Chemical Engineering Master's Defense

Reliability of PV modules:
Dependence on manufacturing quality and field climatic conditions

School for Engineering of Matter, Transport and Energy

Shantanu Pore

Co-Advisors: Govindsamy Tamizhmani
Matthew Green

abstract

This is a two-part thesis aimed at assessing the long-term reliability of photovoltaic modules through statistical analysis and material characterization testing. To provide an overall picture, this analysis was split into two parts: 1) Manufacturing dependent reliability and 2) Climate dependent reliability

Part 1: Manufacturing dependent reliability - Adapting FMECA for quality control in PV module manufacturing

Part 1 of this thesis is aimed at introducing a statistical tool in quality assessments in PV module manufacturing. This work adapts the Failure Mode Effect and Criticality Analysis (FMECA, IEC 60812) to quantify the impact of failure modes observed at the time of manufacturing. The method was developed through visual inspection and performance analysis of nearly 9000 modules at the pre-shipment evaluation stage in module manufacturing facilities across south east Asia. The objective of this work was to develop a benchmarking system that would allow for accurate quantitative estimations of risk mitigation and project bankability.

Part 2: Climate dependent reliability - Activation energy determination for climate specific degradation modes

This work attempts to model the parameter (Isc or FF) degradation rate of modules in the field as a function of the combination of the climatic parameters (i.e. temperature, relative humidity and ultraviolet radiation) at the site. The objective of this work was to look beyond the power degradation rate of the module and model based on the performance parameter (Isc or FF) directly affected by the degradation mode under investigation (encapsulant browning or intermetallic system degradation of solder bonds). Different physical models were tested and validated through comparing the activation energy obtained for each degradation mode. The work is concluded by suggesting possible modifications to the models based on degradation pathways unaccounted for in the present work.

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