# PV module UV stress test and global PV Sustainability collaboration

## I. General information:


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## II. Summary of the proposed research project/program

### 1. Project description

Exposure to the environmental factors temperature, humidity and UV radiation causes PV modules to degrade over their lifetime of 20-40 years [1]. Annual degradation rates are typically in the range of 0.5% power loss for silicon based PV modules, which account for 95% of the world market [2]. These degradation rates cover a wide range of effects such as EVA discolouring, wear and tear of the glass anti-reflection coating, delamination, cell cracks and metal corrosion (Fig. 1) [3].

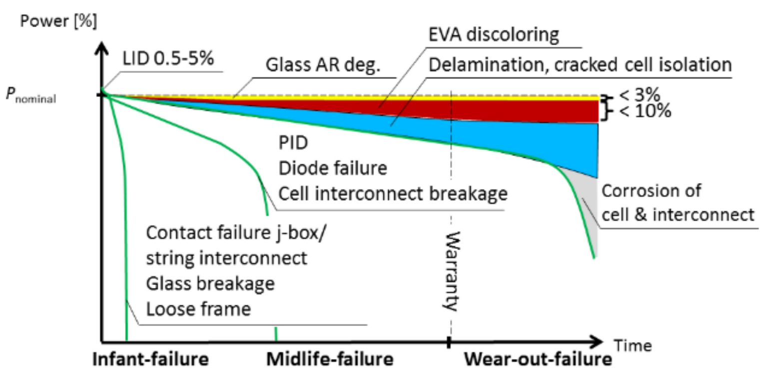


Fig. 1: PV module degradation over time [3].

Fig. 2: Climate chamber with UV light [5].

Combined accelerated aging tests are the most effective approach to determine a PV module's ability to resist these multiple stress factors [4]. Our departments climate chamber currently can only perform tests with the two stress factors humidity and temperature. This project will upgrade the climate chamber with the equipment to also test for the third stress factor UV radiation (Fig. 2) [5]. My students Youri Blom (PhD Candidate) and Daniel Jimenez (MSc. Student) will fabricate test PV modules for the accelerate aging test and measure the reduction in their power output. We expect a decline following the Arrhenius equation [6]. For the case of using the two stress factors humidity and temperature Zhu et al. [7] already showed such an Arrhenius like degradation behaviour of PV module. We will investigate how the addition of the third stress factor (UV irradiation) impacts this behaviour. The experimental investigation will be supported by PV lifetime energy yield modelling, which was developed with my former student Abhishek Velpuru [8]. The results on PV lifetime energy yield will be used to contribute to global PV Sustainability collaboration.

The International Energy Agency (IEA) established the Photovoltaic Power Systems Programme (PVPS) [9] as one of its collaborative R&D agreements in 1993. Since then, PVPS participants have been conducting a variety of joint projects within 18 topical Tasks in the application of photovoltaic conversion of solar energy into electricity. Currently, there are 31 members in the IEA PVPS (Fig. 3) and I am trying to become appointed to Task 12 PV sustainability [10] as an expert representing TU Delft and the Netherlands.

Task 12 aims to foster international collaboration and knowledge creation in PV environmental sustainability and safety, as crucial elements for the sustainable growth of PV as a major contributor to global energy supply and emission reductions of the member countries and the world. The first objective of this Task are life cycle assessments (LCAs) that describe the energy, material, and emission flows in all the stages of the life of PV. The second objective is the analysis of recycling and other circular economy pathways for PV modules. For the third objective, Task 12 develops methods to quantify risks and opportunities on topics of stakeholder interest.

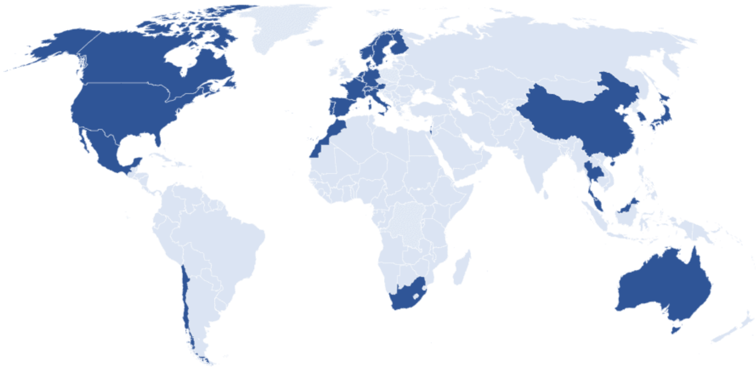

Fig. 3: IEA PVPS members [9].

The experts in the IEA PVPS tasks must fund the cost of travelling to the two annual meetings as well as conducting joint research activities themselves. The output of IEA PVPS Task 12 are research articles as well as open access reports [10] providing advice to governments, researchers and other stakeholders on topics such as the state of PV module recycling, the environmental impacts of different kinds of PV systems or guidelines on how to conduct lifecycle analysis of PV Systems.

**2. Relevance for Climate Action Programme**

Solar energy has the largest potential for contribution to net emission reduction according to the latest IPCC report [11]. As such research on increasing a PV module's lifetime energy yield by reducing degradation falls into the climate change mitigation theme of TU Delft's climate action program. To achieve this reduction in net emission PV Systems need to be installed on a terawatt scale [12]. IEA PVPS Task 12 conducts joint research and sets the global best practices for countries to achieve this in an environmentally friendly manner working towards a circular PV economy having a member in this effort will strengthen the impact and visibility of TU Delft's climate action program around the globe.

**3. Follow-up**

The results from combined accelerated stress testing of PV modules will give us the opportunity to investigate and improve the durability of our PV modules in future research proposals on the national and European level. Getting this advanced equipment and expertise will make the department more attractive as a partner in research collaborations. About half of the IEA PVPS members are from Europe (Fig. 3) consequently many of the joint research activities are funded through joint projects in the Horizon frameworks. Through participation in Task 12, I will be able to strengthen my network for follow-up research proposals on PV module recycling and eventually circular PV modules in Horizon Europe.

## III. Budget overview

The largest part of the budget (18 000€) will go towards upgrading the departments climate chamber with the ability to also expose the test samples to UV irradiation. The material and fabrication cost for the test PV modules is projected at 3 000€. For the year of 2023, the approximate cost of travelling to the two annual meetings is 4 000€. The remaining money (5 000€) will be spent on joint Task 12 research activities towards circular PV modules, to prepare for joint Task 12 proposals in the upcoming Horizon Europe calls.

| **Budget** | |
|---|---|
| Description of costs | Costs in euros |
| UV Stress test equipment | 18 000 |
| Materials for PV module test samples | 3 000 |
| Task 12 activity participation and travel | 9 000 |

## IV. References


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