thus, PVPS cannot provide power except for those that include storage and are capable of providing night-time services. A similar definitional clarification – for example, a PVPS not operating because the array is covered in snow – is in an out-of-environmental specification state even though the PVPS components are fully functional and available. The information model presented in the document is designed to be useful in defining boundaries to facilitate contractual division of responsibilities.

The availability of the total sum of the system, subsystems, and components affects the performance of the PVPS. Typically, revenues depend on the energy delivered, and that energy depends on the availability. The proper functioning of the components is a function of the detailed design specifications and the O&M employed. Tracking downtime is a tool for asset management and reliability of the system. Figure 2 illustrates this interrelationship.

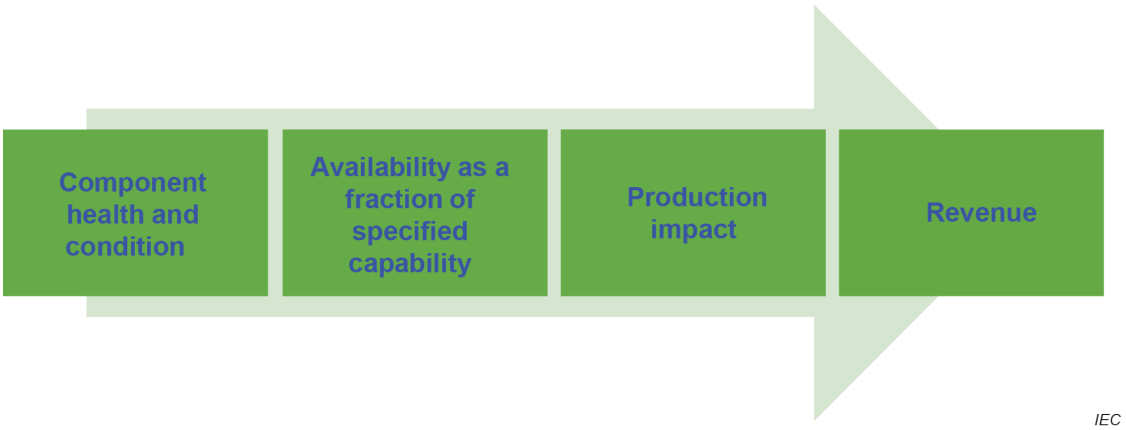

Figure 2 – PVPS component-to-revenue path

Figure 2 presents a logical consequence of reduced capability impacting energy production. The energy production will be c metered, and, in addition, the energy flow may generally be monitored throughout the PVPS, as specified in the design of the monitoring systems. This logical balance between performance (energy) and availability (PVPS physical condition on a time basis) demonstrates the need to measure both in order to facilitate the assessment of required PVPS functions.

It is important to clarify the relationship between this document and the IEC 61724 series. Both address metrics of PVPS performance and the impact of reductions. IEC TS 61724-3 carefully defines energy unavailability so that the stakeholders can determine the losses in performance (according to the In-Service Energy Performance Index) separate from the losses caused by energy unavailability. This will be further explained after the process of using the information model to handle the granularity of component health and condition (Figure 2) is applied to lost capacity and energy. The complementary nature of this document with the IEC 61724 series is characterized in Annex D in verification scenario Clause D.7 – Energy: measured, expected, and lost.

Assessments of required PVPS functions are desirable because the IEC Renewable Energy (IECRE) system addresses certification requirements of PVPSs, and the mandatory reporting requirements of this document are candidates for IECRE procedures. This document is intended to facilitate application in multiple ways. The first is to provide consistency between definitions in measurements and reporting. The second is to support certification requirements that may be specified.

Mandatory information categories defined in the document are written in capital letters. The designation of mandatory applies to data collection but not necessarily the specific data reported because that is determined by the stakeholders' needs.

4.2 The information model

With restatement of the fundamental definitions given in 3.1 and 3.20, the information model follows logically in an expansion of the specific categories to be used in this document.

The "available state" is when a unit can provide service per specification regardless of whether it is in service and regardless of the capacity level and other capabilities that can be provided (based on IEEE 762, 4.1.1).

Equipment is in an "unavailable state" when the equipment is not capable of operation to specification due to equipment failures, external restrictions, testing, maintenance, or other plant work being performed or some adverse condition. The unavailable state persists until the unit is made available for operation by being synchronized to the system in service state (based on IEEE 762, 4.1.2).