A Solar ABCs Proposed Standard on:

Nameplate, Datasheet, and Sampling Requirements of Photovoltaic Modules

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Solar America Board for Codes and Standards

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Solar America Board for Codes and Standards Report

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January 2012

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Download a copy of the report:

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Executive Summary

The Solar America Board for Codes and Standards (Solar ABCs) recently (March 2011) published a recommended policy report entitled "Photovoltaic Module Power Rating Requirements." The purpose of the report was to develop a Solar ABCs power rating policy statement that establishes requirements for the procurement of photovoltaic (PV) modules for consumers, states, and organizations providing incentives for PV systems in the United States. The purpose of this document, "A Solar ABCs Proposed Standard on Nameplate, Datasheet, and Sampling Requirements of Photovoltaic Modules," is to convert the policy report into a PV module standard with a text format acceptable to the standard developing organizations such as ASTM International, Institute of Electrical and Electronics Engineers (IEEE), and the International Electrotechnical Commission (IEC).

The European Union has developed a related standard (EN 50380) titled "Datasheet and nameplate information for photovoltaic modules." This European standard (EN), published in 2003, details the information that manufacturers must supply with a PV module. The EN requires manufacturers to report module data (voltage, current, and power at maximum power point, V_{oc}, and I_{sc}) at standard test conditions (STC), nominal operating cell temperature (NOCT), and low irradiance conditions (LIC) as well as temperature coefficients.

The proposed standard by the Solar ABCs differs from the EN in three major respects:

Difference 1: The EN requirement can be represented using this equation: $(P_{measured} + m) \geq (P_{rated} - t)$, where "m" is the measurement uncertainty and "t" is the production tolerance.

The above EN requirement allows leniency for the nameplate rating by the manufacturers on both sides of the equation—the production tolerance leniency on the right side of the equation and the measurement uncertainty leniency on the left side of the equation. Unfortunately, the measurement uncertainty varies from one lab to another and one technology to another. Also, the EN does not impose any specific lower/upper limit for the production tolerance. The proposed standard by the Solar ABCs accounts for these issues in the EN.

Difference 2: EN 50380 requires reporting the module data at only three rating conditions: STC, NOCT, and LIC. The newly published (January 2011) standard IEC 61853-1 titled "Photovoltaic Module Performance Testing and Energy Rating" (IEC, 2011) requires reporting the module data at two additional rating conditions of high temperature conditions (HTC) and low temperature conditions (LTC). The proposed standard by the Solar ABCs recommends the use of the test conditions required by the IEC 61853-1 standard.

Difference 3: The EN 50380 standard does not impose any statistical sampling requirement to select the modules for the independent power rating measurements. The proposed standard by the Solar ABCs incorporates a simple statistical sampling method to determine the number of samples required for the power rating measurements by the independent testing organizations.

Author Biographies

Dr. (Mani) Govindasamy TamizhMani is the president of TUV Rheinland PTL (Photovoltaic Testing Laboratory) and a professor in the Department of Electronic Systems at Arizona State University. Dr. Mani has been involved in R&D activities related to photovoltaics and fuel cells for more than 25 years, and photovoltaic module testing and certification activities for more than 10 years. He has been involved in test standard development activities since 1996. He has served or is serving on various standards committees including the Canadian Standards Council, IEEE, IEC, and ASTM. He has taught graduate level courses related to photovoltaics, fuel cells, electrolysis, and batteries, and has published more than 60 journal and conference papers.

Alex Mikonowicz is an ISO-9001 Consultant on Quality Systems & Photovoltaic Reliability and the executive director of PowerMark, Inc. He has spent 28 years in the aerospace and computer industries and 18 years in photovoltaics, managing quality organizations at SolarWorld USA, Siemens, and Shell Solar Industries, USA. He was appointed five times to be an examiner for the Malcolm Baldrige National Quality Award. Mr. Mikonowicz is active on the standards committees of the IEC, IEEE, and ASTM, and is the present USA TAG Technical Advisor for the IEC-TC 82, and votes on the behalf of the United States for the IEC, TC-82, Photovoltaic Standards. He holds degrees in electrical engineering and business.

Joseph Kuitche is a Ph.D. student at Arizona State University (ASU) and is the research and development and certification manager of TUV Rheinland PTL. He has taught undergraduate level courses at ASU and has published three papers related to statistical reliability prediction of photovoltaic (PV) modules and several papers related to the performance and qualification testing of PV modules.

Solar America Board for Codes and Standards

The Solar America Board for Codes and Standards (Solar ABCs) is a collaborative effort among experts to formally gather and prioritize input from the broad spectrum of solar photovoltaic stakeholders including policy makers, manufacturers, installers, and consumers resulting in coordinated recommendations to codes and standards making bodies for existing and new solar technologies. The U.S. Department of Energy funds the Solar ABCs as part of its commitment to facilitate wide-spread adoption of safe, reliable, and cost-effective solar technologies.

For more information, visit the Solar ABCs website:

www.solarabcs.org

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PROPOSED STANDARD

Nameplate, Datasheet, and Sampling Requirements of Photovoltaic Modules

1. Scope

1.1 This standard identifies the required information on the production and measurement tolerances of nameplate rating of flat plate photovoltaic (PV) modules.

1.2 This standard identifies five rating conditions under which the performance parameters of PV modules shall be reported.

1.3 This standard identifies a simple statistical method to determine the number of samples required for the power rating measurements.

1.4 The samples shall be drawn at random by the responsible authority without regard to their quality as defined in ANSI/ASQ Z1.4 (ANSI/ASQ, 2003). The responsible authority is a representative agreed between purchaser and seller or producer and user.

1.5 The power rating measurements shall be carried out by the independent testing organizations.

1.6 When specified by the responsible authority, this standard shall be referenced in the specification, contract, inspection, instructions, or other documents. The “responsible authority” shall be designated in one of the above documents.

1.7 This standard requires that the nameplate on the PV module carry certain minimum information identified in this standard.

1.8 This standard requires that the datasheet supplied by PV module manufacturers carry certain minimum information identified in this standard.

1.9 Unless otherwise agreed between purchaser and seller or producer and user, every model/type label rating shall be tested to this standard. For the purpose of this standard, a model/type is defined as modules that have a nameplate rating within 5% of the tested modules as per this standard.

1.10 This standard does not specify annual sampling frequency and it shall be agreed upon between purchaser and seller.

1.11 This standard does not apply to concentrator PV modules.

2. Overall Requirements of the Standard

After accounting for the light induced degradation as per IEC 61215 (crystalline silicon) (IEC, 2005) or IEC 61646 (thin film) (IEC, 2008), the measured average power shall be equal to or higher than the nominal nameplate power rating at STC and no individual module power shall be more than 3% below nominal. These requirements are represented by the following two equations:

$P_{measured,\ average} \geq P_{rated,\ nominal}$
&
$P_{measured,\ individual} \geq (P_{rated,\ nominal} - 3\%$ production tolerance)

where $P_{measured,\ average}$ is the measured average power of "n" samples and $P_{measured,\ individual}$ is the measured power of individual samples. $P_{measured,\ average}$ is the independently measured average power of "1-to-100" samples (n). The number of samples "n" must be calculated as described in Section 5 below.

In addition, a minimum of one module (more modules may be required as dictated by the purchaser or user) closest to the nominal rated power shall be measured at the other four rating conditions given in the IEC 61853-1 standard (NOCT, LIC, HTC, and LTC). All five rating conditions are presented in Table 1 below. The nameplate on the individual PV modules shall carry the minimum information identified in Section 3 below. Similarly, the datasheet supplied by the PV module manufacturer shall carry the minimum information identified in Section 4 below. The number of samples used to calculate the measured average power shall be determined using the method identified in Section 5 of this standard.

3. Nameplate Requirements

The nameplate on the individual PV modules shall carry the following minimum information:

- Name and logo of original manufacturer or supplier
- Type designation and serial number
- Maximum system voltage
- Rated nominal power (P_{max}) at STC (1000 W/m², 25°C cell temperature, and air mass [AM] 1.5 global spectrum)
- Maximum negative production tolerance (- % or ± %) of P_{max} at STC
- Rated nominal short circuit current (I_{sc}), open circuit voltage (V_{oc}), voltage at maximum power point (V_{max}), and current at maximum power point (I_{max}) at STC.

4. Datasheet Requirements

The datasheet supplied by the PV module manufacturer shall carry the following minimum information:

- All the nameplate information identified in Section 3 of this standard
- Temperature coefficients (%/°C) of V_{oc}, I_{sc}, and P_{max} at STC
- Performance data for at least one module closest to the nominal rated power measured by an acceptable independent laboratory at the five rating conditions given in IEC 61853-1 standard and shown in Table 1 below. In addition, the independent laboratory shall report the uncertainty of measured value at each test condition shown in Table 1, and the uncertainty value of the measured STC data shall appear on the datasheet.

- Number of samples used by the independent test lab to obtain measured average power
- Measured power of all the individual modules used to obtain average power
- The measurement uncertainty of each test sample at STC along with calibration traceability chain for the measuring equipment of the test laboratory and calibrated modules used in the production line by the manufacturer
- A statement from the manufacturer attesting that the test modules were stabilized by the independent test laboratory for light induced degradation by preconditioning the test samples according to IEC Standard 61215 (crystalline silicon), Section 5, or after light soaking according to IEC Standard 61646 (thin film), Section 10.19, or other stabilizing methods as recommended by the manufacturer (if they are consistent with outdoor operation)
- Name and address of the responsible authority, as agreed between purchaser and seller or producer and user, for random sample selection from production lines
- A statement from the manufacturer confirming that the sampling requirements identified in Section 5 of this standard are met by the responsible authority
- Name of an acceptable independent ISO 17025 accredited laboratory that measured the test samples.

Table 1: Five Rating Conditions as Required by IEC 61853-1 Standard

Abbreviation	Description	Irradiance (W/m²)	Module Temperature (°C)	Ambient Temperature (°C)	Wind Speed (m/s)	Spectrum
HTC	High temperature conditions	1000	75	---	---	AM 1.5
STC	Standard test conditions	1000	25	---	---	AM 1.5
NOCT	Nominal operating cell temperature conditions	800	---	20	1	AM 1.5
LTC	Low temperature conditions	500	15	---	---	AM 1.5
LIC	Low irradiance conditions	200	25	---	---	AM 1.5

5. Sampling Requirements

The samples shall be drawn at random by the responsible authority without regard to their quality as defined in ANSI/ASQ Z1.4 (ANSI/ASQ, 2003). $P_{measured,average}$ is the independently measured average power of "1-to-100" samples (n). The exact number of samples "n" to be used by the independent testing lab is determined based on the percent standard deviation "σ (%)" of 30 (thirty) samples provided by the manufacturer from a production batch or batches acceptable to the sampling procedure of the responsible authority. Table 2 identifies the required number of samples (n) depending on the standard deviation of 30 samples. A detailed explanation of the statistical approach for the sample size determination is provided in the appendix.

Table 2: Sample Size Determination Based on the Standard Deviation of 30 Samples
(Supplied by Manufacturer and Acceptable to Responsible Authority)

σ (%)	≥ 6.0	≥ 5.0, < 6.0	≥ 4.3, < 5.0	≥ 3.8, < 4.3	≥ 3.0, < 3.8	≥ 2.5, < 3.0	≥ 2.1, < 2.5	≥ 1.8, < 2.1	≥ 1.7, < 1.8	≥ 1.5, < 1.7	≥ 1.4, < 1.5	≥ 1.2, < 1.4	≥ 1.0, < 1.2	≥ 0.7, < 1.0	< 0.7
n	100	75	50	40	30	20	15	10	8	6	5	4	3	2	1

REFERENCES

American National Standards Institute (ANSI)/ American Society for Quality (ASQ). (2003). ANSI/ASQ Z1.4. *Sampling procedures and tables for inspection by attributes.*

International Electrotechnical Commission (IEC). (2005). IEC 61215. *Crystalline silicon terrestrial photovoltaic (PV) modules-Design qualification and type approval.*

International Electrotechnical Commission (IEC). (2008). IEC 61646. *Thin film terrestrial photovoltaic (PV) modules-Design qualification and type approval.*

International Electrotechnical Commission (IEC). (2011). IEC 61853-1. *Photovoltaic module performance testing and energy rating.*

Appendix: Sample Size (n) Determination

The required number of samples (n) for the average is dictated by three parameters:

- The maximum production tolerance (E) allowed by the specification, currently 3%
- The population standard deviation, σ
- The degree of confidence.

Assuming a normal population,
Let $\lambda = E/\sigma$, the ratio of the production tolerance and standard deviation; i.e. $3\% P/\sigma$

We hypothesize that:

- Ho: The measured mean (a) is equal to the nominal mean (μ)
- H1: The two means are not equal.

The degree of confidence defines the risk involved in rejecting Ho when it is actually true. Such probability is set to 5% (i.e. 95% confidence level).

To choose a proper sample size for 95% confidence level, the table below, derived from operating curves of Figure 1, will be used. It plots the risk of mistakenly accepting that the measured mean is equal to the nominal mean, against λ for given sample size. Note that the table was generated based on the fact that all independently measured P_{max} data shall be within 3% of the rated value.

Estimating Standard Deviation "σ"

When historical data is available (assuming the sample size is larger than 30), it can be used to estimate the population standard deviation σ. However, when there is no such historical data, conventional statistical understanding calls for a minimum of 30 samples to obtain a normal distribution. The manufacturer shall supply the standard deviation (in %) based on the in-line flash tests and the sampling procedure accepted between the manufacturer and the "responsible authority." The flash tester shall be calibrated using calibrated modules as per the quality system traceability requirements of the standard.

Estimating Sample Size "n"

For example, assuming a maximum population standard deviation of 1% (based on historical/typical data), from table below, a minimum of 3 samples would be required.

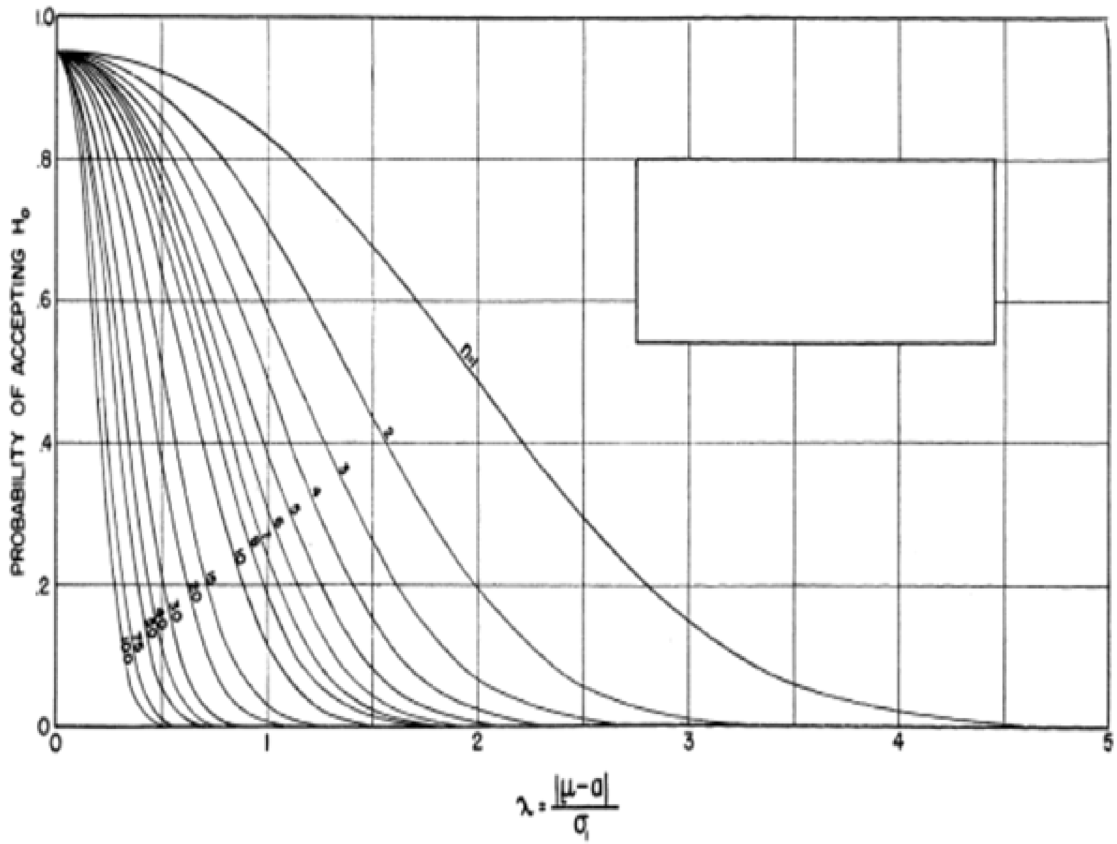

Figure 1: Operating Characteristic curve for 95% confidence and available historical data

(Reproduced from "*Operating Characteristics For The Common Statistical Tests Of Significance*", C. D. Ferris, F. E. Grubbs, and C. L. Weaver, The Annals of Mathematical Statistics, June 1946)

σ (%)	≥ 6.0	≥ 5.0, < 6.0	≥ 4.3, < 5.0	≥ 3.8, < 4.3	≥ 3.0, < 3.8	≥ 2.5, < 3.0	≥ 2.1, < 2.5	≥ 1.8, < 2.1	≥ 1.7, < 1.8	≥ 1.5, < 1.7	≥ 1.4, < 1.5	≥ 1.2, < 1.4	≥ 1.0, < 1.2	≥ 0.7, < 1.0	< 0.7
n	100	75	50	40	30	20	15	10	8	6	5	4	3	2	1

ACRONYMS

AM	air mass
ANSI	American National Standards Institute
ASTM	ASTM International (formerly the American Society for Testing and Materials)
ASQ	American Society for Quality
E	maximum production tolerance
EN	European standard (French: Norme, German: Norm)
HTC	high temperature conditions
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
I_{max}	current at maximum power point
I_{sc}	short circuit current
LIC	low irradiance conditions
LTC	low temperature conditions
n	number of samples
NOCT	nominal operating cell temperature
P_{max}	peak power
PV	photovoltaic
STC	standard test conditions
V_{max}	voltage at maximum power point
V_{oc}	open circuit voltage

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ABCS-06-SR