PEARL PV

Introduction to COST Action PEARL PV

Performance and Reliability of Photovoltaic Systems:
Evaluations of Large-Scale Monitoring Data

Hello, we are PEARL PV!

COST Action CA16235 – "Performance and Reliability of Photovoltaic Systems: Evaluations of Large-Scale Monitoring Data" - sounds rather official. We call ourselves PEARL PV and we are actually seasoned researchers with a passion for photovoltaic (PV) solar energy. In this booklet, we would like to introduce interested readers to our research network, its objectives and the people that make it work regarding management, execution of research and arranging network meetings and exchanges.

Knowing that 75% of EU's greenhouse gas emissions originate from energy production and energy consumption, renewable energy technologies with low CO_2 emissions will play a pivotal role in the global energy transition. If we would like to reduce global warming and hence climate change, we will need to apply more renewable energy systems. Solar PV systems can significantly contribute to greenhouse gas emission reductions with their very low value of approximately 30 g CO_2 equivalents per kWh electricity produced.

The PV market in the EU-28 has been steadily in the past decades. From 2017 to 2018 it grew with 36% resulting in a market for PV systems of 8 GWp per year, see Figure 1. It is for instance estimated that in 2018 more than 500 gigawatt of PV systems was installed worldwide. Actual numbers of PV systems vary considerably per country: in some European countries the share of solar power in the total electricity mix exceeds 5% even up to 8%, see Figure 2, while in others this share is in the order of 2% or less.

Due to the distributed nature and the relative newness of this clean energy technology in the power sector, we lack good insights in the long term performance of PV systems in the field. This is a requirement though for reliable operation with low risks in a broader context of the complete energy system in the EU.

Therefore COST Action PEARL PV has started in 2017 with 32 initiators and has grown to a research network with more than 180 participants aiming at increasing performance and lowering costs of electricity produced by photovoltaic solar electricity systems in Europe via (i) obtaining higher energy yields, (ii) achieving longer operational life time and (iii) lowering the perceived investment risk in PV projects. These objectives will be achieved by a cooperative pan-European COST Action partnership, which geographically covers at present 34 countries, see Figure 3. For this purpose, 5 Working Groups were set up conducting research on the performance and reliability of PV systems using a shared data bank and shared simulation tools and models, see Figure 4.

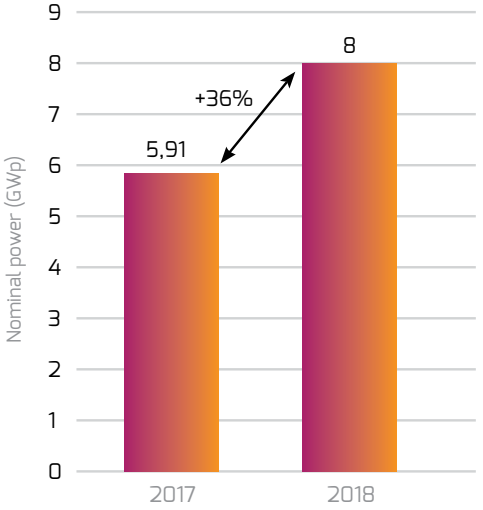

Fig. 1. Installed nominal power of solar PV systems per year in the EU-28 in 2017 and 2018.

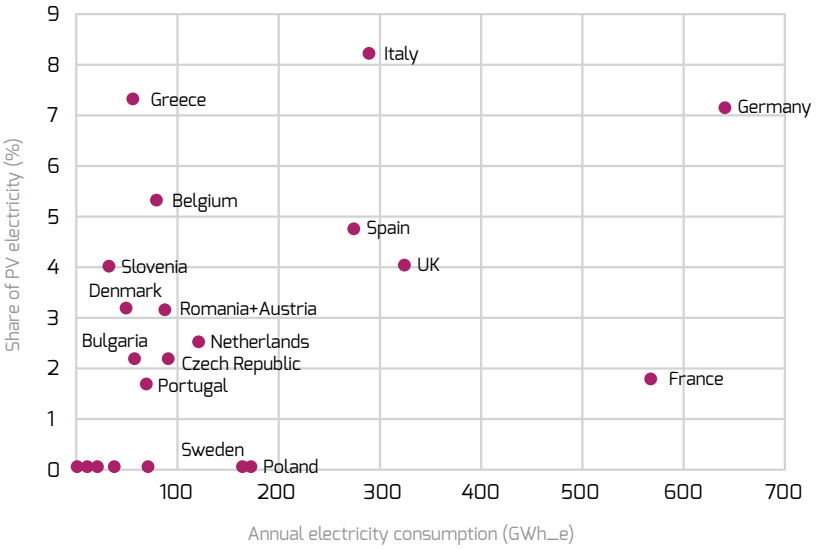

Fig. 2. Share of solar PV electricity in the total electricity consumption in Europe

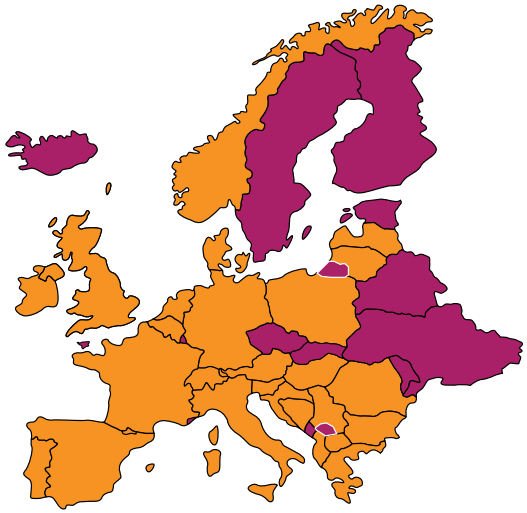

Fig. 3. Map with all PEARL PV member countries, in orange, excluding USA, Turkey and Australia.

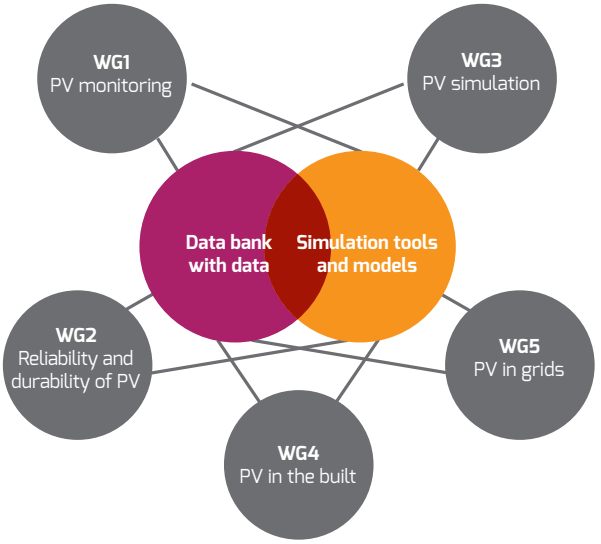

Fig. 4. The 5 Working Groups of COST Action PEARL PV in relation to a shared data bank and simulation tools.

Trained in experimental physics, I wrote my PhD thesis on PV systems monitoring and simulation. Consequently, I have done a great deal of system research since then.

CHAIR OF PEARL PV

Angèle Reinders

‘By bringing people together, you can make bigger steps’

A platform for PV systems
I always found it very difficult to find other researchers of PV systems to share experiences and data. So, as the opportunity came up to create a network for this type of interdisciplinary research, I jumped! Together with 32 other colleagues.

Although similar platforms for solar cells do exist, for PV systems this was not the case. While the market for solar systems rapidly is growing, we lack the means to have a good insight in their proper operation on a large scale. PV is currently being used in the electricity system next to power from coal- and gas-fired power plants, operated by skilled technicians. In contrast, PV systems are usually owned by citizens, and while their performance also needs to be checked on a regular basis, this is not done as the owners lack sufficient technical knowledge to do this. Within the PEARL PV network, we have people with all kinds of expertise in this field, which is extremely helpful for developing a framework for performance and reliability of PV installations.

Network goals
The aim of the PEARL PV network is two-fold. First, to establish a research network, in which participants share their expert knowledge, and second, dissemination of this knowledge aimed at various stakeholders, such as governments, investors, the banking sector, PV installation technicians and system design engineers, as well as consumer organisations. Therefore, we invest in training schools for

Angèle Reinders studied experimental physics at Utrecht University, where she also received her doctoral degree in chemistry. Her research is trans-disciplinary, with a focus on performance of energy technologies, environmental aspects, user interactions as well as prototyping and testing of innovative energy products. Next to being an Associate Professor in Sustainable Energy and Design at University of Twente, she is a full Professor in Design of Sustainable Energy Systems at Eindhoven University of Technology.

young researchers and colleagues from business as well as in various workshops and seminars for researchers. In addition, we have five Working Groups with many great researchers on board. And their number is still growing!

Collaboration
At the moment, we have about 180 people connected to PEARL PV from all over Europe, from Norway and Germany to Portugal and Serbia. Besides, we have recently incorporated researchers from the US, Australia, Israel and Armenia. People from countries outside of Europe can join the network as well, as long as they can demonstrate that their scientific institute can contribute to sharing knowledge or data to the goals of PEARL PV.

I think that a collaboration of this kind is of great importance. No matter from which part of Europe or the world they are from, the only thing candidate participants need to do is to conduct joint research in relation to PV system performance. Collaboration enables us to make use of joint facilities, as well as shared data, while other participants can function as a mirror and define your focus as a group. I really believe that by bringing people together, you can make bigger steps!

Useful networking tools and events
In the past two years we have seen more international collaboration resulting in various publications and papers by researchers involved in the various Working Groups. In addition, participants are setting up a data repository on PV performance. The training school in Cyprus that took place in the fall of 2018, was attended by some 30 people. Participants were offered information by international experts and were provided with a set of tools. In only one week's time, they learned how to apply simulation tools in building integrated PV projects. The training school was highly appreciated: it was graded with a 9 - out of 10!

Interrelations
In the various Working Groups all kinds of new activities

‘The PEARL PV networking events and tools provide a great means not only to get to know many PV experts with a mutual interest, but also to have discussions and make decisions.’

have been set up. In Working Group 5, for instance, many young researchers have joined the network with a focus on PV in grids, which is related to quality control and matching of electricity production and demand. And in Working Group 3, which has its focus on simulation, new studies are taking place that haven’t been done before, such as simulation environments for bifacial solar systems and floating panels. There are, of course, all kinds of subjects that include more than one Working Group. Which is also the benefit of such a network: by being aware of those interrelations, you can make connections with researchers with a different expertise and learn from each other. In the first two years of the project we have invested in setting up the network, defining research lines and activities. Now it is time to harvest: beside the realisation of the databank, many collaborative papers are being planned.

David Moser, Vice Chair

Since the mid 80s I have been working on various scientific topics with one thing in common: photovoltaic solar energy. Moving from analysing electrical properties of PV on to working on different solar cell materials, more recently, I have specialised in analyses of PV performance data. My current research focus is on the integration of PV systems in society, and more specifically the built environment, while ensuring that the electricity network can handle massive amounts of solar panels.

WORKING GROUP 1

Wilfried van Sark

‘Combining performance data with analysis is necessary to improve solar PV systems and to achieve higher revenues’

PV monitoring

Working Group 1 focuses on PV monitoring. For achieving the aim of the PEARL PV project, being to improve *the energy performance and reliability of solar systems*, the collection of performance data combined with analysis is essential. Therefore, we are now working on setting up a databank for the collection of data on how much energy is generated by PV systems. At the same time, the scientists involved in Working Group 1 are developing methods by which we can properly analyse performance data. This will help us recommend improvements, so that in the end the systems will not only be more reliable, but will also generate more energy and make sure that the owners or investors have higher revenues.

We expect to see differences across Europe due to climate differences, to be visualised by using colourful maps. When installing a solar panel in the South of Europe, it is obvious that it will generate about twice the amount of energy of what it would generate in the North, due to the sunnier climate. We might, however, identify other differences as well, such as those due to different climate zones.

function according to its specifications, and that it will do so for 25 years. But *how* can we guarantee that a solar panel is performing well? If you buy a television set, it is easy to assess if it operates well. This is much more complex for a solar panel. First, you need to measure the generated energy. For which you need measuring equipment that will tell you *whether* the panel is functioning at all. But to see how well it is functioning, you have to measure the amount of solar irradiation as well. This is currently being done for large solar parks, but not in residential areas with PV systems of around 10 panels. To fill this gap we are now developing methods that will allow to automatically analyse performance data.

Holding a master's degree in experimental physics from Utrecht University, Wilfried van Sark finalised his PhD research on 'GaAs solar cell development' at Radboud University. He is currently full professor 'Integration of Photovoltaics' at the Copernicus Institute of Sustainable Development of Utrecht University in the Netherlands.

Massive amount of data

For this reason our activities are focused on collecting massive amounts of data of performance of PV systems, which will be stored in a large databank. The idea is that we develop methods for the analysis of those data that will enable us to draw the conclusion whether a certain PV system is "healthy" or not, that is whether it generates energy as expected. Up to now, it has been highly difficult to collect data of energy performance of PV systems. In accordance with societal movements towards an open science, open publications and open data, this might change. Our goal then is to collect all available data on PV performance for systems across Europe.

We need a pan-European network for solar PV to demonstrate how PV systems are performing all over Europe. Therefore we have to make use of data from all kinds of settings, such as solar panels on roofs in residential areas, which is the focus of WG 4, but also large solar parks and solar panels floating on water or at sea. This is essential, as in the following 30 years, shifting to a fully renewable energy European society, we will depend on their proper performance. The PEARL PV network will help us point out the differences in performance. At the same time the collaboration with other researchers enables us to develop methods to ensure a secure electricity supply.

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Cooperation
Carrying out research ‘in splendid isolation’ is no longer possible. Cooperation in science is not only more efficient but also effective. Scientists from different research disciplines as well as different regions might come up with useful suggestions to solve a problem. An example: for an earlier study we had collected PV data that were available on the Internet, but this included only a few European countries, such as the Netherlands, Germany and Italy. Thanks to the collaboration with fellow scientists of Working Group 5 we could add data from France and Belgium that were not available to us earlier.

The PEARL PV network’s aim is to establish a highly necessary set of data and analysis methods to investigate energy generation by PV systems. To move forward to a more sustainable Europe, we need to be able to rely on massive amounts of renewables such as solar and wind, to secure our electricity supply. Therefore, we must have reliable methods to be able to ensure that our PV systems are functioning according the expectations, not only now but also for in the decades to come.