IEC 61853-3

Edition 1.0 2018-08

INTERNATIONAL STANDARD

NORME INTERNATIONALE

Photovoltaic (PV) module performance testing and energy rating –
Part 3: Energy rating of PV modules

Essais de performance et caractéristiques assignées d'énergie des modules photovoltaïques (PV) –
Partie 3: Caractéristiques assignées d'énergie des modules PV

IEC 61853-3:2018-08(en-fr)

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

COMMISSION ELECTROTECHNIQUE INTERNATIONALE

ICS 27.160

ISBN 978-2-8322-5989-4

CONTENTS

FOREWORD 3
INTRODUCTION 5
1 Scope 6
2 Normative references 6
3 Terms and definitions 7
4 Testing 7
5 Report 7
6 Module energy collection 8
6.1 General 8
6.2 Input module data for energy rating 8
6.3 Input standard reference climatic profiles 9
7 Procedure for energy rating 9
7.1 General 9
7.2 In-plane global irradiance corrected for angular incidence effects 10
7.3 Spectrally corrected global in-plane irradiance 11
7.4 Calculation of module temperature 12
7.5 Determination of instantaneous module power 12
7.6 Calculation of hourly module energy output 13
7.7 Calculation of annual module energy output 13
7.8 Climatic specific energy rating 13

Figure 1 – Flow chart of calculation procedure 10

INTERNATIONAL ELECTROTECHNICAL COMMISSION

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PHOTOVOLTAIC (PV) MODULE PERFORMANCE TESTING AND ENERGY RATING –

Part 3: Energy rating of PV modules

FOREWORD

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International Standard IEC 61853-3 has been prepared by IEC technical committee 82: Solar photovoltaic energy systems.

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

FDIS	Report on voting
82/1441/FDIS	82/1451/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 61853, published under the general title *Photovoltaic (PV) module performance testing and energy rating*, 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- withdrawn,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.

INTRODUCTION

This International Standard series establishes IEC requirements for determining PV module performance in terms of power (watts), specific module energy rating (kWh/kW) and climatic specific energy rating (dimensionless). It is written to be applicable to all PV technologies including non-linear devices. The methodology does not take into account either progressive degradation or transient behaviour such as light induced changes and/or thermal annealing.

This series consists of four parts:

- IEC 61853-1: *Photovoltaic (PV) module performance testing and energy rating – Part 1: Irradiance and temperature performance measurements and power rating*, which describes requirements for evaluating PV module performance in terms of power (watts) rating over a range of irradiances and temperatures;
- IEC 61853-2: *Photovoltaic (PV) module performance testing and energy rating – Part 2: Spectral responsivity, incidence angle, and module operating temperature measurements*, which describes test procedures for measuring the effect of varying angles of incidence and sunlight spectra as well as the estimation of module temperature from irradiance, ambient temperature, and wind speed;
- IEC 61853-3*: Photovoltaic (PV) module performance testing and energy rating – Part 3: Energy rating of PV modules*, which describes the calculations for PV module ratings; and
- IEC 61853-4: *Photovoltaic (PV) module performance testing and energy rating – Part 4: Standard reference climatic profiles*, which describes the standard time periods and environmental data set that shall be used for the energy rating calculations.

PHOTOVOLTAIC (PV) MODULE PERFORMANCE TESTING AND ENERGY RATING –

Part 3: Energy rating of PV modules

1 Scope

This part of IEC 61853 describes the calculation of PV module energy rating values. IEC 61853-1 describes requirements for evaluating PV module performance at various temperatures and irradiances in terms of power (watts) rating. IEC 61853-2 describes test procedures for determining module temperature from irradiance, ambient temperature and wind speed, a method for measuring angle of incidence effects, and spectral responsivity. IEC 61853-4 describes the standard reference climatic profiles (standard environmental data sets) that are used for calculating energy rating values.

The purpose of this document is to define a methodology to determine the PV module energy output (watt-hours), and the climatic specific energy rating (dimensionless) for a complete year at maximum power operation for the reference climatic profile(s) given in IEC 61853-4. It is applied to determine a specific module output in a standard reference climatic profile for the purposes of comparison of rated modules.

The methodology does not take into account either progressive degradation or transient behaviour such as light induced changes and/or thermal annealing.

The present document applies to mono-facial modules.

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 60891, *Photovoltaic devices – Procedures for temperature and irradiance corrections to measured I-V characteristics*

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

IEC 60904-7, *Photovoltaic devices – Part 7: Computation of the spectral mismatch correction for measurements of photovoltaic devices*

IEC 60904-8, *Photovoltaic devices – Part 8: Measurement of spectral responsivity of a photovoltaic (PV) device*

IEC 60904-8-1, *Photovoltaic devices – Part 8-1: Measurement of spectral responsivity of multi-junction photovoltaic (PV) devices*

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

IEC 61853-1, *Photovoltaic (PV) module performance testing and energy rating – Part 1: Irradiance and temperature performance measurements and power rating*

IEC 61853-2, *Photovoltaic (PV) module performance testing and energy rating – Part 2: Spectral responsivity, incidence angle and module operating temperature measurements*

IEC 61853-4, *Photovoltaic (PV) module performance testing and energy rating – Part 4: Standard reference climatic profiles*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC TS 61836 and the following apply.

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
climatic specific energy rating
CSER
normalised energy collection for the reference climatic profile, i.e. the ratio of the actual energy collection to that which would have been obtained if the PV module always performed with the energy conversion efficiency measured under standard test conditions

Note 1 to entry: CSER is dimensionless.

4 Testing

No testing is performed within this document; however, the energy rating calculations defined in Clause 7 use data from measurements made according to IEC 61853-1 and IEC 61853-2 and the standard reference climatic profiles from IEC 61853-4.

5 Report

Following completion of the procedure, a report with the resulting energy ratings shall be prepared by the test agency. Each certificate or test report shall include at least the following information.

a) a title;

b) name and address of the test laboratory and location where the calibration or tests were carried out;

c) unique identification of the report and of each page;

d) name and address of client, where appropriate;

e) description and identification of the item calibrated or tested;

f) characterization and condition of the calibration or test item;

g) date of receipt of test item and date(s) of calibration or test, where appropriate;

h) identification of calibration or test method used;

i) reference to sampling procedure, where relevant;

j) any deviations from, additions to or exclusions from the calibration or test method, and any other information relevant to a specific calibration or test, such as environmental conditions;

k) the filenames of the reference climate data files and the version of IEC 61853-4 corresponding to the data files;

l) a specification of the interpolation routines used to derive the module data from the measured performance tables;

m) module energy output for the individual test devices, as well as the averaged data (for the three modules submitted for testing in IEC 61853-1);

n) climatic specific energy rating for the individual test devices, as well as the averaged data (for the three modules submitted for testing in IEC 61853-1);

o) a statement of the estimated uncertainty of the energy rating results;

p) a signature and title, or equivalent identification of the person(s) accepting responsibility for the content of the report, and the date of issue;

q) where relevant, a statement to the effect that the results relate only to the items calibrated or tested;

r) a statement that the report shall not be reproduced except in full, without the written approval of the laboratory.

6 Module energy collection

6.1 General

The output power of a PV module depends primarily on the following parameters:

- Irradiance incident on the module
- Module temperature

Module temperature is a derived parameter, and is determined from the tabulated irradiance, ambient temperature and wind speed, together with module thermal parameters as determined in IEC 61853-2.

These parameters are a function of the environmental conditions over the defined year long time period of each standard reference climatic profile, tabulated as an hourly data set in IEC 61853-4. Angle of incidence and spectral effects are considered in the calculations for reasons of completeness, and to ensure that modules with special characteristics are rated correctly.

6.2 Input module data for energy rating

The following module performance parameters influence the instantaneous power output and hence energy production of a PV module:

a) Matrix of P_{max} versus irradiance (at AM 1,5 g) and versus module temperature (IEC 61853-1) which may be interpolated to obtain the instantaneous power at a given irradiance and module temperature.

b) Thermal coefficients u_0, u_1 describing module operating temperature as a function of irradiance and wind speed, which are used to calculate instantaneous module temperature (IEC 61853-2).

c) Angle of incidence response a_r (IEC 61853-2) used to calculate the effective light transmission into the module at different incidence angles.

d) Spectral responsivity (IEC 61853-2), used to calculate spectral mismatch and hence correct to reference spectral conditions. It is provided as a table of values for a range of wavelengths over which the module is responsive.

The performance parameters listed in a) are measured by procedures given in IEC 61853-1. The performance parameters listed in items b), c) and d) are determined according to procedures given in IEC 61853-2. In accordance with procedures in IEC 61853-2, in some cases the parameters in points b), c) may be nominal values provided therein.

6.3 Input standard reference climatic profiles

IEC 61853-4 provides the standard reference climatic profiles to be used for energy rating. The information provided with each standard reference climatic profile is described in IEC 61853-4:2018, subclause 4.2.

7 Procedure for energy rating

7.1 General

For each of the three modules and for the average of the values of the three modules reported from IEC 61853-1 the following procedure shall be followed. The module peak power and energy output for a particular time step is determined by following a series of calculations described in this clause. The module energy output is calculated per hour. These individual hourly energy values are then summed over the data set to determine the annual energy production.

The procedures for each time step are outlined in Figure 1.

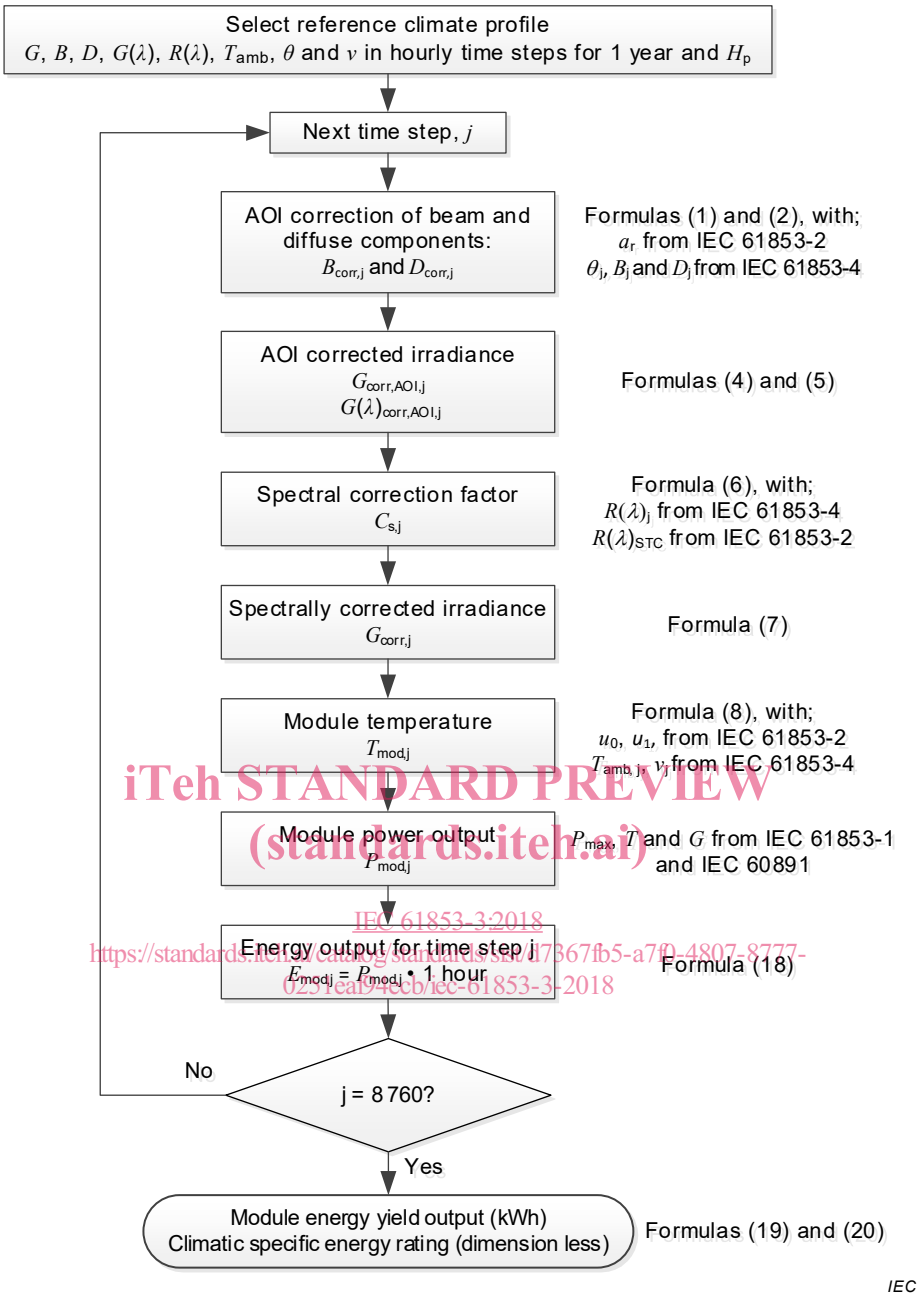

Figure 1 – Flow chart of calculation procedure

7.2 In-plane global irradiance corrected for angular incidence effects

The corrected in-plane direct B_{corr} and diffuse D_{corr} components for angle of incidence are given by:

$$B_{corr,j} = B_j \left[\frac{1-\exp\left(-\frac{\cos(\theta_j)}{a_r}\right)}{1-\exp\left(-\frac{1}{a_r}\right)} \right] \quad (1)$$

$$D_{corr,j} = D_j \left\{ 1 - exp\left[-\frac{1}{a_r} \left(\frac{4}{3\pi} \left(\sin\beta + \frac{\pi-\beta-\sin\beta}{1+\cos\beta} \right) + (0{,}5a_r - 0{,}154) \left(\sin\beta + \frac{\pi-\beta-\sin\beta}{1+\cos\beta} \right)^2 \right) \right] \right\} \quad (2)$$

where

B_j is the uncorrected in-plane direct irradiance at the jth hour,

D_j is the uncorrected in-plane diffuse irradiance at the jth hour,