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Requirements on accelerated testing to ensure 25 years without moisture ingression problems

Introduction

The aim of this study was to find out the correlation between moisture stress in the field and accelerated tests. To do this a model for the equivalent moisture load in different climates was generated. The model is based on the moisture barrier behavior of standard PV edge sealants (e.g. butyl). In the model a number of different climate sites around the world were implemented, with different installation alternatives. The model calculations were used to determine the necessary test times and conditions corresponding to 25 years of moisture load in the field. Three different installation options were simulated for every climate; “standard modeling” based on NOCT tests according to standards, “free field installation” and “bad backside ventilation”.

Method

1. &Setup of moisture acceleration model based on previous work on moisture transmission in polymers with and without desiccants
2. &Accelerated testing in different environments, with different edge seal widths and with different edge seal materials to validate model
3. &Setup of module environment model based on ambient temperature, ambient humidity, in-plane irradiance and type of installation
4. &Implementation of hourly climates from different sites around the world
5. Calculation of test times corresponding to 25 years in the field

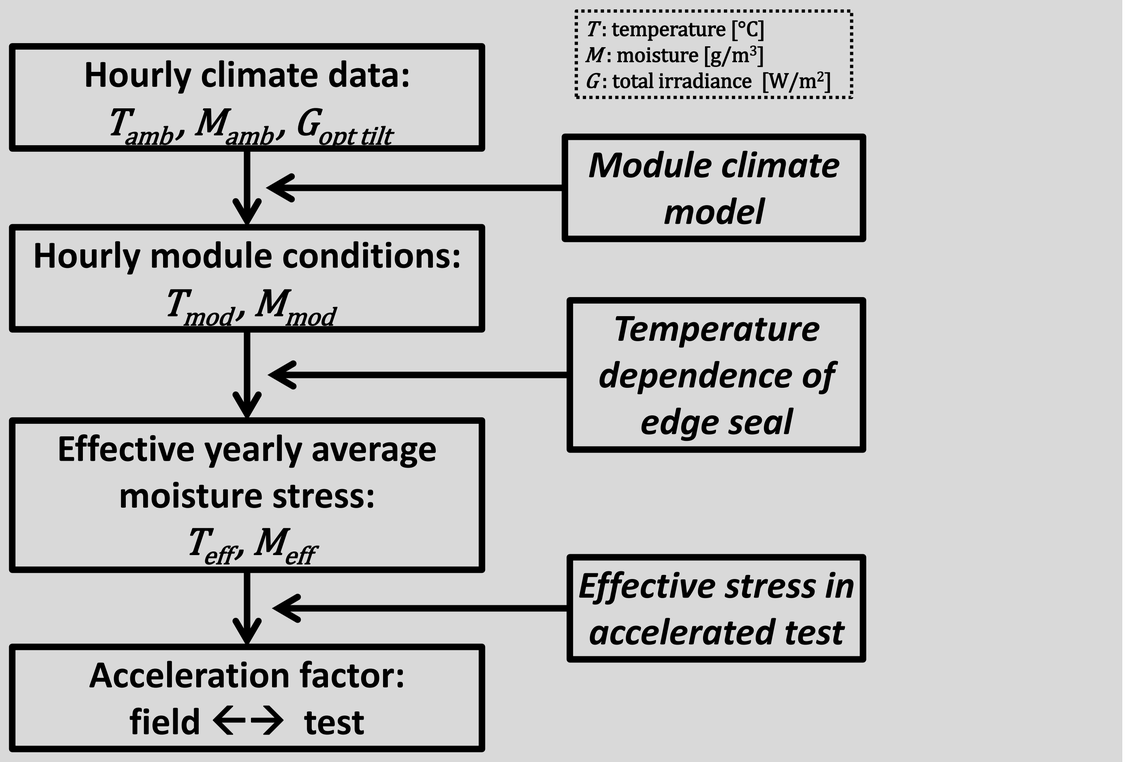
Results

Effective moisture load in different climates

Hours in DH 85 °C & 85 % RH that is equivalent to 25 years in the field				
[hours per 25 years]		Free field installation	Standard modeling	Bad backside ventilation
Temperate climate	Bremen	256	340	518
	Munich	247	340	539
	Bern	293	393	604
	Moscow	192	256	387
	Camborne	268	352	529
	Stockholm	190	254	387
Polar climate	Tromsö	89	113	161
	Östersund	119	159	246
Desert	Alice Springs	793	1175	1983
	Tamanrasset	511	749	1250
	Riyadh	960	1352	2137
	Johannesburg	523	784	1361
Tropical	Jodhpur	1454	1954	2932
	Kuala Lumpur	2124	2744	3968
	Miami	1573	2117	3219
	Accra	2266	3009	4495
	Brasilia	1010	1383	2155
	Bangkok	2385	3133	4606
	Singapore	2234	2887	4183
	Hainan	1605	2089	3051
Mediterranean climate	Zaragoza	504	706	1121
	San Francisco	431	611	997
	Perth	730	1061	1769
	Athens	736	1044	1691

Fig. 1: Table with required test times in DH 85 °C & 85 % RH corresponding to 25 years in the field with different installation types in different climates.

Schematic view of moisture load model



Module overtemperature modeling

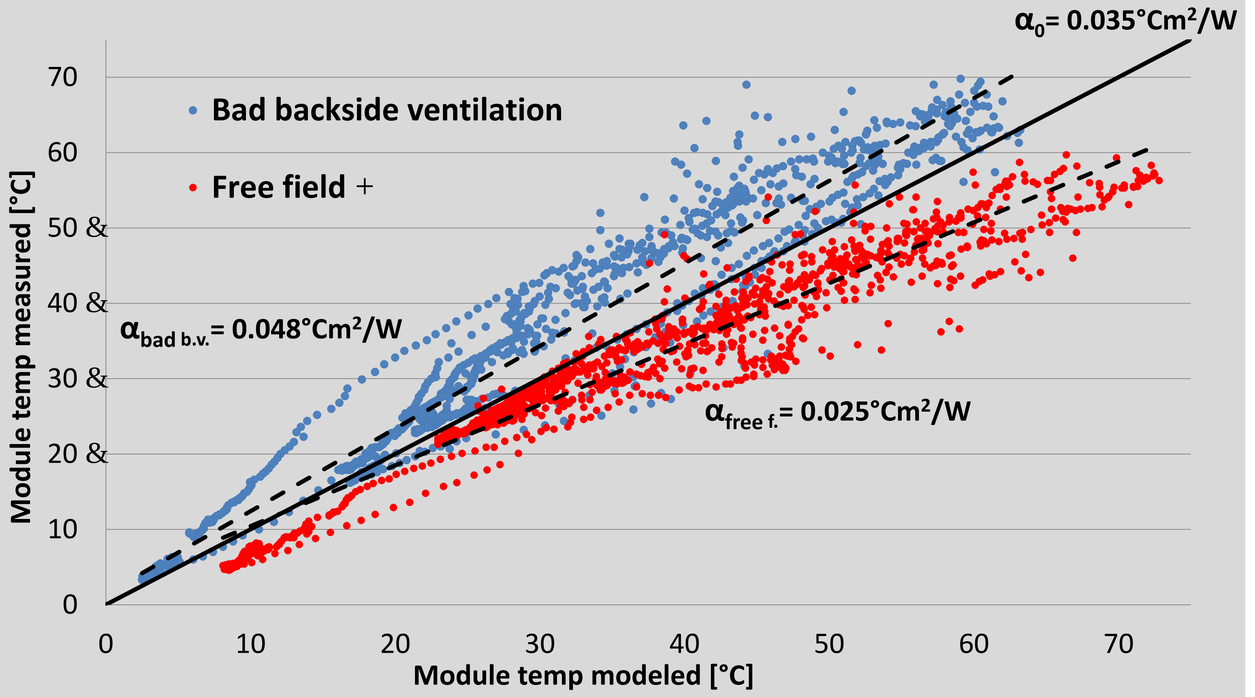


Fig. 4: Measured module temperature vs. modeled module temperature for different installation types. Best fit model parameters are indicated by the dashed lines

Summary & conclusions

- In non-tropical climates the DH1000 in the IEC standards is a good test to quantify the moisture resilience over a module lifetime in the field
- In tropical climates the equivalent moisture load over 25 years is much worse than in the DH1000 test. Considerably longer test times are needed to prove the moisture resilience in such climates.
- The type of installation is very important for the environmental stress that a module will experience over 25 years in the field. The difference in moisture stress between free field installations and installations with bad backside ventilation (e.g. residential roof top) is roughly a factor of 2.