



BSI Standards Publication

Photovoltaic system performance

Part 2: Capacity evaluation method

National foreword

This Published Document is the UK implementation of IEC/TS 61724-2:2016.

The UK participation in its preparation was entrusted to Technical Committee GEL/82, Photovoltaic Energy Systems.

A list of organizations represented on this committee can be obtained on request to its secretary.

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

© The British Standards Institution 2016.

Published by BSI Standards Limited 2016

ISBN 978 0 580 92308 1

ICS 27.160

Compliance with a British Standard cannot confer immunity from legal obligations.

This Published Document was published under the authority of the Standards Policy and Strategy Committee on 31 October 2016.

Amendments/corrigenda issued since publication

Date	Text affected
------	---------------



TECHNICAL SPECIFICATION

**Photovoltaic system performance –
Part 2: Capacity evaluation method**

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

ICS 27.160

ISBN 978-2-83223-664-2

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

CONTENTS

FOREWORD.....	4
INTRODUCTION.....	6
1 Scope.....	7
2 Normative references.....	7
3 Terms and definitions	8
4 Test scope, schedule and duration.....	10
5 Equipment and measurements	11
6 Procedure	12
6.1 Documentation of the performance targets under “unconstrained” and “constrained” operation	12
6.1.1 General	12
6.1.2 Definition of test boundary to align with intended system boundary	12
6.1.3 Definition of the reference conditions for “unconstrained” operation	12
6.1.4 Definition of the performance target under “unconstrained” and “constrained” operation	13
6.1.5 Definition of the temperature dependence of the plant output under “unconstrained” operation.....	13
6.1.6 Definition of irradiance dependence.....	14
6.1.7 Definition of the performance target under “constrained” operation.....	14
6.1.8 Uncertainty definition	14
6.2 Measurement of data.....	14
6.2.1 General	14
6.2.2 Data checks for each data stream	15
6.2.3 Shading of irradiance sensor	16
6.2.4 Calibration accuracy	16
6.2.5 Using data from multiple sensors.....	16
6.2.6 Unconstrained operation and constrained operation when the output limit of the inverter is reached	17
6.3 Calculation of correction factor	17
6.3.1 General	17
6.3.2 Measure inputs	17
6.3.3 Verify data quality	17
6.3.4 Calculate the correction factor for each measurement point	17
6.3.5 Correct measured power output.....	18
6.3.6 Average all values of corrected power	18
6.3.7 Analyse discrepancies.....	18
6.4 Comparison of measured power with the performance target.....	18
6.5 Uncertainty analysis	19
7 Test procedure documentation	20
8 Test report.....	21
Annex A (informative) Example of model for module temperature calculations.....	22
A.1 General.....	22
A.2 Example heat transfer model to calculate expected cell operating temperature	22
Annex B (informative) Example of model for system power	25
B.1 General.....	25

B.2 Example model	25
Annex C (informative) Inconsistent array orientation	26
Bibliography	27
Table 1 – Data validation and filtering criteria	15
Table 2 – Example guide for seasonal minimum stable irradiance requirements for flat-plate applications.....	16
Table A.1 – Empirically determined coefficients used to predict module temperature	23
Table A.2 – Hellmann coefficient, α , for correction of wind speed according to measured height, if values in Table A.1 are used.....	23

Currently in preview, click buy full version

INTERNATIONAL ELECTROTECHNICAL COMMISSION

PHOTOVOLTAIC SYSTEM PERFORMANCE –**Part 2: Capacity evaluation method**

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.

The main task of IEC technical committees is to prepare International Standards. In exceptional circumstances, a technical committee may propose the publication of a technical specification when

- the required support cannot be obtained for the publication of an International Standard, despite repeated efforts, or
- the subject is still under technical development or where, for any other reason, there is the future but no immediate possibility of an agreement on an International Standard.

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

IEC TS 61724-2, which is a technical specification, has been prepared by IEC technical committee 82: Solar photovoltaic energy systems.

The text of this technical specification is based on the following documents:

Enquiry draft	Report on voting
82/1101/DTS	82/1159/RVC

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.

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 publication will remain unchanged until the stability date indicated on the IEC website under "<http://webstore.iec.ch>" in the data related to the specific publication. At this date, the publication 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.

INTRODUCTION

The performance of a PV system is dependent on the weather, seasonal effects, and other intermittent issues, so measurement of the performance of a PV system is expected to give variable results. IEC 62446-1, *Photovoltaic (PV) systems – Requirements for testing, documentation and maintenance – Part 1 Grid connected – Documentation, commissioning tests and inspection*, describes a procedure for ensuring that the plant is constructed correctly, but does not attempt to verify that the output of the plant meets the design specifications. IEC 61724-1¹, *Photovoltaic system performance – Part 1: Monitoring*, defines the performance data that may be collected, but does not define how to analyze that data in comparison to predicted performance. ASTM E2848-13 *Standard test method for reporting photovoltaic non-concentrator system performance* describes a method for determining the power output of a photovoltaic system based on a regression. IEC TS 61724-3 *Photovoltaic system performance – Part 3: Energy evaluation method* describes a one-year test that evaluates performance over the full range of operating conditions and is the preferred method for evaluating system performance. However, it is essential that plant performance can also be quantified with a shorter test, even if there can be higher uncertainty associated with that test. This document is designed to complete an evaluation in a short time as a complement to IEC TS 61724-3. As a capacity test, it measures power (not energy) at a specified set of reference conditions (which can differ from standard test conditions that have been designed to facilitate indoor measurements). The method in IEC TS 61724-2 is a non-regression-based method for determining power output.

This method uses the design parameters of the plant to quantify a correction factor for comparing the plant's measured performance to the performance targeted under reference conditions. In other words, the measured performance, adjusted by the correction factor, is then compared with the target plant performance to identify whether the plant operates above or below expectations at the target reference condition.

Multiple aspects of PV system quality are dependent on both the weather and the system's quality, so it is essential to have a clear understanding of the system being tested. For example, the module temperature is primarily a function of irradiance, ambient temperature, and wind speed, all of which are weather effects that can be difficult to simulate precisely. However, the module-mounting configuration also affects the module temperature, and the mounting is an aspect of the system that is being tested. This document presents a process for test development and clarifies how measurement choices can affect the outcome of the test so that users can benefit from streamlined test design with consistent definitions, while still allowing flexibility in the application of the test so as to accommodate as many unique installations as possible.

It is to be noted that when the output of a PV system exceeds the capability of the inverter, the output of the system is defined more by the inverter operation than by the PV modules. In this case, the measurement of the capacity of the plant to generate electricity is complicated by the need to differentiate situations in which the inverter is saturated and when the output of the PV system reflects the module performance. For PV plants with high DC-to-AC power ratios, the operation of the plant can reflect the capability of the inverters for the majority of the day, with the capability of the DC array only being measurable for a short time in the morning and in the evening. In this case, it can be necessary to disconnect parts of the DC array to reduce the DC-to-AC power ratio during the measurement period.

IEC TS 61724-2 is applicable to times when the system is fully available.

Methods presented in this document can be used in place of ASTM E2848-13 to determine photovoltaic system performance.

¹ Under preparation. Stage at time of publication: IEC/FDIS 61724-1:2016

PHOTOVOLTAIC SYSTEM PERFORMANCE –

Part 2: Capacity evaluation method

1 Scope

This part of IEC 61724 defines a procedure for measuring and analyzing the power production of a specific photovoltaic system with the goal of evaluating the quality of the PV system performance. The test is intended to be applied during a relatively short time period (a few relatively sunny days).

In this procedure, actual photovoltaic system power produced is measured and compared to the power expected for the observed weather based on the design parameters of the system. The expected power under reference and measured conditions are typically derived from the design parameters that were used to derive the performance target for the plant as agreed prior to the commencement of the test. For cases when a power model was not developed during the plant design, a simple model that increases transparency is presented in the annexes as a possible approach.

The intent of this document is to specify a framework procedure for comparing the measured power produced against the expected power from a PV system on relatively sunny days. This test procedure is intended for application to grid-connected photovoltaic systems that include at least one inverter and the associated hardware.

The performance of the system is quantified both during times when the inverters are maximum-power-point tracking and during times when the system power is limited by the output capability of the inverter or interconnection limit, reducing the system output relative to what it would have been with an inverter with generation freely following irradiance, if this condition is relevant.

This procedure can be applied to any PV system, including concentrator photovoltaic systems, using the irradiance (direct or global) that is relevant to the performance of the system.

This test procedure was designed and drafted with a primary goal of facilitating the documentation of a performance target, but it can also be used to verify a model, track performance (e.g., degradation) of a system over the course of multiple years, or to document system quality for any other purpose. The terminology has not been generalized to apply to all of these situations, but the intent is to create a methodology that can be used whenever the goal is to verify system performance at a specific reference condition chosen to be a frequently observed condition. A more complete evaluation of plant performance can be accomplished by using the complementary Technical Specification IEC TS 61724-3, *Photovoltaic system performance – Part 3: Energy evaluation method*.

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.