SOLAR ENERGY TECHNOLOGIES OFFICE
U.S. Department Of Energy

DuraMAT
Durable Module Materials Consortium

The DuraMAT Consortium:

Integrating National Lab Expertise with Industry Needs to Improve PV Module Durability

4th Atlas/NIST Workshop on Photovoltaic Materials Durability

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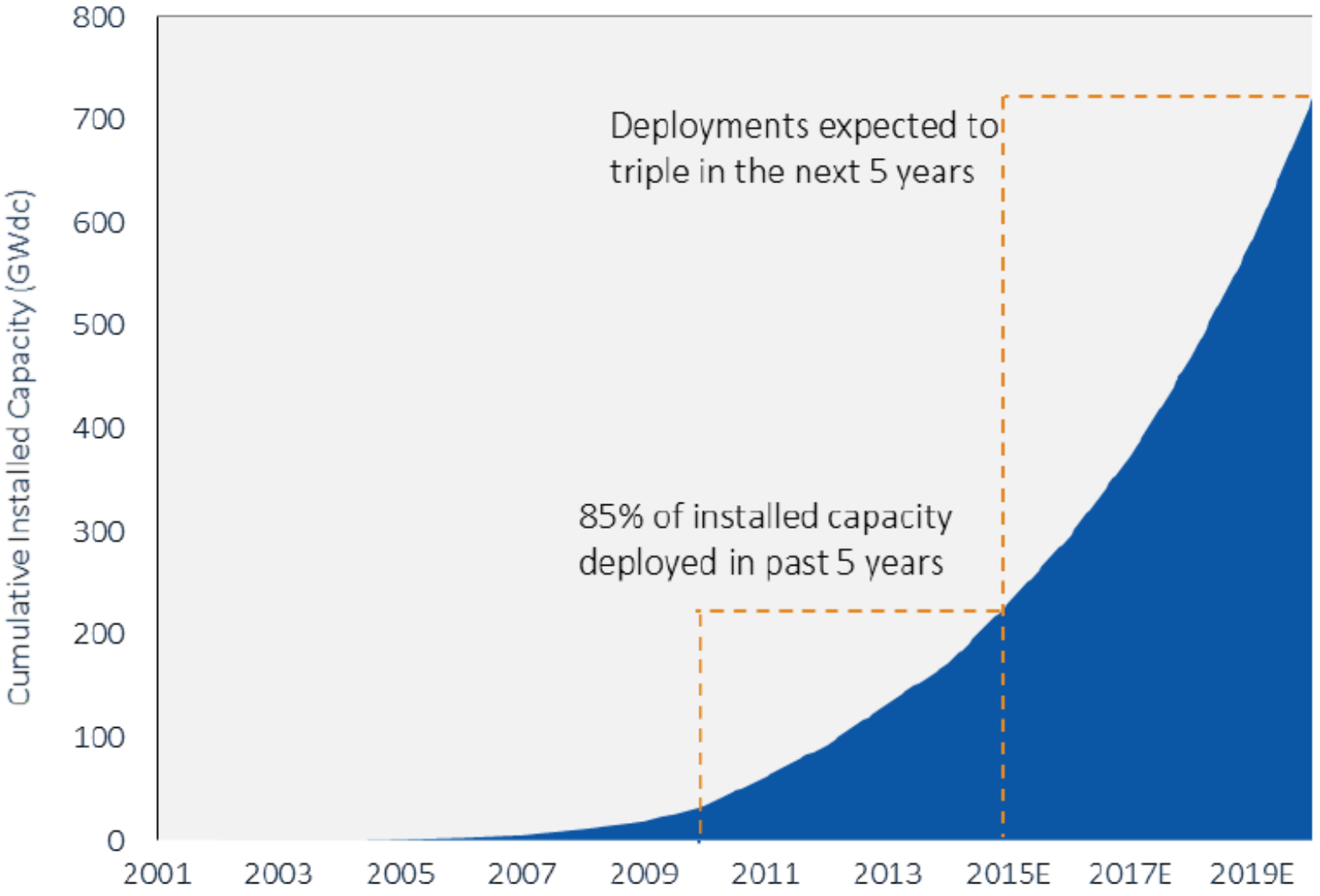
December 5, 2017

Outline

- Reliability Challenges and SunShot Cost Goals
- DuraMAT Consortium Overview
- Examples of DuraMAT Technical Work
- Ways to Be Involved

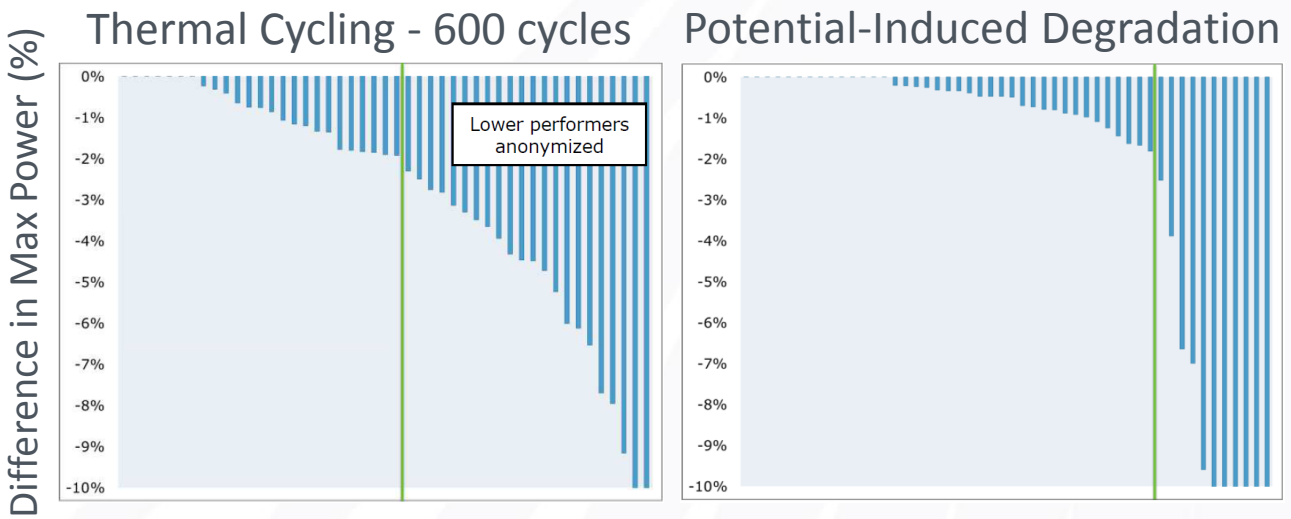
The Growth of the PV Industry

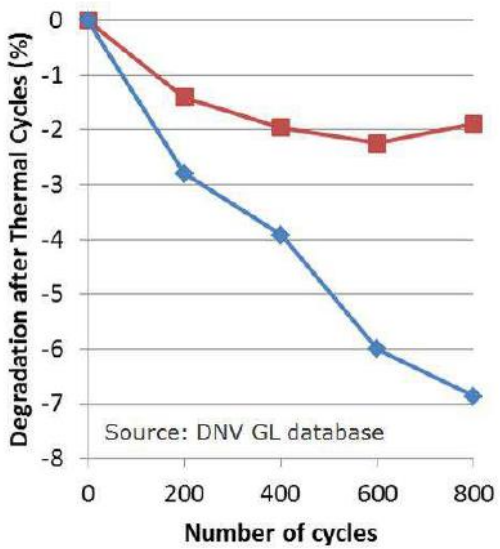


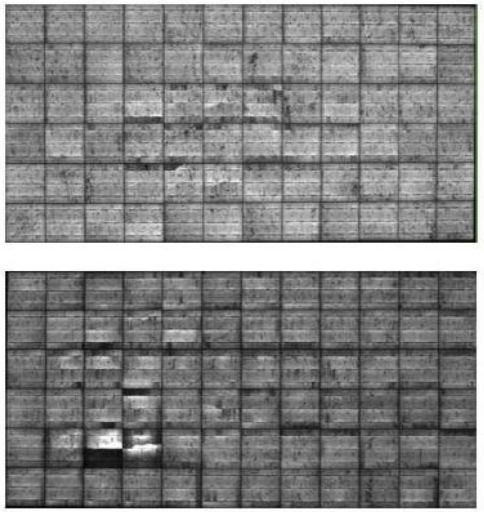
Source: GTM Research/DNVGL

Reliability and Durability Challenges Remain

- Variability in performance based on manufacturer and bill of materials
- Same nameplate label, different BOM
- Can material quality differentiate products?

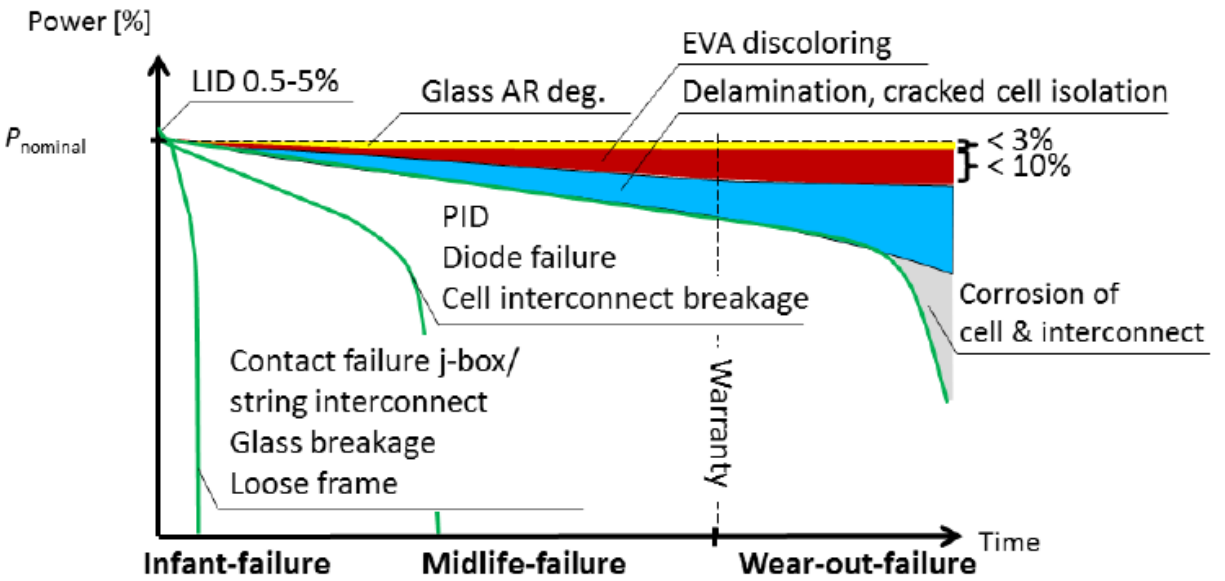






Source: DNV-GL, PV Reliability Scorecard 2017

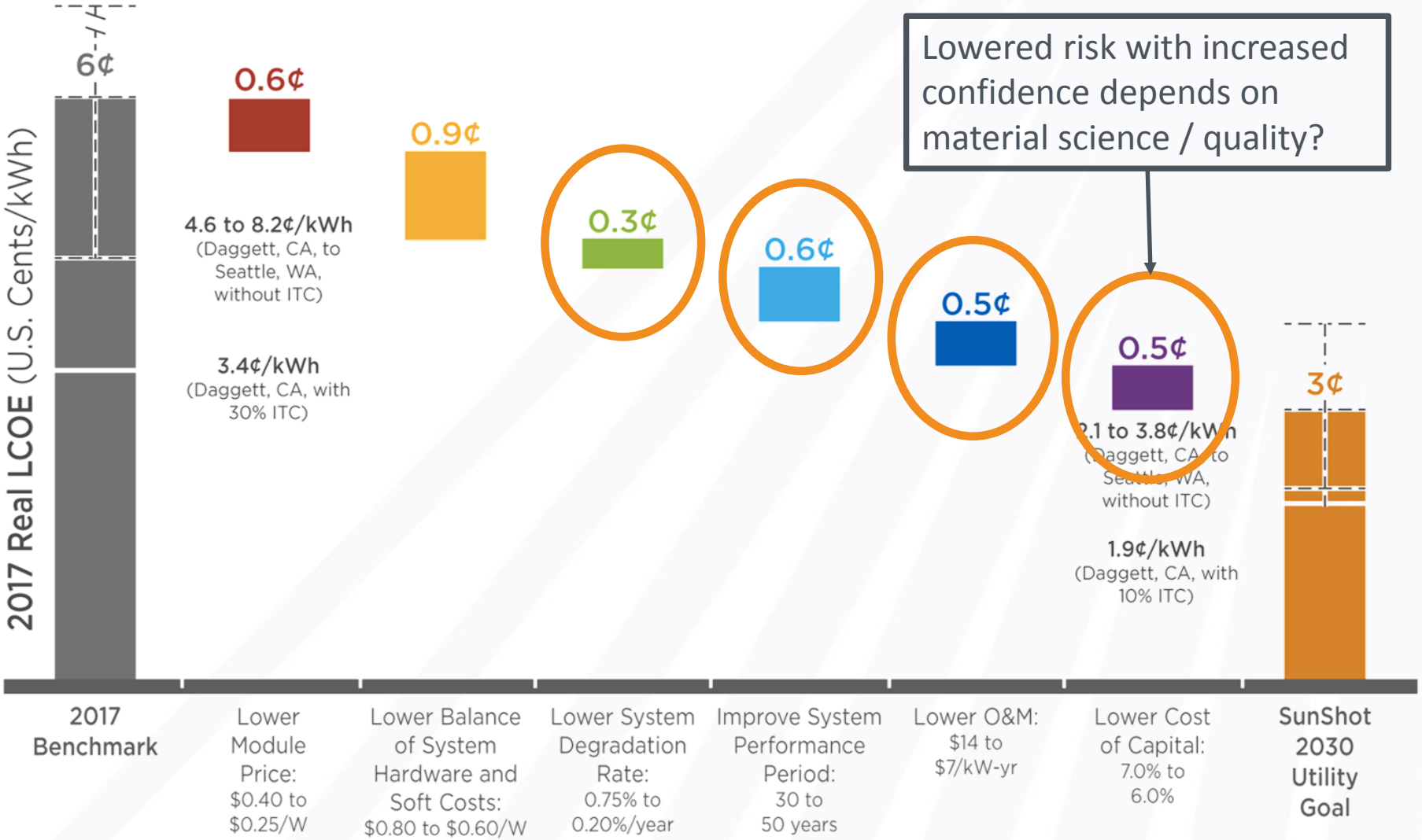
Reliability and Durability Research Challenges



- Can we connect **specific bills of materials** and **climates** to degradation patterns?
- Do **new materials** introduce new (and old) degradation modes?
- Develop more accurate and shortened **accelerated tests**?
- Can **physical models** describe the degradation mechanisms induced by accelerated tests and field exposure?

Source: Kontges et al, IEA-PVPS, 2014

Role of Durability and Lifetime to Reach SunShot Goals



100 $MW_{(DC)}$ One-Axis Tracking Systems With 1,860 $kWh_{(AC)}/kW_{(DC)}$ First-Year Performance. Includes 5 Year MACRS.

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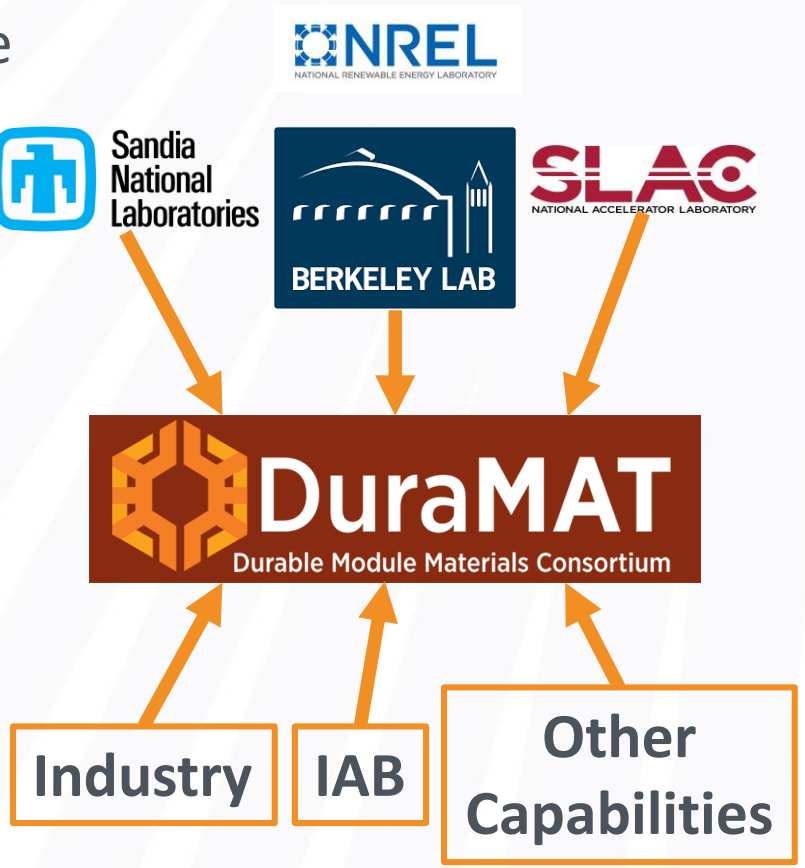
The Durable Module Materials Consortium (DuraMAT)

- 5-year Energy Materials Network consortium focused on precompetitive research into **module packaging**
- **Who Is Involved**
  - PV industry: R&D goals
  - National Labs: capability expertise
  - Universities: research infrastructure
- **Goal:** Accelerate PV module material design and improve durability
- **Industrial Advisory Board (IAB)**
  - 13 members, open to new members
  - Guides scope of funded projects and research focus



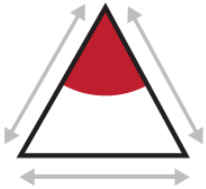
National Lab Core Capabilities: Just the Beginning

Data Hub Infrastructure and Analytics
Lead: Anubhav Jain, LBNL

Infrastructure: Build data hub
Demonstration: Clear sky detection for degradation profiles

Predictive Simulation
Lead: James Hartley, Sandia

Demonstration: Build full-size, high-aspect-ratio module simulation toolset

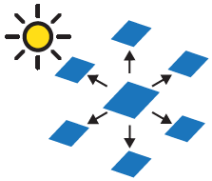


Material Forensics / Characterization
Lead: Mike Toney, SLAC

Demonstration: Multi-functional anti-soiling / anti-reflection coating, backsheet degradation

Module Prototype / Testing
Lead: Peter Hacke, NREL

Demonstration: Combinatorial accelerated testing of backsheet degradation



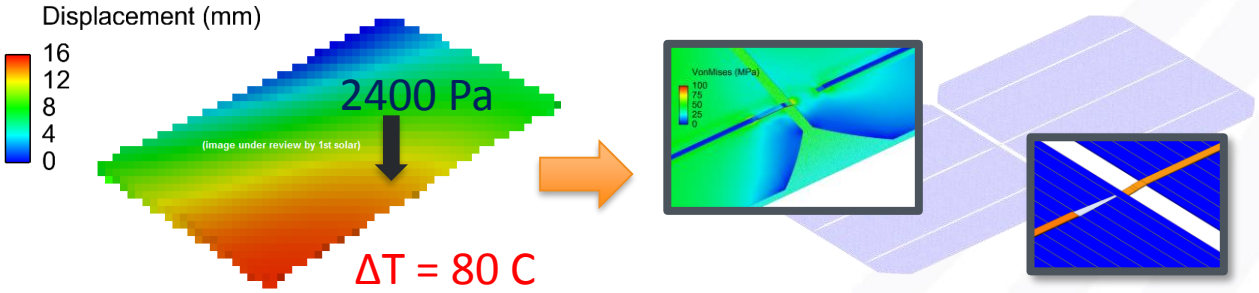
Field Deployment
Lead: Bruce King, Sandia

Demonstration: Development of non-destructive field test methods; upgrading data transmission

Technoeconomic Analysis
Lead: Mike Woodhouse, NREL

Infrastructure: Provide economic guidance impacts of capabilities and projects, critical industry issues

National Lab Capabilities to Understand Reliability



Predictive Simulation

Multistress models

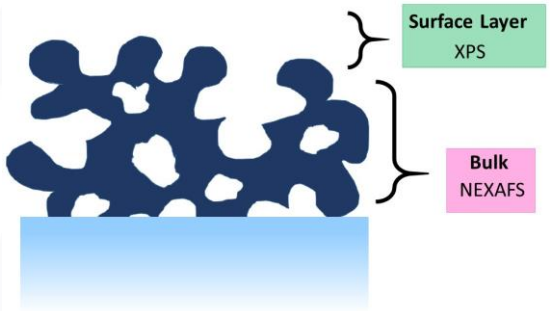
Sandia National Laboratories

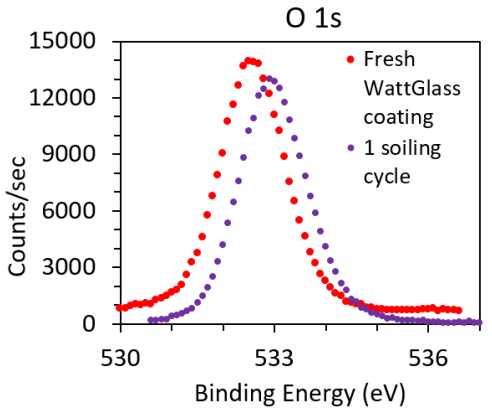
Material Characterization

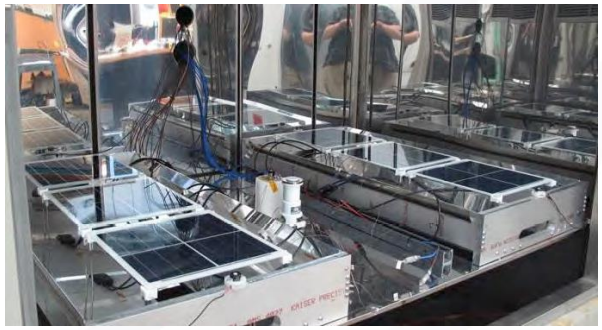
Anti-soiling coating characterization

Project: WattGlass

SLAC NATIONAL ACCELERATOR LABORATORY







Module Testing

Combinatorial Accelerated Testing

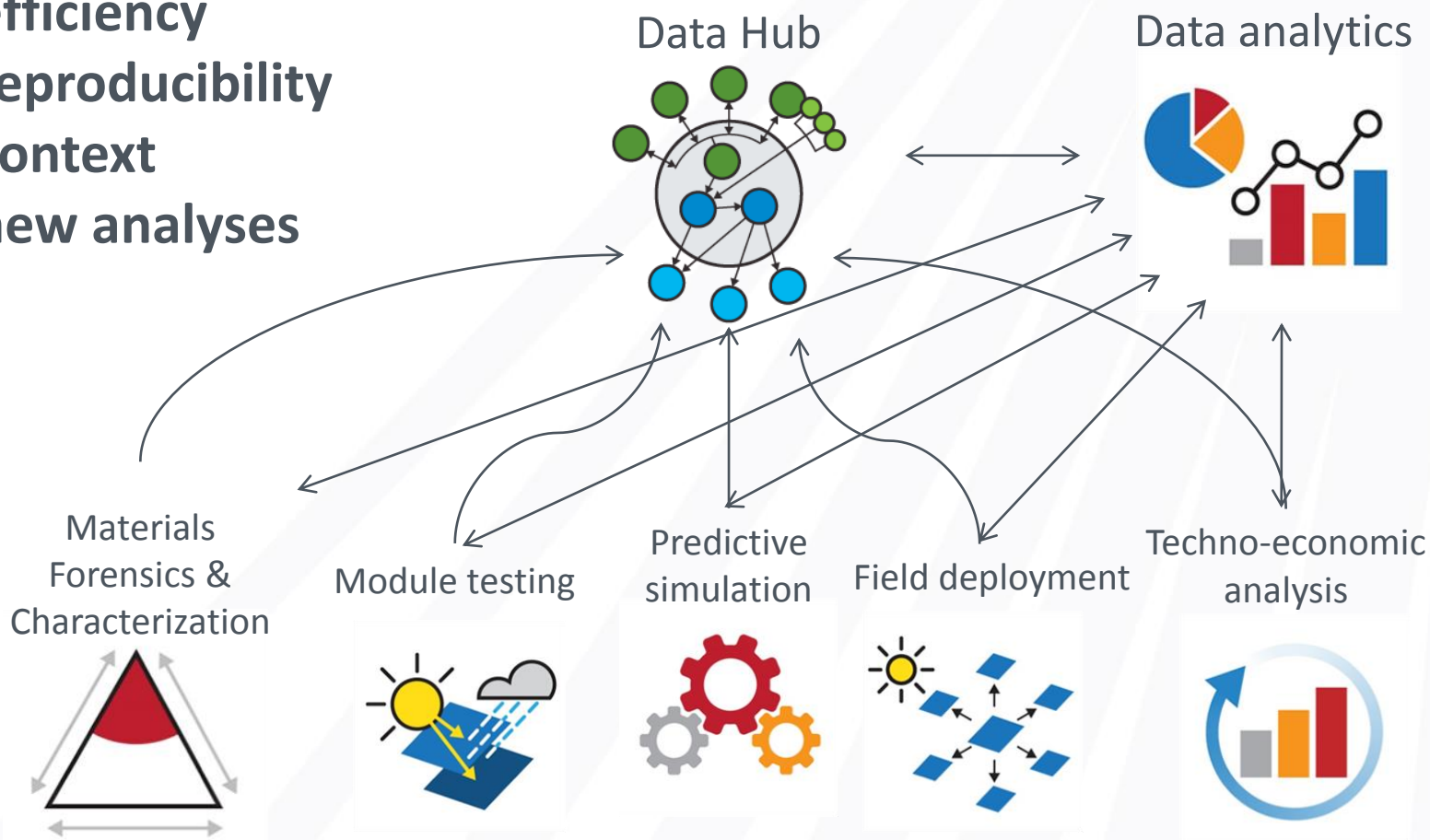
Project: Backsheet degradation

NREL NATIONAL RENEWABLE ENERGY LABORATORY

Why a Data Hub?

A centralized data hub enhances:

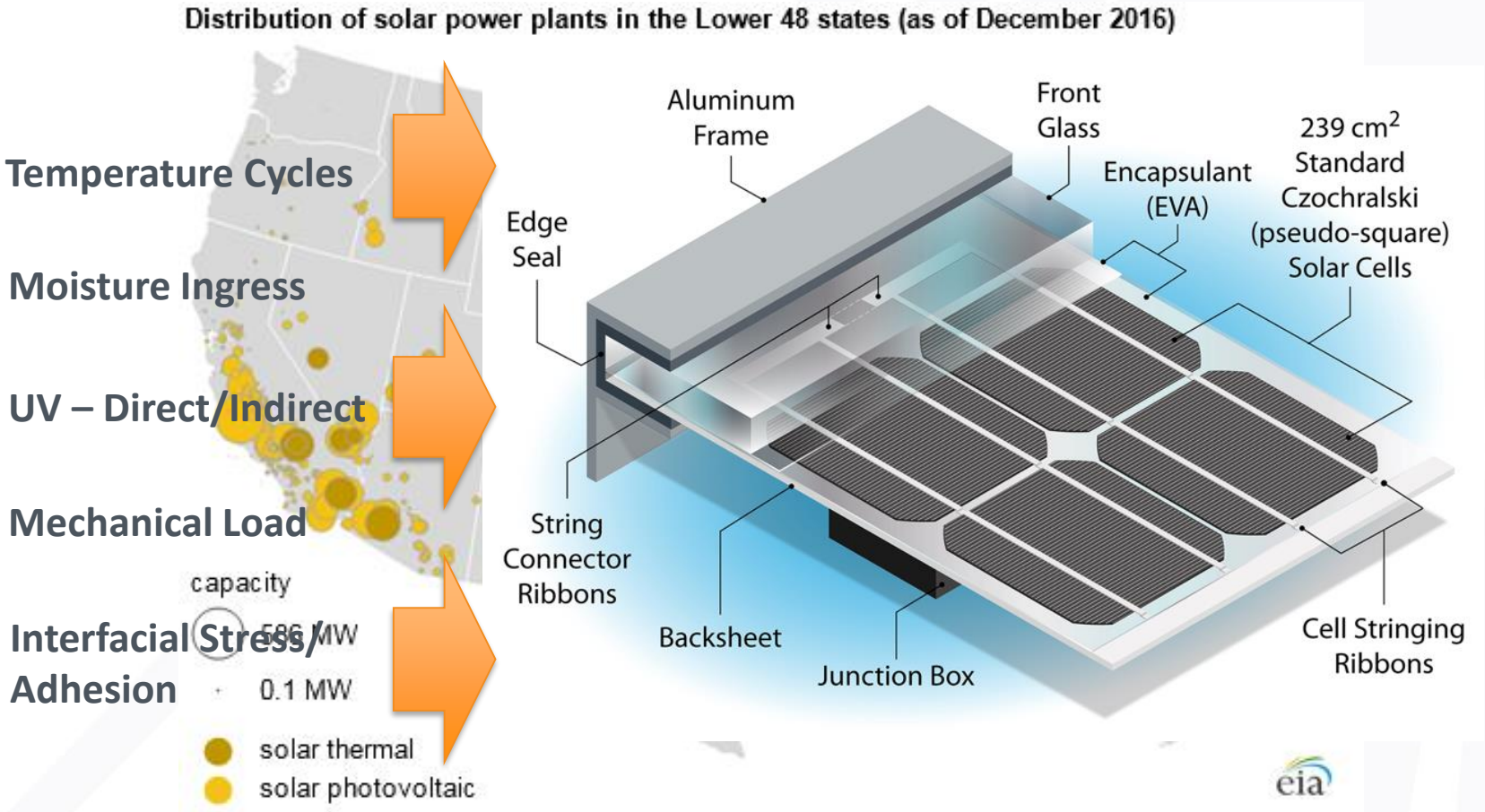
- **efficiency**
- **reproducibility**
- **context**
- **new analyses**



Supports both **open and private data**.
Aids in **data standardization** while providing flexibility to data providers.
Contributes data with high **acquisition cost** as generated by DuraMat.

How Can National Labs Help Address Reliability?

- The ‘big data’ challenge to understanding degradation
- Climate/stressor/material combinations and interactions



Source: EIA, 2017

PV Time Series Data in the Hub

- Slice and examine performance in time scales from minutes to years.
- Upgrade of current PVDAQ time-series database
- Location, climate, and material metadata.
- Cross-compare system performance.

Field Sites

FTP Site

Translation Scripts

API

Time-Series Database

Public Website

Data Hub

API

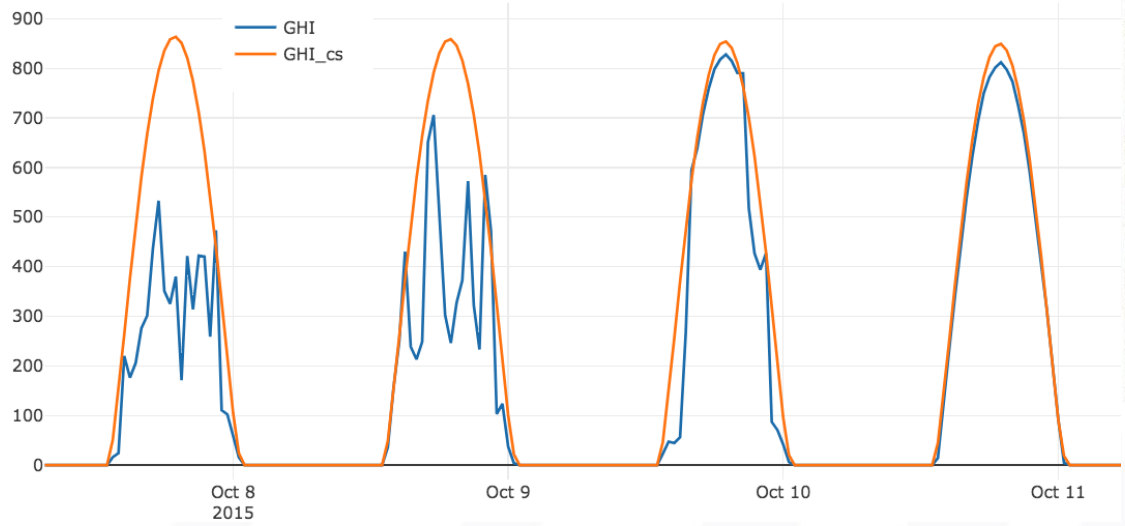
Programmatic Access

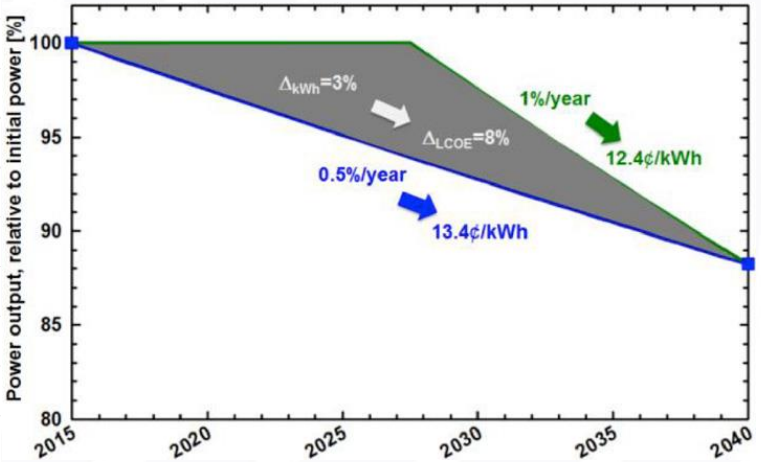
Data Analytics: Clear Sky Detection

Given measured solar irradiance and expected clear sky irradiance, can we automatically detect clear versus cloudy sky periods?

- Important for downstream data analyses – e.g., correctly filtering out cloudy / noisy points can significantly change degradation rate calculation
- **98% accuracy in predicting clear sky events**

NREL NATIONAL RENEWABLE ENERGY LABORATORY kWh analytics **rdtools**





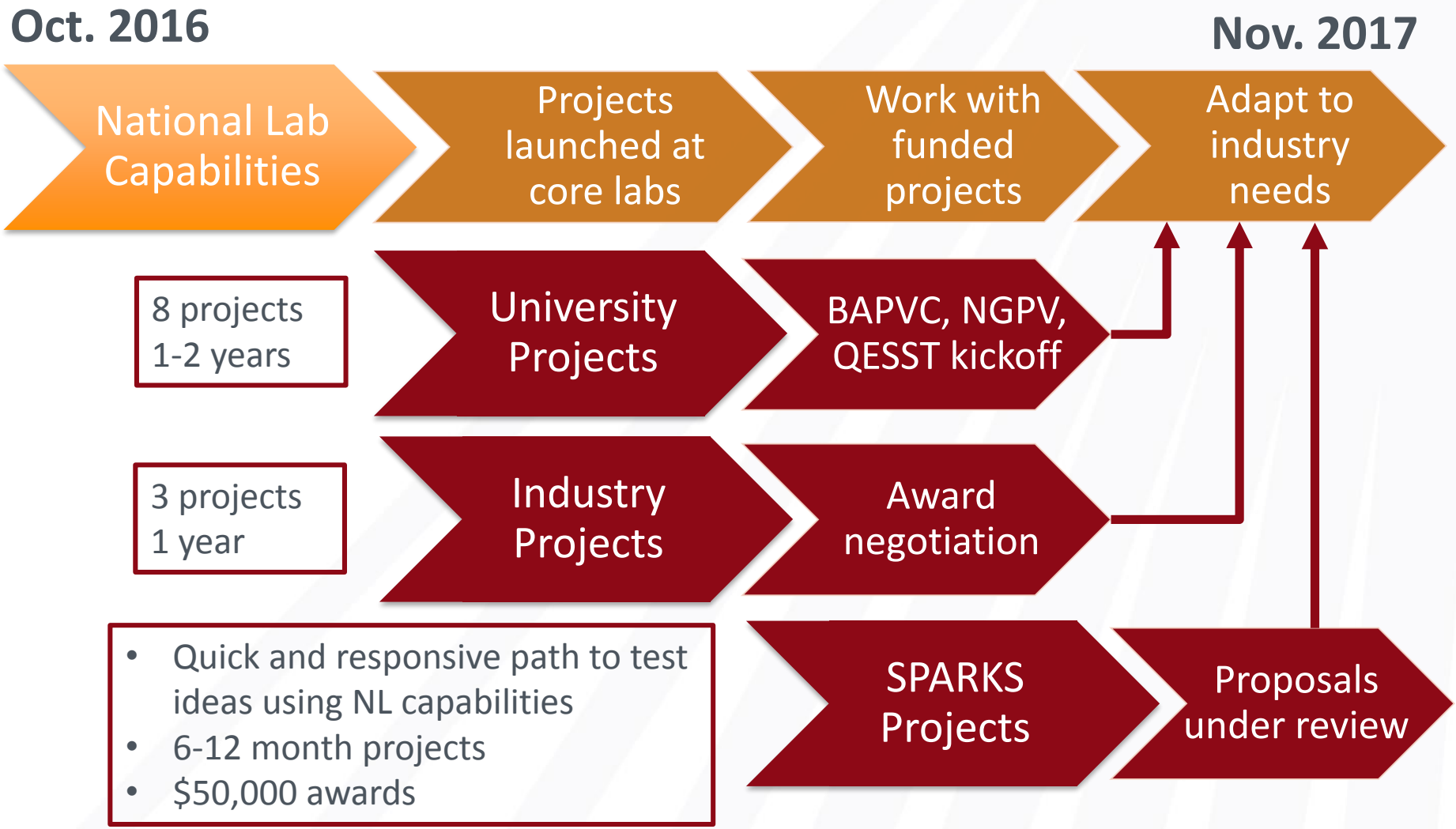
Persistently cloudy, noisy

Persistently cloudy, noisy

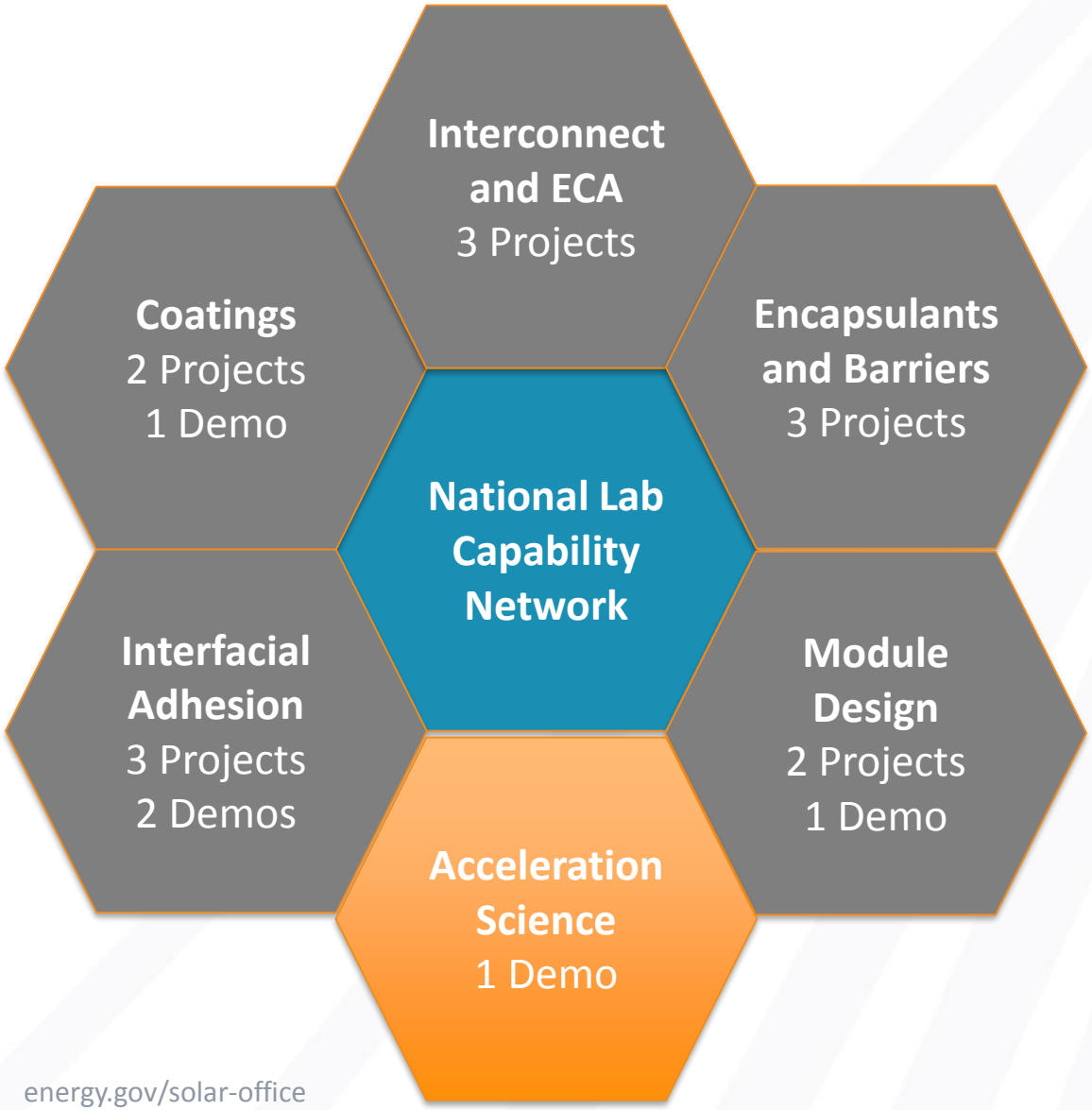
Borderline cases

Generally clear

DuraMAT Activities Over the Past Year



Funded Durability Research



Funded Institutions

- Georgia Tech
- Univ. of Akron
- City Univ. of NY
- Stanford Univ.
- Colorado State Univ.
- Arizona State Univ.
- WattGlass, Inc.
- Osazda Energy

Multifunctional Coating Characterization (WattGlass)

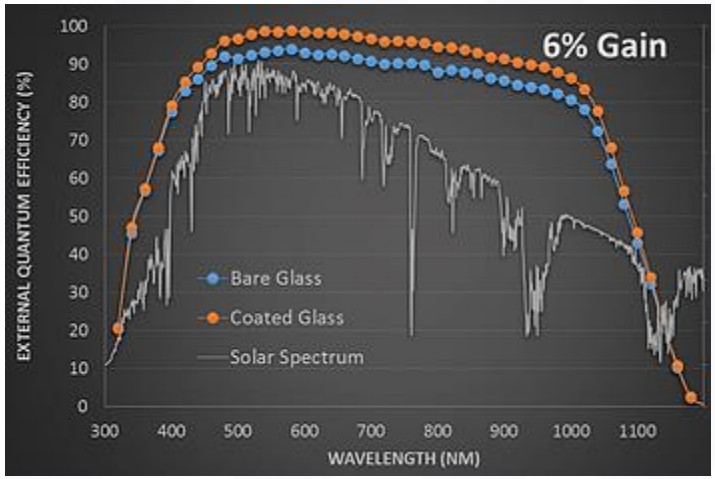
- Examine climate-related reliability and economic viability of anti-reflection/anti-soiling coating
- Foundational science to understand chemistry of anti-soiling coatings and potential PID mitigation

Capability Area & Teaming

Materials Characterization (SLAC): characterize surface chemistry that leads to effective soiling removal

Technoeconomic Analysis (NREL): assess economic advantage of coatings by climate

Accelerated Soiling Testing (Sandia)



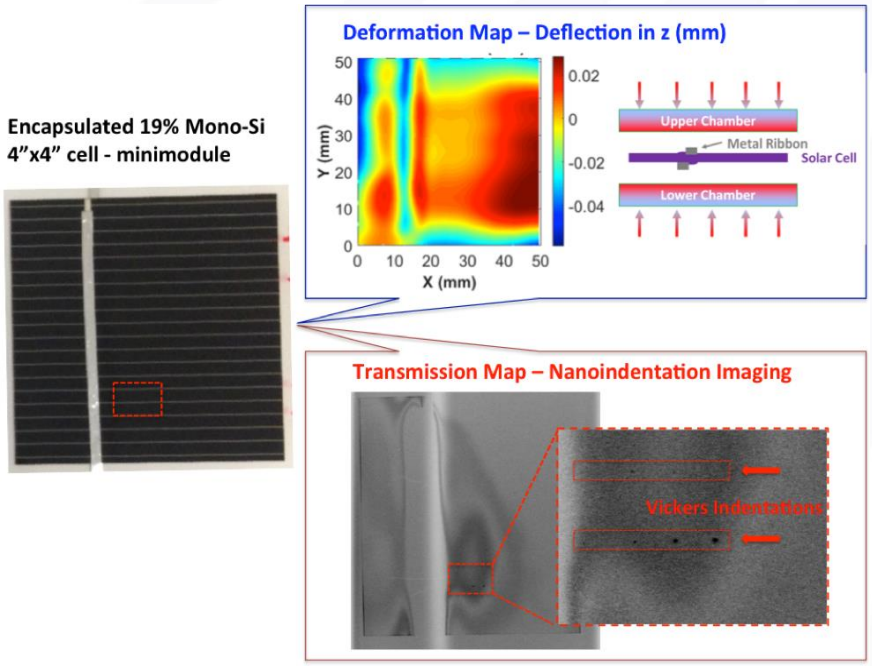
Direct Imaging of Stress in c-Si Modules (ASU)

- Demonstrate x-ray topography as non-destructive method to monitor crack evolution as function of stressors

Capability Area & Teaming

Module Testing (NREL): mechanical testing and EL/PL measurements to connect to topography results

Predictive Simulation (Sandia): develop model of stress distribution using finite element analysis to complement topography data



Ways to Be Involved

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Durable Module Materials Consortium

- **Expanding DuraMAT Capabilities**
  - Are there capabilities from industry, universities, or national labs that **you could contribute to the DuraMAT network**?
  - What other **capabilities would you like to see**?
- **DuraMAT Research Funding**
  - Are there **R&D projects** that you could propose to DuraMAT funding opportunities to work with the capability network?
- **Data**
  - What **dream dataset** would you like to see in the Data Hub?
  - What types of **analytic tools** would be most helpful?
  - What dataset related to module durability would you be **open to contributing to the Hub**?

Contact: jonathan.trinastic@ee.doe.gov

Thank You! Questions?

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