



NSAI
Standards

Irish Standard
I.S. EN 61724-1:2017

Photovoltaic system performance - Part 1: Monitoring

I.S. EN 61724-1:2017

Incorporating amendments/corrigenda/National Annexes issued since publication:

The National Standards Authority of Ireland (NSAI) produces the following categories of formal documents:

I.S. xxx: Irish Standard — national specification based on the consensus of an expert panel and subject to public consultation.

S.R. xxx: Standard Recommendation — recommendation based on the consensus of an expert panel and subject to public consultation.

SWiFT xxx: A rapidly developed recommendatory document based on the consensus of the participants of an NSAI workshop.

This document replaces/revises/consolidates the NSAI adoption of the document(s) indicated on the CEN/CENELEC cover/Foreword and the following National document(s):

NOTE: The date of any NSAI previous adoption may not match the date of its original CEN/CENELEC document.

This document is based on:

EN 61724-1:2017

Published:

2017-05-26

This document was published under the authority of the NSAI and comes into effect on:

2017-06-13

ICS number:

NOTE: If blank see CEN/CENELEC cover page

NSAI
1 Swift Square,
Northwood, Santry
Dublin 9

T +353 1 807 3800
F +353 1 807 3838
E standards@nsai.ie
W NSAI.ie

Sales:
T +353 1 857 6730
F +353 1 857 6729
W standards.ie

Údarás um Chaighdeán Náisiúnta na hÉireann

National Foreword

I.S. EN 61724-1:2017 is the adopted Irish version of the European Document EN 61724-1:2017, Photovoltaic system performance - Part 1: Monitoring

This document does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

For relationships with other publications refer to the NSAI web store.

Compliance with this document does not of itself confer immunity from legal obligations.

In line with international standards practice the decimal point is shown as a comma (,) throughout this document.

This page is intentionally left blank

EUROPEAN STANDARD

EN 61724-1

NORME EUROPÉENNE

EUROPÄISCHE NORM

May 2017

ICS 27.180

Supersedes EN 61724:1998 (partially)

English Version

Photovoltaic system performance - Part 1: Monitoring (IEC 61724-1:2017)

Performance d'un système photovoltaïque - Partie 1:
Surveillance
(IEC 61724-1:2017)

Betriebsverhalten von Photovoltaik-Systemen - Teil 1:
Überwachung
(IEC 61724-1:2017)

This European Standard was approved by CENELEC on 2017-04-07. CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the CEN-CENELEC Management Centre or to any CENELEC member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CENELEC member into its own language and notified to the CEN-CENELEC Management Centre has the same status as the official versions.

CENELEC members are the national electrotechnical committees of Austria, Belgium, Bulgaria, Croatia, Cyprus, the Czech Republic, Denmark, Estonia, Finland, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Norway, Poland, Portugal, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.



European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

CEN-CENELEC Management Centre: Avenue Marnix 17, B-1000 Brussels

EN 61724-1:2017

European foreword

The text of document 82/1215/FDIS, future edition 1 of IEC 61724-1, prepared by IEC/TC 82 "Solar photovoltaic energy systems" was submitted to the IEC-CENELEC parallel vote and approved by CENELEC as EN 61724-1:2017.

The following dates are fixed:

- latest date by which the document has to be implemented at national level by publication of an identical national standard or by endorsement (dop) 2018-01-07
- latest date by which the national standards conflicting with the document have to be withdrawn (dow) 2020-04-07

This document supersedes EN 61724:1998 (partially).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CENELEC shall not be held responsible for identifying any or all such patent rights.

Endorsement notice

The text of the International Standard IEC 61724-1:2017 was approved by CENELEC as a European Standard without any modification.

Annex ZA (normative)

Normative references to international publications with their corresponding European publications

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

NOTE 1 When an International Publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.

NOTE 2 Up-to-date information on the latest versions of the European Standards listed in this annex is available here: www.cenelec.eu.

<u>Publication</u>	<u>Year</u>	<u>Title</u>	<u>EN/HD</u>	<u>Year</u>
IEC 60050-131	-	International Electrotechnical Vocabulary (IEV) -- Part 131: Circuit theory	-	-
IEC 60904-2	-	Photovoltaic devices - Part 2: Requirements for photovoltaic reference devices	EN 60904-2	-
IEC 60904-3	-	Photovoltaic devices - Part 3: Measurement principles for terrestrial photovoltaic (PV) solar devices with reference spectral irradiance data	EN 60904-3	-
IEC 60904-5	-	Photovoltaic devices -- Part 5: Determination of the equivalent cell temperature (ECT) of photovoltaic (PV) devices by the open-circuit voltage method	EN 60904-5	-
IEC 60904-10	-	Photovoltaic devices -- Part 10: Methods of linearity measurement	EN 60904-10	-
IEC 61557-12	-	Electrical safety in low voltage distribution systems up to 1 000 V a.c. and 1 500 V d.c. - Equipment for testing, measuring or monitoring of protective measures -- Part 12: Performance measuring and monitoring devices (PMD)	EN 61557-12	-
IEC 62053-21	-	Electricity metering equipment (a.c.) - Particular requirements -- Part 21: Static meters for active energy (classes 1 and 2)	EN 62053-21	-
IEC 62053-22	-	Electricity metering equipment (a.c.) - Particular requirements -- Part 22: Static meters for active energy (classes 0,2 S and 0,5 S)	EN 62053-22	-
IEC 62670-3	-		EN 62670-3	-
IEC 62817	2014	Solar trackers for photovoltaic systems - Design qualification	EN 62817	2015
ISO 9060	-	Solar energy; specification and classification of instruments for measuring hemispherical solar and direct solar radiation	-	-
ISO 9488	-	Solar energy - Vocabulary	EN ISO 9488	-
ISO 9846	-	Solar energy -- Calibration of a pyranometer using a pyrliometer	-	-
ISO 9847	-	Solar energy - Calibration of field pyranometers by comparison to a reference pyranometer	-	-
IEC/TS 61836	-	Solar photovoltaic energy systems - Terms, definitions and symbols	CLC/TS 61836	-
ISO/IEC Guide 98-1	-	Uncertainty of measurement – Part 1: Introduction to the expression of uncertainty in measurement	-	-

EN 61724-1:2017

ISO/IEC Guide 98-3 -	Uncertainty of measurement -- Part 3: Guide to the expression of uncertainty in measurement (GUM:1995)	-	-
ASTM G 183 -	Standard Practice for Field Use of Pyranometers, Pyrheliometers and UV Radiometers	-	-
WMO No 8 -	Guide to meteorological instruments and methods of observation	-	-



IEC 61724-1

Edition 1.0 2017-03

INTERNATIONAL STANDARD

**Photovoltaic system performance –
Part 1: Monitoring**





THIS PUBLICATION IS COPYRIGHT PROTECTED

Copyright © 2017 IEC, Geneva, Switzerland

All rights reserved. Unless otherwise specified, no part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from either IEC or IEC's member National Committee in the country of the requester. If you have any questions about IEC copyright or have an enquiry about obtaining additional rights to this publication, please contact the address below or your local IEC member National Committee for further information.

IEC Central Office
3, rue de Varembe
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
Fax: +41 22 919 03 00
info@iec.ch
www.iec.ch

About the IEC

The International Electrotechnical Commission (IEC) is the leading global organization that prepares and publishes International Standards for all electrical, electronic and related technologies.

About IEC publications

The technical content of IEC publications is kept under constant review by the IEC. Please make sure that you have the latest edition, a corrigenda or an amendment might have been published.

IEC Catalogue - webstore.iec.ch/catalogue

The stand-alone application for consulting the entire bibliographical information on IEC International Standards, Technical Specifications, Technical Reports and other documents. Available for PC, Mac OS, Android Tablets and iPad.

IEC publications search - www.iec.ch/searchpub

The advanced search enables to find IEC publications by a variety of criteria (reference number, text, technical committee,...). It also gives information on projects, replaced and withdrawn publications.

IEC Just Published - webstore.iec.ch/justpublished

Stay up to date on all new IEC publications. Just Published details all new publications released. Available online and also once a month by email.

Electropedia - www.electropedia.org

The world's leading online dictionary of electronic and electrical terms containing 20 000 terms and definitions in English and French, with equivalent terms in 16 additional languages. Also known as the International Electrotechnical Vocabulary (IEV) online.

IEC Glossary - std.iec.ch/glossary

65 000 electrotechnical terminology entries in English and French extracted from the Terms and Definitions clause of IEC publications issued since 2002. Some entries have been collected from earlier publications of IEC TC 37, 77, 86 and CISPR.

IEC Customer Service Centre - webstore.iec.ch/csc

If you wish to give us your feedback on this publication or need further assistance, please contact the Customer Service Centre: csc@iec.ch.



IEC 61724-1

Edition 1.0 2017-03

INTERNATIONAL STANDARD

Photovoltaic system performance – Part 1: Monitoring

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

ICS 27.160

ISBN 978-2-8322-3988-9

Warning! Make sure that you obtained this publication from an authorized distributor.

CONTENTS

FOREWORD.....	5
INTRODUCTION.....	7
1 Scope.....	9
2 Normative references	9
3 Terms and definitions	10
4 Monitoring system classification	13
5 General	13
5.1 Measurement uncertainty.....	13
5.2 Calibration	14
5.3 Repeated elements.....	14
5.4 Power consumption.....	14
5.5 Documentation.....	14
5.6 Inspection	14
6 Data acquisition timing and reporting.....	15
6.1 Sampling, recording, and reporting	15
6.2 Timestamps	16
7 Measured parameters.....	16
7.1 General requirements	16
7.2 Irradiance	20
7.2.1 On-site irradiance measurement.....	20
7.2.2 Satellite remote sensing of irradiance	25
7.3 Environmental factors	26
7.3.1 PV module temperature	26
7.3.2 Ambient air temperature	27
7.3.3 Wind speed and direction	27
7.3.4 Soiling ratio	28
7.3.5 Rainfall.....	30
7.3.6 Snow	30
7.3.7 Humidity	30
7.4 Tracker system	31
7.4.1 Single-axis trackers	31
7.4.2 Dual-axis trackers for >20x systems	31
7.5 Electrical measurements.....	31
7.6 External system requirements	32
8 Data processing and quality check	32
8.1 Daylight hours.....	32
8.2 Quality check	33
8.2.1 Removing invalid readings.....	33
8.2.2 Treatment of missing data	33
9 Calculated parameters.....	33
9.1 Overview	33
9.2 Summations.....	34
9.3 Irradiation	34
9.4 Electrical energy.....	35
9.4.1 General	35
9.4.2 DC output energy	35

9.4.3	AC output energy.....	35
9.5	Array power rating	35
9.5.1	DC power rating.....	35
9.5.2	AC power rating.....	35
9.6	Yields	35
9.6.1	General	35
9.6.2	PV array energy yield	36
9.6.3	Final system yield.....	36
9.6.4	Reference yield	36
9.7	Yield losses	36
9.7.1	General	36
9.7.2	Array capture loss	36
9.7.3	Balance of systems (BOS) loss.....	36
9.8	Efficiencies	37
9.8.1	Array (DC) efficiency	37
9.8.2	System (AC) efficiency	37
9.8.3	BOS efficiency.....	37
10	Performance metrics.....	37
10.1	Overview	37
10.2	Summations.....	38
10.3	Performance ratios	38
10.3.1	Performance ratio	38
10.3.2	Temperature-corrected performance ratios	39
10.4	Performance indices	40
11	Data filtering.....	41
11.1	Use of available data	41
11.2	Filtering data to specific conditions	41
11.3	Reduced inverter, grid, or load availability	41
Annex A (informative)	Sampling interval	42
A.1	General considerations	42
A.2	Time constants	42
A.3	Aliasing error	42
A.4	Example	43
Annex B (informative)	Module backsheet temperature sensor selection and attachment	44
B.1	Objective	44
B.2	Sensor and material selection	44
B.2.1	Optimal sensor types	44
B.2.2	Optimal tapes	44
B.2.3	Cyanoacrylate adhesives and backsheet integrity	44
B.3	Sensor attachment method	45
B.3.1	Permanent versus temporary	45
B.3.2	Attachment location	45
B.3.3	Sensor attachment.....	45
Annex C (informative)	Derate factors	48
Annex D (normative)	Systems with local loads, storage, or auxiliary sources	49
D.1	System types	49
D.2	Parameters and formulas	51

Bibliography.....	57
Figure 1 – Possible elements of PV systems.....	7
Figure 2 – Sampling, recording, and reporting.....	15
Figure B.1 – Sensor attachment, permanent.....	46
Figure B.2 – Sensor attachment, temporary.....	46
Figure B.3 – Sensor element wire strain relief.....	46
Figure D.1 – Energy flow between possible elements of different PV system types.....	49
Table 1 – Monitoring system classifications and suggested applications.....	13
Table 2 – Sampling and recording interval requirements.....	16
Table 3 – Measured parameters and requirements for each monitoring system class.....	18
Table 4 – Relation between system size (AC) and number of sensors for specific sensors referenced in Table 3.....	20
Table 5 – Sensor choices and requirements for in-plane and global irradiance.....	21
Table 6 – Irradiance sensor alignment accuracy.....	22
Table 7 – Irradiance sensor maintenance requirements.....	23
Table 8 – PV module temperature sensor maintenance requirements.....	26
Table 9 – Ambient air temperature sensor maintenance requirements.....	27
Table 10 – Wind sensor maintenance requirements.....	28
Table 11 – Inverter-level electrical measurement requirements.....	32
Table 12 – Plant-level AC electrical output measurement requirements.....	32
Table 13 – Calculated parameters.....	34
Table 14 – Performance metrics.....	38
Table D.1 – Elements of different PV system types.....	50
Table D.2 – Parameters and equations for different system types.....	51

INTERNATIONAL ELECTROTECHNICAL COMMISSION

PHOTOVOLTAIC SYSTEM PERFORMANCE –**Part 1: Monitoring****FOREWORD**

- 1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as “IEC Publication(s)”). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
- 2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
- 3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
- 4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
- 5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
- 6) All users should ensure that they have the latest edition of this publication.
- 7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
- 8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
- 9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

International Standard IEC 61724-1 has been prepared by IEC technical committee 82: Solar photovoltaic energy systems.

This first edition cancels and replaces the first edition of IEC 61724, published in 1998. This edition constitutes a technical revision.

This edition (in conjunction with IEC TS 61724-2:2016 and IEC TS 61724-3:2016) includes the following significant technical changes with respect to IEC 61724:

- a) IEC 61724 is now written with multiple parts. This document is IEC 61724-1, addressing PV system monitoring. IEC TS 61724-2 and IEC TS 61724-3 address performance analysis based on the monitoring data.
- b) Three classes of monitoring systems are defined corresponding to different levels of accuracy and different intended applications.
- c) Required measurements for each class of monitoring system are stated, along with the required number and accuracy of sensors.

- d) Options for satellite-based irradiance measurement are provided.
- e) Soiling measurement is introduced.
- f) New performance metrics are introduced, including temperature compensated performance ratios and others.
- g) Numerous recommendations and explanatory notes are included.

The text of this standard is based on the following documents:

FDIS	Report on voting
82/1215/FDIS	82/1248/RVD

Full information on the voting for the approval of this International Standard 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.

A list of all parts in the IEC 61724 series, published under the general title *Photovoltaic system performance*, can be found on the IEC website.

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

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

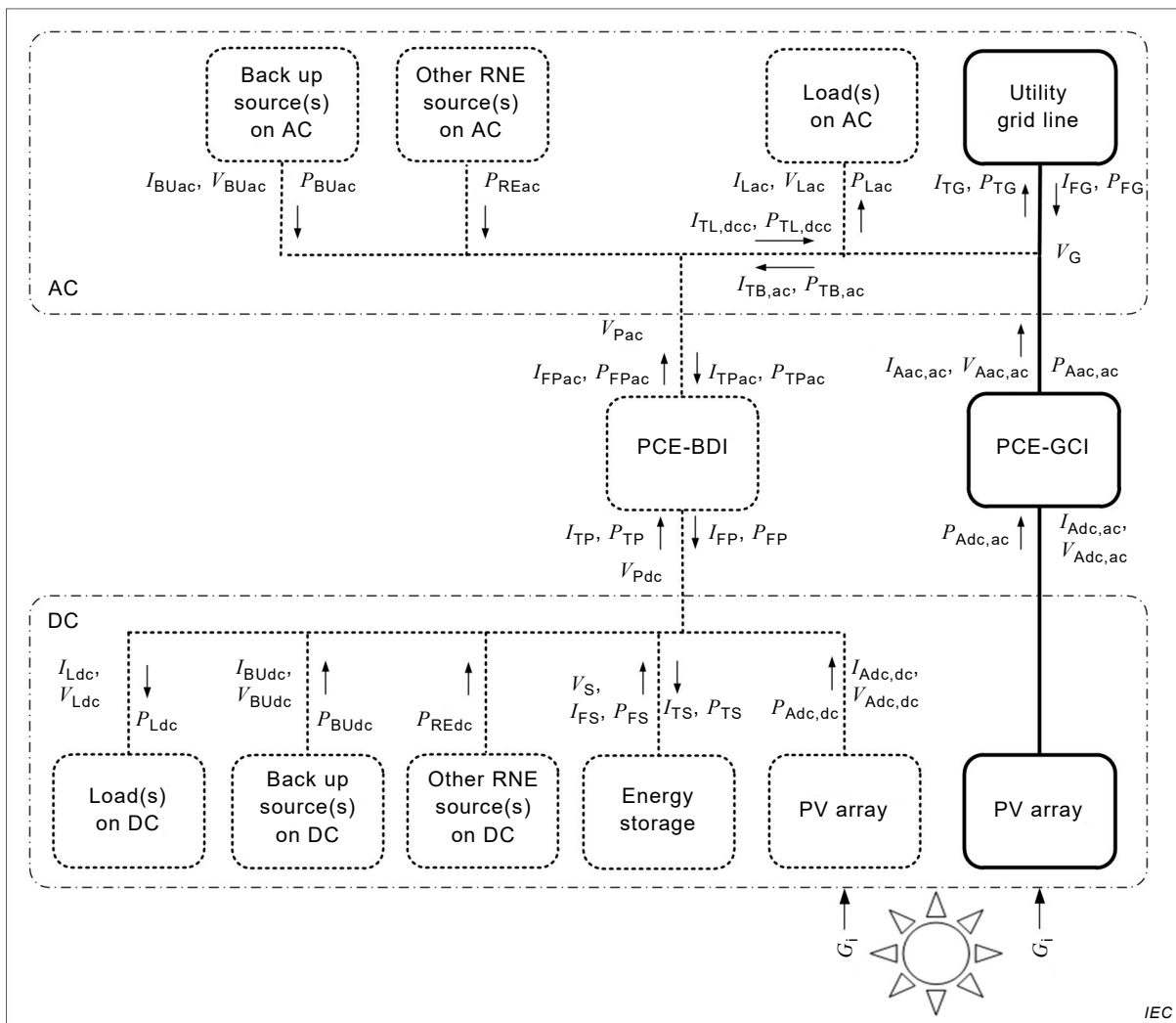
A bilingual version of this publication may be issued at a later date.

INTRODUCTION

This International Standard defines classes of photovoltaic (PV) performance monitoring systems and serves as guidance for various monitoring system choices.

Figure 1 illustrates possible major elements comprising different PV system types. The PV array may include both fixed axis and tracking systems and both flat plate and concentrator systems. Module-level electronics, if present, may be a component of the monitoring system.

For simplicity, the main clauses of this document are written for grid-connected systems without local loads, energy storage, or auxiliary sources, as shown by the bold lines in Figure 1. Annex D includes details for systems with additional components.



Key

- RNE renewable energy
- PCE power conditioning equipment
- BDI bi-directional inverter
- GCI grid-connected inverter

Bold lines denote simple grid-connected system without local loads, energy storage, or auxiliary sources.

Figure 1 – Possible elements of PV systems

The purposes of a performance monitoring system are diverse and can include the following:

- identification of performance trends in an individual PV system;
- localization of potential faults in a PV system;
- comparison of PV system performance to design expectations and guarantees;
- comparison of PV systems of different configurations; and
- comparison of PV systems at different locations.

These diverse purposes give rise to a diverse set of requirements, and different sensors and/or analysis methods may be more or less suited depending on the specific objective. For example, for comparing performance to design expectations and guarantees, the focus should be on system-level data and consistency between prediction and test methods, while for analysing performance trends and localizing faults, there may be a need for greater resolution at sub-levels of the system and an emphasis on measurement repeatability and correlation metrics rather than absolute accuracy.

The monitoring system should be adapted to the PV system's size and user requirements. In general, larger and more expensive PV systems should have more monitoring points and higher accuracy sensors than smaller and lower-cost PV systems. This document defines three classifications of monitoring system with differentiated requirements which are appropriate to a range of purposes.

PHOTOVOLTAIC SYSTEM PERFORMANCE –

Part 1: Monitoring

1 Scope

This part of IEC 61724 outlines equipment, methods, and terminology for performance monitoring and analysis of photovoltaic (PV) systems. It addresses sensors, installation, and accuracy for monitoring equipment in addition to measured parameter data acquisition and quality checks, calculated parameters, and performance metrics. In addition, it serves as a basis for other standards which rely upon the data collected.

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 60050-131, *International Electrotechnical Vocabulary – Part 131: Circuit theory*

IEC 60904-2, *Photovoltaic devices – Part 2: Requirements for photovoltaic reference devices*

IEC 60904-3, *Photovoltaic devices – Part 3: Measurement principles for terrestrial photovoltaic (PV) solar devices with reference spectral irradiance data*

IEC 60904-5, *Photovoltaic devices – Part 5: Determination of the equivalent cell temperature (ECT) of photovoltaic (PV) devices by the open-circuit voltage method*

IEC 60904-10, *Photovoltaic devices – Part 10: Methods of linearity measurement*

IEC TS 61836, *Solar photovoltaic energy systems – Terms, definitions and symbols*

IEC 61557-12, *Electrical safety in low voltage distribution systems up to 1 000 V a.c. and 1 500 V d.c. – Equipment for testing, measuring or monitoring of protective measures – Part 12: Performance measuring and monitoring devices (PMD)*

IEC 62053-21, *Electricity metering equipment (a.c.) – Particular requirements – Part 21: Static meters for active energy (classes 1 and 2)*

IEC 62053-22, *Electricity metering equipment (a.c.) – Particular requirements – Part 22: Static meters for active energy (classes 0,2 S and 0,5 S)*

IEC 62670-3, *Photovoltaic concentrators (CPV) – Performance testing – Part 3: Performance measurements and power rating*

IEC 62817:2014, *Photovoltaic systems – Design qualification of solar trackers*

ISO/IEC Guide 98-1, *Uncertainty of measurement – Part 1: Introduction to the expression of uncertainty in measurement*

This is a free preview. Purchase the entire publication at the link below:

[Product Page](#)

-
- [Looking for additional Standards? Visit Intertek Inform Infostore](#)
 - [Learn about LexConnect, All Jurisdictions, Standards referenced in Australian legislation](#)
-