How to Create Certification Programs

That Minimize the Risk of Premature PV Module Failures

如何创建认证项目以最大程度降低光伏组件过早失效的风险

Weathering Testing as a Tool to Reduce Risk

耐候老化测试作为降低风险的工具

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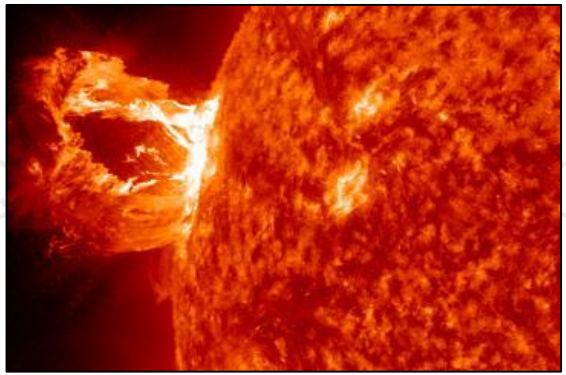
What is Product Certification?
什么是产品认证

Product certification or product **qualification** is the process of certifying that a certain product has passed performance tests and quality assurance tests, and meets qualification criteria stipulated in contracts, regulations, or specifications.

产品认证或产品合格鉴定是指验证某一产品已通过性能测试和质量保证测试，并符合合同、法规或规范中规定的合格标准的流程。

--Wikipedia

What is Weathering?
什么是耐候老化



Sunlight
阳光

Heat
热

Moisture
潮湿

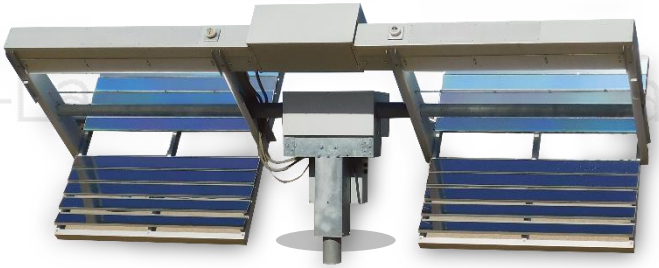
Weathering Technologies

Fluorescent UV

QUV

Xenon Arc

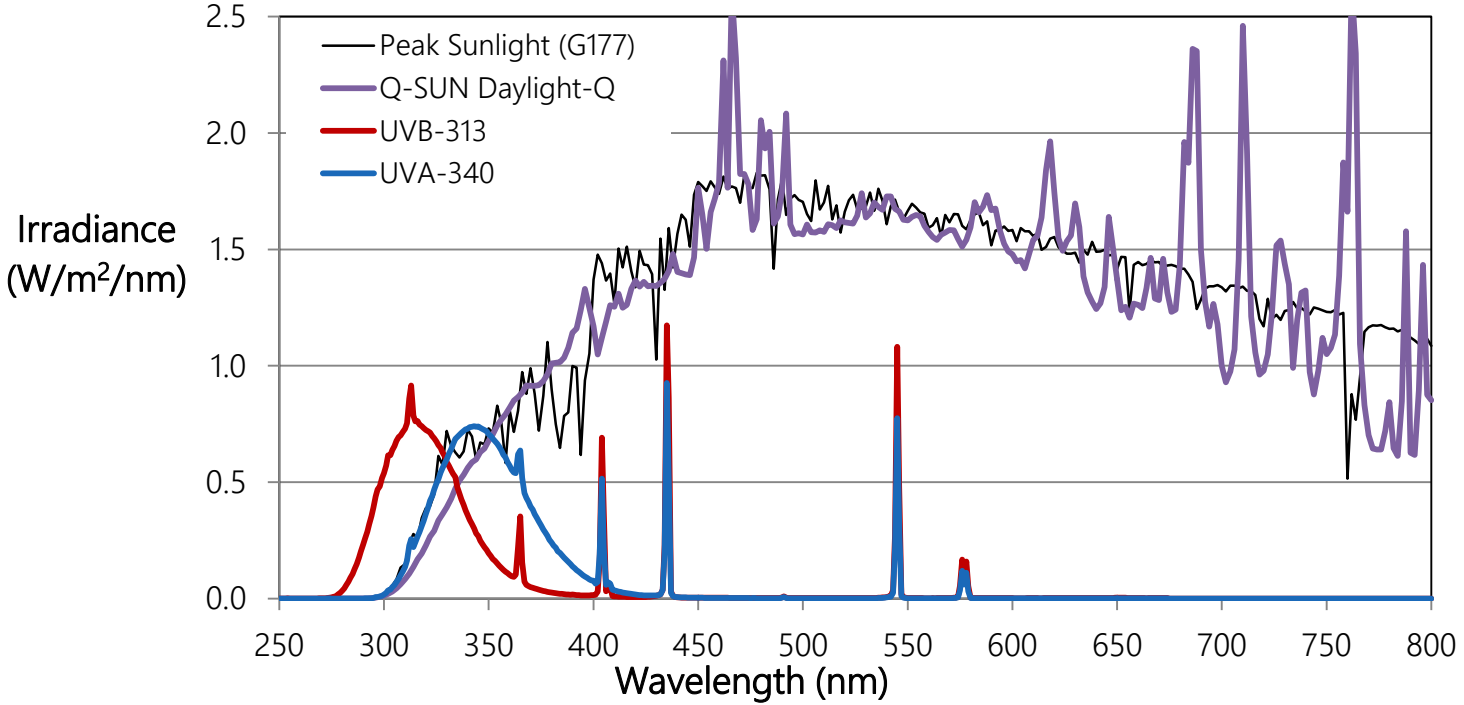
Q-SUN



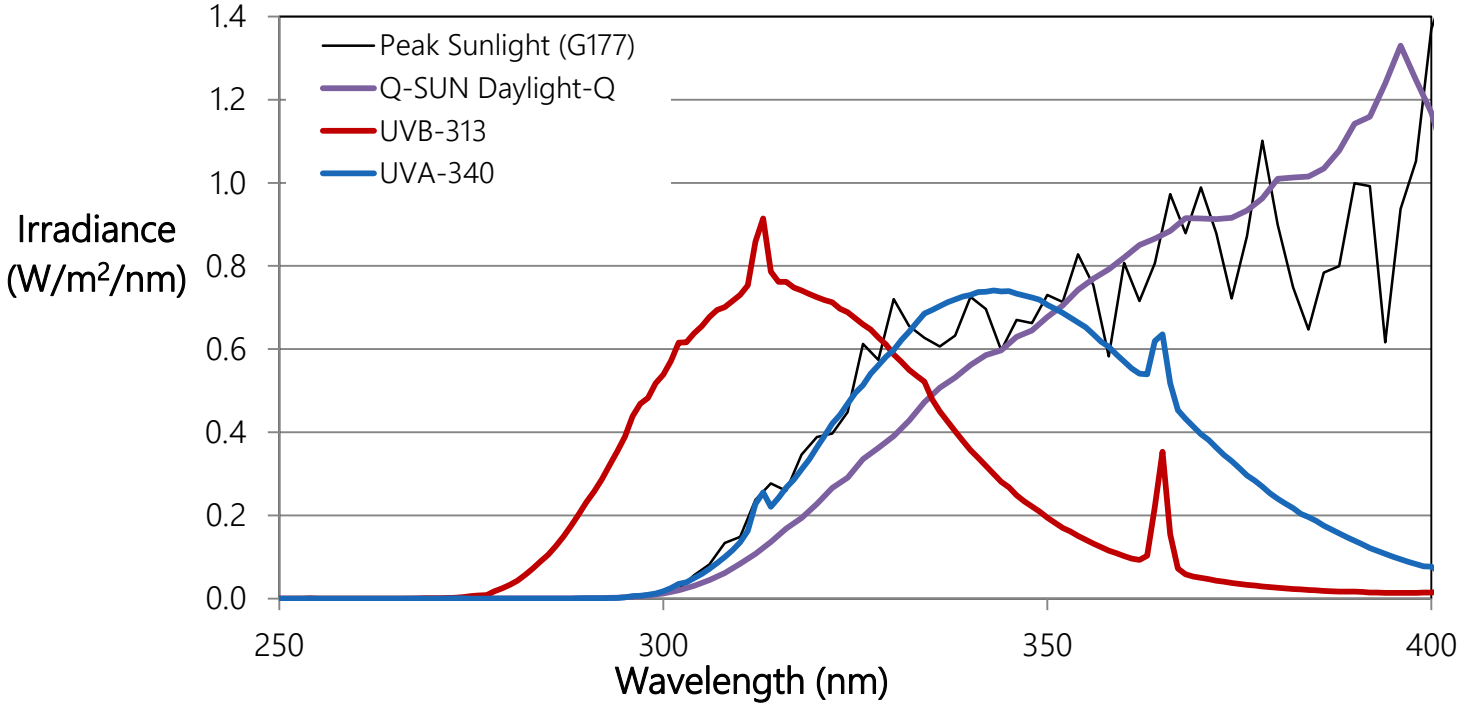
Solar Concentrators

Q-TRAC

Laboratory Light Sources vs. Sunlight
实验室光源 vs. 太阳光



Laboratory Light Sources vs. Sunlight
实验室光源 vs. 太阳光



What is a Useful Weathering Test?
什么是一个有用的光老化测试?

- A test that helps you make decisions better and/or faster

助您做出更明智和/或更迅速的决策

- Reduces risk of making bad decisions

降低做出错误决策的风险

- Reduces risk of making decisions too slowly

降低决策过于迟缓的风险

Types of Weathering Tests
老化测试的目的

- Material Screening 材料筛选
  - Rapid pass/fail test to find gross formulation problems
    快速通过/失败测试，以发现配方中的严重问题
  - Designed to verify quality in production environment
    旨在验证生产环境中的质量

- Material Validation 材料验证
  - Relatively long pass/fail test required by contract
    合同要求相对较长的通过/失败测试
  - Designed to qualify a material & reduce commercial risk
    旨在鉴定材料并降低商业风险

- Comparative 对比测试
  - R&D test to evaluate relative performance
    研发测试以评估相对性能
  - Works best with test control materials
    与测试对照材料配合使用效果最佳
  - When done correctly minimizes risk of long-term durability claims
    如果操作得当，可最大限度地降低长期耐久性索赔的风险

- Predictive 寿命预测
  - Develop acceleration factor or mathematical model to predict service life
    开发加速因子或数学模型以预测使用寿命
  - Requires large amounts of data
    需要大量数据
  - Acceleration factors are unique to a specific material
    加速因子对特定材料具有唯一性
  - Acceleration factors are usually different for various failure modes
    对于不同的失效模式，加速因子通常各不相同

Difficulties with “Predictive Weathering Tests”
“寿命预测老化测试”的难点

- Degradation is *assumed* to be independent of UV dosage rate (reciprocity)

老化降解被认为与紫外线总能量无关（互易性）

- Photo-oxidation is often limited by oxygen diffusion

光氧化过程往往受到氧气扩散的限制

  - Recovers during night (dark) time conditions

    在夜间（黑暗）条件下恢复

  - Limits effectiveness of high-irradiance tests

    限制了高辐照度测试的有效性

Difficulties with “Predictive Weathering Tests”
“寿命预测老化测试”的难点

- Temperature affects photo-oxidation kinetics differently for various materials (activation energy, E_a, varies by material)

温度对不同材料的光氧化动力学影响不同（活化能Ea因材料而异）

- Hydrolysis 水解
  - Can affect and be affected by photo-oxidation

    能够影响光氧化作用，也能受光氧化作用的影响
  - Temperature affects kinetics differently by material

    温度对不同材料动力学的影响不同
- In other words, weathering is too complex for predictive modeling or universal acceleration equations

换言之，光老化作用太过复杂，无法通过预测建模或通用加速方程来描述

Now what do we do?

Look to examples of other industries

参考其他行业：

- Automotive

汽车

- Building products (windows, roofing, siding)

建材（门窗，屋面材料，墙板）

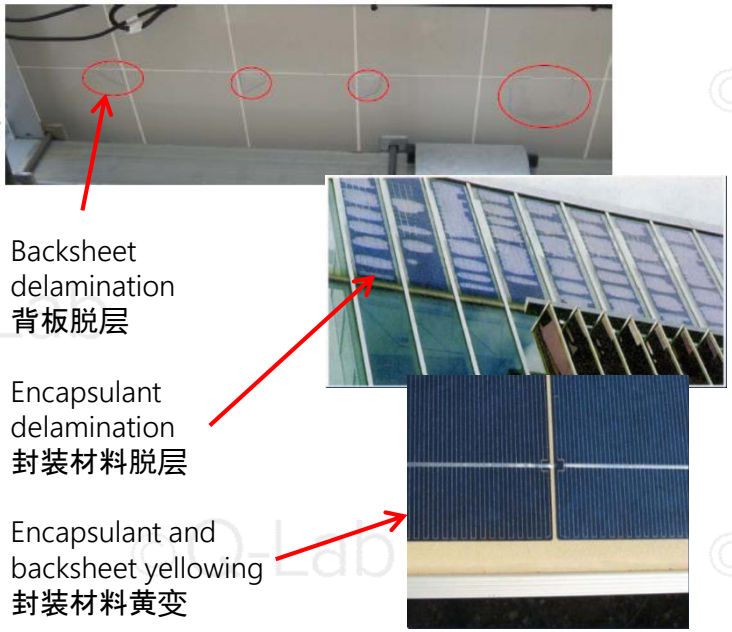
- Use weathering tests to reduce risk, not to predict the future

利用光老化测试来降低风险，而非预测未来

Now what do we do?

- Material Validation Tests (Laboratory)
实验室材料验证测试
  - Xenon Arc 氙灯
  - Fluorescent UV 紫外
- Qualification Test Sequence
序列测试
- Comparative Tests
对比测试
- Material Screening Tests for Quality Control
质量控制中的材料筛选测试
- Real World Tests
户外实证测试
  - Standardized outdoor exposures
  标准化的户外曝晒
  - Standardized data collection
  标准化数据收集

Material Screening & Validation
材料筛选与验证



Photos courtesy of SunPower
http://www.nrel.gov/ce/ipvmqa_task_force/pdfs/10-ipvmqaf_degraaff_sunpower.pdf

- Tests of materials or components for suitability in module construction

对材料或组件在模块构建中的适用性进行测试

- Design "Specimen coupon" tests for:

为以下项目设计 "试样" 测试

  - Backsheets 背板
    - Sun-facing (though glass) and ground facing (albedo effects)

      朝向阳光（尽管是通过玻璃）和朝向地面（反射效应）
  - Encapsulants

    封装材料
  - Coupon tests allow use of common weathering methods

    小样测试允许使用常见的光老化方法

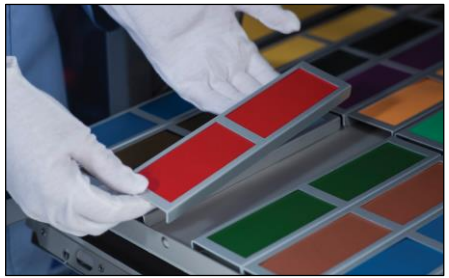
Material Screening & Validation
材料筛选与验证

Fluorescent UV 荧光紫外

- Excellent UV match to sunlight
很好地匹配太阳光
- Up to 3~4 × AM 1.5 sunlight at normal temperature (ISO 4892-3 cycle 8/9)
3-4倍以上AM 1.5, 参考ISO 4892-3 循环8/9
- Temperature control
温度控制
- Condensation & Water Spray
冷凝和水喷淋

Xenon Arc 氙灯

- Excellent match to entire sunlight spectrum
很好地模拟全光谱太阳
- Temperature control (BP & CAT)
温度控制（黑板和空气温度）
- Controlled RH & Water Spray
湿度和水喷淋控制



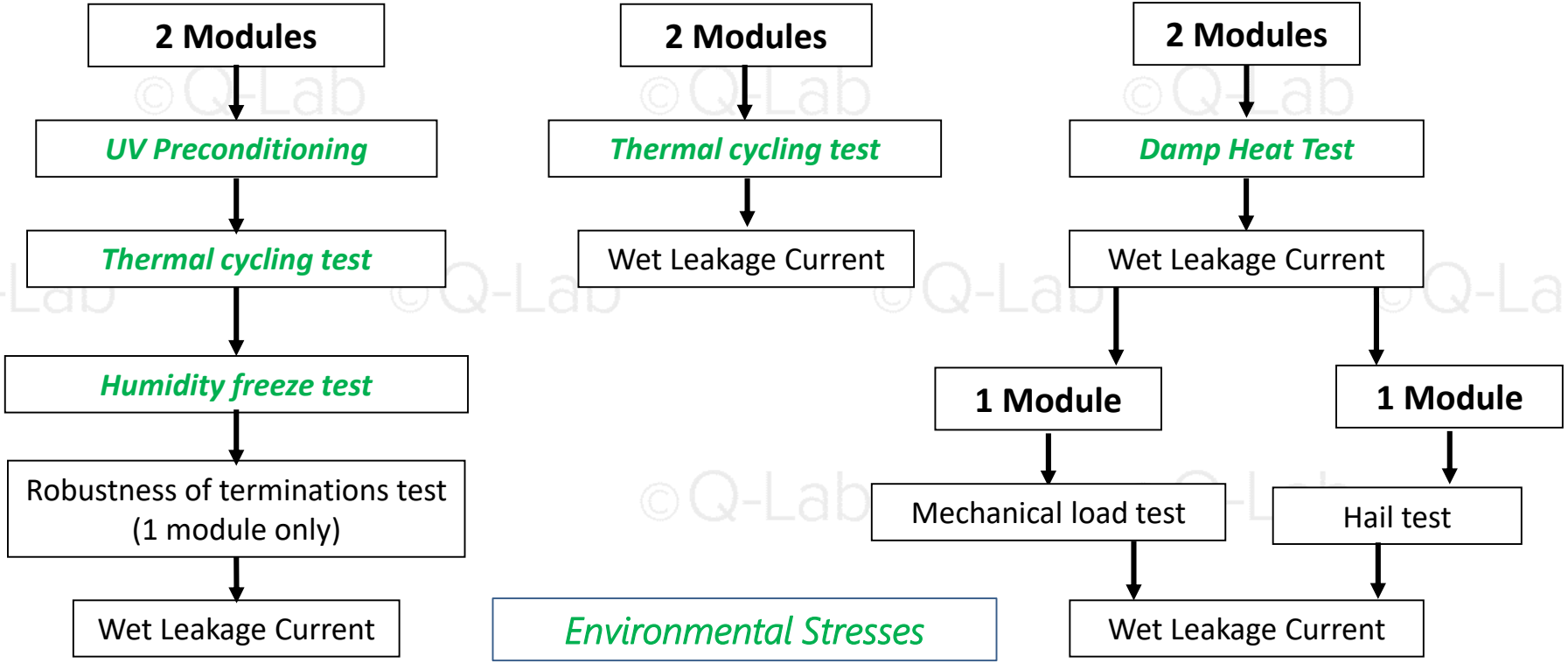
Module Qualification Tests IEC (International Electrotechnical Commission)
组件认证测试

- IEC 61215
  - Module test sequence
    组件测试序列
  - Designed to verify initial quality & prevent failures in 1-3 years (early mortality)
    旨在验证早期质量并预防1-3年内出现故障（早期失效）
  - Tests address specific failure modes commonly seen
    测试针对的是常见的特定故障模式

- IEC 61730
  - Safety qualification
    安全认证
  - Address safety over 1-3 years (more on that later)
    解决1-3年内的安全问题（稍后详述）
- *Do not address long-term durability*

不要涉及长期耐用性

IEC 61215 Test Sequence



UV Preconditioning Test (MQT 10)
紫外预处理测试

- Test Procedure:
  - Irradiance does not exceed 250W/m^2 @ 280-400nm

  辐照度不超过250W/m^2
  - Module temp reads 60+/-5℃

  组件温度为60 ℃
  - UVB (280-320nm) / TUV (280-400nm) is between 3-10%

  UVB 占紫外波段的含量为3-10%
  - At least 15 kWh/m^2 at 280-400nm

  至少曝晒15千瓦时每平方米

- Notes: MQT 10 is meant to detect gross susceptibility to UV degradation, as the dose is small compared to typical lifetime expectations for modern modules, and wavelength distribution of the UV source is not tightly specified.

MQT 10旨在检测对紫外线降解的严重易感性，因为与现代组件的典型预期寿命相比，其剂量较小，且紫外线光源的波长分布并未严格规定。

Component Qualification Tests
材料认证测试

- IEC 62788 Series
  - Test methods and component material test requirements
    测试方法及部件材料测试要求
  - Tests address specific failure modes commonly seen
    测试针对的是常见的特定故障模式
  - IEC 62788-7-2, Accelerated weathering tests of polymeric materials
    IEC 62788-7-2，聚合物材料的加速老化试验
- IEC 61730
  - Safety qualification of modules, but…
    组件的安全认证，但是…
  - Require component material qualification according to 62788 series
    根据62788系列标准，要求对组件材料进行合格鉴定
- *Do not fully address product lifetime durability*

未充分阐述产品的使用寿命

IEC 62788-7-2 Accelerated Weathering Tests of Polymeric Materials
光伏聚合物材料的老化测试

- Method A (reference method): filtered xenon arc with daylight filters

方法A使用日光过滤片的氙灯

- Method B(auxiliary method): Fluorescent UVA-340

方法B使用荧光紫外UVA-340灯管

- Exposure duration is recommended: 1,000hrs, 2,000hrs, or 4,000hrs

推荐测试时长为：1000小时，2000小时或4000小时

- The methods in this document are comprised of steady state temp, irradiance, and RH. Cycling (e.g. thermal, moisture, and/or humidity/freeze/thaw) to achieve stresses representative of daily thermal and/or moisture fluctuations may be considered in the future version

本标准中的方法是稳态温度、辐照度和相对湿度。未来版本中可能会考虑采用循环（如热循环、潮湿循环和/或湿度/冷冻/解冻循环）来模拟日常热和/或潮湿波动的应力

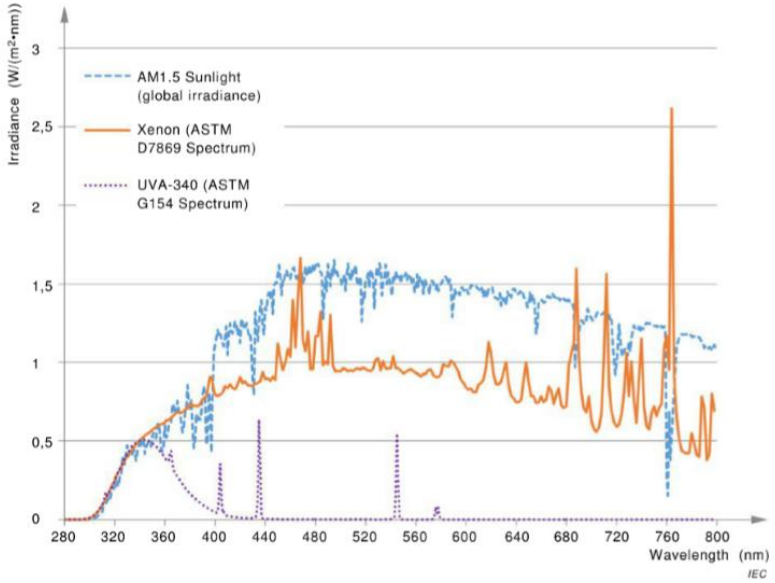


Figure 1 – Spectral irradiance power distributions: solar, xenon arc, fluorescent UV

NOTE The reference terrestrial solar spectrum is shown as in IEC 60904-3. Xenon arc and fluorescent UVA-340 spectra are scaled to match the solar spectrum at 340 nm, whereas the exposures specified in this document are elevated to 0,8 W/(m²·nm) at 340 nm.

Comparative Tests
对比测试

- Comparative tests are designed to rank long-term durability of materials or modules but do not provide service life prediction.

对比测试旨在评估材料或组件的长期耐久性，但并不提供使用寿命预测。

- Comparative tests may use specimen coupons or small modules for simultaneous UV, heat, and moisture exposure.

对比测试可使用试样或小模块同时进行紫外线、温湿度的暴露。

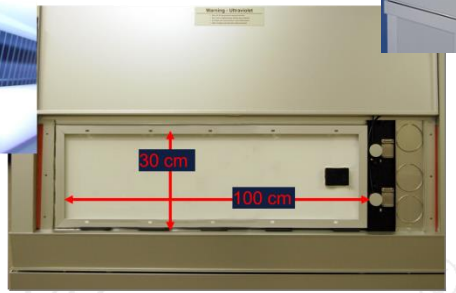
- Full module tests using modified Qualification tests also possible in large chambers.

在大型试验箱中，也可使用经修改的合格性测试进行完整的组件测试。

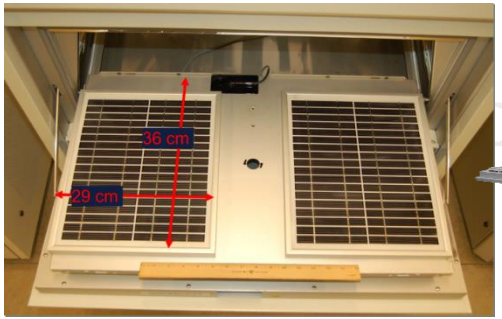
Specimen area of QUV

View from outside

View from inside



Specimen area of Q-SUN



Standardized Outdoor Exposure Tests
标准化的户外曝晒测试

- Module mounting and electrical connectivity

组件安装与电气连接

- Data collection

数据收集

- Evaluation tests

评估报告

- Visual evaluations

目测评估

- Put modules on test when qualification tests are started

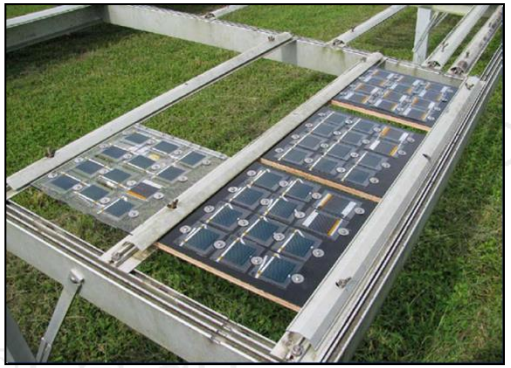
在鉴定测试开始时，对组件进行测试

- Over time, correlate outdoor performance with laboratory test results

随着时间的推移，将室外性能与实验室测试结果进行关联

- More economical when planned up front

提前规划更经济



Florida

Arizona

How do we accomplish this?
我们如何实现这一目标?

- Standards Community 测试标准
  - Qualification standards (IEC 61215 & 61730) 鉴定标准
  - Material validation (IEC 62788) 材料验证标准
  - Quality control (IEC 62941) 质量控制标准
  - Extended Stress Testing (National Renewable Energy Laboratory, NREL) 加严测试
    - Qualification Plus (www.nrel.gov/docs/fy14osti/60950.pdf)
    - IEC TS 63209-1 (modules) 组件
    - IEC TS 63209-2 (polymeric component materials) 聚合物材料
- Manufacturers & Suppliers 组件和材料厂家
  - Quality control 质量控制
    - Material screening prior to production 生产前的材料筛选
  - Data collection (outdoor, real world performance) 数据收集（户外）
  - Feed data back into Standards Process (test method improvements, or “sharpening tools”)
    将数据反馈到标准流程中（测试方法改进）

Improving the Methods
改进方法

- Today, obtaining data on old modules is very difficult

如今，获取旧组件的数据非常困难

  - Travel to old sites and measure performance

    前往旧址并评估其表现

  - This requires a lot of resources for relatively little information

    这需要大量资源，但获取的信息却相对较少

- Tests done according to existing standards rarely correlated to real-world performance

根据现有标准进行的测试很少与实际性能相关

- Data collection in outdoor environment should be standardized and required in certification program

户外环境中的数据收集应实现标准化，并纳入认证程序的要求中

  - Module and material qualification tests compared to real world performance in the future

    组件和材料合格性测试与实际性能的对比

  - Standards community responsible for using data to improve methods

    标准制定应利用数据改进方法

  - More economical to do this up front

    提前做这件事更经济

PV Module Testing Summary

- A variety of tests have been developed to address PV module performance

已经开发出多种测试方法来评估光伏组件的性能

  - Screening and validation 筛选和验证
  - Module qualification 组件鉴定
  - Component durability 材料耐久性

- Comparative tests along with outdoor testing help establish long-term durability

对比测试与户外测试有助于确定产品的长期耐久性

- 15 years ago, 25-year long-term PV durability seemed like a far-off goal

15年前，光伏技术实现25年的长期耐久性似乎是一个遥不可及的目标

  - Today, talk is more along 30-40 years

    如今谈论的话题更多是30-40年

  - PV is one of the fastest-growing energy sectors, and materials and module durability is a major reason why

    光伏是发展最快的能源领域之一，而材料和组件的耐久性是其主要原因

Thank you for your time.

Questions?

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