IEA INTERNATIONAL ENERGY AGENCY

PHOTOVOLTAIC POWER SYSTEMS PROGRAMME

TASK 13

Performance, Operation and Reliability of Photovoltaic Systems

Work Plan 2018 - 2021

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Updated Version

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1. Foreword

The International Energy Agency (IEA), founded in November 1974, is an autonomous body within the framework of the Organization for Economic Co-operation and Development (OECD) which carries out a comprehensive programme of energy co-operation among its member countries. The European Union also participates in the work of the IEA. Collaboration in research, development and demonstration of new technologies has been an important part of the Agency's Programme.

The IEA Photovoltaic Power Systems Programme (PVPS) is one of the collaborative R&D Agreements established within the IEA. Since 1993, the PVPS participants have been conducting a variety of joint projects in the application of photovoltaic conversion of solar energy into electricity.

The mission of the IEA PVPS Technology Collaboration Programme is: To enhance the international collaborative efforts which facilitate the role of photovoltaic solar energy as a cornerstone in the transition to sustainable energy systems. The underlying assumption is that the market for PV systems is rapidly expanding to significant penetrations in grid-connected markets in an increasing number of countries, connected to both the distribution network and the central transmission network.

This strong market expansion requires the availability of and access to reliable information on the performance and sustainability of PV systems, technical and design guidelines, planning methods, financing, etc., to be shared with the various actors. In particular, the high penetration of PV into main grids requires the development of new grid and PV inverter management strategies, greater focus on solar forecasting and storage, as well as investigations of the economic and technological impact on the whole energy system. New PV business models need to be developed, as the decentralized character of photovoltaics shifts the responsibility for energy generation more into the hands of private owners, municipalities, cities and regions.

IEA PVPS Task 13 engages in focusing the international collaboration in improving the reliability of photovoltaic systems and subsystems by collecting, analyzing and disseminating information on their technical performance and failures, providing a basis for their technical assessment, and developing practical recommendations for improving their electrical and economic output.

The current members of the IEA PVPS Task 13 include:

Australia, Austria, Belgium, Canada, Chile, China, Denmark, Finland, France, Germany, Israel, Italy, Japan, Netherlands, Norway, South Africa, Spain, Sweden, Switzerland, Thailand and the United States of America.

This document is the first draft work plan for the extended Task 13 "Performance, Operation and Reliability of Photovoltaic Systems" for the period 2018-2021. It has been prepared based on the outcome of the Task 13 Meeting in Lugano, on March 27 to 29, 2017. Forty experts from twenty IEA PVPS member countries participated in this meeting and discussed topics for the new work programme. As follow-up, the Operating Agents with the support of the designated activity leaders prepared and elaborated the Task proposals from those topics for future Task 13 work. The first draft workplan of 31 July 2017 was prepared by the OAs based on those proposals, but they re-arranged the proposals in three main subtasks and added the commitments of the 36 Task members to each activity of extended Task work programme.

The First Draft Workplan and its 12 activities were discussed in detail and approved by all Task 13 experts of 38 organizations, who participated in the recent Task 13 expert meeting in Cologne, 12-13 October 2017. The modified and approved Draft Workplan as of 24 October 2017 was submitted for PVPS ExCo review prior to the PVPS ExCo Meeting in Melbourne, Australia 30 Nov - 01 Dec 2017.

2. Task Description

The overall mission of the PVPS Implementing Agreement for 2013 - 2017 is to enhance the international collaborative efforts, which facilitate the role of photovoltaic solar energy as a cornerstone in the transition to sustainable energy systems. The PVPS programme follows a strategy, which shall help to:

- Ensure sustainable PV deployment,
- Improve PV performance and reliability, and
- Assist in designing new market structures and regulations which will be suitable for the widespread adoption of unsubsidized PV.

Within the framework of PVPS, Task 13 aims at supporting market actors to improve the operation, the reliability and the quality of PV components and systems. Operational data of PV systems in different climate zones compiled within the project will allow conclusions on the reliability and on yield estimations. Furthermore, the qualification and lifetime characteristics of PV components and systems shall be analysed, and technological trends identified.

2.1. Motivation for Task 13 Extension

The scheduled end of Task 13 in August 2017 triggered discussions on a potential extension of ongoing work. Received feedback on this potential extension has been very positive, from both Task 13 participants and interested stakeholders. During the 14th Task meeting in Denver in September 2016 all Task 13 participants were in favour of striving for an extension, while suggesting new and relevant working topics for the coming three years. The current work in most of the activities has been very efficient and will be finalized as planned. As reported earlier the overwhelming responses to the workshops & webinars on the assessment of PV module failures and on PV system performance analysis as well as on financial models, which took place during Intersolar 2017 and EUPVSEC 2017, show a great interest of PV component and system developer, PV industry, test equipment companies as well as O&M companies to our work.

Together with Task 1, Task 13 will continue to be needed for the foreseeable future, and is of critical importance to the health of the industry. The reliability of PV plants and modules has been, and will continue to be an issue for investors and users. The PV industry continues to undergo rapid change, both in magnitude with a near-doubling of global capacity every 3-4 years, and new technology uses (e.g. changing cell thicknesses, PERC technology uptake, bifacial cells) and new deployment locations and methods, such as floating PV and bifacial modules.

The impact of these combined effects is that the reliability and performance of PV modules and systems requires further study to ensure that PV continues to be a good investment, as past performance of similar technologies is not guaranteed to be a complete/reliable predictor of future performance of new installations.

Performance and reliability of PV modules and systems is a topic that is attracting every day more attention from various stakeholders. In recent times it also comes in combination with the terms quality and sustainability. Task 13 has so far managed to create the right framework for the calculations of various parameters that can give an indication of quality of components and system as a whole. The framework is now there and can be used by the industry who has expressed in many ways appreciation towards the results included in the high quality reports.

What is still missing is the answer to the following questions (just as an example) that comes naturally out of the created framework: what is the range of degradation rates of PV systems? What is the uncertainty in PV plant performance predictions? Does the degradation rate depend on the methodology used to calculate it? What is the occurrence of failures in PV systems? Which failures are the most relevant? How can we rapidly detect failures or even predict when they may occur? The continuation of Task 13 will allow us to answer questions such as these based on a statistically relevant number of PV plants and on meaningful PV plant average age. Only now it is in fact possible to start answering to these questions as only now we have a large number of installations older than 10 years (milestones considered very important for the warranty production of PV modules.

The quality of Task 13 reports and deliverables stems from the continued participation of highly motivated experts in the field. Similar to the development of long-term databases for degradation and performance analyses, the relationships established in previous years need to be maintained and supported, as the work of this Task needs to show a similar momentum as the PV market.

The proposed work plan aims to perform work and produce deliverables in the following revised structure of Subtasks:

Subtask 1: New Module Concepts and System Designs
Subtask 2: Performance of Photovoltaic Systems
Subtask 3: Monitoring - Operation & Maintenance
Subtask 4: Dissemination

In summary, the motivation for extension is clear. The rapidly changing PV landscape with new emerging research activities and challenges means that the field is constantly evolving with new technologies and system designs being built each year. International collaboration in the areas of performance and reliability is critical for ensuring that members of the IEA and its stakeholders remain current on critical issues facing the industry.

2.2. Goals and Objectives

The general setting of Task 13 provides a common platform to summarize and report on technical aspects affecting the quality, performance, and reliability of PV systems in a wide variety of environments and applications. By working together across national boundaries we can all take advantage of research and experience from each member country and combine and integrate this knowledge into valuable summaries of best practices and methods for ensuring PV systems perform at their optimum. Specifically we aim to:

- Gather the most up-to-date information from each member country on a variety of technical issues related to PV performance and reliability. This will include summaries of different practices from each country, experiences with a variety of PV technologies and system designs.
- Gather measured data from PV systems from around the world. This data will be used to test and compare data analysis methods for PV degradation, operation & monitoring (O&M), performance and yield estimation, etc.
- Communicate to our stakeholders in a number of impactful ways including reports, workshops, webinars, and web content.

2.3. Approaches and Challenges

- The industry has a continued high interest in information on performance and reliability of PV modules and systems. In addition, financial models and their underlying technical assumptions have gained increased interest in the PV industry, with reliability and performance being key parameters used as input in such models.
- Companies, which have the respective data of reliability and performance at their disposal, however, tend to be reluctant to share this information. This is particularly true, if detailed numbers in question allow for financial insights.
- Here, legal contracts that restrict partners to secrecy on financial details often prohibits data sharing, even if project partners are highly motivated to share data in general terms.

2.4. Task Duration

The extended Task work is expected to be undertaken over a period of 36 months (September 2018 to August 2021).

2.5. Responsibilities for the Task Work

The work is structured on three levels: Task, Subtask and Activity. While the Operating Agent (OA) is responsible for leading the Task, the subtask and activity leaders are in charge of the work undertaken at these levels.

Responsibilities are shared in the following way:

A) Operating Agent (OA)

- Implementing the decisions of the PVPS Executive Committee
- Overall technical and administrative management of the task work
- Coordination, scheduling and communication between subtasks
- Preparing, leading and summarizing task meetings (twice annually)
- Reporting to PVPS Executive Committee regarding task meetings (status & annual reports)
- Coordination with other PVPS tasks, and with other relevant IEA Implementing Agreements
- Coordinate and ensure publications of technical reports, database and other material

B) Subtask Leader

- Coordination, scheduling and communication between activities
- Coordinating subtask activity with the Operating Agent and other subtask leaders
- Reporting to Operating Agent

C) Activity Leader

- Prepare activity plan and scheduling
- Coordinate activity work and communicate with other participants
- Produce and submit deliverables to the Operating Agent

2.6. Interaction with other Tasks, TCPs and international organizations

Co-operative work will be developed with other Tasks of PVPS on the following issues:

- Exchanging data and information on technical, environmental and economic aspects of PV power systems with **Task 1**
- Exchanging data and information on existing system performance & reliability, risk assessment methods for PV, data collection and monitoring needs as well as PV system technology changes with extended **Task 12** on "PV Sustainability".
- Providing output, especially on issues on performance, operation and failure analysis, to the stakeholders of extended Task 12 "PV Sustainability".

Co-operative work will be developed with other international organizations on the following issues:

- International Renewable Energy Agency (**IRENA**): Task 13 will collaborate with IRENA on failure risk assessment, PV quality infrastructure, management & quality services, risk mitigation and cooperation in quality assurance & standards. It is foresees to join the IRENA Assembly, webinars and other dissemination events.
- Industry Forum **SOLARUNITED**: Task 13 will support preparing whitepapers on performance of PV systems, understanding of failures and performance losses as well as tracking of PV defects in the field.
- IEA Task 13 will also collaborate with the International PV Quality Assurance Task Force (**PVQAT**). The aim of this collaboration is to exchange and disseminate results jointly. By this measure it can be expected that the output of Task 13 will reach a larger audience and that the work results are considered in the standardization process.

3. Subtasks

Task 13 is divided into four subtasks:

Subtask 1: New Module Concepts and System Designs
Subtask 2: Performance of Photovoltaic Systems
Subtask 3: Monitoring - Operation & Maintenance
Subtask 4: Dissemination

Subtask 1: New Module Concepts and System Designs

Subtask Leader: USA (SNL), Austria (PCCL)

Other Participants: AUT (AIT, OFI), BEL (IMEC, Engie Laborelec), CHL (SERC), CHN (CAS), DNK (SiCon), FIN (TUAS), FRA (EDF), DEU (TRE, ISE, ISFH), ISR (MGL), ITA (EURAC, RSE, IMT), NLD (UU), ZAF (CSIR), SWE (ABB, SP), CHE (SUPSI, TNC), USA (CWRU, NREL)

Context:

Objectives:

Total Duration: 36 months

<table>
<tr><td colspan="2">1.1: New Module Concepts, Designs and Materials</td></tr>
<tr><td>Activity Leader:</td><td>Joshua Stephenson Stein, USA (SNL)
Gernot Oreski, Austria (PCCL)</td></tr>
<tr><td>Other Participants:</td><td>AUT (AIT, OFI), DNK (SiCon), DEU (ISE, ISFH), ITA (IMT), JPN (AIST), NLD (UU), SWE (ABB), CHE (SUPSI), USA (CWRU)</td></tr>
<tr><td>Motivation to contribute</td><td>The activity will:
Provide a global survey of technical efforts aimed at lowering cost and increasing performance and reliability of PV modules by employing new designs, materials and concepts.
Result in the possibility to exchange information about promising materials, design concepts, and means for increasing the value of PV modules.
Provide recommendations on characterization methods for new technologies and give input regarding new requirements for standardization.</td></tr>
<tr><td>Target Audience:</td><td>PV customers, PV industry, testing equipment developers, testing companies, standardisation authorities, research institutions</td></tr>
<tr><td>Approach:</td><td>Part 1: Advanced Materials for PV
Part 2: New Module Concepts and Designs</td></tr>
<tr><td>Description of Work:</td><td>Part 1: New modules are using newly developed materials designed especially for PV applications. These range from solar cells, glazing materials, encapsulants, coatings, back sheets, cover sheets, electrical conductive adhesives, interconnectors, metallization pastes etc.

In the recent years many new crystalline silicon solar cells technologies came into the market, where standard interconnection and lamination processes were not applicable any more. These cells also require modified or new interconnection technologies and encapsulation materials, where were developed in parallel.

Another research focus was given to materials with functional properties like selective optical or permeation properties. The properties and benefits of such materials</td></tr>
</table>

	and their expected lifetimes as well as interactions with other module components within different climates is of great interest. This task will collect data and results on materials and durability testing from member countries. Part 2: New module designs are being investigated by many companies and promise lower costs, higher yields, and lighter weight. These innovations include but are not limited to bifacial, glass-glass, thin glass, frameless, shingled cells with conductive adhesive, back-contacted cells, lightweight modules, module coatings for anti-reflective and anti-soiling, and integrated power electronics. This task will collect data, summarize research results, and make recommendations on the constraints as well as opportunities for achieving module level performance and reliability gains. Consequences for standardization activities will be discussed as well.
Deliverables:	• Report: "Designing New Materials for Photovoltaics: Opportunities for Lowering Cost and Increasing Performance through Advanced Material Innovations" • Workshop: International workshop to present global innovations in PV materials, module and system designs for PV applications.
Duration:	36 months

1.2: Bifacial Photovoltaic Modules and Concepts	
Activity Leader:	Joshua Stephenson Stein, USA (SNL) Christian Reise, DEU (ISE)
Other Participants:	AUT (AIT, PCCL), BEL (Engie Laborelec), CHL (SERC), CHN (CAS), DNK (SiCon), FIN (TUAS), FRA (EDF), DEU (TRE), ITA (RSE), NLD (UU), ZAF (CSIR), SWE (ABB, SP), CHE (SUPSI, TNC)
Motivation to contribute	The activity will: • Result in a collection and analysis of field and laboratory performance data from bifacial PV modules and systems from member countries.

	• Provide a summary of factors that affect bifacial PV performance, quantitative methods to estimate performance gains, and review system design guidelines, standards, and models aimed at supporting bifacial PV deployments.
Target Audience:	PV customers, PV industry, testing equipment developers, testing companies, standardisation authorities, research institutions
Approach:	Part 1: Collect and summarize field and laboratory data from bifacial modules and systems from member countries. Part 2: Summarize available bifacial module designs, system design guidelines, and predictive performance modeling methods being used by member countries.
Description of Work:	Part 1: Many research institutions and companies are currently collecting data from bifacial PV modules and systems in a wide range of climates and design scenarios. This activity will collect and examine this information to summarize important findings from these numerous studies. Part 2: New testing and characterization standards, system design guidelines, and predictive performance models are being developed and tested by member countries. This activity will invite member countries to evaluate these new standards, guidelines, and models and provide feedback that will help to improve these new tools.
Deliverables:	• Report: "Bifacial Photovoltaic Modules and Systems: Experience and Results from International Research and Pilot Applications" • Workshop in partnership with the "bifiPV" group (http://bifipv-workshop.com)
Duration:	36 months

1.3: Performance of New Photovoltaic System Designs	
Activity Leader:	Marc Koentges, DEU (ISFH)
Other Participants:	AUT (AIT), BEL (Engie Laborelec), FIN (TUAS), DEU (ISE), ISR (MGL), ITA (RSE), NLD (UU), CHE (SUPSI, TNC), USA (SNL)
Motivation to contribute	The activity will: • Give recommendations how to characterize the performance of innovative parts in PV systems where the current methods cannot be applied. • The economic impact of these concepts is analysed. • Collect performance experiences with innovative PV systems and summarize as case studies.
Target Audience:	PV system or PV component developer, PV industry, testing equipment developers, testing companies, standardisation authorities, Utilities
Approach:	In this task we will present new characterization methods for “New PV System Designs” to determine the performance and the usability of the new system or new system parts. Where no methods are available the performance, pros and cons will be explained by case studies.
Description of Work:	New PV system designs are being developed to increase the value of the energy produced by either lowering the installation costs, increasing the efficiency or adding functions to the system. Some of these innovations include advanced power electronics to optimize the performance ratio of PV systems. Furthermore, new PV systems with additional functions like coupling PV energy with storage and power grid, including storage for electro mobility, agricultural PV, and floating PV systems will be evaluated. For most of the mentioned new system components and double function systems no standards exist how to characterize and normalise the performance of the system or parts in the PV system. We will summarize system-level innovations, show how the system performance of such new systems can be characterized and demonstrate

	their opportunities for achieving high system level performance.
Deliverables:	• Report: "Performance of New Photovoltaic System Designs" • Workshop: International workshop to present methods to determine the performance of new components in PV systems
Duration:	36 months

1.4: Service Life Prediction	
Activity Leader:	Karl-Anders Weiß, DEU (ISE)
Other Participants:	AUS (Eki), AUT (AIT, OFI, PCCL), BEL (IMEC), FRA (EDF, INES), ITA (EURAC, IMT), JPN (AIST), CHE (SUPSI), USA (NREL, CWRU)
Motivation to contribute	The Service Life Prediction (SLP) activity will: • Harmonize the terms to describe life time, durability and service life predictions of PV modules and systems • Provide service life models for PV modules and systems under different climatic conditions including degradation effects of components (in cooperation with Subtask 2) and the interaction of different stress-factors including the effect of voltage and current • Provide good practice recommendations for accelerated service life testing for PV modules • Provide scientifically validated background for the service life models for specific module types in different climates which allows SLP rating of modules (and plants)
Target Audience:	Operation companies of PV plants, PV customers, PV industry, investors, standardisation authorities

Approach:	Part 1: Development of a glossary for terms to describe lifetime, durability and service life predictions of PV modules and systems. Part 2: Evaluation of available data on microclimatic loads including voltage, current and soiling effects for PV modules and plants and related performance data and definition of end-of-life conditions for modules and plants. Part 3: Development of degradation models for different types of PV modules using the climatic load data of part 1 and models for degradation, O&M and quality effects in materials and components of modules. Part 4: (eventually, if data of additional components is available) degradation model for PV plants.
Description of Work:	Part 1: Terms used to describe service life and life time prediction of PV modules and systems are collected and the best terms are selected and defined in a way that they can be used and interpreted in the same way internationally. Part 2: PV modules and plants are installed in different climatic regions leading to different microclimatic stress situations for materials. Part 2 evaluates available data sets including climatic data and performance data for modules and plants which already show degradation effects. Special emphasis will be put on the effects of the operation conditions like voltage, current and temperature (BIPV). Part 3: will also determine end-of-life conditions in terms of a power-loss limit for modules and a statistical approach for the module power loss leading to a defined plant power loss based on information from plant operators and investors. Part 4: Degradation models for materials and components of modules are developed and collected for selected module types (amongst them at least one basic type with poly Si, EVA encapsulation and polymeric backsheet) and integrated in a degradation model which allows simulation of the performance behaviour over at least 25 years in different climatic or operational conditions. Part 4: If enough data for degradation models for additional components of PV power plants (additional to modules) is available, a model is developed which integrated the degradation models for modules and other components to a model for complete plants for deterministic module degradation, potential induced

	degradation and statistically distributed degradation of modules.
Deliverables:	• Report: "Service Life Estimation Models for PV Modules" • Report: "Effect of Module Degradation on PV Power Plants"
Duration:	36 months

Subtask 2: Performance of Photovoltaic Systems

Subtask Leader:	David Moser, ITA (EURAC)
Other Participants:	AUS (Eki, MU), AUT(AIT), BEL (3E, IMEC, Engie Laborelec), CAN (CANMET), CHL (SERC), CHN (CAS), DNK (SiCon), FIN (TUAS, FORTUM), FRA (EDF), DEU (HZB, ISE,TRE), ISR (MGL), ITA (RSE), NLD (UU), ZAF (CSIR), SWE (ABB, PE, SP), CHE (SUPSI), THA (CSSC), USA (CWRU, SNL)
Objectives:	The objectives of Subtask 2 is to study the uncertainty related to the main parameters affecting yield assessment and long-term yield prediction. This will in turn have an impact on the LCOE and on the business model selected (ST2.1). Special attention will then be given to some aspects related to the factors studied in ST2.1. Availability has an important impact on yield and failure avoidance through predictive monitoring will be studied in ST2.2. In ST2.3 the focus is on the impact of climate of the energy performance of modules. In ST2.4 we will study the impact of soiling. Finally, all the degradation factors will be taken into account to analysis performance loss rates on large amount of high quality and low quality data in ST2.5.
Total Duration:	36 months

2.1: Uncertainty in Yield Assessments and Photovoltaic LCOE	
Activity Leader:	David Moser, ITA (EURAC)
Other Participants:	AUS (Eki), BEL (3E, IMEC), CHL (SERC), DNK (SiCon), FRA (EDF), DEU (ISE, TRE), ISR (MGL), SWE (ABB)
Motivation to contribute	The activity will: • Build upon the results of ST2.3 2014-2017 by translating the uncertainty framework into real examples on the influence of various parameters on the initial and lifetime Yield Assessment • Investigate further the features for the most important influencing parameters • Create scenarios for the evaluation of the impact of the uncertainty on the P90/P50 ratio • Link the uncertainty framework and the scenarios with cash flow models and LCOE calculations comparing with real case studies.
Target Audience:	PV customers, PV industry, O&M companies, investors, asset managers, research institutions
Approach:	Part 1: Estimation of the uncertainty in the energy yield (initial yield assessment and life time yield assessment). Part 2: Real case studies collection and impact on P90/P50 ratio. Part 3: Uncertainty scenarios and influence on business models and LCOE.
Description of Work:	Part 1: The topic was covered by ST2.3 and 3.1 (and in ST1) during the previous period but the output so far is just the beginning of the definition of an uncertainty framework. There is now the need to translate the uncertainty framework into real examples of the influence of various parameters on Yield Assessment and LTYA. The activity will involve the analysis of distributions (Irradiance, temperature, degradation, PR, Yield, etc.) and the estimation of the uncertainty in the energy yield (initial yield assessment and life time yield assessment) studies including all important factors

	starting from the work carried out in ST2 and ST3 in the 2014-2017 period. Part 2: Collect real case studies to identify how the uncertainty was calculated and if it fits with real operational data. This activity will be used to create scenarios to show the impact of the uncertainty in the P90/P50 ratio. Part 3: The scenarios will be used to show how uncertainty can influence the life time assessment of cash flow models and ultimately the LCOE. This exercise will also be done using data coming from real PV projects. A result will be the creation of a link with a standardised PV business model.
Deliverables:	• Flash Report (M12): "How Uncertain is the Yield Assessment in Photovoltaic Projects?" • Short Report (M24): "Uncertainties of Initial Yield Assessment and Scenarios in Real Case Studies" • Short Report (M36): "From Modelled to Real LCOE of PV Projects"
Duration:	36 months

Total Duration: 36 months

2.2: Predictive Monitoring	
Activity Leader:	Mike Green, ISR (MGL) David Moser, ITA (EURAC)
Other Participants:	AUS (Eki), AUT (AIT), BEL (3E, Engie Laborelec), DNK (SiCon), FIN (FORTUM), DEU (HZB), ITA (RSE), NLD (UU), CHE (SUPSI), USA (CWRU, SNL)
Motivation to contribute	The activity will: • Increase the knowledge at international level on the use of predictive monitoring to prevent failures based on real field data

	• Attempt to link predictive monitoring with specific failures • Assess the possibility to integrate the algorithms in monitoring platforms, data loggers, inverters, etc. and how this can have an impact on O&M strategies (in collaboration with Subtask 1)
Target Audience:	PV customers, PV industry, inverter manufacturers, O&M companies, testing equipment developers, testing companies, research institutions
Approach:	Part 1: Definition of algorithms used in the field of predictive monitoring as literature review Part 2: Analysis of the effectiveness of predictive monitoring in avoiding failures in real case studies (at least 20 case studies with real and false alarms) and link with specific failure modes Part 3: Evaluate the interest in integrating the algorithms in monitoring platforms and data loggers and the use of the methodology to optimise O&M strategies
Description of Work:	Part 1: In the literature review we will summarize all the work carried out so far in Task 13 in terms of algorithms used for predictive monitoring and we will also report the work from other projects Part 2: More intensive study of clustering methods and use other of machine learning techniques is needed for the application of predictive monitoring. This needs an analysis of different type of failures and the identification of more specific failures. At least 20 real cases of (inverter) failures will be explored describing the effectiveness of the methodology assessing real predictions with false alarms (depending on the number of proposed models a round robin to assess their effectiveness could be organized). The next step is to try to link the results with more specific failures. Part 3: Interested parties will be included in the discussion for the implementation of the methodologies to study how the algorithms can be successfully integrated into existing platforms and what impact this can have in O&M strategies.
Deliverables:	• Flash report (M12) "State of the Art in Predictive Monitoring: Where do we Stand?"

	• Short Report (M24): "The Use of Predictive Monitoring as Failure Avoidance in Real Case Studies" • Short Report (M36): "The Use of Predictive Monitoring in O&M Strategies"
Duration:	36 months

2.3: Climatic Rating of Different Technologies for Different Countries	
Activity Leader:	Markus Schweiger, DEU (TRE)
Other Participants:	AUT (AIT, OFI), BEL (IMEC), CHL (SERC), CHN (CAS), FIN (TUAS), DEU (ISE, HZB), NLD (UU), SWE (SP), CHE (SUPSI), THA (CSSC), USA (CWRU, SNL), JPN (AIST), ZAF (CSIR)
Motivation to contribute	This activity will investigate all technology related influencing factors on the energy yield of PV modules in different climates. In particular: • Reduce investment risks • Reduce uncertainties of energy yield estimations • Provide good practise method for energy yield prediction in different climates • Provide reference data sets for PV modules and climates • Asses different PV module technologies performance in different climates • Facilitate a comparison between different PV module types
Target Audience:	Modellers and institutes, O&M companies, end customers, investors, testing companies, standardisation authorities, manufacturers, project developers, software engineering and users.

Approach:	• Collect climatic data sets for different mounting conditions and different climates • Collect energy rating data for different PV module technologies • Generate reference climate data sets according to IEC 61853-4 and linear loss factor analysis (LPLA) approach • Quantify performance loss factors due to temperature conditions, low irradiance behaviour, spectral effects, angular losses and soiling for different technologies and climates • Perform a comparison between energy rating approaches
Description of Work:	A major part of PV investment is given by the price of photovoltaic modules, which is determined by their output power rated at standard test conditions (STC). Real outdoor operating conditions are in general substantially different from STC conditions. Energy rating of PV modules according to IEC 61853 parts 1 to 4 is facing some structural problems and is thus not published yet. The energy yield estimation of different PV module technologies by simulation tools exhibits high uncertainties due to limited availability of sufficient PV module performance data. Thus it is important to understand all influencing factors on the energy yield performance of PV modules in detail. Such knowledge will provide a scientific basis to enable accurate yield estimates for different technologies and optimize energy yield performance for different climates. Preliminary results have shown significant differences in the energy yield of PV modules available at the market of up to 23% depending on power rating, technology and climate. The ultimate owner of the PV power plant should consider a well-defined module performance ratio before making an investment decision. The competiveness of solar projects can be enhanced by PV modules with reliable long-term performance and optimal energy yield performance for the climate of installation. With a linear performance loss analysis (LPLA) the MPR of PV modules can be forecasted fast, accurately and inexpensively for different climates. Simple reference environmental data sets and energy rating data according to IEC 61853 series measured in the

	laboratory serve as input data. As latest results have shown an energy yield prediction based on calculated MPR values with a deviation of ± 3% to measured MPR values can be achieved. The approach takes into account all relevant impact factors on energy yield such as the influence of module temperature, low irradiance conditions, spectral and angular effects as well as soiling. Furthermore, it allows quantifying and comparing the various influencing factors for different PV module technologies and different climates. Therefore, according to this new approach the energy yield of PV modules is influenced by five individual loss factors. The mechanisms correspond to loss terms ΔMPR for different climates which can be separated. Loss mechanisms which influence the MPR of electrically stable PV modules are temperature (ΔMPR_{TEMP}), low irradiance (ΔMPR_{LIRR}), spectral effects (ΔMPR_{MMF}), angular losses (ΔMPR_{AOI}) and soiling (ΔMPR_{SOIL}).
Deliverables:	• Report: "Guidance for Energy Rating of Different PV Module Technologies in Different Climates"
Duration:	36 months

2.4: Impact of Soiling on PV System Performance and Reliability	
Activity Leader:	Boris Farnung, Christian Schill, DEU (ISE)
Other Participants:	AUS (Eki, MU), BEL (3E, Engie Laborelec), CAN (CANMET), CHL (SERC), FIN (FORTUM), DEU (TRE), ISR (MGL), ZAF (CSIR), ESP (CENER), SWE (SP), USA (SNL)
Motivation to contribute	The activity will: • Compare and summarize different approaches and methods to determine soiling. This includes soiling measurements from "soiling sensors" (e.g. module + self-cleaning reference cell or similar), determination of soiling effects from inverter readings and overall plant performance.

	• Estimate potential energy yield losses of utility scale PV installations due to soiling and snow, based on satellite derived risk maps and performance models. • Compare existing soiling models with real world PV installation losses based on local on-site-soiling measurements. • Mitigation of soiling losses by implementing new plant concepts and plant designs, new module technologies and materials (Link to Subtask 1). • Provide an overview and summary of cleaning technologies and a categorization of these technologies into effectiveness vs. cost vs. water consumption as input to ST 3.3.
Target Audience:	PV customers, PV industry, O&M companies, investors, asset managers, testing equipment developers, testing companies, standardization authorities, research institutions
Approach:	Arid regions tend to have a stronger soiling risk but also have a very high solar potential. Secondly, PV power plant operators in moderate climates (e.g. Europe, North America, Canada) observe high losses due to snow. Part 1: Estimate real world PV installation losses based on local on-site-soiling measurements. Analysis of metrics to quantify soiling losses; Analysis of measurement techniques to measure physical soiling losses (M_{pp}-, I_{sc}-, spectral transmission of glasses-, inverter-based), summarized into Good Practice Recommendations as input to Activity 3.3. Part 2 will estimate potential energy yield losses of plants in high soiling and snow risk zones (as derived from satellite derived global risk maps) by modelling standard performances of typical PV plants – subjected to periodical yield losses from soiling and snow. Part 3: Comparison of the results from Part 1 and 2. Determining in-the-field revenue losses of power plants due to soiling and a simple economic operation model of power plants. Part 4: Summarize and categorize to-date available cleaning technologies, their effectiveness, water consumption, weighted average cost of cleaning and impact on return on operating asset.

	Part 5: Outlook, mitigation of soiling and snow losses by new plant and module concepts and designs, new materials (link to Subtask 1).
Description of Work:	From operational data of plants and based on local experience, it is evident that soiling and snow losses do play a major role in affecting energy yield outcome. However, the real extent of the problem on a global scale remains unclear. Just a few PV power plants do operate soiling measurement stations to try to estimate real world PV installation losses, and if so, the problem persists of how to estimate the performance of utility-scale power plants. Same problem exists for the detection and measurement of snow losses. This activity addresses the question of how to model soiling and snow losses for a specific location. Moreover, generalize losses from point-wise measurements to utility-scale plant losses. Potential energy yield losses of PV plants in high and moderate risk zones (as derived from satellite derived global risk maps) will be estimated in the activity by modelling standard performances of typical PV plants – subjected to periodical yield losses from soiling, snow, and under consideration of climatological long-term time series of rainfall events. An increasing number of publications exists in the literature, quantifying the extent of losses due to soiling – mainly based on empirical studies from all the world, with real world electrical plant data and also losses on a per-module basis. However, little is known about the real impact these soiling effects do have on the revenue from operating power plants in e.g. arid regions over longer time spans. Therefore, potential revenue losses of PV installations due to soiling will be summarized. Mitigation strategies like novel plant designs (e,g bifacial modules on trackers, ST 1.2) or cleaning technologies will be discussed. Finally, an outlook in the future is given with link to Subtask 3: What economic impact will soiling and snow have, if module prices decrease further, anti-soiling coating becomes more reliable, new module designs to catch on (e.g. bifacial).
Deliverables:	• Report: “Assessment of Soiling Losses – Impact on the Performance of PV Power Plants.”

Duration:	36 months

2.5: Assessment of Performance Loss Rate	
Activity Leader:	David Moser, ITA (EURAC) Roger French, USA (CWRU)
Other Participants:	AUS (Eki), AUT (AIT), BEL (3E, Engie Laborelec), CAN (CANMET), CYP (UOC), CHN (CAS), FRA (EDF), DEU (ISE, TRE), ITA (RSE), NDL (UU), SWE (PE), USA (SNL)
Motivation to contribute	The activity will: • Explore the methodologies for the calculation of the degradation and/or performance loss rate (PLR) • Support the standard IEC 61724-4 for a standardised definition of performance loss rate and degradation • Evaluate the impact of filtering techniques (if used) • Calculate the uncertainty in the modelling of degradation/performance loss rate • Use the methodologies on real field data including data from the Task 2 / Task 13 performance database
Target Audience:	PV customers, PV industry, O&M companies, investors, asset managers, testing equipment developers, testing companies, standardization authorities, research institutions
Approach:	Part 1: Literature review of the existing methodologies for the calculation of degradation / PLR in PV plants. Part 2: Determination of the uncertainty in the calculation of degradation / PLR (to be fed back to Activity 2.1) based on high quality data (irradiance, yield, etc.) and based on low quality data (only energy data available)

	Part 3: Support to the definition of a standardized methodology
Description of Work:	Part 1: Various models can be applied for the calculation of degradation (or Performance Loss Rate) of the performance of PV systems. In this activity there will be a comparison of results using statistical and deterministic methods. The impact of filtering techniques will also be studied. Part 2: What is the uncertainty of degradation/PLR when high quality data is available? What happens if only energy data is available (large amount of data)? In Part 2 we will compare uncertainties and perform a survey to understand which typical values are used in Yield Assessments (feedback loop to Activity 2.1). Part 3: Finally the results will be used to support the proposed standard IEC 61724-4
Deliverables:	• Flash Report (M12): "How is Degradation / PLR Currently Calculated?" • Short Report: "Calculation of Degradation of PV Systems with High Quality and Low Quality Data" • Short Report: "How Uncertain is Degradation / PLR in PV Projects?"
Duration:	36 months

Subtask 3: Monitoring – Operation & Maintenance

Subtask Leader: Ulrike Jahn, DEU (TRE)

Other Participants: AUS (Eki, MU), AUT (AIT, OFI), BEL (3E, IMEC, Engie Laborelec), CHL (SERC), CHN (CAS), DNK (SiCon), FIN (TUAS), DEU (ISE, ISFH), ISR (MG), ITA (EURAC, IMT), SWE (PE), CHE (SUPSI), USA (CWRU, SNL)

Objectives: To increase the knowledge of methodologies to assess technical risks and mitigation measures in terms of economic impact and effectiveness during operation (ST 3.1). Special attention will be given to provide best

	practice on methods and devices to qualify PV power plants in the field (ST 3.2). To compile guidelines for O&M procedures in different climates and to evaluate how effective O&M concepts will affect the quality in the field (ST 3.3) The latter will include best practise recommendations for the assessment of energy losses due to soiling & snow. Task 13 aims at contributing with the O&M guidelines to its objectives and to improve the communication among the different stakeholders.
Total Duration:	36 months

3.1: Quantification of Technical Risks during Operation & Maintenance	
Activity Leaders:	Magnus Herz, Erin Ndrio, DEU (TRE) David Moser, ITA (EURAC)
Other Participants:	AUT (AIT), BEL (3E), FIN (FORTUM), DEU (ISE, ISFH), SWE (PE), CHE (SUPSI), USA (SNL)
Motivation to contribute	The activity will: • Increase the knowledge of methodologies to assess technical risks and mitigation measures in terms of economic impact and effectiveness during operation (link to ST2.2 / ST2.5 and ST1.2 of phase 2014-2017) • Investigate the most important risk parameters and their related uncertainties by collecting real case studies and building up a database with the acquired information (link to ST1.4 /ST 2.1/ ST2.5 and ST3.4 of phase 2014-2017)
Target Audience:	O&M companies of PV plants, PV customers, PV industry, standardisation authorities, investors, banks, insurances, asset managers
Approach:	Part 1: Literature review of common practice in quantifying the impact of Technical Risks during operation. Part 2: Definition of the most important parameters for the risk analysis, e.g. probability, occurrence, yield loss,

	repair cost (link to ST2.5). Collection of real case studies in order to derive the characteristic risk-values. Part 3: Overview of O&M measures, which are aiming to reduce the Technical Risks (link to ST3.3). Collection of typical costs for individual O&M services and estimated cost-benefit analysis based on examples and real case studies.
Description of Work:	Part 1: The typical approach in evaluating Technical Risks is to apply a classic Failure Modes and Effects Analysis (FMEA). With the resulting Risk Priority Number (RPN) the evaluated risk can be ranked and compared with other risks. The disadvantage of this approach is that the risk is evaluated in a qualitative way and cannot be transferred to further calculations, e.g. into a financial model. Within the framework of the recently completed Solar Bankability project a Cost Priority Number (CPN) has been introduced. This CPN includes the economic impact of each risk on a quantitative basis. Therefore, part 1 shall give an overview of common methodologies how the Technical Risks during operation can be evaluated and shall provide recommendations for the best practice. Part 2: In order to quantify the risk, the risk itself and its structure has to be defined. The main criteria are the probability of the occurring failure and the expected loss. The probability can be determined by statistical surveys. The loss can be divided into smaller fragments, e.g. yield loss, repair cost, labour cost or substitution cost, and further translated into economic loss. These parameters, which are partly also applied in ST2.1, needs to be defined and their values shall be determined by collecting and analysing real case studies. The collected data shall be stored in a database. Part 3: Most of the risks can be mitigated with appropriate O&M measures. These O&M measures will be introduced in ST3.3. For the most important measures the cost range shall be collected and implemented in the subsequent cost-benefit analysis of the O&M measures. The theoretical approach to estimate the effectiveness of the mitigation measures shall be compared with several real case studies, which shall be also collected in Part 3 and can be derived from ST3.2.

Deliverables:	• Flash report (M12): "Common Practice for Quantifying the Impact of Technical Risks during Operation" • Database (M24): "Database with Quantified Technical Risks during Operation" • Short report (M36): "Cost-benefit Analysis of O&M Strategies – How to Quantify the Impact of Risk Mitigation Measures"
Duration:	36 months

3.2: Characterization of PV Power Plants using Mobile Devices	
Activity Leader:	Werner Herrmann, DEU (TRE) Karl Berger, AUT (AIT)
Other Participants:	AUS (MU), AUT (OFI), BEL (IMEC, Engie Laborelec), CHN (CAS), DNK (SiCon), FIN (TUAS), DEU (ISE, ISFH), ITA (EURAC, IMT), CHE (SUPSI)
Motivation to contribute	The activity will: • Provide good practice on methods and devices to qualify PV power plants in the field, e.g. mobile I-V curve measurement, IR/EL imaging, UV-Fluorescence method, dark I-V measurement, daylight lock-in thermography, spectroscopic methods • Evaluate uncertainties of mobile devices for characterising PV power plants, comparison with laboratory data • Legal framework for using mobile devices (e.g. drones)
Target Audience:	Operation & Maintenance companies of PV plants, PV customers, PV industry, testing equipment developers, testing companies, standardization authorities
Approach:	Part 1: Collect field data, as well as literature review and local reports, on power plants operating multiple years in the field. Market research of common test devices for I-V curve measurements, IR/EL imaging/ UV FL

	method, dark I-V measurement , daylight lock-in thermography, spectroscopic methods Part 2: Determining the uncertainties of mobile devices, required calibration procedures as well as strengths and weaknesses of field measurements. Comparison to laboratory measurements. Best practice recommendations and guidelines on using mobile devices for qualification of PV power plants. Part 3: Collect information on legal framework for using mobile devices (e.g. drones)
Description of Work:	Part 1: Participants will each collect and share with other participants' field data from several PV power plants per country. Participants will also compile a list of existing sources of literature/market research for mobile test devices. Part 2: The different measurement methods/devices to collect I-V curve data, EL, IR, UV FL images, dark I-V, spectroscopic methods in the field will be discussed and assessed regarding different quality levels and involved costs. Thereby the uncertainty, the required calibration procedures and the strengths & weaknesses of the field measurements will be derived. Finally, recommendations and guidelines for best practices to qualify PV power plants using mobile devices will be developed. These guidelines will provide harmonized methods to handle warranty claim issues for different target audiences. Part 3: Which legal framework conditions have to be considered in different countries? Existing regulations for using "unmanned aerial vehicles"(UAV) are compiled and discussed for different countries.
Deliverables:	• Report: "Good Practice Recommendations to Qualify Photovoltaic Power Plants using Mobile Devices"
Duration:	36 months

3.3: Guidelines for Operation & Maintenance Procedures in Different Climates/Countries	
Activity Leader:	Ulrike Jahn, DEU (TRE) Christian Schill, DEU (ISE)
Other Participants:	AUS (Eki, MU), AUT (AIT), BEL (IMEC, Engie Laborelec), CHL (SERC), FIN (FORTUM), ISR (MGL), ITA (EURAC), JPN (AIST), ESP (CENER), SWE (PE), CHE (SUPSI), USA (SNL)
Motivation to contribute	The activity will: • Prepare guidelines for O&M procedures in different climates and countries • Evaluate how an effective O&M concept will affect the quality in the field • Assess how an effective O&M strategy will reduce/avoid failures and risks • Improve quality measures, e.g. training of installers • Provide good practice recommendations for the assessment of energy losses due to soiling • Assess and provide socio-economic "best-time-to-clean models" based on constraints like local labour costs, local feed-in-tariffs, water availability and local weather forecast if possible.
Target Audience:	Operation & Maintenance companies of PV plants, PV customers, PV industry, testing equipment developers, testing companies, standardization authorities
Approach:	Part 1: Literature review of climate/country specific O&M requirements, concepts and strategies. Part 2: Analysis and evaluation of the effectiveness (link to ST3.1) of the common procedure depending on climate/country specific conditions. Part 3: Model the "best-time-to-clean" the power plant under various constraints, e.g. medium range weather forecast, local labour costs, local feed-in-tariffs, also water availability (Environmental impact assessment might need to be considered as well).

	Part 4: Climate/country specific best practices and guidelines with the focus on reducing safety and performance risks in a most efficient way.
Description of Work:	Part 1: There exist various O&M concepts and only a few O&M guidelines on a national level. The existing O&M guidelines will be summarized highlighting the similarities and differences. Part 2: Procedures for plant monitoring and supervision, methods of performance analysis as well as procedures for preventative and corrective maintenance measures will be evaluated and assessed in terms of economic impact in different climates and countries. Part 3: When is the best time to clean – that might depend on what kind of quantity one wants to optimize: is it the energy yield or the revenue? Depending on per-site constraints like local labour costs, local feed-in-tariffs, water availability and local weather forecast, this question might be answered by a suitable socio-economic model. Part 4: From this rating in part 2, best practice guidelines on O&M procedures will be developed for specific countries in order to optimize energy production and revenues and to reduce technical and economic risks during the important O&M phase.
Deliverables:	• Short report: "Good Practice Recommendations for the Assessment and Mitigation of Revenue Losses due to Soiling" • Report: "Guidelines for Operation & Maintenance Procedures in Different Climates/Countries".
Duration:	36 months

Subtask 4: Dissemination

Subtask Leader:	Ulrike Jahn, DEU (TRE) Boris Farnung, DEU (ISE)
Other Participants:	All Task 13 participates
Context:	Up-to date information on performance, reliability and maintenance of photovoltaic systems is rare and sought after. As such information is of vital importance for yields and guarantee issues as well as for safety aspects, manufacturers, plant owners, banks and EPCs have stressed their interest in respective information and data to be compiled in the course of the project.
Objectives:	To disseminate information on the work and results of Task 13 To provide a forum for exchange of information between research and industry
Total Duration:	36 months

4.1: Information Material	
Activity Leader:	DEU (TRE)
Other Participants:	All Task 13 participants
Target Audience:	PV industry, PV component manufacturer, utilities, technological research laboratories, PV system operators, PV system owners, developers and construction consortia, political decision makers, standardisation authorities
Approach:	To reach a maximum level of dissemination, various kinds of information material will be prepared and distributed through different communication channels.
Description of Work:	Ways of dissemination will include: • Presentations and papers • Webinar • Workshop

	• Best Practice Guide • Posters • Flyers • Website
Deliverables:	D 4-1: Task 13 work and results presented in slides or papers at eight international and national events D 4-2: Posters on Task work and results designed and presented at three international events D 4-3: Flyers on Task 13 work and objectives edited and distributed in hard copy and digitally D 4-4: Articles or announcements contributed to PVPS Annual Report D 4-5: All deliverables available at the PVPS website; selected deliverables available at the IEA website
Duration:	36 months

4.2: Workshops	
Activity Leader:	Ulrike Jahn, DEU (TRE) Boris Farnung, DEU (ISE)
Other Participants:	All Task 13 participants
Target Audience:	PV industry, PV component manufacturer, utilities, technological research laboratories, PV system operators, PV system owners, developers and construction consortia, political decision makers, standardisation authorities
Approach:	To give the opportunity of interactive exchange and discussion
Description of Work:	To organise workshops at national and international level on different topics elaborated in Task 13
Deliverables:	• Workshop at EU PVSEC 2019 • Workshop at Intersolar Europe 2020 • Workshop at EU PVSEC 2021
Duration:	36 months

4. Lead of Activities and Contributions to Work Plan

2018 - 2021 — Performance, Operation & Reliability of Photovoltaic Systems

		AUS		AUT			BEL			CAN	CHL	CHN	CYP	DNK	FIN		FRA		DEU				ISR	ITA			JPN	NLD	ZAF	ESP	SWE			CHE		THA		USA	
		Eki	MU	AIT	OFI	PCCL	3E	IMEC	Labor elec	CANMET	SERC	CAS	UOC	SiCon	TUAS	FORTUM	INES	EDF	TRE	ISE	ISFH	HZB	MGL	EURAC	RSE	IMT	AIST	UU	CSIR	CENER	ABB	PE	SP	TNC	SUPSI	CSSC	CWRU	NREL	SNL
Subtask Leader	**Subtask / Activity**																																						
SANDIA / PCCL	**Subtask 1: New Module Concepts and System Designs**																																						
SANDIA/PCCL	1.1 New Module-Concepts, -Designs and -Materials			C	C	AL								C						C	C					C	C	C			C				C		C		AL
SANDIA/ISE	1.2 Bifacial Photovoltaic Modules and Concepts			C		C			C		C	C		C	C			C	C	AL					C			C	C		C		C	C	C				AL
ISFH	1.3 Performance of New Photovoltaic System Designs			C					C						C		R			C	AL		C		C			C						C	C		R		C
FhG ISE	1.4 Service Life Prediction	C		C	C	C		C									C	C		AL				C		C	C								C		C	C	
EURAC	**Subtask 2: Performance of Photovoltaic Systems**																																						
EURAC	2.1 Uncertainty in Yield Assessments and PV LCOE	C					C	C			C			C				C	C	C			C	AL							C								
MG Israel / EURAC	2.2 Predictive Monitoring	C		C			C		C					C		C						C	AL	AL	C			C							C		C		C
TRE	2.3 Climatic Rating of Different Technologies for Different Countries			C	C			C			C	C			C				AL	C		C					C	C	C				C		C	C	C		C
FhG ISE	2.4 Impact of Soiling on PV System Performance and Reliability	C	C				C		C	C	C					C			C	AL			C						C	C		C	C						C
EURAC / CWRU	2.5 Assessment of Performance Loss Rate	C		C			C		C	C		C	C					C	C	C				AL	C			C				C					AL		C
TÜV Rheinland	**Subtask 3: Monitoring - Operation & Maintenance**																																						
TRE/EURAC	3.1 Quantification of Technical Risks during O&M			C			C							R		C			AL	C	C			AL								C			C		R		C
TRE/AIT	3.2 Characterization of PV Power Plants using Mobile Devices		C	AL	C			C	C			C		C	C				AL	C	C			C		C									C				
TÜV R /FhG ISE	3.3 Guidelines for O&M Procedures in Different Climates/Countries	C	C	C				C	C		C					C			AL	AL			C	C			C			C		C			C				C
TRE / FhG ISE	**Subtask 4: Dissemination / Outreach**																																						

5. Deliverables

No.	IEA PVPS Task 13 Deliverables (2018 - 2021)
D 1-1	Report: “Designing New Materials for Photovoltaics: Opportunities for Lowering Cost and Increasing Performance through Advanced Material Innovations”
D 1-2	Report: “Bifacial Photovoltaic Modules and Systems: Experience and Results from International Research and Pilot Applications"
D 1-3	Report: "Performance of New Photovoltaic System Designs"
D 1-4	Report: "Service Life Estimation Models for Photovoltaic Modules"
D 1-5	Report: "Effect of Module Degradation on Photovoltaic Power Plants"
D 2-1	Flash Report: “How Uncertain is the Yield Assessment in Photovoltaic Projects?”
D 2-2	Short Report: “Uncertainties of Initial Yield Assessment and Scenarios in Real Case Studies”
D 2-3	Short Report: “From Modelled to Real LCOE of PV Projects”
D 2-4	Flash Report: “State-of-the-Art in Predictive Monitoring: Where do we Stand?”
D 2-5	Short Report: “The Use of Predictive Monitoring as Failure Avoidance in Real Case Studies”
D 2-6	Short Report: “The Use of Predictive Monitoring in O&M Strategies”
D 2-7	Report: “Guidance for Energy Rating of Different PV Module Technologies in Different Climates”
D 2-8	Report: “Assessment of Soiling Losses – Impact on the Performance of Photovoltaic Power Plants”
D 2-9	Flash Report: “How is Degradation / PLR Currently Calculated?”
D 2-10	Short Report: “Calculation of Degradation of PV Systems with High Quality and Low Quality Data”
D 2-11	Short Report: “How Uncertain is Degradation / PLR in Photovoltaic Projects?”
D 3-1	Flash report: “Common Practice for Quantifying the Impact of Technical Risks during Operation”
D 3-2	Database: “Database with Quantified Technical Risks during Operation”
D 3-3	Short report: “Cost-Benefit Analysis of O&M Strategies – How to Quantify the Impact of Risk Mitigation Measures”
D 3-4	Report: “Good Practice Recommendations to Qualify Photovoltaic Power Plants using Mobile Devices”
D 3-5	Short report: “Good Practice Recommendations for the Assessment and Mitigation of Revenue Losses due to Soiling”
D 3-6	Report: “Guidelines for Operation & Maintenance Procedures in Different Climates/Countries”

The deliverables will include full technical reports listed as “Report” in the table above. A “Flash report” is a report in the form of leaflet or factsheet that gives some preliminary insight of the topic of the subtask after one year (M12). A “Short report” is defined as a concise report with a limited number of pages and very focused on one specific topic or aspect.

6. Country Involvement

In the current Task 13 phase, twenty-two member countries and associations are indicating their interests and contributions. They are Australia, Austria, Belgium, Canada, Chile, China, Copper Alliance, Denmark, Finland, France, Germany, Israel, Italy, Japan, The Netherlands, Norway, South Africa, Spain, Sweden, Switzerland, Thailand and the USA. Most of them have provided information related to their participation and their contributions in this Task. An overview of the 38 involved entities with respect to activity lead (AL) and contribution (C) is given in the table in section 4.

7. Organisational Issues and Key Dates

The Task Operating Agents with active support of the activity leaders prepared the Task Work Plan as of 31 July 2017. The planned schedule for the coming Task 13 Meeting and PVPS ExCo Meeting is as follows:

31 July 2017:	Preparation of First Draft Work Plan
02 October 2017:	Preparation of Draft Work Plan
13 October 2017:	Approval of Draft Work Plan for Task 13 extension by experts during Task Meeting in Cologne, Germany
24 October 2017:	Submission of Final Draft Work Plan to PVPS ExCo
01 December 2017:	Presentation of Final Draft Work Plan for Task 13 extension at 50th PVPS ExCo Meeting in Melbourne, Australia. PVPS ExCos voted on Final Draft Work Plan and approved Task 13 work for 2018 – 2021.
11 December 2017:	Distribution of Final Work Plan of PVPS Task 13 to PVPS secretariat and Task 13 experts.
10-12 October 2018:	Kickoff Task 13 meeting at ISFH, Hamelin, Germany.