Recommended Protocol for Accelerated Aging Testing

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Accelerated aging tests of PV modules

	Accelerated Qualification Testing	Accelerated Comparative Testing	Accelerated Lifetime Testing
Design Quality Confidence	Minimum *	Medium **	High ***
Objective	Minimum testing for reliability / durability of specific module design	Extended qualification testing to compare relative reliability / durability of multiple designs	Site (and configuration) specific testing or worst case site (s) testing of any specific module design
Cost and time	Low	Medium	High
Goal	Introduce the specific design in the market	Compare (to improve / purchase / invest) multiple designs	Predict lifetime and/or protect warranty
Testing protocol	Test standards exist	Tester defined protocols exist but a uniform protocol is needed	None publicly exists, if any. Needs a comprehensive understanding on failure mechanisms, failure modes and mathematical models to develop an appropriate testing protocol
Test requirement	Pass / Fail (>5% Pmax drop = Fail)	Relative power loss for a specific stress time or relative stress time for a specific power loss	Identify ultimate failure mode and/or to determine / substantiate warranty period
User	Manufacturers / Consumers / Investors	Manufacturers / Consumers / Investors	Manufacturers

Current Study

Literature search and review on failure mechanisms	Literature search on failure modes	Literature search and review on mathematical models	Literature search and review on potential accelerated testing protocols to simulate the failure mechanisms and ultimate failure modes

Future Work Needed

Develop an appropriate accelerated lifetime testing protocol
Design and execution of preliminary experiments
Develop initial mathematical models
Validate and improve the mathematical models through detailed experiments
Develop "Recommended Protocol for Accelerated Lifetime Testing"

Details on the presentation

Accelerated aging tests of PV modules may be classified as:

- Accelerated qualification testing (minimum design quality confidence)
- Accelerated comparative testing (medium design quality confidence)
- Accelerated lifetime testing (high design quality confidence)

Accelerated qualification testing:

- Objective: Define **minimum testing** requirements to **substantiate minimum** durability and reliability of **a specific module design**.
- Cost and time: **Minimum** so that the time-to-market can be reduced
- Goal: It is a test-to-pass testing to **introduce** module in the market
- Testing protocol: **Standardized** protocols defined by the test standards (Examples: IEC 61215 and IEC 61646).
- Test requirement: It is a pass / fail test with a maximum allowed limit of **5% drop** in power after accelerated stresses.
- User: Used by **most manufacturers** and it is a **market driven requirement** in Europe but it is not a requirement in the United States, except in the State of Florida.

Accelerated comparative testing:

- Objective: Define **extended / repetitive qualification testing** requirements to **compare** the durability and reliability of **different module designs**.
- Cost and time: **Medium** – falls between qualification testing and lifetime testing
- Goal: It is a relative testing to **compare** different module designs
- Testing protocol: Currently, **tester defined relative / comparative testing** is used by the industry (Examples: BP Solar, NREL and ESTI protocols). A uniform protocol could be developed and adopted by Solar ABCs and recommended to a standard committee.
- Test requirement: It is a relative testing with a maximum allowed **limit** (limit the time and identify relative power loss OR limit the power loss and identify relative time; former is preferred) **defined by the tester**.
- User: It could be used by the **manufacturers** (or consumers / investors) to **improve** their module designs and/or to **compare** with competitors' module designs.

Accelerated lifetime testing:

- Objective:

  Define **site (and configuration) specific testing** requirements to **predict site specific lifetime** of **any module design**.

  OR

  Define **worst case sites (and configuration) testing** requirements to predict the **worst case lifetime** of **any module design**.
- Cost and time: **Maximum** so that the warranty period can be substantiated or determined
- Goal: It is an ultimate failure testing to **predict** lifetime and/or to protect warranty.
- Testing protocol: Currently, **none is publicly available [if any]**. Based on the field failure mechanisms, failure modes and physical / statistical models, a unique consensus testing protocol needs to be developed. It may be developed by Solar ABCs and recommended to a standard committee. As a first step, a **comprehensive literature search will be conducted** on the field failure mechanisms, life-limiting failure modes, potential accelerated testing methods and mathematical models.
- Test requirement: It is a testing to determine **ultimate failure mode** or to a maximum allowed power loss **limit dictated by the manufacturer warranty** (20% or 25%). A consensus definition for the term "ultimate failure" needs to be developed.
- User: It could be used by the individual manufacturers to **determine / substantiate their warranty**.