



Photovoltaic Power Systems TCP

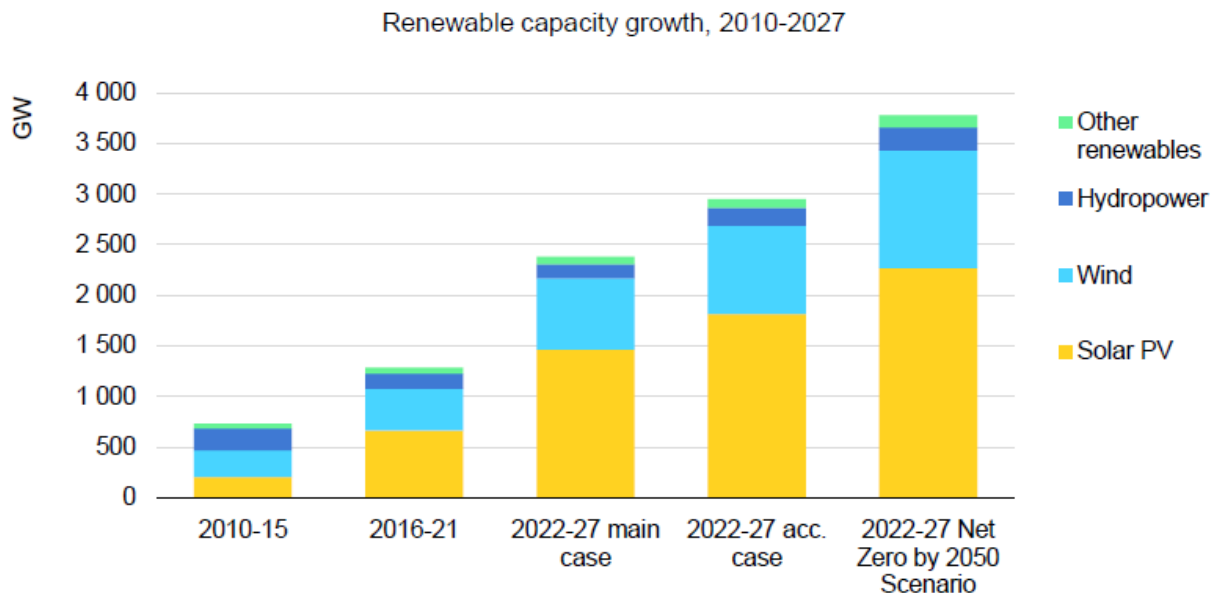
Daniel Mugnier, Chair

IEA Wind “Hydrogen in a 100% Renewable Energy System” Topical Expert Meeting #106

Solar PV is set to lead global markets



Improved policies can further narrow the gap with net zero by 2050



Faster permitting, addressing grid and system integration issues and enabling affordable financing in developing countries could unlock 25% additional capacity in the accelerated case narrowing the gap with net zero by 2050

PV Industry Status



- **Global PV markets expanding rapidly**, significantly over **230 GW** by end 2022
- **Decentralised market growing**, as well as new applications (AgriPV, floating PV)
- Climate change mitigation in 2022 = **3% of global emissions saved**
- Cost competitive → **removal of subsidies**, sale of “merchant PV”
- Initiatives to diversify global PV manufacturing **supply chain**
- Increasing **grid congestion**, need for flexible generation, demand side response
- Need to focus on **social acceptance** (land use concerns, circularity)
- **Complexity of policies** needed to frame PV will increase, especially with regard to grid costs and contribution to system stability.

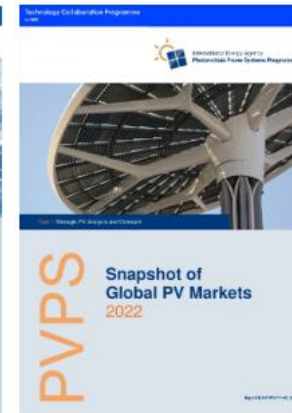
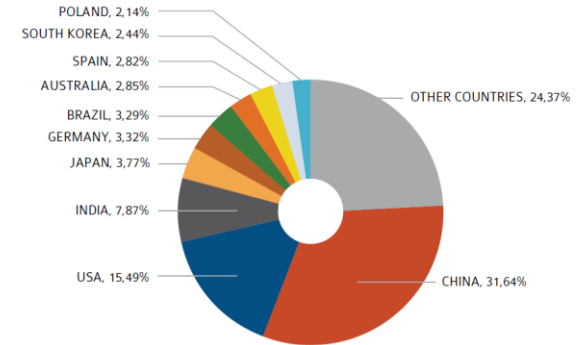


Task 1 - Strategic PV Analysis and Outreach



- Foundational never-ending Task
- Participation by **all PVPS Members**
- **Systematic analysis of PV market development, costs, industry trends, support policies & business models**
- Annual publication of:
 - **Trends in Photovoltaic Applications**
 - 27 years
 - Snapshot of Global PV Markets
 - National Survey Reports

FIGURE 2.5: GLOBAL PV MARKET IN 2021



Evolution of Top 10 PV Markets (from Trends report 2022)



RANKING	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
1	ITALY	GERMANY	CHINA	CHINA	CHINA	CHINA	CHINA	CHINA	CHINA	CHINA	CHINA
2	GERMANY	ITALY	JAPAN	JAPAN	JAPAN	USA	INDIA	INDIA	USA	USA	USA
3	CHINA	CHINA	USA	USA	USA	JAPAN	USA	USA	INDIA	VIETNAM	INDIA
4	USA	USA	GERMANY	UK	UK	INDIA	JAPAN	JAPAN	JAPAN	JAPAN	JAPAN
5	FRANCE	JAPAN	ITALY	GERMANY	INDIA	UK	TURKEY	AUSTRALIA	VIETNAM	GERMANY	GERMANY
6	JAPAN	FRANCE	UK	SOUTH AFRICA	GERMANY	GERMANY	GERMANY	TURKEY	AUSTRALIA	AUSTRALIA	BRAZIL
7	BELGIUM	AUSTRALIA	ROMANIA	FRANCE	KOREA	THAILAND	KOREA	GERMANY	SPAIN	KOREA	AUSTRALIA
8	UK	INDIA	INDIA	KOREA	AUSTRALIA	KOREA	AUSTRALIA	MEXICO	GERMANY	INDIA	SPAIN
9	AUSTRALIA	GREECE	GREECE	AUSTRALIA	FRANCE	AUSTRALIA	BRAZIL	KOREA	UKRAINE	SPAIN	KOREA
10	GREECE	BULGARIA	AUSTRALIA	INDIA	CANADA	TURKEY	UK	NETHERLANDS	KOREA	NETHERLANDS	POLAND
RANKING EU	1	1	2	3	3	4	5	4	2	2	2
MARKET LEVEL TO ACCESS THE TOP 10											
	426 MW	843 MW	792 MW	779 MW	675 MW	818 MW	944 MW	1 621 MW	3 130 MW	3 492 MW	3 710 MW

Overview of currently active Tasks



<u>Task:</u>	<u>Topic:</u>	<u>Running:</u>
• Task 1	“PV market analysis”	29 years
• Task 12	“PV sustainability activities”	15 years
• Task 13	“PV Reliability & Performance”	12 years
• Task 14	“PV Grid Integration”	12 years
• Task 15	“Building-Integrated PV”	7 years
• Task 16	“Solar Resource Forecasts”	45 years*
• Task 17	“PV & Transport”	4 years
• Task 18	“Off-Grid & Edge-of-Grid PV”	2.5 years

T1



Gaetan Masson



Izumi Kaizuka

T12



Garvin Heath



Jose Bilbao

T13



Ulrike Jahn

T14



Roland Bründlinger



Gerd Heitscher

T15



Francesco Frontini



Helen Rose Wilson

T16



Jan Remund



Manajit Sengupta

T17



Keiichi Komoto



Manuela Sechilariu

T18



Christopher Martell


PVPS

* Task 16 was part of SHC from 1977 until 2017, when it moved across to PVPS.

More information on Tasks

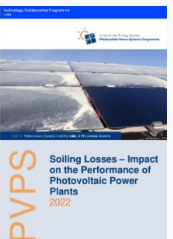


- Technical report highlights in PVPS Annual Report
- Task overview pages on PVPS Website
- Task publications available on PVPS Website

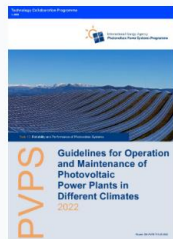


Publications Research tasks Events About us

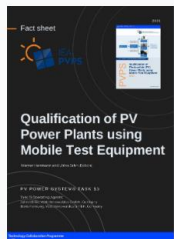
Task 13 Reports




Soiling Losses – Impact on the Performance of Photovoltaic Power Plants 2022



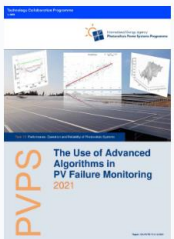
Guidelines for Operation and Maintenance of Photovoltaic Power Plants in Different Climates 2022



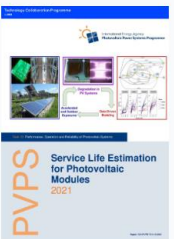
Fact sheet: Qualification of PV Power Plants using Mobile Test Equipment



Quantification of Technical Risks in PV Power Systems 2021



The Use of Advanced Algorithms in PV Failure Monitoring 2021



Service Life Estimation for Photovoltaic Modules 2021

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22 | IEA PVPS ANNUAL REPORT 2024 TASK 14 HIGHLIGHT



ANCILLARY SERVICES FROM PV

TASK 14 HIGHLIGHT

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Task 14 Webpage



Fig. 17 - Hierarchical model for the definition of interrelations between various grid support functions of PV inverters

KEY MESSAGE

Laboratory and field experiences from IEA PVPS countries highlight the technical capabilities and the future potential of Solar PV systems to provide power system services.

OBJECTIVE

The report aims to highlight the status and the potential of PV and PV hybrids as ancillary service providers. The report provides a collection of laboratory and field experiences from different IEA PVPS countries and for different ancillary services and PV inverter functions.

METHODOLOGY

Field experiences and lessons learned for different ancillary services provided by PV systems and PV hybrids are presented in the report. Frequency control services, power curtailment, voltage support [1], PV hybrids in insular power systems, Power quality support and new services from PV systems [2].

Target: Solar PV VRE	Target: PV Hybrid	Target: PV Hybrid (with storage)	Target: PV Hybrid (with storage and grid)
Frequency control services	Frequency control services	Frequency control services	Frequency control services
Power curtailment	Power curtailment	Power curtailment	Power curtailment
Voltage support	Voltage support	Voltage support	Voltage support
Power quality support	Power quality support	Power quality support	Power quality support
New services from PV systems	New services from PV systems	New services from PV systems	New services from PV systems

Fig. 16 - PV penetration levels and identified challenges for the integration of Solar PV and VRE in the electrical power system

Grid integration challenges heavily depend on the local, regional and system wide penetration of PV and other Variable Renewable Energy (VRE) systems. To address the challenges, a model has been developed representing a different penetration stages in electric power systems, associated challenges, needs and barriers.



Fig. 18 - PV hybrid system on the island of St. Eustatius, Lutz PV storage system view from above. Right: system setup

The St. Eustatius PV hybrid power plant, with its conventional and inverter-based generation, combined with battery storage and a parallel operation of grid forming and grid supporting control, proves that a stable operation of power grids is feasible without conventional must-run units and their inertia and fault current contribution.

REFERENCES

These are relevant older reports from Task 14:

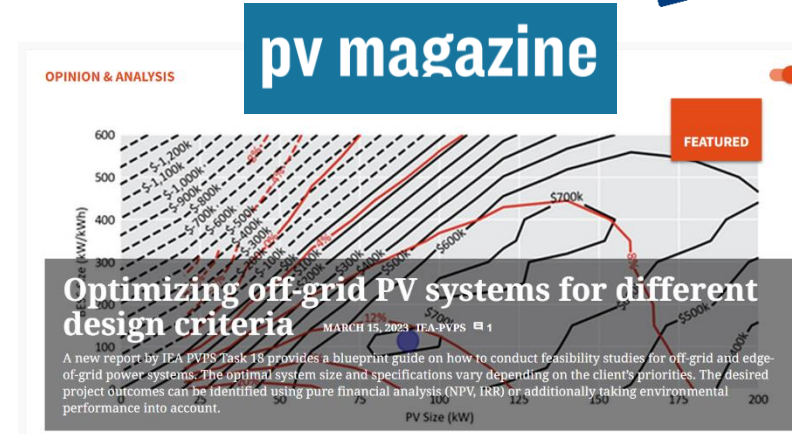
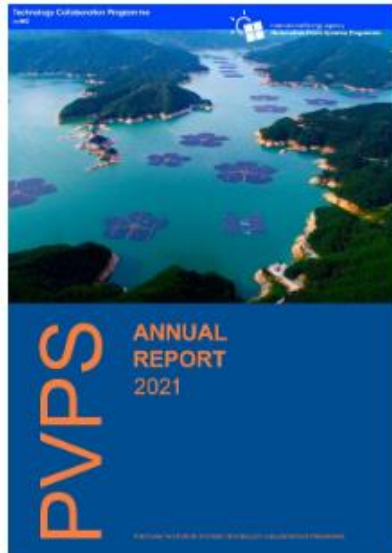
M. Krayan, A. Mithal, T. Sato and M. Brown, "The St. Eustatius Island Hybrid Support by Distributed Generation – A Management Summary" Report IEA-PVPS 14-08-2017, 2017.

T. Sato, M. Rakegier, I. Theophilidis and et al., "Transition from the Decentralized to the Centralized Distribution Grids: Management Summary of IEA Task 14 Subtask 2" Report IEA PVPS 14-03-2014, 2014.

Communications and Outreach



- Monthly featured articles in PV Magazine
- Workshops & Exhibitions
- Annual report, Newsletters, Social Media





- Green energy targets very high worldwide (100% RES-energy systems)
- Several possible answers for PV grid integration : curtailment but not only...
- Green H₂ is a very promising solution
-but often adapted at commercial level for large green electricity production



- **Several challenges** of interest for PVPS :
 - Perspectives for small to medium size electrolyzers (TRL ?) adapted for PV
 - H2 electrolysis dynamics : how to conciliate variable PV production and Green H2 production in a commercial and cost competitive approach ? Complexity of integration ?
 - Seasonal management very interesting for Green H2 but difficulties to compete with battery storage at distribution grid level

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