

# New approaches for identifying and analysing failures in PV

Report on the online WG 2  
workshop of 2<sup>nd</sup> February 2021

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# 1. Introduction

WG2 objectives are focused around improving the “Reliability and durability of PVs.” The WG’s Chair is dr. Mohammadreza Aghaei (TU/e) and its Vice Chair is dr. Jeff Kettle (University of Glasgow). Because of the ongoing COVID-19 pandemic Cost Action, PEARL-PV has reorganized the format of workshops so that be conducted online for the period from November 2020 until April 2021. The purpose remains the same; participants from the Action are invited to actively engage in the various research topics covered by the working group. To enhance participation and reach a wider audience, invites for the workshops were also send to keynote speakers from other institutions. WG2 organised their online seminar on the 2<sup>nd</sup> February 2021. This report details the activities undertaken during the seminar and summarises some of the key findings. The title of the seminar was *“New approaches for identifying and analysing failures in PV.* The seminar was advertised to all COST members via the mailing list as well as via social media channels (twitter, LinkedIn).

The workshop consisted of three parts:

- 1) A series of research presentations showing the state-of-the-art progress in this field, including presentations from key note speakers from around the world
- 2) Discussions about collaborative work that has been performed within the PEARL PV Action from WG members
- 3) The formation of two interactive workshops, where small groups informally discussed future research directions in order the prepare for the next stages of the WG. These groups were based upon current trends in research as well as overlap with the research being undertaken by the members of the WG. The aim was to define sub-groups within the COST action members to work together on future research projects and collaborations.

As a main result from the workshop, foundations for two collaborative papers have been identified.





## 2. Agenda and participation

Time	Item/Title	Presenter
9:00	Introduction to WG2 and workshop	Mohammadreza Aghaei, Eindhoven University of Technology (TU/e) and Jeff Kettle, University of Glasgow
<b>Keynote presentation</b>		
9:10	"Lifetime prediction: when is it useful and when is it a distraction"	Sarah Kurtz, University of California Merced
<b>Plenary presentations</b>		
9:40	"Outdoor inspection of PV modules using drone-based electroluminescence imaging"	Gisele Alves dos Reis Benatto, Technical University of Denmark (DTU)
10:00	"Combined-accelerated stress testing of PV modules and materials"	Michael Owen Bellini, National Renewable Energy Laboratory (NREL)
-----Break-----		
10:30	"Degradation mechanism of CIGS devices"	Mirjam Theelen, TNO, Solliance
10:50	"Assessing end-of-life failure modes in PV modules"	Andrew Fairbrother École polytechnique fédérale de Lausanne (EPFL)
<b>Parallel sessions</b>		
11:10	"Big data for identifying material instability issues in next generation solar cell"	Lead by Jeff Kettle, University of Glasgow and Jesper Jacobson, Helmholtz-Zentrum Berlin (HZB)
	"How can data from Pearl PV repository (CKAN) be used for assessing new types of failures"	Lead by Mohammadreza Aghaei, TU/e and Christian Braun, Fraunhofer ISE
11:40	Workshop summary and closing	Mohammadreza Aghaei, TU/e and Jeff Kettle, University of Glasgow

In total 90 researchers attended the workshop. Due to privacy regulations, an attendance list cannot be provided in the report, however it has been registered in the e-Cost administration of PEARL PV.



## 3. Outcomes

### 3.1. Summary of the talks

Sarah Kurtz from the University of California Merced gave a thought-provoking talk about “Lifetime prediction: when is it useful and when is it a distraction”. She started her speech with a question of “when is lifetime prediction useful?” and then she presented the general approach to lifetime prediction and the uncertainty factors in it; such as ability to analyze type of failure mechanisms, kinetics variation, definitions of test conditions, process variation of the window, and how insufficient quality control at all stages is likely to limit the ability to make an accurate 25 year lifetime prediction. She showed numerous examples of these from lab and field experience. She ended her talk by answering the question of ‘When is lifetime prediction a distraction?’ She explained that it may be difficult to use predictions due to other factors such as lack of quality control and variable use conditions of installed PV systems.

Gisele Alves dos Reis Benatto from the Technical University of Denmark (DTU) presented work about “Outdoor inspection of PV modules using drone-based electroluminescence imaging”. She started her talk about PV inspection and electroluminescence imaging and also a comparison of inspection techniques for PV modules. She introduced drone-based EL inspection with showing various results from the PV fields during the day and night times. She described the process of image acquisition using the drone and the EL sensor onboard. She also explained the post-processing of EL images by showing some results.

Michael Owen Bellini from the US National Renewable Energy Laboratory (NREL) presented work related to the “Combined-Accelerated Stress Testing of PV Modules and Materials”. He showed the construction of a multi stress testing system capable of stressing photovoltaic devices with light, heat, moisture, and motion simultaneously. This accelerates degradation and more closely mimics the real-life stressors and as a result, degradation.

Mirjam Theelen from TNO, Solliance presented work related to the “Degradation mechanism of CIGS devices”. The focus of her work is on thin-film CIGS, the applications, and the advantages of the technology, namely, the flexibility, low materials usage, aesthetic quality, and low CO<sub>2</sub> footprint compared to other PV technologies. She discussed the reliability issues and degradation mechanism of CIGS. Later, she expressed the three main failure mechanisms in CIGs i.e. potential induced degradation, partial shading, and humidity ingress. In this presentation, she showed numerous results of the testing procedures of these mechanisms.

Andrew Fairbrother from École polytechnique fédérale de Lausanne (EPFL) gave a presentation on “Assessing end-of-life failure modes in PV modules”. He presented the assessment procedure of the end-of-life failures of PV modules, how can we test for these types of failures and what effect do they have on the long term performance in the lifetime of modules. He discussed the degradation mechanisms of delamination and corrosion failures and related accelerated testing.



## 3.2. Research collaborations

After the seminar presentations, two parallel break-out sessions were formed. Short presentations were provided and after brainstorm and discussions the following research topics were identified.

The first break out session was titled; "How can data from Pearl repository (CKAN) be used for assessing new types of failures" (lead; Reza Aghaei from TU/e & Christian Braun from Fraunhofer ISE)

After a short introduction about this session by Reza, Christian gave a talk about data acquisition, sampling rate, data processing, and quality and data treatment according to IEC 61724 standard. He presented also the CKAN data portal and the instruction on how to upload/download the data. He also explained the API Python script used for the automatic downloading of datasets. After his talk, Reza presented the defects and failure mechanisms in PV modules, components, and systems. He showed examples of failures on the PV modules and also the electrical sides of PV systems. Moreover, he discussed the effect of different failures on the performance of PV systems and introduced novel approaches for PV failure detection and analysis. At the end of this presentation, Reza showed the recent development of automatic faults detection and classification on PV modules and systems by using novel techniques e.g. Machine learning which may lead to developing innovative approaches to assess new types of failures using the potential of PEARL PV repository (CKAN).

By this introduction, the participants came to each other with a very interesting brainstorming to overcome the barriers for using the potential of CKAN repository. According to the discussion, the main challenge is that the uploaded datasets are not sufficient or not related to the reliability topics in order to initiate productive research on the reliability and durability assessment of PV. The members did not contribute significantly probably due to the confidentiality of their data or not assure of the outcomes. The participants have discussed the solutions to increase the motivation for sharing the data. To end this, all agreed to initiate a research project on this topic and to involve the members of COST countries to share the relevant datasets for the development of new approaches for the reliability of PV. The outcomes can be published as a joint publication or report.

The second break out session was title; "*Big data for identifying material instability issues in next generation solar cell*". Jesper Jacobsson from Helmholtz Zentrum Berlin (HZB) initially presented information on the Volunteer project and how an extensive database of 44000 perovskite solar cell devices has been collated. It is an international project involving around 50 academics and is going live soon. Discussions were conducted and opportunities in a number of areas of research collaboration were found. This include

- Using the dataset to identify experiments which haven't been conducted before to improve the data coverage
- Using the existing results to predict future combinations of materials and structures, rather than identifying trends in the existing database
- Combining the data with material and production costs so that the database could be used to find the lowest cost solar cells
- Considerations of how the database could be modified to include field (outdoor data)data

Next steps; Follow up meeting are now planned following on from discussions from the break-out sessions. WG2 members will be automatically emailed details of these follow up meetings before the end of February. Nevertheless, if you are not a WG2 member and our wish to be involved, please contact Jeff kettle ([jeff.kettle@glasgow.ac.uk](mailto:jeff.kettle@glasgow.ac.uk)) or Reza Aghaei ([m.aghaei@tue.nl](mailto:m.aghaei@tue.nl))

