Degradation Rate Modeling for Encapsulant Discoloration of Photovoltaic Modules Discoloration

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1. INTRODUCTION

- Fielded PV modules experience various degradation modes depending on the climatic conditions, electrical configurations and manufacturing quality → Reliability concerns
- Encapsulant discoloration is one of the two most common degradation modes found in the field survey conducted over 56,000 modules in 4 climatic regions of USA [1]
- Improving the module’s reliability is the pathway to increase their lifetime of 25+ years and to reduce the levelized cost of energy (LCOE)

2. METHODOLOGY

- Hourly weather data are obtained from the Typical Meteorological Year (TMY) database
- UV irradiance: 5% of the plane of array (POA) irradiance
- Module temperature: Calculated using Sandia model

3. TESTING AND PHYSICAL MODELING RESULTS

Outdoor field degradation

AZ module (21 years) NY module (18 years)

Lower browning in AZ module → higher oxygen bleaching due to higher operating temperature

Indoor accelerated UV testing degradation

Unique merits of our testing approach:
- 3 module temperatures in one chamber
- 6 cells (backsnap cut) per module per temperature (more data points per temperature for statistical confidence)
- Activation energy and acceleration factor are determined based on Isc degradation, not based on Pmax degradation because Pmax may be influenced by other degradation modes

4. CONCLUSIONS

- The physical modelling approach developed is able to closely predict the Isc degradation rate in glass/backsnap specific modules deployed in AZ and NY field
- It can be extended to other construction, manufacturer and climate-type.
- This work will be instrumental in designing the accelerated stress testing to study the long-term reliability issues associated with polymeric encapsulant and hence evaluating the fielded module’s electrical performance and service lifetime.

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Reference