

Physics of failure of PV module

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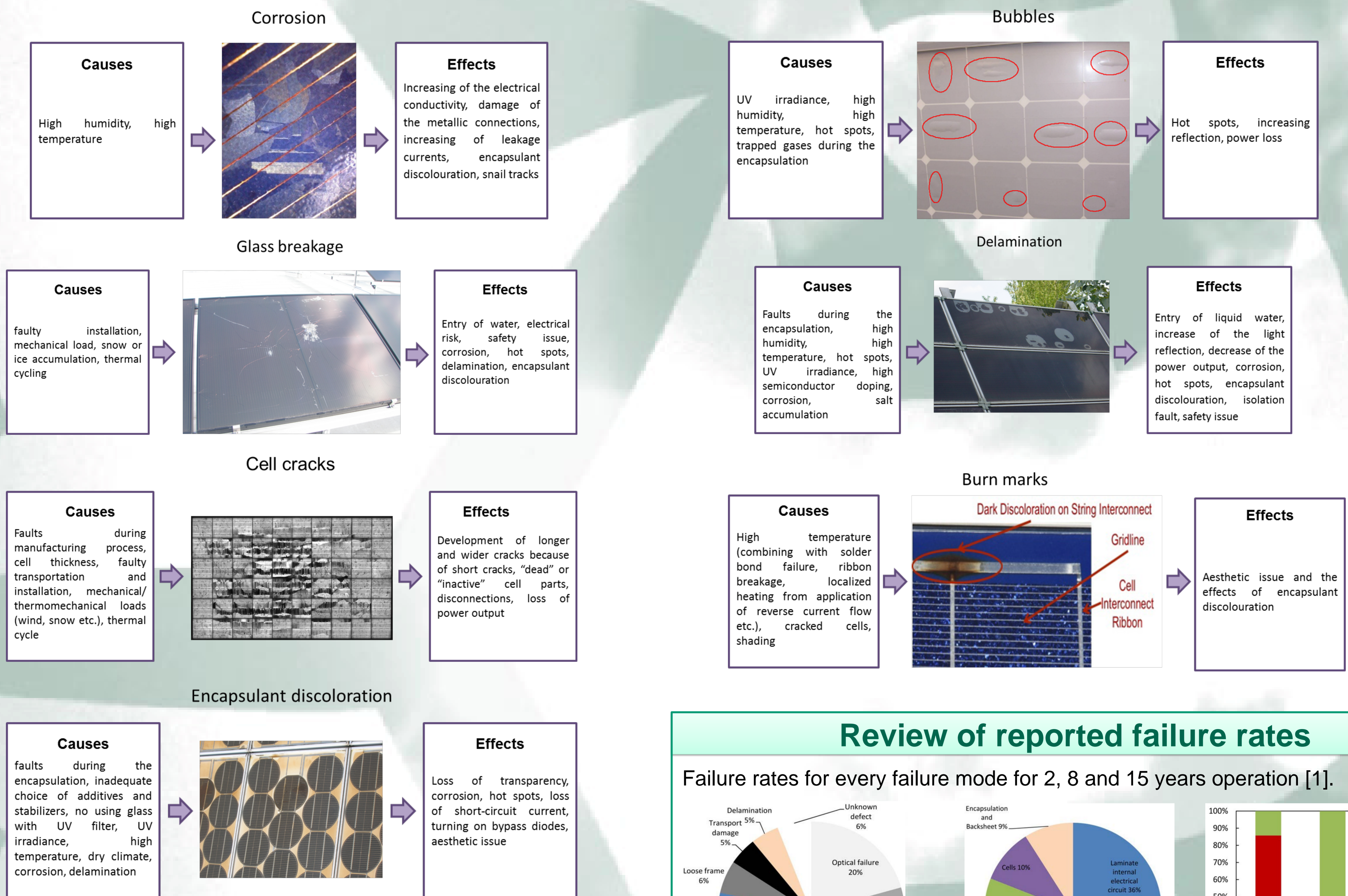
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Abstract

Photovoltaic (PV) modules are renowned for their reliability. However, some modules degrade or even fail when operating outdoors for extended periods. Electricity generated using photovoltaic (PV) technology can only be economical if the PV modules operate reliably for 25–30 years under field conditions. To reduce the degradation, and the number of failures, extensive research is needed on the performance of PV modules. Degradation leading to failure in photovoltaic modules follows a progression that is dependent on multiple factors. Some of the main failure modes, that are described, are corrosion, delamination, bubbles and glass breakage. Encapsulant and AR coating discolouration, cell cracks, burn marks and snail tracks, are also analysed. Their causes could be environmental or other failure modes. Also the failure rates for every failure mode are mentioned for 2, 8 and 15 years operation. The project will investigate key failure modes, link these to operating environments and develop a physics-of-failure based model for the progression of the degradation.

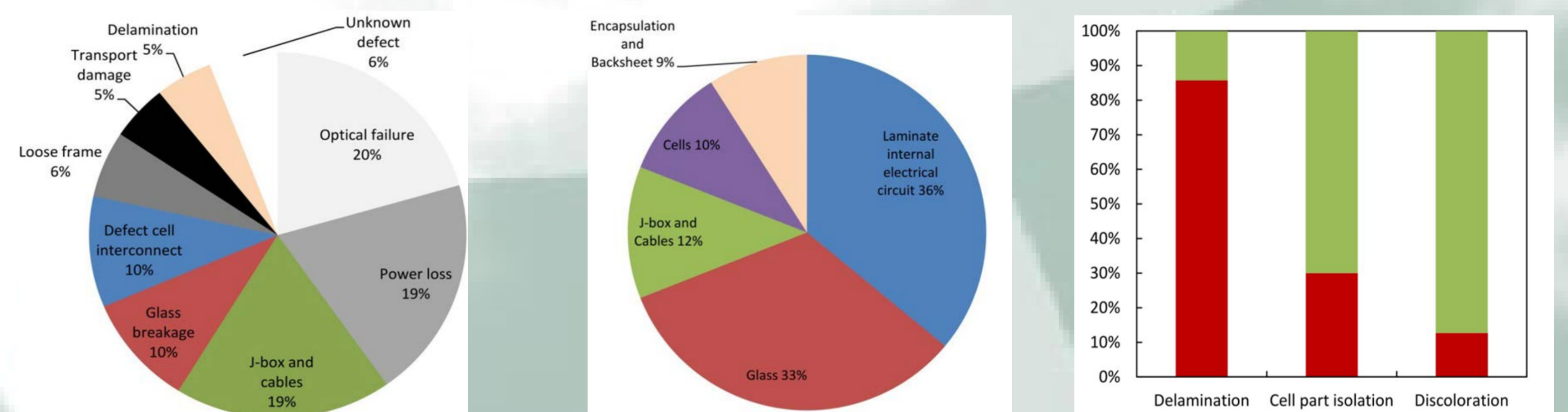
Review of module failures

Some of the visible main failure modes, their causes and their effects are demonstrated [1, 2, 3, 4, 5, 6].



Review of reported failure rates

Failure rates for every failure mode for 2, 8 and 15 years operation [1].



Directions of work

- Identification of most relevant failure modes and link to material/polymer properties and environmental conditions
- Analyse behavior of key parameters during ageing and model effects on performance
- Investigate potential for early detection of developing device failures
- Life-time energy yield prediction of modules with different production conditions and in different environments

- ▶ Failure rates due to customer complaints in the first two years after delivery. The rate is given relative to the total number of failures. The statistic is based on a total volume of approximately 2 million delivered PV modules. Unknown defects are drawn in grey scale.
- ▶ Field study of PV module failures found for various PV modules of 21 manufactures installed in the field for 8 years. The rate is given relative to the total number of failures. Approximately 2% of the entire fleet are predicted to fail after 11-12 years.
- ▶ Failures occurring in a fleet of 272 PV modules of 3 different manufacturers after more than 15 years of operation. Each PV module may be affected by more than one failure type. The red and green colours indicate the percentage of modules having or not having a specific failure respectively.

References

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