INCREASED RELIABILITY FOR PV IN ALPINE ENVIRONMENT

PV DETECT

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Motivation

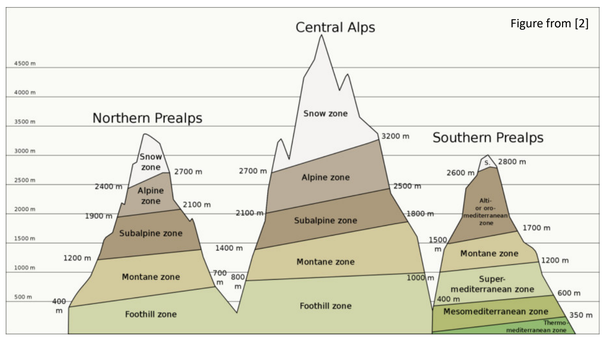
In Alpine countries such as Austria and Switzerland, PV systems are to be increasingly installed in mountain regions in the future. The main reasons for this are **(i) the lack of open space in the valleys and plains** and **(ii) the expected higher (winter) energy production at higher altitudes**. Due to higher irradiation and lower ambient temperatures, systems at high altitudes can lead to higher energy yields than systems in the valley. In addition, the reflectivity of snow can have a positive effect, especially in winter when electricity is most needed. However, **PV systems operating in harsh and demanding environments have to withstand more mechanical stress compared to those in temperate climate zones [1]**.

No specific accelerated aging tests are currently available to simulate these harsh alpine conditions. Therefore, **the main objective of the PV-Detect project is to develop an advanced test methodology for an accelerated and optimized product development of PV modules suitable for operation in demanding environments (e.g. strong solar radiation, heavy snow or wind loads).**

PVDetect workflow

1. Identify existing alpine PV installations in different altitude zones + Collect data on the environmental conditions at the individual sites
2. On-site characterization of the existing alpine PV systems
   - Non-destructive material identification and aging analysis (spectroscopic tools)
   - Electrical: power, degradation rate, electroluminescence
3. Detect typical failure modes of PV modules and systems installed in alpine environment and correlate them to losses in the electrical performance
4. Develop accelerated ageing tests, which mimic the conditions and produce similar failures as detected in the alpine environment within short testing time
5. Develop a method for early detection of failures through advanced reliability testing combined with sensitive degradation detection
6. Define a test matrix for fast product development for innovative PV-materials, components and module-designs to be used in the demanding environmental conditions of the alps.

Altitude Zone	Height (East Alps AUT)	Vegetation
Reference: Lowland	< 1000 m	Grassland, forest (AUT, SUI)
Montane Zone	800-1800 m	Mostly coniferous forests, some deciduous trees
Sub-alpine Zone	1500-2500 m	Small trees (mountain pine)
Alpine Zone	2000-3000 m	Treeless; grassland, small bushes
Snow Zone	> 3000 m	Mostly snow, rocks



We are still searching for

- PV Systems installed in alpine environment
- Reference modules (I) Siemens/Arco M55 (~1988) and (II) Solarwatt M220 60 Get AK

Preliminary results of measurement campaigns of alpine PV-sites

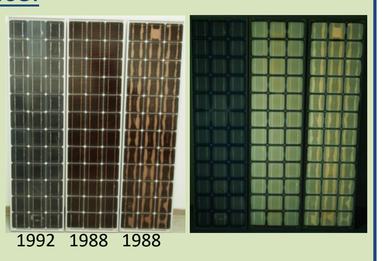
Kanzelhöhe

Montane zone - 1530 m

Modules SM55/installed in 1988/1992

Visual inspection & UV-Fluorescence:

- Yellowing of encapsulant only in modules from 1988
- EVA was modified for modules in 1992
- Strong fluorescence in the old modules

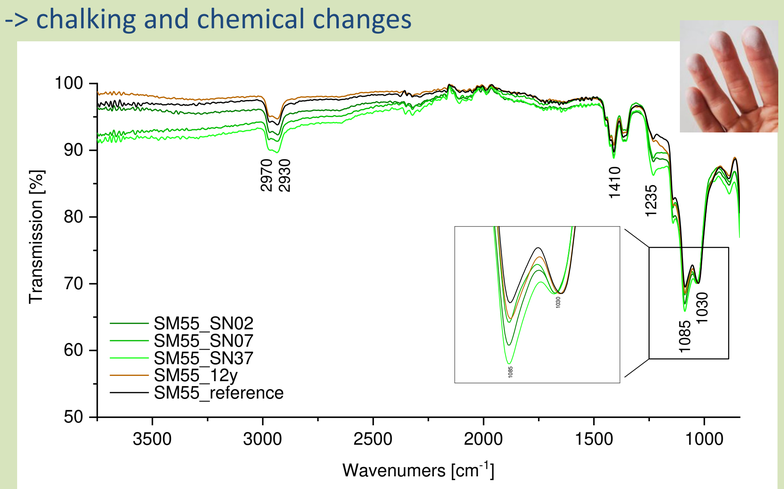


Material identification & analysis:

NIR and IR identified it as EVA and Tedlar (PVF/PET/PVF)

IR: surface degradation of outer backsheet layer (PVF)

-> chalking and chemical changes



Electrical measurements:

IV-Curve and EL measurements done; Analysis of data + comparison with SM55 at different altitude still ongoing

Lac de Toules

Sub-alpine zone - 1800 m

PERT Modules installed in 2013

Reference system in lowlands: BAPV

Material analysis & visual inspection:

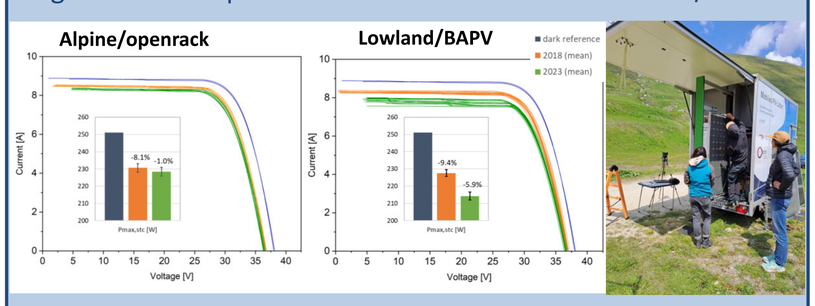
NIR and IR identified it as EVA and Tedlar (PVF/PET/PVF)

NIR IR UV/Vis-color microscopy

In the alpine environment, the polymeric materials did not show aging effects so far. Only one backsheet had a mechanical failure (figure on the right). Only BAPV modules showed cell discoloration.

Electrical measurements [3]:

Degradation in alpine environment less then in lowland/BAPV.



PLR analysis might give insight in the degradation mechanism.

Dobratsch

Alpine zone - 2050 m

Two module types (c-Si) installed 2011

Visual inspection & light microscope:

Backsheet I: intact

→ NIR identified the BS as Polypropylene-stack

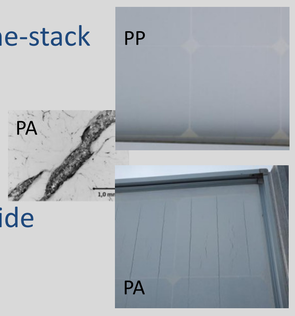
→ PP/PP/PP

Backsheet II: cracked

- Longitudinal cracks along busbars
- Microcracks

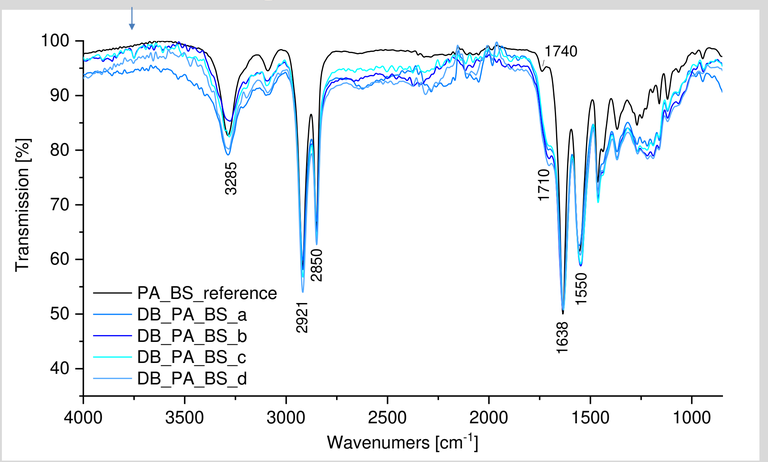
→ NIR identified the BS as pure Polyamide

→ PA/PA/PA



Material identification & analysis:

IR: Photo-oxidative degradation of outer BS surface in PA & PP



Electrical measurements:

Analysis of electrical performance of the PV system still ongoing

Summary and Outlook

On already installed alpine PV systems, detailed on-site characterization is used to record and interpret (i) the change in electrical performance and (ii) detect material degradations induced by aging and specific stress. This helps to identify specific failures and their cause.

The detailed analysis is completed and supplemented by further measurements of relevant alpine systems and data from the literature. Based on the detected failures and degradation rates in the field (existing alpine PV systems) and the recorded typical environmental stress conditions in the different altitude zones, specific highly accelerated aging tests will be developed. These aim to enable rapid product development of innovative PV materials, components, mounting systems and module designs for reliable PV systems in the Alpine region.

Reference: [1]: M.Köhl, M. Heck and S. Wiesmeier, "Categorization of weathering stresses for photovoltaic modules," Energy Science & Engineering, pp. 6(2):93-111, 2018; [2]: Altitudinal zones of Alps mountains Extended diagram-en.svg – Wikipedia; [3] The measurements with the mobile flasher were performed by OST-SPF.

Acknowledgement: This work was performed within the Solar Eranet Project PV-DETECT/Accelerated product development for unconven-tional PV-applications through advanced reliability testing combined with early degradation detection; PV-Detect receives funding of the Austrian government, represented by the Austrian Research Promotion Agency (FFG) and the Swiss government represented by the Swiss Federal Office of Energy (SFOE).