Solar energy

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REDUCE INVESTOR'S RISK BY TESTING AND MODELING CRITICAL FAILURE MODES

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ENVIRONMENTAL STRESSES

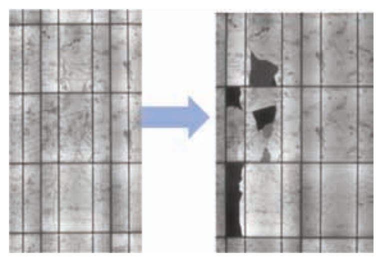
Climatic stresses:	Transport & Installation
Desert	
Coastal	
Snow & Wind	Mounting configurations
...	

MECHANISMS LEADING TO DEGRADATION

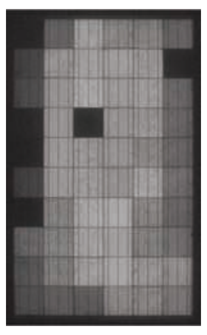
Cell cracks, hot spots, humidity in- and outflow, ion migration (reversible and irrversible) chemical reactions : EVA/acetic acid, corrosion, ...

TEST AND MODEL CRITICAL FAILURE MODES

- **Cell cracks** mechanical stress followed by thermal cycling.



- **PID**



INDOOR STRESS TESTS - categories

How to reduce Design and Quality issues?

	IEC Qualification	Comparative	Service Life	Protection against specific module risks
Purpose	Minimum design qualification	Comparison of products	Reduction of cost while meeting warranty	**2nd qualification test, complementary to IEC Fast, combined stresses**
Quantification	Pass/Fail	Relative	Absolute	**Resistance to specific failures**
Climate or application (mounting)	Not differentiated	Differentiated	Differentiated	**Differentiated**
Specificity	Silicon, thin film, cpv	Package specific	Product specific	**Products and risk specific**
Chamber test times	< 2 months	6 months	3 years (?)	**2 months (?)**

Source: Sarah Kurtz, NREL, Juin 2014
Sophia workshop et PVQAT status on module testing

4th type of test protocole for risk mitigation on specific failure modes

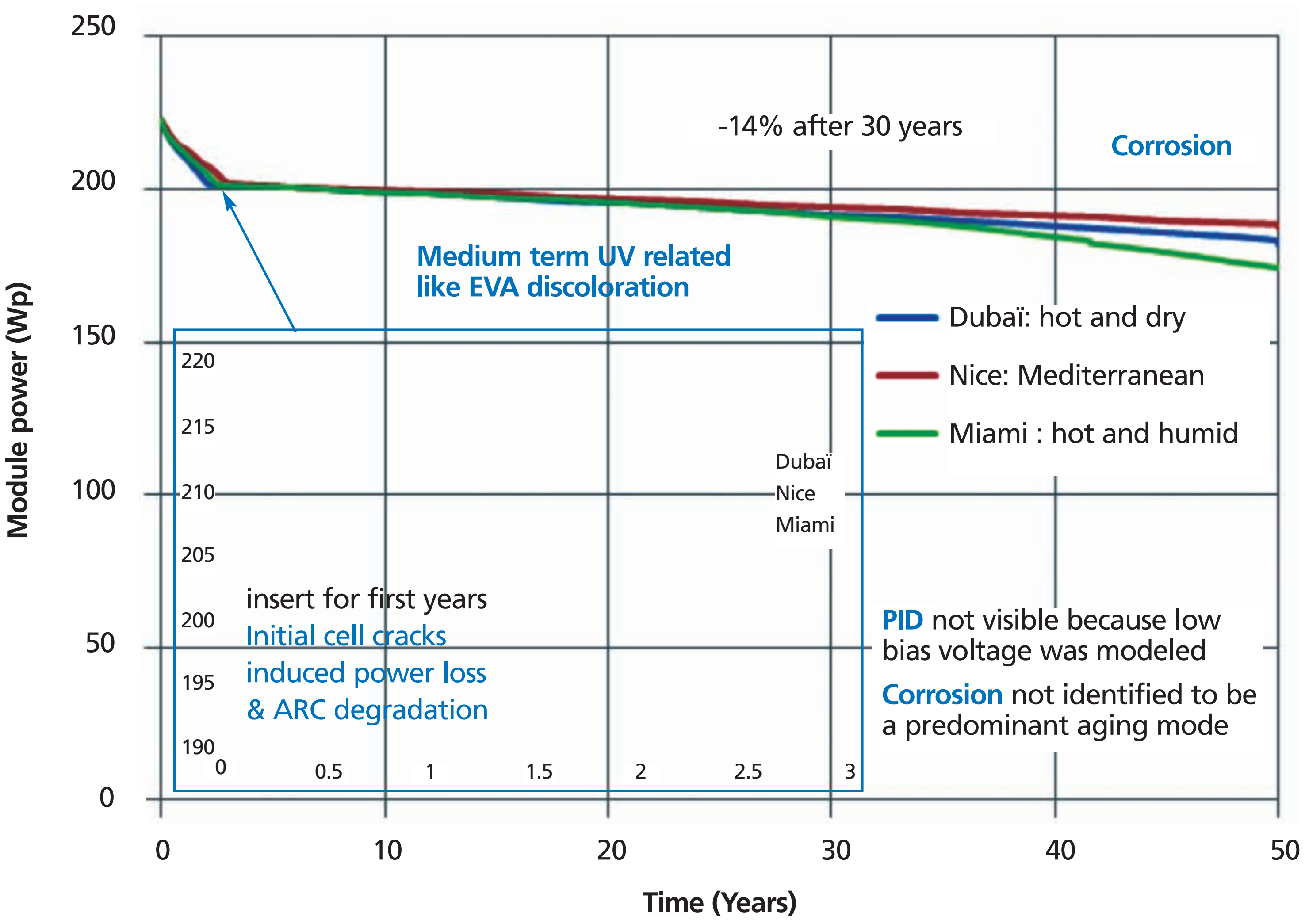
At the module's frontsheet:

- Declining Anti-Reflective Coating (ARC).
- Delamination and optical loss.
- Discoloration, partial and diffuse shading …

ESTIMATIONS OF INDUCED PERFORMANCE LOSS

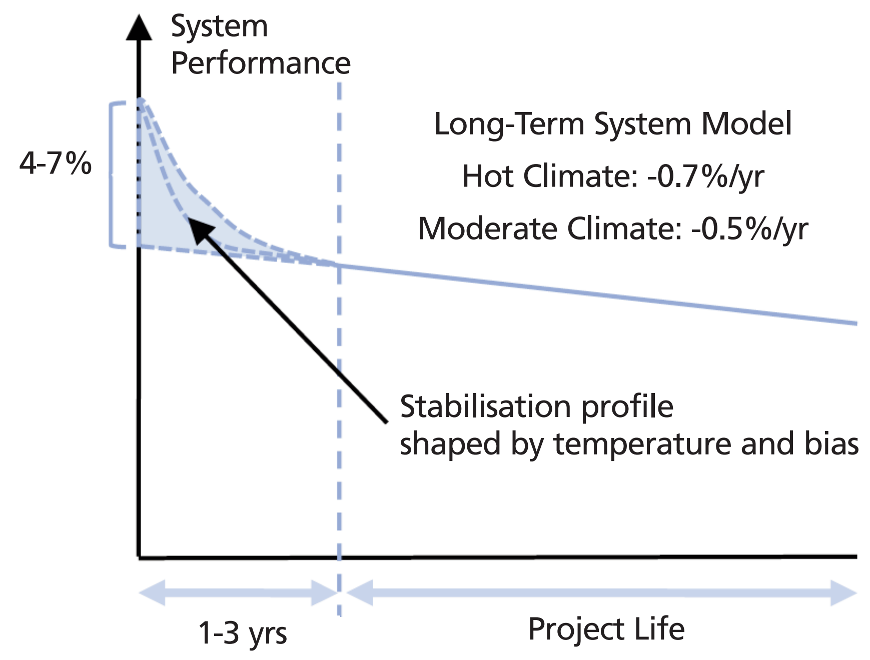
Emperical and/or modelled degradation rates are obtained. In our model (below), each major failure mode evolution is modeled, it's impact can be described in a cell by cell model of a PV plant, for hypotheses see mentioned articles.

Standard C-Si with evolution of major failure modes



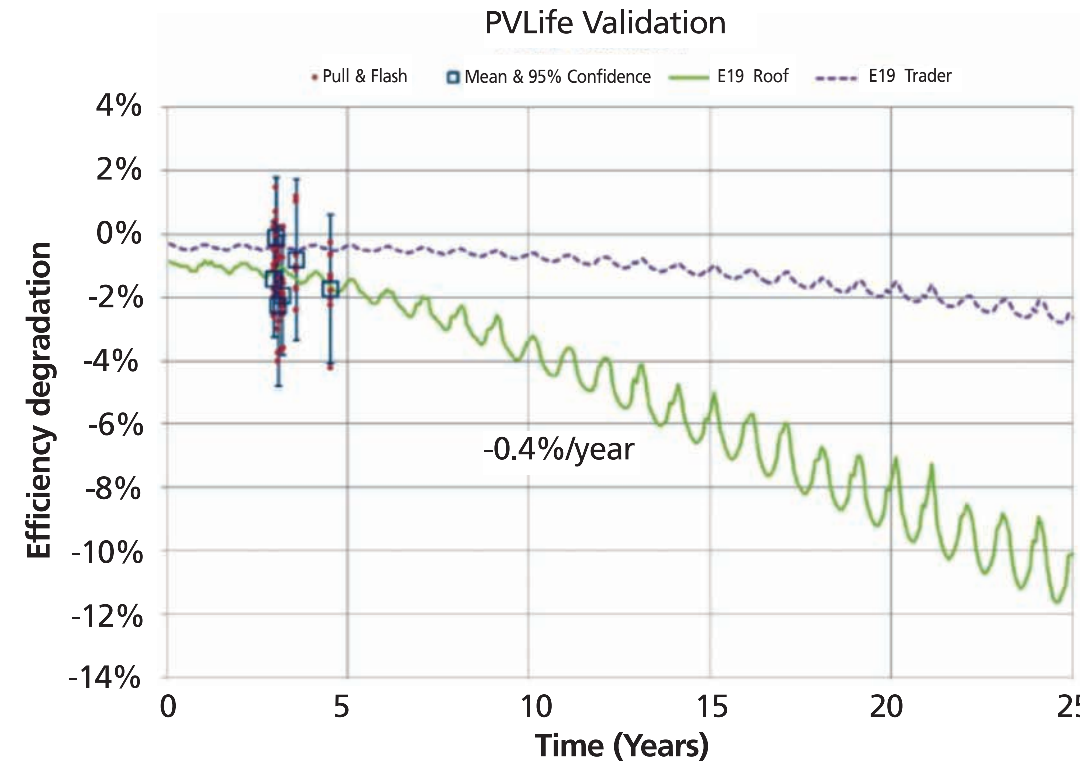
Source B. Braisaz, C. Duchayne, M. Van Iseghem, K. Radouane (EDF), PV aging model applied to several meteorological conditions - EU PVSEC 2014 - 5CO.5.4.

CdTe model



Source N. Strevel, L.Trippel, M. Gloeckler, Performance characterization and superior energy yield of First Solar PV power plants in high-temperature conditions, Photovoltaics International, August 2012, pp148-154.

other model for specific C-Si



PV life predictions and validation for rooftop mounted (green lines) and open rack (purple) Sunpower E19 modules - Source : M. Mikofski, D. Kavulak, D. Okawa, Y-C. Shen, A. Terao, M. Anderson, E. Hasselbrink et al. (SunPower Corp), PVLife: An Integrated Model for Predicting PV Performance, Degradation over 25+ Years - IEEE 2012.

SOME PERSPECTIVES

- Need for better physical assumptions in failure-mode models.
- Improved soiling models for O&M strategies.

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This presentation contains no confidential information.

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