
PV Module Power Rating

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PAST

Allowed production tolerance in the Past

Measured power = Nameplate rated power +/- 10%

Past practice (example)

Nameplate rated power: 100W

Measured power: > 90W ~ < 110W

Reason for the past allowed tolerance

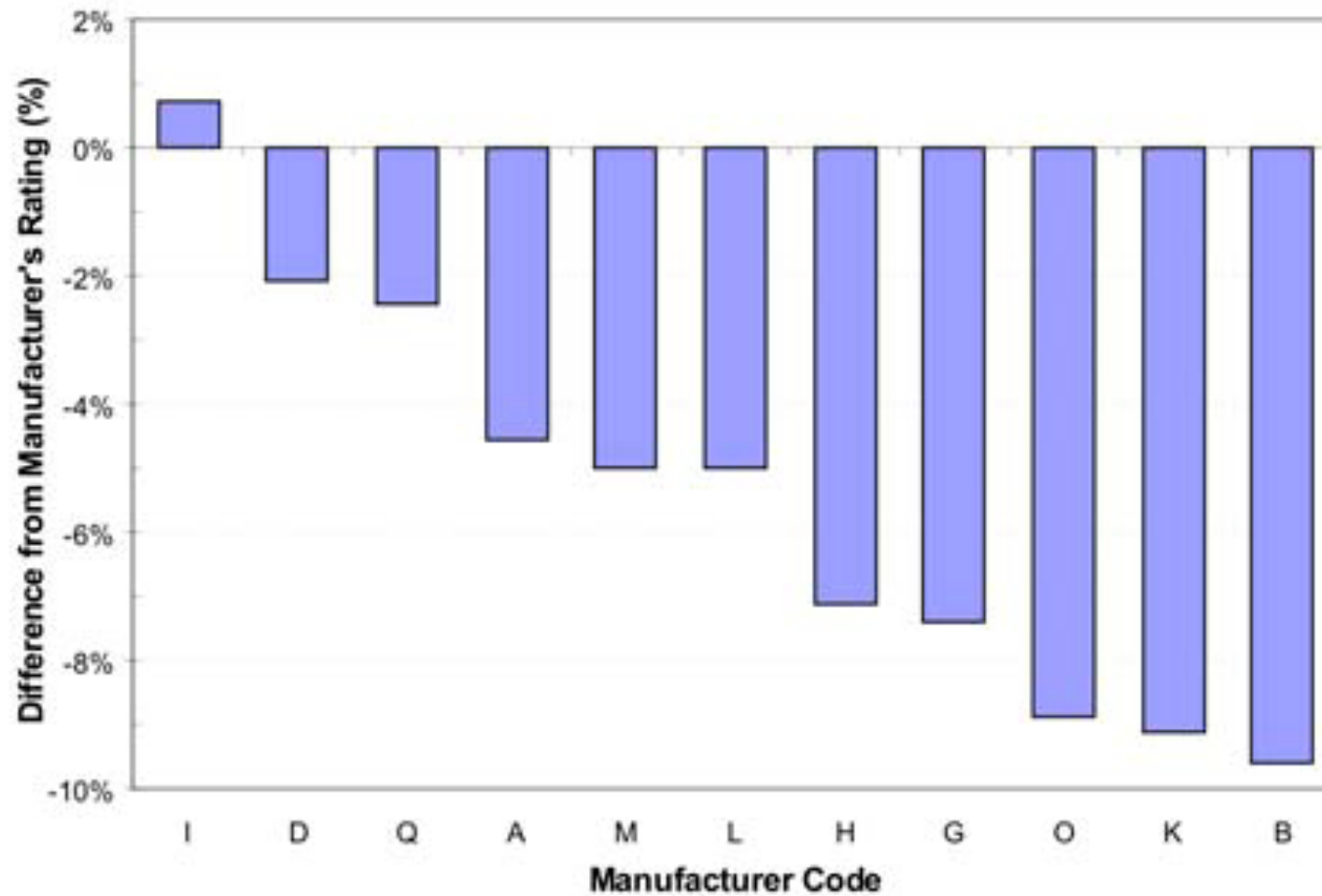
- Measurement tolerance was **high** in the **past!**
- Reproducibility tolerance between test labs was **high** in the **past!**

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' Previous Policy (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.”



PRESENT

Current Measurement Tolerance

- Measurement tolerance is **now smaller** (for example, +/- 3% for c-Si)
- Reproducibility tolerance between test labs is **now smaller** (for example, +/- 3% for c-Si; see NREL paper-WCPEC4-2006 and Shell Solar's RR data)



Reproducibility Tolerance

NREL Round Robin Testing – 2006 (WCPEC4-2006)

	<u><Pmax>, W</u>	<u>NREL</u> pre	<u>SNL</u>	<u>ASU</u>	<u>FSEC</u>	<u>ESTI</u>	<u>LEEE</u>	<u>TUV</u>	<u>ISE</u>	<u>JET</u>	<u>NREL</u> post
Mono-Si											
SIE0577	66.84	-2.9	3.2	1.6	-4.2	0.4	-0.2	-0.2	0.8	1.3	-2.6
SIE0586	67.22	-3.2	2.9	1.3	-4.2	0.4	0.6	-0.6	0.7	1.7	-2.8
Thin Film Si											
AsP0123	51.54	-3.5	1.7	0.7		0.9	-1.4	0.3	0.8	-0.6	-2.4
AsP0247	52.87	-3.1	1.8	0.6		1.4	-1.5	0.1	0.6	-0.9	-2.1
a-Si/a-Si:Ge											
BPS4213	41.04	4.8	-0.3	2.3		-7.2*		3.3			1.8
BPS4223	36.82	3.7	1.8	3.7		-3.3*		-3.9			1.6
a-Si/a-Si/a-Si											
USSC234	19.24	3.2	-0.6	-0.2		-7.8*		9.1			-0.5
USSC382	19.41	2.7	-0.5	-0.6		-7.2*		8.7			-0.5
CdTe											
BP4405	84.13	0.1	-0.7	4.7		-2.9		-1.0			-0.1
BP4505	87.96	-1.3	-0.5	4.1		-3.4		-1.0			0.7
CIS											
Sie9257	40.54	-3.3	5.0	3.1		-3.1		-1.3			-3.7
Sie9260	40.10	-3.5	7.6	4.2		-4.7		-3.0			-4.1
Concentrator											
PTEL#1	3.015	3.3	0.8			-3.8					3.0
PTEL#2	2.913	-0.3	3.0			-7.3					4.3

* No spectral mismatch correction applied.



Shell Solar Round Robin Testing - 2003

Tester	P _{max} (W)	I _{max} (A)	V _{max} (V)	I _{sc} (A)	V _{oc} (V)	%FF	P _{max} -Delta(%)
Ref.Lab Grand Average	48.6	2.88	16.9	3.14	21.3	72.8	
NREL -(LACSS, NOV '02)	47.5	2.82	16.8	3.07	21.2	72.9	-2.4%
NREL -OUTDOORS (NOV '02)	48.7	2.96	16.7	3.18	21.2	72.2	0.2%
NREL -(SPIRE240A, NOV '02)	48.5	2.80	17.3	3.11	21.4	73.0	-0.3%
TUV, (FEB'03)	48.3	2.91	16.6	3.14	21.2	72.7	-0.8%
ESTI (MARCH '03)	49.2	2.93	16.8	3.17	21.4	72.8	1.1%
RS/T -MD, (APRIL '03)	49.3	2.86	17.2	3.14	21.7	72.4	1.4%
SSI -USA(LAPSS, DEC '02)	49.3	2.90	17.0	3.15	21.4	73.1	1.3%
SSI -USA(LAPSS, APR '03)	49.1	2.91	17.0	3.16	21.49	72.9	1.0%



Shell Solar Round Robin Testing - 2003

Tester	Pmax(W)	I _{max} (A)	V _{max} (V)	I _{sc} (A)	V _{oc} (V)	% FF	Pmax-Delta(%)
Ref.Lab Grand Average	67.9	3.95	17.2	4.29	21.6	73.2	
NREL-(LACSS, NOV '02)	66.3	3.86	17.2	4.23	21.5	72.8	-2.4%
NREL-OUTDOORS (NOV '02)	67.4	4.03	17.0	4.34	21.4	72.5	-0.8%
NREL-(SPIRE240A, NOV '02)	67.8	3.90	17.4	4.27	21.7	73.1	-0.1%
TUV, Germany (FEB '03)	67.3	3.95	17.0	4.25	21.5	73.7	-0.9%
ESTI (MARCH '03)	68.6	3.99	17.2	4.35	21.7	72.8	1.0%
RS/T-MD, Germany (APRIL '03)	68.4	3.94	17.4	4.31	21.9	72.5	0.7%
SSI-USA(LAPSS, DEC '02)	69.6	4.04	17.2	4.42	21.69	72.5	2.5%
SSI-USA(LAPSS, APR '03)	67.9	3.92	17.4	4.29	21.67	73.2	0.0%



Datasheet specifications of various major manufacturers (Feb 2010)

Manufacturer # 1

- Production tolerance = +/- 3%
- The datasheet complies with the requirements of EN 50380

Manufacturer # 2

- Production tolerance = +/- 3%
- The datasheet complies with the requirements of EN 50380

Manufacturer # 3

- Production tolerance = +/- 3%
- No indication of the datasheet complying with the requirements of EN 50380

Manufacturer # 4

- Production tolerance = -5% and +10%
- No indication of the datasheet complying with the requirements of EN 50380

Manufacturer # 5

- Production tolerance = -0% and +5%
- No indication of the datasheet complying with the requirements of EN 50380 but it indirectly complies with EN 50380 as the negative tolerance is 0%



EN 50380:

Datasheet and nameplate information for photovoltaic modules

- No specific production tolerance is imposed (for example, +/- 5%) by the EN standard but manufacturer shall provide production tolerance to comply with the following:

$$(P_{\text{measured}} + \underline{m}) > (P_{\text{rated}} - \underline{t})$$

- This standard takes the measurement tolerance into account
- This standard takes light stabilization into account (but 20 kWh light exposure is not adequate; we need to use IEC 61215/61646 light stabilization methods)
- Most importantly, EN approach is applicable to all the technologies as it uses “ $P_{\text{measured}} + \underline{m}$ ” rather than “ P_{measured} ” as in CEC (measurement tolerance for c-Si is less than 4% whereas it is as high as 8% for thin-film and CPV technologies – see NREL round robin test data – WCPEC4-2006)



EXAMPLE EN 50380:

A PV module is rated with a nominal power of " P_{\max} " of 50 watts at STC (with consideration of pre-ageing at start of operation) and production tolerances " $\pm t$ " of $\pm 10\%$. This module is measured in an external test laboratory with measurement tolerances " $\pm m$ " of $\pm 4\%$.

In the unfavourable case (lower tolerance limit), the photovoltaic module from production has an electrical power " P " of

$$P = P_{\max} \left(1 - \frac{t[\%]}{100} \right)$$

P_{\max} = Nominal rated power = 50 W

Production tolerance = -10%

P = Minimum rated power = $50 \times 0.9 = 45$ W

(1)

In this example, $P = 45$ watts.

In the unfavourable case (lower measurement tolerance), the external test laboratory measures the electrical power " $P_{\text{measurement}}$ " of

$$P_{\text{measurement}} = P \cdot \left(1 - \frac{m[\%]}{100} \right)$$

Measurement tolerance = -4%

$P_{\text{measurement}} = 45 \times 0.96 = 43.2$ W

(2)

In this example, $P_{\text{measurement}} = 43,2$ watts.

**If the measured power is higher than 43.2 W,
the datasheet complies with the requirements
of EN 50380**

This means in this example that a photovoltaic module, measured with 43,2 watts, agrees with the statement "Nominal power of 50 watts with production tolerances of $\pm 10\%$ ".



CEC Module Eligibility Requirement:

- “The lower bound of the manufacturer’s stated tolerance must be no less than 95% of the maximum power reported to the Energy Commission.” Thus, the requirement is:

$$P_{\text{measured}} > (P_{\text{rated}} - 5\%)$$

- This requirement does not take the measurement tolerance into account
- This standard takes light stabilization into account (IEC 61215/61646 light stabilization methods used)
- Most importantly, CEC approach is NOT applicable to all the technologies as it uses “measured” rather than “measured maximum” as in EN (measurement tolerance for c-Si is less than 4% whereas it is as high as 8% for thin-film and CPV technologies – see NREL round robin test data – WCPEC4-2006)



Scope and Limitations of the Proposed Power Rating Policy:

- **Power rating policy is a living document and its scope is dictated by the market requirements and the availability of existing standards.**
- **In this presentation, the power rating requirements of two major markets (California and Europe) and the availability of existing standards (EN 50380 & CEC's Equipment Eligibility) are considered.**
- **Both EN and CEC requirements call for the power rating at three different conditions: STC (standard test conditions), NOCT (nominal operating cell temperature) and Low Irradiance (200 W/m² at 25°C).**
- **Limitation of the current proposed policy: "The current power rating policy is limited to only three test conditions of STC, NOCT and Low Irradiance (200 W/m²)"**
- **Future power rating policy of Solar ABCs intends to include the requirements of new power rating standard of IEC (IEC 61853-1 draft). This new IEC standard covers almost all the field conditions in the US and world.**



Options for Power Rating

1) EN:

$$(P_{\text{measured}} + \underline{m}) > (P_{\text{rated}} - \underline{t})$$

\underline{m} = Measurement tolerance

\underline{t} = Production tolerance

2) CEC:

$$P_{\text{measured}} > (P_{\text{rated}} - 5\%)$$

3) EN-modified:

$$P_{\text{measured}} + \underline{m} > P_{\text{rated}}$$



Questions:

- Can we adopt EN 50380 as a Solar ABCs report after some editorial revision? Later, a standard's organization may consider adopting it as a standard (for example, an IEEE standard).
- Can we simply adopt CEC's approach of eligible PV modules with a slight revision which requires " $P_{\text{measured} + \underline{m}}$ " rather than " P_{measured} "?



Questions:

- Do we need a Solar ABCs recommended policy or recommendation report, or can we wait until the standard is developed/adopted?
- Do we need it for all technologies, or just for c-Si?

