

CFV Labs

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CEC Testing

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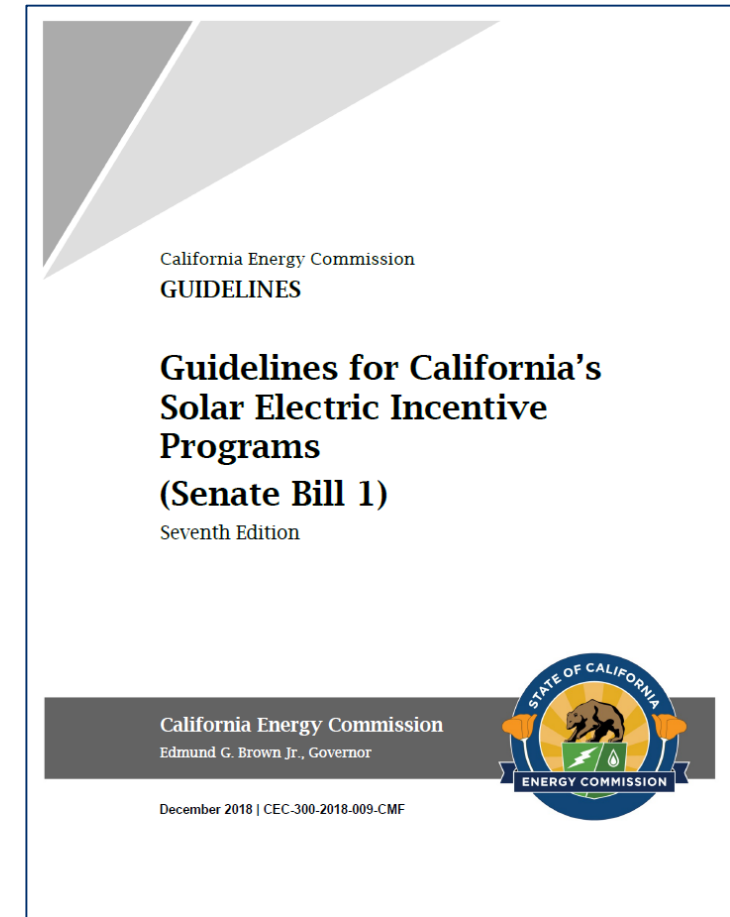


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What is CEC Testing?

- CEC Testing is a set of tests required for listing PV modules at CEC (California Energy Commission).
- The tests are described in Appendix B of “Guidelines for California’s Solar Electric Incentive Programs (Senate Bill 1)”.
 - Last version: 7th edition, December 2018
- California’s PV incentive programs have ended, but incentive programs in other US states have started to require that CEC-listed modules be used.
- For the time being, CEC listing continues to be a de-facto requirement for selling PV modules in the US market.



Required Tests

- CEC uses the concept of “Group” and “Subgroup” (explained in the next slide).
- For each “Group” of modules, a sample with power rating $\geq 95\%$ of highest power class is subjected to the following set of tests per IEC 61215:2005 (Si) or IEC 61646:2008 (thin film).
 - 10.5 Nominal Operating Cell Temperature (NOCT)
 - 10.4 Temperature Coefficients
- For each “Subgroup” of modules in the Group, a sample is subjected to the following set of tests. The highest power class of the Subgroup must be $\leq 110\%$ of the tested class, and the lowest power class must be $\geq 90\%$ of the tested class.
 - Preconditioning (Si) or 10.19 Light Soaking (thin film)
 - 10.6 Performance at STC and NOCT
 - 10.7 Performance at Low Irradiance

“Group” for CEC Testing

- It is up to the ISO 17025-accredited laboratory to determine which modules are similar enough to be considered a “Group”. CFV is qualified.
- As the CEC-required tests are those related to performance modeling, CFV finds that a “Group” of modules must share the following:
 - Same manufacturer
 - Same glass type (AR-coated vs non-AR glass)
 - Same backsheet color (white vs black vs transparent)
 - Same interconnection type (ribbon/shingle/multi-wire, number of busbars)
 - Same cell type (for silicon, poly AI BSF/poly PERC/mono AI BSF/mono PERC/n-type)
- 60- and 72-cell module types can belong under a single Group.

“Subgroup”, “LTM”

- A “Subgroup” is effectively a bundle of modules in a similar rated power range.
 - The models in a Subgroup must have the same number of cells.
 - One model from each Subgroup is chosen for testing → “LTM” (laboratory-tested model)
 - Subgroup 1 is always the highest-power subgroup.
- Example: a Group of mono-PERC modules (60- and 72-cell models included)

Subgroup 1		Subgroup 2	
Nameplate Power	Can be LTM?	Nameplate Power	Can be LTM?
375 W	Yes	305 W	Yes
370 W	Yes	300 W	Yes
365 W	Yes	295 W	Yes
360 W	Yes	290 W	Yes
355 W		285 W	Yes

For Subgroup 1, the LTM must be $\geq 95\%$ of highest power class ($375 \times 0.95 = 356.3$).

Regardless of which model is used, all the models in the subgroup are within LTM rating $\pm 10\%$

CEC Testing Sequence for Silicon Modules

Subgroup 1	
Incoming Inspection	
Visual Inspection, EL Imaging	
5 kWh/m ² Preconditioning	NOCT
Performance at STC	
Performance at Low Irradiance	
Performance at NOCT	
Temperature Coefficients	

Subgroup n (n ≥ 2)
Incoming Inspection
Visual Inspection, EL Imaging
5 kWh/m ² Preconditioning
Performance at STC
Performance at Low Irradiance
<i>Wait for Subgroup 1 NOCT</i>
Performance at NOCT

- 2 samples are required for Subgroup 1, and 1 sample required for other Subgroups.
- Customer is notified if there are signs of shipping damage or error, and also if the STC I-V values are found to be significantly different from the nameplate values (more on this on a different slide).

CEC Testing Sequence for Thin-Film Modules

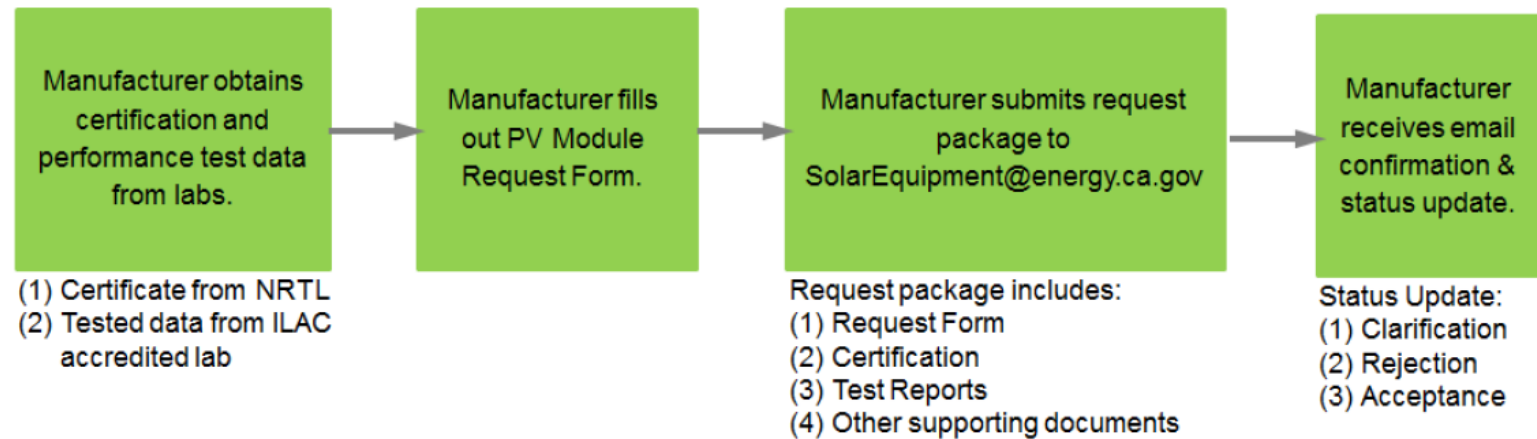
Subgroup 1	
Incoming Inspection	
Visual Inspection, EL Imaging	
43 kWh/m ² Light Soak	NOCT
Performance at STC	
43 kWh/m ² Light Soak	
Performance at STC	
Performance at Low Irradiance	
Performance at NOCT	
Temperature Coefficients	

Subgroup n (n ≥ 2)
Incoming Inspection
Visual Inspection, EL Imaging
43 kWh/m ² Light Soak
Performance at STC
43 kWh/m ² Light Soak
Performance at STC
Performance at Low Irradiance
<i>Wait for Subgroup 1 NOCT</i>
Performance at NOCT

- 2 samples are required for Subgroup 1, and 1 sample required for other Subgroups.
- Customer is notified if there are signs of shipping damage or error, and also if the STC I-V values are found to be significantly different from the nameplate values (more on this on a different slide).

CEC Listing Request

- CEC requires that the module manufacturers make the CEC listing requests directly via e-mail.
- CFV can aid its customer in filling out the request forms if help is needed, but it cannot make the listing request in place of the customer.
- “PV Module Listing Request Form” and “PV Module Listing Request Procedure” are available at: https://www.gosolarcalifornia.ca.gov/equipment/pv_modules.php
- CEC listing procedure visualized in “PV Module Listing Request Procedure” (Revised 12/20/2018):



Measured Power vs Nameplate Rating

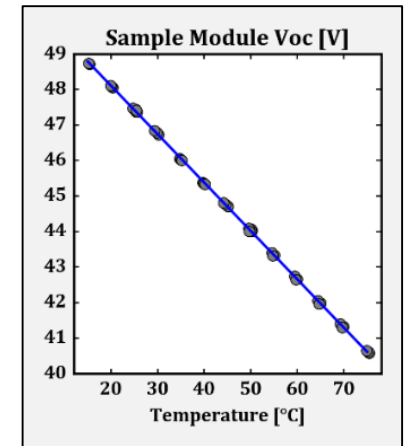
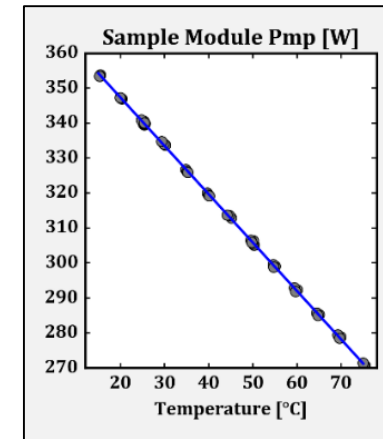
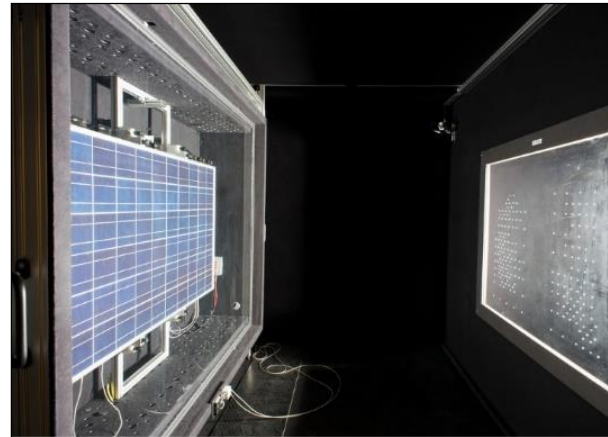
- Although not explicit in the CEC guidelines, CEC enforces a $\pm 5\%/\pm 10\%$ rule in practice. The LTM's measured STC Pmp must fall within $\pm 5\%$ of the rated power. Isc, Voc, Imp, and Vmp must fall within $\pm 10\%$ of the nameplate values.
- At the present CEC does not seem to consider the laboratory's measurement uncertainties when applying this rule.
- CFV's measurement uncertainties (k=2):

Technology	Isc	Voc	Imp	Vmp	Pmp
Silicon	$\pm 1.8\%$	$\pm 0.7\%$	$\pm 2.2\%$	$\pm 1.3\%$	$\pm 2.2\%$
CdTe	$\pm 2.6\%$	$\pm 2.5\%$	$\pm 2.9\%$	$\pm 2.5\%$	$\pm 3.8\%$
CIGS	$\pm 2.2\%$	$\pm 1.6\%$	$\pm 2.6\%$	$\pm 1.9\%$	$\pm 3.0\%$

- CFV measures power after $> 5 \text{ kWh/m}^2$ preconditioning (Si) or $2 \times 43 \text{ kWh/m}^2$ light soak (thin film).

Why Test at CFV?

- Excellent weather conditions in Albuquerque, NM, U.S.A. allows timely completion of the NOCT test. NOCT is typically completed in 2 weeks, and the whole CEC project typically takes 3-4 weeks.
- The 2018 version of the guidelines states that the required tests may be replaced by 61853 tests in the future. CFV is one of the best know labs for the 61853 testing, with state-of-the-art equipment.



New CEC Requirements on UL 61730

- According to the latest edition of CEC guidelines (7th edition, 2018), only the PV modules certified to UL 61730-1/2:2017 will be accepted starting 2020-01-01:

The PV module eligibility requirements are as follows:

- PV modules shall have a safety certification indicating compliance with an American National Standard for safety from a Nationally Recognized Testing Laboratory²⁹ (NRTL). Prior to January 1, 2020, safety certification to either UL 61730 (Parts 1 and 2) or UL 1703 will be accepted as proof of compliance as of the effective date of these guidelines. Starting January 1, 2020, only safety certification to UL 61730 will be accepted.
- All modules, even the higher power classes of a UL 1703-certified module type family already listed at CEC, must present UL 61730-1/2:2017 certificate to be listed after 2020-01-01.
 - This information was received by CFV from CEC on 2019-03-29 after an inquiry.

Summary

- Despite the conclusion of California's solar incentive programs, "CEC listing" continues to be a de facto requirement in selling PV modules in the US market.
- For CEC listing, performance testing on Group/Subgroup of modules is necessary.
- CFV is an ISO/IEC 17025-accredited laboratory with major manufacturers as repeat customers for the CEC testing.
- The excellent weather in Albuquerque, NM, U.S.A. allows timely completion of the CEC testing.

Annex 1: Precautions on Sample Preparation and Shipping

- Samples sent for CEC testing **must** have nameplates attached by the manufacturer.
- We recommend that the customer check the STC power of the modules prior to shipment, if the equipment is available.
- Please communicate with CFV prior to packaging. We have recommendations on the packaging practices.



Annex 2: CFV Policies on CEC Testing Samples

- CFV uses the nameplate label attached on the module as the ONLY source of information for determining the module type and power class.
- Photographs of the nameplate labels of all samples are included in the report.
- CFV cannot treat samples as if they belong to a different power class. CFV also cannot replace or cover up the original nameplate labels with something else.
- CFV cannot use nameplate-less samples for CEC testing, as these samples do not meet the Markings requirement in IEC 61215 or ANSI/UL 1703.
- CFV cannot treat nameplate-less samples as if they are of a specific module type or power class. CFV cannot attach nameplates on behalf of the customer.
- CFV's sample-handling policies are in conformity with ISO 17025 Section 7.4 "Handling of test or calibration items".

Annex 3: PTC Power

- The CEC homepage gives a list of CEC-listed modules, along with the PTC power.
- “PTC Power” is the expected power of the module at “PVUSA Testing Conditions” (irradiance at 1000 W/m², wind speed at 1 m/s, module temperature at NOCT), using a performance model from the PVUSA (PV for Utility Scale Applications) study in 1990s.
- CFV advises against a project developer making module purchasing decisions based on the PTC Power, due to the following reasons:
 - NOCT test is only $\pm 2.7^{\circ}\text{C}$ accurate, and many NOCTs difference shown on the CEC website are probably due to the test variability, as was revealed in an NREL study (Muller 2010).
 - IEC 61215:2005 allows temperature coefficients to be measured with a “hot-potato” method (a module is first heated in a chamber, and I-V measurements are taken as it cools down). New IEC 61215-2:2016 now references IEC 60891:2009 which explicitly disallows the hot-potato method, but for CEC testing the hot-potato method is still accepted.

Annex 4: NOCT and Temperature Coefficients

- The previous version (2017-11-21) of CEC’s “PV Module Listing Request Procedure” required that the Temperature Coefficients and the NOCT tests be carried out on a single sample. This clause was removed since the 2018-10-15 version of the document.
- As there is very little sample-to-sample difference in the temperature coefficients for a single module type and power class, CFV has revised its test flow accordingly to accelerate the CEC testing.
 - Previously, the Temperature Coefficients and the NOCT tests were conducted on the same sample.
 - Now, the NOCT test will proceed separately.
 - CFV learned through a communication with CEC that the previous version actually meant that those tests be carried out on a single module type, and not a single sample.

Annex 5: 7th Edition of CEC Guidelines

- The 7th edition (the most recent version) of the CEC guidelines can be obtained at: <https://www.gosolarcalifornia.org/equipment/events.php>
- Major changes compared to the previous edition are:
 - Modules certified to UL 61730-1/2:2017 are now accepted.
 - **Modules certified to UL 1703 will no longer be accepted starting 2020-01-01.**
 - IEC 61853-1 data may be submitted voluntarily.
- CEC does not distinguish between (1) adding a new module type family and (2) adding a higher power class to an already listed module type family.
- Even when adding a higher power class to an already listed module type family, the applicant (module manufacturer) will need to present UL 61730-1/2:2017 certificate, starting 2020-01-01.

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Thank you.

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