
*Solar ABCs Standard:
Nameplate, Datasheet and Sampling
Requirements for Photovoltaic Modules*

*“This Solar ABCs standard has been adopted as UL 4730
Subject (Outline of Investigation) which is to be balloted as UL
4730 Standard and be referenced in UL1703 as a requirement”*

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Solar ABCs Standard – Motivation

- Without a nameplate rating tolerance requirement in a national standard, some PV modules may have a **significantly lower power output than the module's nameplate rating indicates**. This results in reduced performance of installed PV systems that will not meet consumers' expectations.
- Without power rating data at multiple **low/high irradiance and temperature conditions**, the energy collection predictions for installed PV modules and systems will not be accurate.



Can the nameplate tolerance be **practically** tightened to -3%?

- Measurement uncertainty is now smaller (less than +/- 3% for c-Si)
- Reproducibility error between test labs is now smaller (less than +/- 3% for c-Si)
- Nameplate tolerance declared by several manufacturers is now typically low (less than +/- 3% for c-Si).

Answer:

Yes, nameplate rating tolerance can practically be tightened to -3%.

Solar ABCs Standard and UL 4730 Subject – Current (2013)

$$P_{\text{measured, average}} \geq P_{\text{rated, nominal}} \quad (1)$$

$$P_{\text{measured, individual}} \geq (P_{\text{rated, nominal}} - 3\% \text{ production tolerance}) \quad (2)$$

where:

$P_{\text{measured, average}}$ is the measured average power of “n” samples

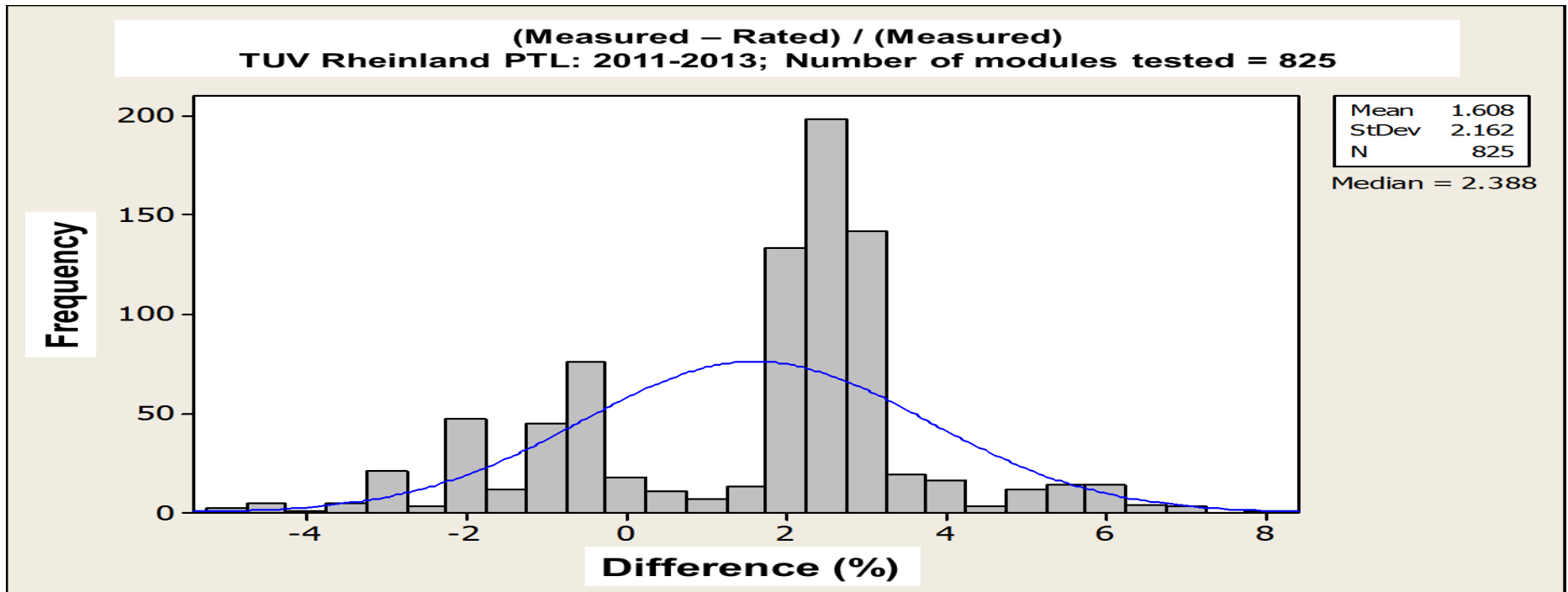
$P_{\text{measured, individual}}$ is the measured power of “individual” samples

“n” is dictated by the ratio between production tolerance (3%) and standard deviation ($\sigma\%$) of Pmax data of 30 samples, and statistical operating curves

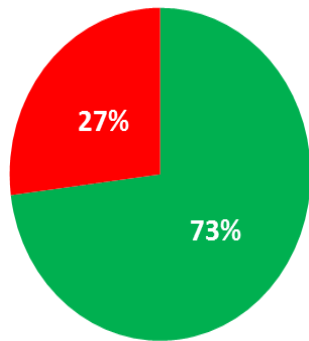
		\geq	\geq	\geq	\geq	\geq	\geq	\geq	\geq	\geq	\geq	\geq	\geq	\geq	
σ	\geq	5.0,	4.3,	3.8,	3.0,	2.5,	2.1,	1.8,	1.7,	1.5,	1.4,	1.2,	1.0,	0.7,	
(%)	6.0	<	<	<	<	<	<	<	<	<	<	<	<	<	<
n	100	6.0	5.0	4.3	3.8	3.0	2.5	2.1	1.8	1.7	1.5	1.4	1.2	1.0	0.7
		75	50	40	30	20	15	10	8	6	5	4	3	2	1



Solar ABCs Standard and UL 4730 Subject – Validation

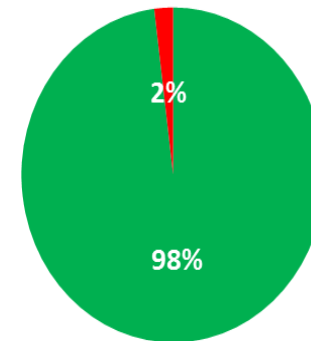


TUV Rheinland PTL: 2011-2013
Number of modules tested = 825
Compliance to UL 4730 Nameplate **Nominal** Rating



■ Compliance ■ Non-Compliance

TUV Rheinland PTL: 2011-2013
Number of modules tested = 825
Compliance to UL 4730 Nameplate **-3%** Rating



■ Compliance ■ Non-Compliance

Solar ABCs **Standard** and UL 4730 **Subject** – **Concerns** **expressed by the stakeholders**

$$P_{\text{measured, average}} \geq P_{\text{rated, nominal}}$$

&

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

where:

$P_{\text{measured, average}}$ is the measured average power of “n” samples

$P_{\text{measured, individual}}$ is the measured power of “individual” samples

Issues:

- No laboratory measurement **uncertainty** is included in the equations (solution: include the uncertainty in both equations)
- Production tolerance is **restricted to +/-3%** (solution: allow production tolerance from +/- 0% to +/- 5%)



UL 4730 Standard – Revised Future (2015?)

$$P_{\text{measured, average}} (1 + [m\%/100]) \geq P_{\text{rated, nominal}}$$

&

$$P_{\text{measured, individual}} (1 + [m\%/100]) \geq P_{\text{rated, nominal}} (1 - [t\%/100])$$

where:

m% is laboratory measurement uncertainty

t% is manufacturer production tolerance

$P_{\text{measured, average}}$ is the measured average power of “n” samples

$P_{\text{measured, individual}}$ is the measured power of “individual” samples

“n” is dictated by the ratio between production tolerance (**t%**) and standard deviation (**σ%**) of Pmax data of 30 samples, and statistical operating curves

t% ≤ 1	σ < 0.2	0.2 ≤ σ < 0.3	0.3 ≤ σ < 0.4	0.4 ≤ σ < 0.5	0.4 ≤ σ < 0.5	0.5 ≤ σ < 0.6	0.5 ≤ σ < 0.6	0.6 ≤ σ < 0.7	0.7 ≤ σ < 0.8	0.8 ≤ σ < 1.0	1.0 ≤ σ < 1.3	1.3 ≤ σ < 1.4	1.4 ≤ σ < 1.7	1.7 ≤ σ < 2.0	σ ≥ 2.0
t% = 2	σ < 0.5	0.5 ≤ σ < 0.7	0.7 ≤ σ < 0.8	0.8 ≤ σ < 0.9	0.9 ≤ σ < 1.0	1.0 ≤ σ < 1.1	1.1 ≤ σ < 1.2	1.2 ≤ σ < 1.4	1.4 ≤ σ < 1.7	1.7 ≤ σ < 2.0	2.0 ≤ σ < 2.5	2.5 ≤ σ < 2.9	2.9 ≤ σ < 3.3	3.3 ≤ σ < 4.0	σ ≥ 4.0
t% = 3	σ < 0.7	0.7 ≤ σ < 1.0	1.0 ≤ σ < 1.2	1.2 ≤ σ < 1.4	1.4 ≤ σ < 1.5	1.5 ≤ σ < 1.7	1.7 ≤ σ < 1.8	1.8 ≤ σ < 2.1	2.1 ≤ σ < 2.5	2.5 ≤ σ < 3.0	3.0 ≤ σ < 3.8	3.8 ≤ σ < 4.3	4.3 ≤ σ < 5.0	5.0 ≤ σ < 6.0	σ ≥ 6.0
t% = 4	σ < 1.0	1.0 ≤ σ < 1.3	1.3 ≤ σ < 1.6	1.6 ≤ σ < 1.8	1.8 ≤ σ < 2.0	2.0 ≤ σ < 2.2	2.2 ≤ σ < 2.4	2.4 ≤ σ < 2.9	2.9 ≤ σ < 3.3	3.3 ≤ σ < 4.0	4.0 ≤ σ < 5.0	5.0 ≤ σ < 5.7	5.7 ≤ σ < 6.7	6.7 ≤ σ < 8.0	σ ≥ 8.0
t% = 5	σ < 1.2	1.2 ≤ σ < 1.7	1.7 ≤ σ < 2.0	2.0 ≤ σ < 2.3	2.3 ≤ σ < 2.5	2.5 ≤ σ < 2.8	2.8 ≤ σ < 2.9	2.9 ≤ σ < 3.6	3.6 ≤ σ < 4.2	4.2 ≤ σ < 5.0	5.0 ≤ σ < 6.3	6.3 ≤ σ < 7.1	7.1 ≤ σ < 8.3	8.3 ≤ σ < 10.0	σ ≥ 10.0
n	1	2	3	4	5	6	8	10	15	20	30	40	50	75	100

Number of Rating Conditions Required in the UL 4730 Standard

IEC 61853-1: 23 Reporting Conditions

(Best input data for system energy rating models/software)

**Too many test conditions;
Pushback from
manufacturers.**

Irradiance (W/m ²)	Spectrum	Module Temperature			
		15°C	25°C	50°C	75°C
1100	AM1.5	NA			
1000	AM1.5				
800	AM1.5				
600	AM1.5				
400	AM1.5				NA
200	AM1.5				NA
100	AM1.5			NA	NA

Abbrev.	Description	Irradiance (W/m ²)	Module Temp. (°C)	Ambient Temp. (°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

Already required by CEC

IEC 61853-1: 5 Rating Conditions

5 rating conditions;
One module closest to
rated power



UL 4730 Standard – Future (2015?)

Nameplate Requirements

- Data at STC: P_{max}, V_{oc}, I_{sc}, V_{max}, I_{max}
- Negative production tolerance (-%)

Datasheet and Installation Manual Requirements

- A statement from the manufacturer declaring that the overall requirements of the standard including PV-specific QMS are met
- Data at STC: P_{max}, V_{oc}, I_{sc}, V_{max}, I_{max}
- Negative production tolerance (-%)
- Temperature coefficients (%/°C) of V_{oc}, I_{sc}, V_{max}, I_{max} and P_{max} at STC
- Power rating as per IEC 61853-1 at 5 other test conditions
- Number of samples used to obtain average power
- Methodology about how the manufacturer established the nominal rating
- Uncertainty and calibration traceability (test lab and calibrated modules at production)

Sampling Procedure

Samples shall be drawn at random without regard to their quality as defined in the “Standard for sampling procedures and tables for inspection by attributes (ANSI/ASQ Z1.4)”

Summary – Status and Goals

- Solar ABCs Standard – Released in January 2012
- UL 4730 Subject – Released in April 2013
- UL 4730 Subject Revision – Scheduled to be completed in October 2014
- UL 4730 Standard - STP for “Flat-Plate Photovoltaic Modules and Panels” is expected to make a decision on the adoption of the Subject as a Standard (in 2015?).
- UL 1703 Standard - STP for Flat-Plate Photovoltaic Modules and Panels is expected to make a reference (of UL 4730 standard) in UL1703 standard as a requirement (in 2015?).



Information Slides



Sample size (n) determination – Operating curves used to determine “n”

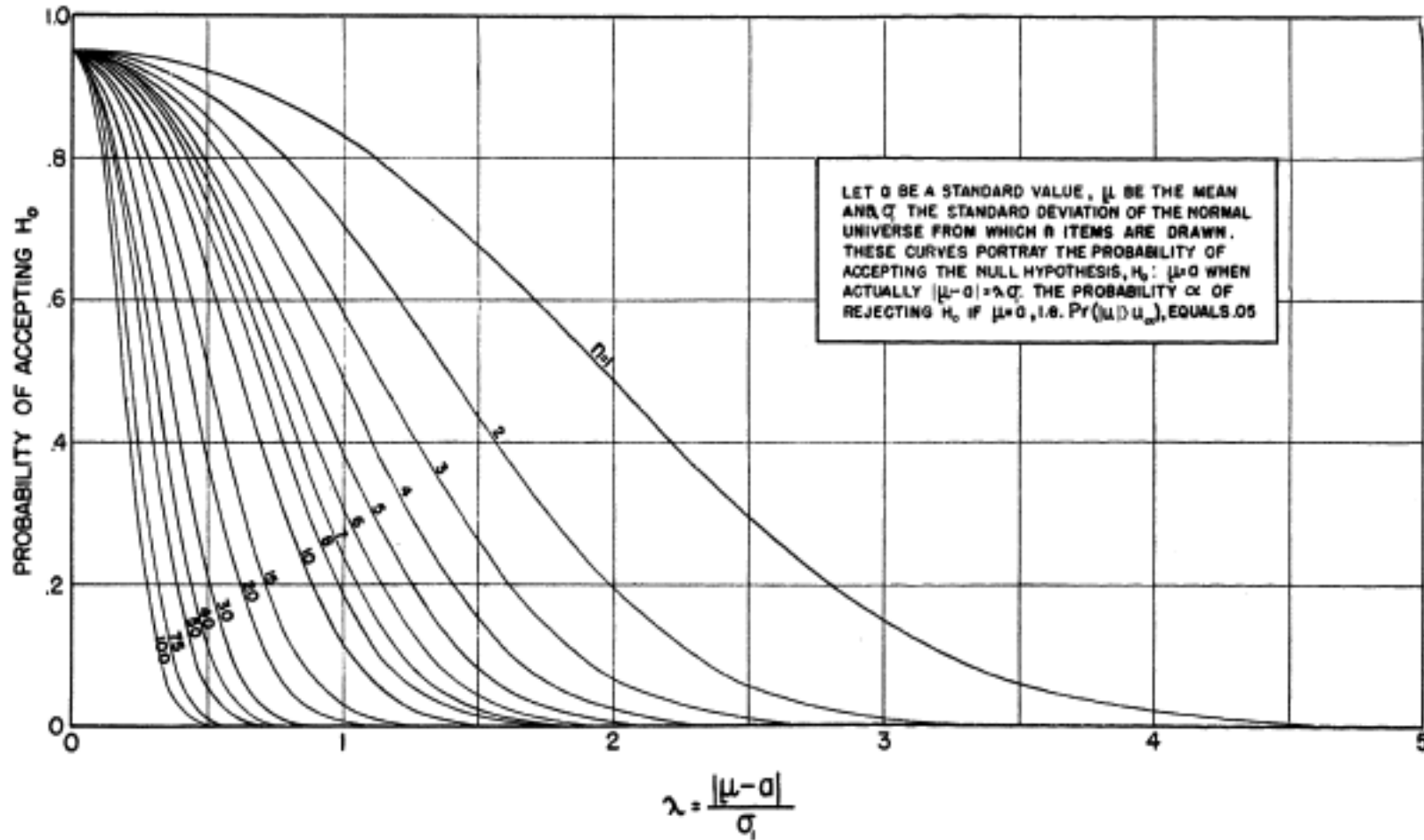


Figure 1: Operating Characteristic curve for 95% confidence and available historical data

(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)



PAST issues in the United States

Allowed nameplate tolerance in the Past and in UL 1703

Measured power = Nameplate rated power **+/- 10%**

Past practice by manufacturers (example)

Nameplate rated power: 100W

Measured power: > 90W ~ < 110W

Reason for the past allowed tolerance

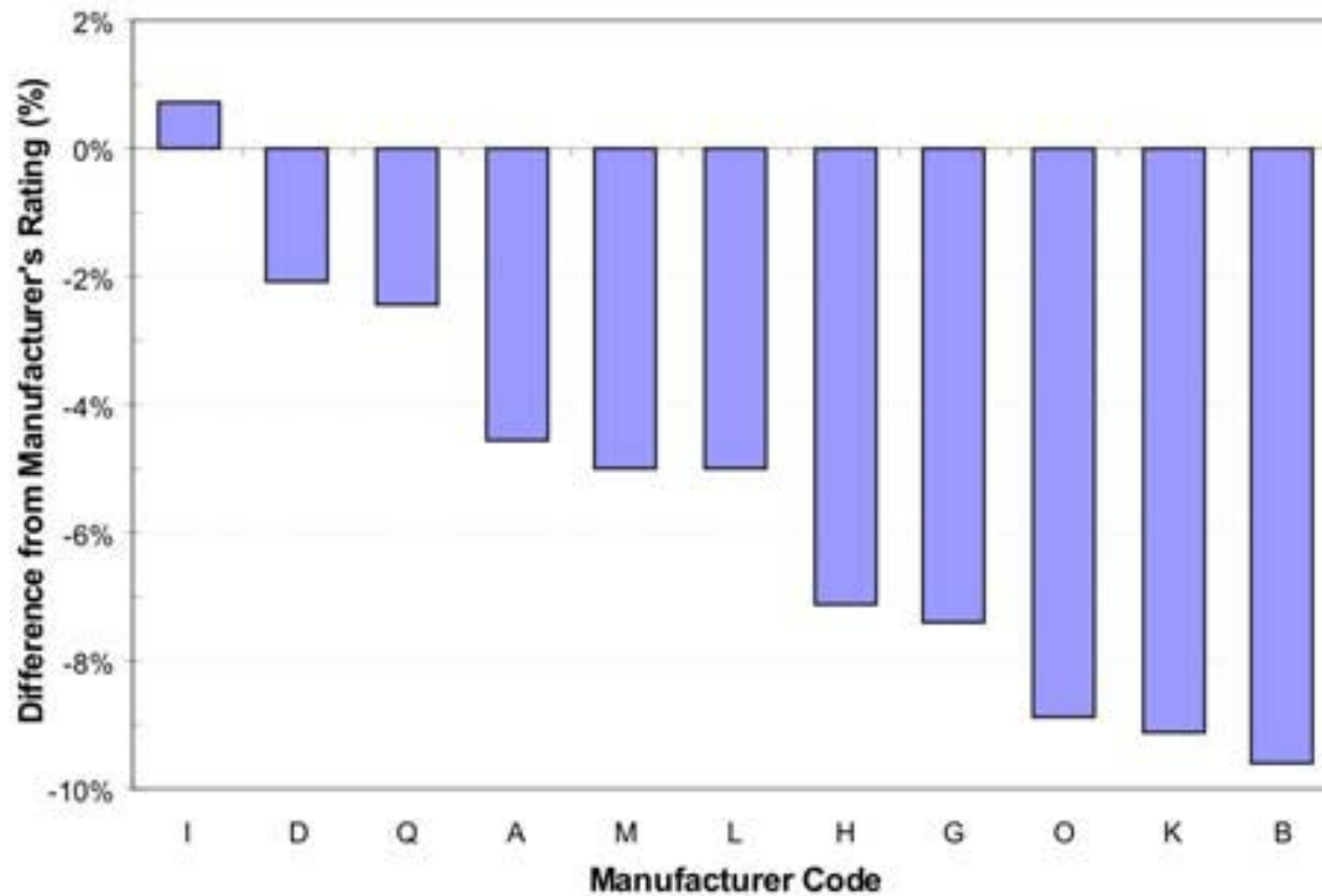
- Measurement uncertainty was high in the past!
- Reproducibility error between test labs was high in the past!

Past market issue

- Measured power: Tended to be towards 90W but priced at 100 W (see FSEC's data next page)



Past market issue



Comparison of PV Module Measured Peak Power at STC with the Module Nameplate Ratings (Source: FSEC Data 2002-2006)



Solar ABCs' Revised Policy Recommendation in November 2008

“The permissible deviation from module nameplate output for current, power, and voltage for modules installed in the U.S. shall be $\pm 5\%$. A more detailed Solar ABCs policy shall be developed to address related issues such as stabilization, measurement uncertainty, warranties and other issues.”



Solar ABCs' Revised Policy Recommendation in March 2011

“It is recommended that photovoltaic modules types sold or installed in the United States be independently measured and certified to the following power rating tolerance: after accounting for the light induced degradation as per IEC 61215 (crystalline silicon) or IEC 61646 (thin film), the measured average power shall be equal to or higher than the nominal nameplate power rating at STC (standard test conditions) and no individual module power shall be more than 3% below nominal. In addition, the modules shall be rated at minimum four other reference conditions as per IEC 61853-1 standard: 200 W/m² & 25°C cell temperature; 500 W/m² & 15°C cell temperature; 1000 W/m² & 75°C cell temperature; 800 W/m² & 20°C ambient temperature.”



www.solarABCs.org

