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Interim report from 10 January 2025

IEA PVPS Task 16

Solar resource for high penetration and large scale applications

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Summary

IEA PVPS Task 16 is currently in the third phase which started in June 2023 and will go on until June 2026. Jan Remund of Meteotest leads the Task as Task Manager on behalf of the PVPS Technology Collaboration Program with support of SFOE.

The main goals of the Task are to lower barriers and costs of grid integration of PV and lowering planning and investment costs for PV by enhancing the quality of the forecasts and the resources assessments. The work is organised in four subtasks:

– Subtask 1: Evaluation of current and emerging resource assessment methodologies

– Subtask 2: Enhanced data & bankable products

– Subtask 3: Evaluation of current and emerging solar resource and forecasting techniques

– Subtask 4: Dissemination and Outreach

Meteotest is mainly involved in leading, presenting and organizing the Task (Subtask 4). This intermediate report of the Swiss supporting project includes the overview of the work done in the last year. 49 participating organisations from 19 countries had to be kept together.

The main result of the first three year of the Task 16 – the update of the Solar Resource Handbook – written in the last 1.5 years. It has been published in October 2024 and presented at different conferences. Additionally, one peer reviewed paper was published.

In 2024 two hybrid Task meetings took place. Two workshops were organized – one at a Task meeting in collaboration with IEA Wind Task 51 and one during EU PVSEC 2024 as a parallel event.

Zusammenfassung

Der IEA PVPS Task 16 befindet sich derzeit in der dritten Phase, die im Juni 2023 begann und bis Juni 2026 andauern wird. Jan Remund von Meteotest leitet den Task als Task Manager im Namen des PVPS Technology Collaboration Program mit Unterstützung des BFE.

Die Hauptziele des Tasks sind die Senkung der Hindernisse und Kosten für die Netzintegration von PV und die Senkung der Planungs- und Investitionskosten für PV durch die Verbesserung der Qualität der Prognosen und der Ressourcenbewertung. Die Arbeit ist in vier Unteraufgaben gegliedert:

- Subtask 1: Bewertung aktueller und neuer Methoden der Ressourcenbestimmung

- Subtask 2: Verbesserte Daten und bankfähige Produkte

- Subtask 3: Bewertung aktueller und neuer Verfahren für Solarvorhersagen

- Subtask 4: Verbreitung und Öffentlichkeitsarbeit

Meteotest ist hauptsächlich an der Leitung, Präsentation und Organisation des Tasks (Subtask 4) beteiligt. Der vorliegende Zwischenbericht des Schweizer Unterstützungsprojekts gibt einen Überblick über die Arbeit des letzten Jahres. 49 teilnehmende Organisationen aus 19 Ländern mussten unter einen Hut gebracht werden.

Das Hauptergebnis der ersten drei Jahre des Task 16 - die Aktualisierung des Solar Resource Handbook - wurde in den letzten 1,5 Jahren geschrieben. Es wurde im Oktober 2024 veröffentlicht und auf verschiedenen Konferenzen vorgestellt. Ausserdem wurden ein von Fachleuten begutachtetes Papier veröffentlicht.

Im Jahr 2024 fanden zwei hybride (online & physisch) Sitzungen statt. Zwei Workshops wurden organisiert - einer bei einem Task-Treffen in Zusammenarbeit mit dem IEA Wind Task 51 und einer während der EU PVSEC 2024 als Parallelveranstaltung.

Contents

List of abbreviations

FOV	Field of view
GHI	Global horizontal irradiance
IEA	International Energy Agency
PVPS	Photovoltaic (PV) Power Systems TCP
RHI	Reflected horizontal irradiance
SFOE	Swiss Federal Office of Energy
SHC	Solar Heating and Cooling TCP
SolarPACES	Solar Power and Chemical Energy Systems TCP
SFOE	Swiss Federal Office of Energy
TCP	Technology collaboration programme
TMY	Typical Meteorological Year

1   Introduction

IEA PVPS Task 16 (T16) started in June 2017 is currently in the 3rd phase which will go on until June 2026. This report covers the period of January – December 2024.

T16 is a joint Task with the TCP SolarPACES (Task V). It will keep also minimal collaboration with the Solar Heating and Cooling (SHC) – the Technology Collaboration Programme of the preceding solar resource and forecast Tasks.

Meteotest leads the Task as Task Manager on behalf of the PVPS TCP with support of Swiss Federal Office of Energy (SFOE). Manuel Silva of Univ. of Sevilla, Spain leads the Task V since summer 2018 on behalf of SolarPACES. Manajit Sengupta from NREL (Golden, CO, USA) is the deputy Task Manager.

The main work of Meteotest was to organise to ongoing work of the Task – meetings, workshops and reports – and informing the Exco about the updates. Meteotest works actively for dissemination, in the benchmarking activity as well as in modelling firm PV power, where a separate project in Switzerland was conducted in 2021, 2022, 2023 and 2024.

2   Workplan

The main goals of third phase of T16 are to lower barriers and costs of grid integration of PV and to lower planning and investment costs for PV by enhancing the quality of the forecasts and the resources assessments.

To reach this main goal the Task has the following objectives:

- Lower uncertainty of satellite retrievals and Numerical Weather Prediction (NWP) models for solar resource assessments and nowcasting

- Develop enhanced analysis of long-term variability and trends in solar resource with an additional focus on effects of climate change.

- Develop and compare methods for

    o Estimating the spectral and angular distributions of solar radiation (clear and all-sky conditions)

    o Modelling point to area forecasts

    o Probabilistic forecasting

- Organize international benchmarks of solar resource and forecast datasets.

In this phase the following focus have been defined:

1.   Analysing long term trends and variability changes induced by climate change (activity 2.4)

2.   Modelling of meteorological data and albedo for bifacial modules (activity 2.7)

3.   Providing models and information for firm power production (new activity 3.5)

The scope of the work in Task 16 concentrates on meteorological and climatological topics needed to plan and run PV, solar thermal, concentrating solar power stations and buildings. As in the preceding Task solar resource assessment and forecasting are the main focus.

To handle this scope the work programme is organized into three main technical subtasks (subtasks 1 – 3) and one dissemination subtask (Subtask 4) (Table 1):

Table 1: Subtasks and Activities of Task 16 (2023-2026)

Subtask	Activity
Subtask 1: Current methodologies for solar data generation	1.1 Radiation measurements
	1.2 Radiation models
	1.4 Benchmarking solar data
	1.5 Additional meteorological parameters
Subtask 2: Enhancement of data & value-added products	2.1 Data quality and format
	2.4 Climate change and long-term variability
	2.5 Products for the end-users
	2.7: Products for upcoming, integrated technologies
Subtask 3: Solar forecasting	3.2 PV power forecasting at different spatio-temporal scales
	3.3 Probabilistic solar forecasting
	3.4 Cloud image based nowcasting (0-6 hours)
	3.5 Firm power generation
Subtask 4: Dissemination and Outreach	4.3 Webinars, workshops, publications and trainings
	4.4. Update of solar resource handbook
	4.5. Program Toolbox
	4.6. Update basic knowledge for a broad public (e.g. Wikipedia)

Whereas Subtasks 1 and 3 are mainly focused on ongoing scientific work, Subtasks 2 and 4 are mostly focused on user aspects and dissemination.

In Table 2 the Task participants are listed.

Table 2: Participating countries (19) and organizations (49) of Task 16.

Country	TCP	PM	Partners
AUS	PVPS	5	Univ. of South Australia (UniSA), Univ. of NSW (UNSW)
AUT	PVPS	4	Fachhochschule Oberösterreich (FH OOE)
CAN	PVPS	3	Natural Resources Canada
CHE	PVPS	21	Meteotest
CHN	PVPS	4	Public Meteorological Service Center (China Meteorological Administration - CMA)
DEU	PVPS SolarPACES	42	Fraunhofer (ISE & IEE), DLR (both TCP), CSP Services
DNK	PVPS	18	Danish Meteorological Institute (DMI), Technical University of Denmark (DTU)
ESP	PVPS SolarPACES	51	CIEMAT, CENER, Public University of Navarra, Univ. Almeria, Univ. Jaen, Univ. Malaga, University of Seville (US), Univ. des Las Palmas de Gran Canaria, Mactech
EU	PVPS	3	JRC
FRA	PVPS	10	MINES Paris PSL, Laboratoire PIMENT, Université la Réunion, Ecole Polytechnique à Palaiseau, EDF R&D, RTE, TotalEnergies, ESA
ITA	PVPS SolarPACES	7	i-em, RSE, Uni Tor Vergata, ENEA and EURAC
NLD	PVPS	2	Univ. Utrecht
NOR	PVPS	2	IFE and Met. Norway
SWE	PVPS	5	SMHI and Univ. Uppsala
USA	PVPS	17	Dep. of Energy/National Renewable Energy Laboratory (NREL), National Aeronautics and Space Administration (NASA), State Univ. of New York at Albany (SUNY), University of Oregon, Clean Power Research (CPR), Solar Consulting Services (SCS)
GBR	SHC	4	Peakdesign Ltd.
GRE	SolarPACES	1	Univ. of Patras
MOR	SolarPACES	1	IRESEN
SVK	SHC	2	Solargis

3   Completed Tasks and achieved results

IEA PVPS Task 16 is among the biggest Tasks in PVPS TCP concerning number of participants (49) and countries (19). Additionally financial resources are not adequate in many countries. Both issues made operating the Task not an easy topic. Missing resources as well as changes of staff of participants led also to re-organisation and changes of activity and subtask leads.

1.1   Reports published

As in the first two phases also for the 3rd phase the main result of Task is the update of the Solar Resource Handbook. This last version has been published in May 2021 in PVPS version[1]:. On October 4th edition of the handbook has been published – the major result of the collaboration during the past four years (Sengupta et al., 2024a and Sengupta et al., 2024b).

The 530 pages handbook is the work of 51 authors from 15 countries. As in previous versions a close collaboration between NREL and the Task enabled this huge document. The Task experts wrote the updates and NREL organized the writing and editing of the document. It shows the state-of-the-art know-how and is the scientific basis and information for analysts and practitioners. **The handbook summarizes techniques used to measure and develop estimates of solar resources from radiometers and weather satellite data and numerical model predictions.**

The new Handbook the following chapters – including two new ones (marked bold):

1. Why Solar Resource Data Are Important to Solar Power
2. Overview of Solar Radiation Resource Concepts
3. Measuring Solar Radiation
4. **Data Quality Assessment and Control**
5. Further Relevant Meteorological Parameters
6. Solar Resource Variability
7. Modeling Solar Radiation: Current Practices
8. Solar Resource Data
9. Forecasting Solar Radiation and Photovoltaic Power
10. **Principles and Practical Methods to Estimate Uncertainty and Evaluation of Solar Irradiance Data**
11. Applying Solar Resource Data to Solar Energy Projects
12. Future work

One of the main tables of the work shows, which data should be used for which state of the planning process of a solar plant depending on it's size.

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[1] https://iea-pvps.org/key-topics/best-practices-handbook-for-the-collection-and-use-of-solar-resource-data-for-solar-energy-applications-third-edition/

Table 3: Solar Irradiation Needs for Different Stages of a Hypothetical Project

		System Size		
		Small	Medium	Large
Phase	1. Prefeasibility and planning	• Long-term averages • Monthly data • Solar cadastres/ maps • Simple shading analysis	• TMY • Hourly data • Shading analysis	• Long-term satellite data • Hourly data
	2. Feasibility			• Satellite data • Time series (> 10 years) • Ground measurements (>1 year) • Shading analysis • Further site- and technology-specific meteorological parameters (e.g., albedo, soiling)
	3. Due diligence and finance		• Satellite data • Time series (>10 years) • Minutely data • Shading analysis • Further site- and technology-specific meteorological parameters (e.g., albedo, soiling)	• Satellite data • Time series (>10 years) • Ground measurements (> 1 year) • Minutely data • Shading analysis • Further site- and technology-specific meteorological parameters (e.g., albedo, soiling)
	4. Operations and maintenance	• Simple (inverter) monitoring	• Local measurements • Forecasts	• Local measurements • Forecasts

The Handbook can be found online and free to download in two formats – one for NREL and one for PVPS (see References).

Another important part of the handbook deals with measurements. With the Solarexpress also in Switzerland measurement campaigns for modelling and monitoring of plants aside buildings are done and planned. The handbook gives important information regarding such measurements regarding instrumentation, quality, and site adaptation for long term evaluations. As an example, the optimal placement of albedo measurements is shown (Fig. 1).
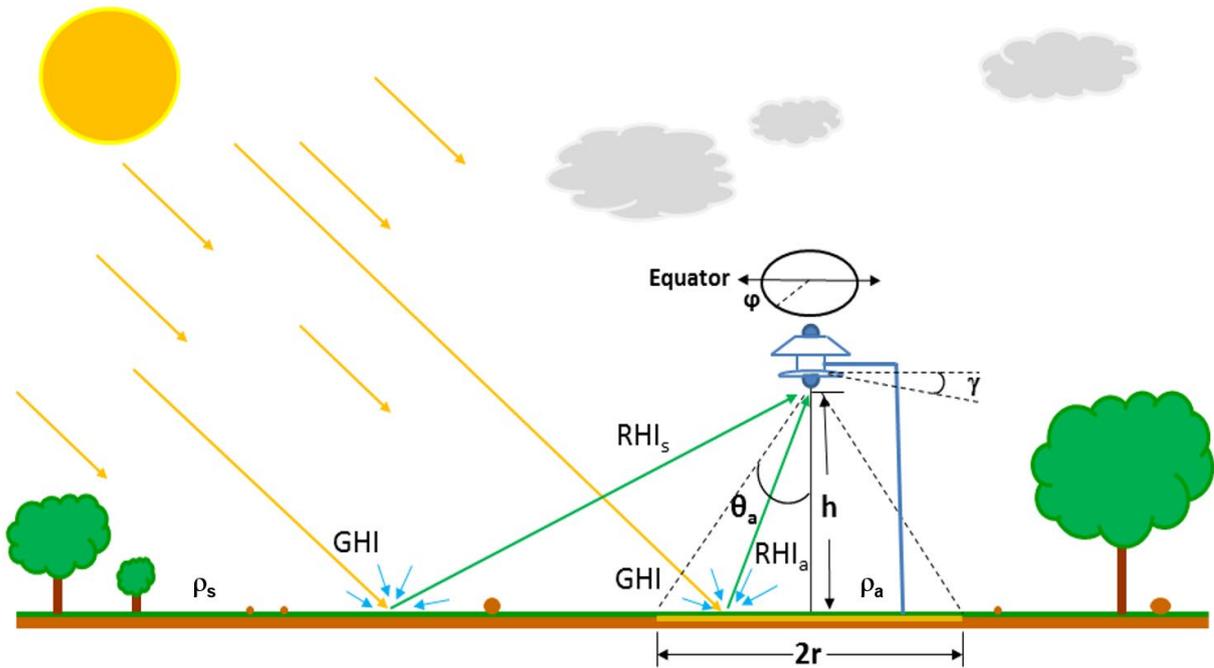
Figure 1: Schematic of an albedometer installed at height h above a part of ground surface with albedo ρ_a. The FOV of the instrument has a half-angle θ_a, corresponding to a radius r at its base. The surrounding surface area has an albedo ρ_s. The obstructed angle by a possible glare screen (used to block direct beams when the sun is near the horizon) is γ. Source: Solargis.

1.2 Papers published

In October 2024 the research paper "The added value of combining solar irradiance data and forecasts: A probabilistic benchmarking exercise" (Lauret et al., 2024) was published in Renewable Energy. This is one of the major outcomes of Activity 3.3. For the first time different probabilistic forecasts have been benchmarked.

1.3 Workshops / Webinars

Two workshops were organized:

1. A public workshop in collaboration with IEA Wind Task 51 about minute scale forecasting (Riso, April 10-11)

2. A side event at the EU PVSEC 2025 (Sept. 25th, Vienna) about the new Solar Resource Handbook

Many presentations have been given at conferences like EU PVSEC 2024, SolarPACES 2024 and PVPMC 24 conference.

1.4 Task meetings

As Task Manager Meteotest organised two (hybrid) meetings in spring and autumn 2024 (Figure 2).

- April 9-12, Risoe, 14th Task meeting, Risoe combined with IEA Wind Task 51 meeting and workshop

- October 28 – 30th, 15th Task meeting, NREL, Golden, CO, USA

The hybrid meetings were successful. About 30-40 persons attended the meetings physically and 30 online.

Figure 2: Group photo of the combined IEA PVPS Task 16 and IEA Wind Task 51 group meeting at Risoe, Denmark (April 2024).

4 National and international cooperation

Together with Clean Power Research and SUNY (both USA) an update of the Firm Power Study for Switzerland has been made and published (Remund et al., 2024). This is linked to the activity 3.5.

This work has been presented at the German conference "Zukünftige Stromnetze" (Berlin, January 24.15) and at the Swiss PV Conference (Lausanne, March 21-22).

More presentations of the Task (Handbook, Firm PV Power) have been given at:

- Deutsche Fachtagung Energiemeteorologie, Bad Staffelstein, January 23

- PVPMC Workshop, Copenhagen, August 21

- Asia PVSEC-35, Yokohama, November 14

Task 16 was collaborating additionally with the Agrivoltaics Action Group of PVPS, with IEA Wind Task 51 and with WMO (framework for a Global Partnership for weather, water and climate services for a clean energy transition).

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