NREL
NATIONAL RENEWABLE ENERGY LABORATORY

Linkage to Previous International PV Module QA Task Force Workshops; Proposal for Rating System

NREL PV Module Reliability Workshop

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Outline

- History of International PV Module QA Task Force
- How do we do something useful without doing something harmful?
- Opportunity for Rating System to provide value over current qualification tests
- Technical basis for Rating System
- Next steps for creating Rating System

Motivation: the question on the street "How do I predict lifetime of PV modules?"

- Reliability engineer: How do I test to determine the number of years for the warranty?
- PV customer: How do I choose the PV module that will last longer?
- PV investor: How do I know that I'm making a safe investment of $1 billion (if the modules fail after 10 yr, the warranty may be worthless if the company is gone)?
- Insurance company: How do I determine rates for insuring PV installations?

International PV Module Quality Assurance Forum

San Francisco, July, 2011

Goals:

1. Create a QA Rating System to differentiate the relative durability of module designs

1) Compare module designs
2) Provide a basis for manufacturers' warranties
3) Provide investors with confidence in their investments
4) Provide data for setting insurance rates

2. Create a guideline for factory inspections of the QA system used during manufacturing.

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International PV Module Quality Assurance Task Force

A little history

The PV QA Task Force was formed at the conclusion of the Forum and consisted of five Task Groups:

Task Group 1: PV QA Guideline for Manufacturing Consistency (leaders Ivan Sinicco, Alex Mikonowicz, Yoshihito Eguchi, Wei Zhou, G. Breggemann)

Task Group 2: PV QA Testing for Thermal and mechanical fatigue including vibration (leader Chris Flueckiger, Tadanori Tanahashi)

Task Group 3: PV QA Testing for Humidity, temperature, and voltage (leaders John Wohlgemuth, Neelkanth Dhere, Takuya Doi)

Task Group 4: PV QA Testing for Diodes, shading and reverse bias (leaders Vivek Gade, Paul Robusto, Yasunori Uchida)

Task Group 5: PV QA Testing for UV, temperature and humidity (leader Michael Köhl, Kusato Hirota, Jasbir Bath)

These groups began meeting by teleconference in summer of 2011. Since then, four other task groups have been added.

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International meeting in parallel with main sessions during next two days

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Task Group 2:

Task Group 3: These four groups are meeting today and tomorrow as a face-to-face regional meeting, with some international participation

Task Group 4:

Task Group 5: Goal: Share technical studies that will guide definition of the most useful tests. Where appropriate: propose useful test structure

These groups began meeting by teleconference in summer of 2011. Since then, four other task groups have been added.

Additional Task Groups:

Task Group 6: Communication of PV QA Ratings to the Community
(leaders David Williams, Sarah Kurtz)

Rest of this talk

Task Group 7: PV QA Testing for Wind and Snow Loads
(leader Joerg Althaus)

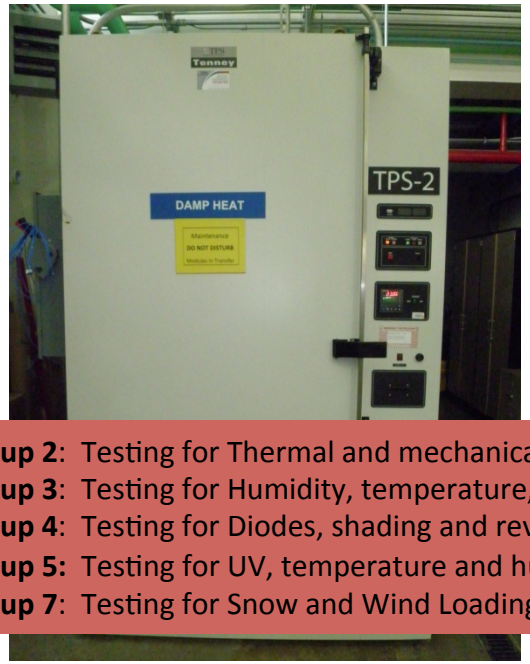
Task Group 8: Thin Film Testing
(leaders: Neelkanth Dhere, Veronica Bermudez, Tobias Roschek, Shuuji Tokuda)

Kick off Feb. 28 – March 1, Golden, CO

Task Group 9: CPV Testing
(leaders: Itai Suez, Nick Bosco)

Need for Rating System

Task Groups develop accelerated tests to predict experience in the field



Task Group 2: Testing for Thermal and mechanical fatigue
Task Group 3: Testing for Humidity, temperature, and voltage
Task Group 4: Testing for Diodes, shading and reverse bias
Task Group 5: Testing for UV, temperature and humidity
Task Group 7: Testing for Snow and Wind Loading

How do we communicate the results?

Rating System

Principles for creating tests/rating system

- Must be predictive & relevant
  - (correlate with decades of field experience, not 1 y or 300 y)
- Must be communicated in useful ways
  - (both simple and detailed for different audiences)
- Must be cost and time effective
  - (manufacturers must bring the product to market)

- Must be beneficial to PV community
  - (use wisdom of community to identify good choices)

To Define the Rating System, First ask:
When are failures slipping past Qualification testing?

What are we missing?

Rating System – What are we missing with current qualification tests?

Prioritize two types of wear-out mechanisms that are being reported:

- Broken interconnections, solder bonds, diodes
- Encapsulant discoloration and/or delamination

We choose to focus first on these; later we'll address the longer list of wear-out mechanisms.

Rating System – First address wear out that is slipping past the qualification tests

1. In response to:

• Broken interconnections, solder bonds, diodes

Add:

- Additional thermal cycling or mechanical stress, plus bypass diode/shading testing

2. In response to:

• Encapsulant discoloration and/or delamination

Add:

- Additional UV stress

Need to apply additional stress to detect early wear out

Level	Humidity	High Temperature	Thermal cycling and diode testing	UV
Qualification test	No new	No new	No new	No new
Wear out comparative test	No new	No new	New	New

To gain confidence in long-term performance in almost all climates, we need to add tests related to thermal cycling, diodes, and UV exposure

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What about for extreme climates?

Marine ✔(salt spray)

Snow loads ✔ (mechanical loads)

Hail ✔ (hail impact)

Heat

Humidity

✔Note: We already have comparative tests for marine, hail, and snow, so we can include these test results in the rating

Additional stress may be needed for extreme climates.

	New Tests Will Require Additional Stress					Targeted Meaning of Rating	
Failure types, loosely grouped	Thermal cycling & diode testing	UV	High Temperature	High humidity	Proposed labels	★ or "C"	★★★★★ or "A"
Infant mortality	-	-	-	-	**Qualification test**	-	-
Interconnects, discoloration, delamination	✔	✔	-	-	Hot-cold	Better than qualification test	30 y in location/appl. w worst thermal cycling
Heat-induced failures	✔	✔	✔	-	Hot-dry	Better than qualification test	30 y in location/appl. w worst heat-induced degradation
Humidity-induced failures	-	✔	✔	✔	Hot-humid	Better than qualification test	30 y for location/appl. w worst humidity-induced degradation

The two primary extremes that have not yet been addressed are:

Heat

Humidity

So add additional stress for these, indicated by ✔

Rating System – *Targets* for defining the min/max meanings for tests

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With these ranges, we can address the full range from today's qual test to the harshest environments on earth

A few climate zones may not be well represented; can we postpone addressing these?

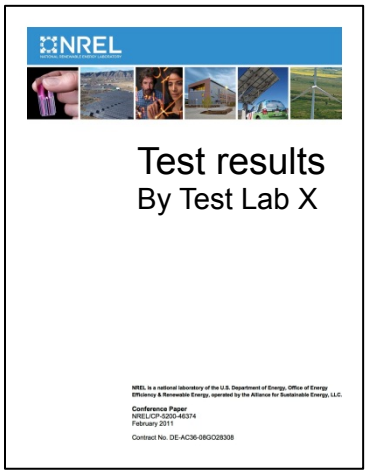
Rating System Proposal – Communicate four ways:

1. Nameplate:

Pmax	205 W
Durability rating:	
Hot-cold	★★★
Hot-dry	★ ★
Hot-humid	not rated
Snow/wind	2400 Pa
Salt spray	
etc.	

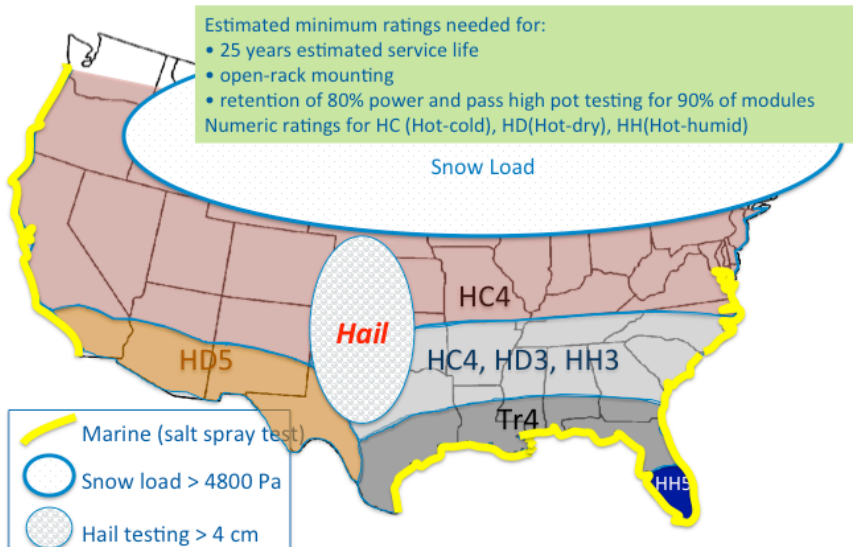
A high level summary on the nameplate will allow researchers to correlate tested rating with field experience 20 y from now.

2. Report:



Standards

A detailed report can be used by engineers to more closely compare specific products



3. Interpretive maps:

Publications/Guides

4. Climate charts that link climates with stresses (not shown):

Next Steps

- A New Work Item Proposal has been submitted to IEC Technical Committee 82, Working Group 2 as a starting point for discussion
- Some countries will identify individuals to participate in rewriting this draft
- Each Task Group will create tests that will be connected by this proposal
- International discussion and voting will determine details.

Summary

- The International PV Module QA Task Force is developing comparative accelerated test standards
- A Rating System is necessary for the success of the QA Task Force
- The Rating System must be developed in parallel with the Test Protocols
- The New Work Item Proposal will serve as a starting point for discussion within WG2
- All of you are welcome to join ongoing international discussion (~ once per month)

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Thank you for your attention!