Transformative approach to forward + inverse modeling of photovoltaic module failures in solar fields

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Introduction

Reliability is a fundamental concern

$$\text{LCOE} = \frac{\text{Total costs over lifetime}}{\text{Electricity produced over lifetime}}$$

We have reached a point where efficiency gains for single junction modules will be incremental [1], but reliability gains through improved packaging could be very substantial [2]

Data collected, but not interpreted

Today, much field data is collected, but the loop between manufacturers, banks, and installers often remains unclosed [3,4].

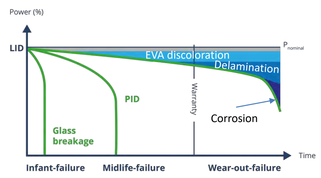
Manufacturer

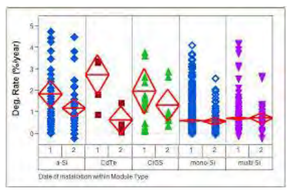
Banks
Government
Standards

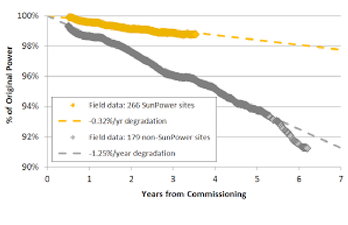
DuraMat?

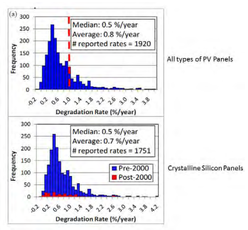
Solar Farms, Data analytics

Application: Interpret field data [5,6]

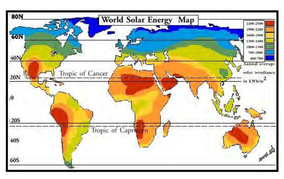


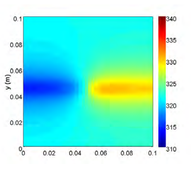


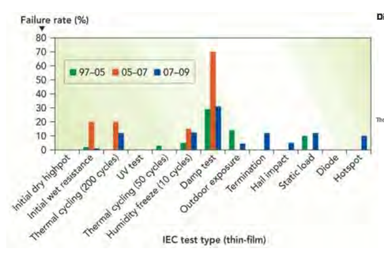


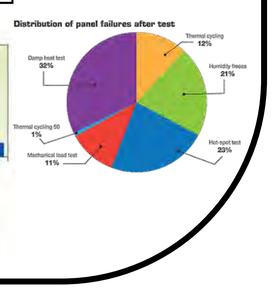


Application: Science-based certification





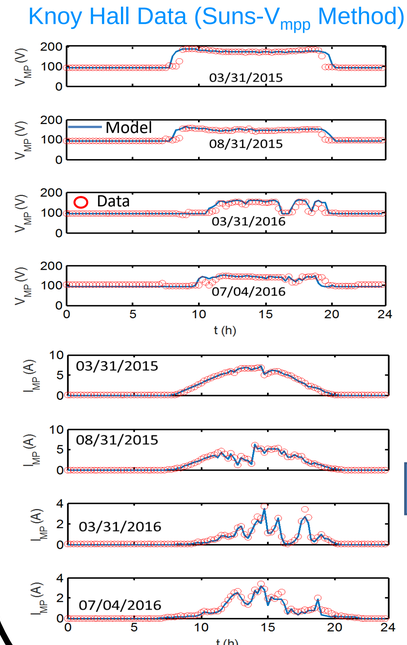




Preliminary Results

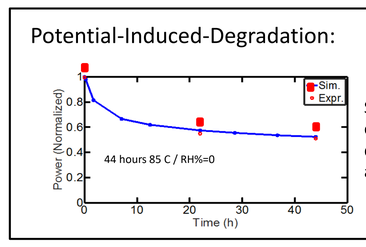
Knoy Hall Installation (Purdue University)

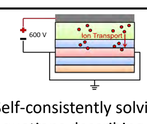
Knoy Hall Data (Suns-V_{mpp} Method)



Physics-Based Failure Models

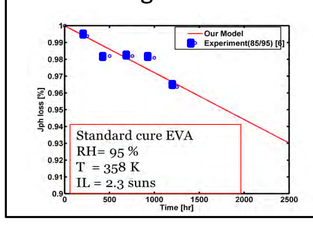
Potential-Induced-Degradation:





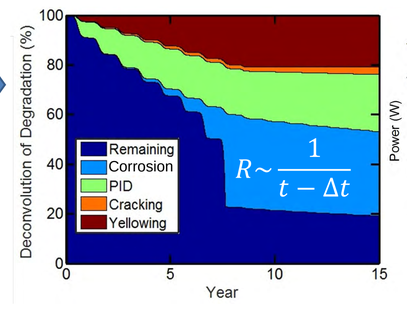
Self-consistently solving equations describing ion diffusion, moisture diffusion, and heat diffusion

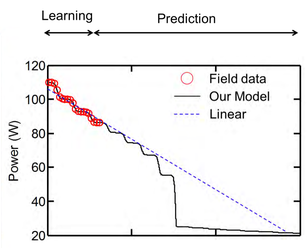
Yellowing:



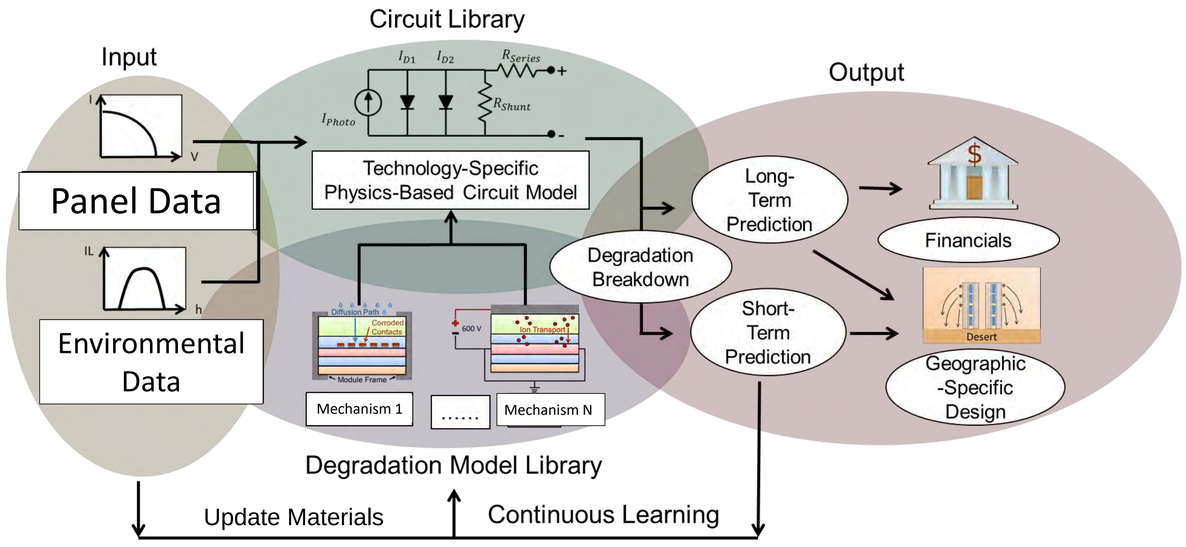
Modeling the photocurrent absorption by EVA encapsulant as a function of humidity, time, and temperature

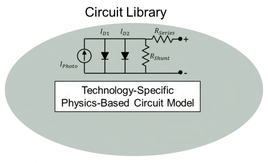
Comparison of Field Data with Model



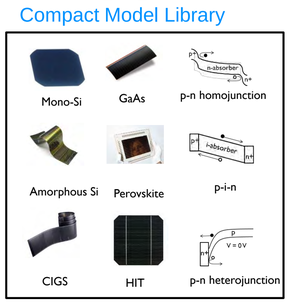


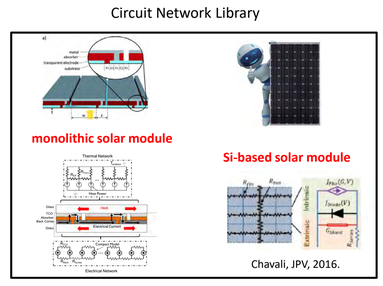
Methodology [7, 8]

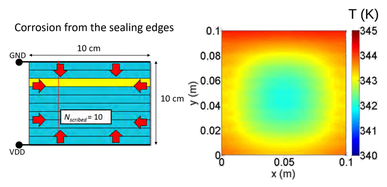




Compact Model Library







Conclusions and Next Steps

1. Developed a methodology to reliably interpret field data using physics-based models
2. Validated approach in preliminary experiments
3. Will now extend to broader range of field data for rapid identification of failure modes
4. Will predict and validate the effects of novel packaging materials
5. Will also investigate geography-specific design & certification

References

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