



IEA PVPS Task 14

High penetration PV in Electricity Grids

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Hangzhou, Nov 6, 2012

PVPS





IEA-PVPS Task 14

High Penetration PV in Electricity Grids

- Contents
 - Challenges of PV integration
 - Overview IEA PVPS Task 14
 - First Results
 - Dissemination activities
 - Summary





IEA-PVPS Task 14

High Penetration PV in Electricity Grids

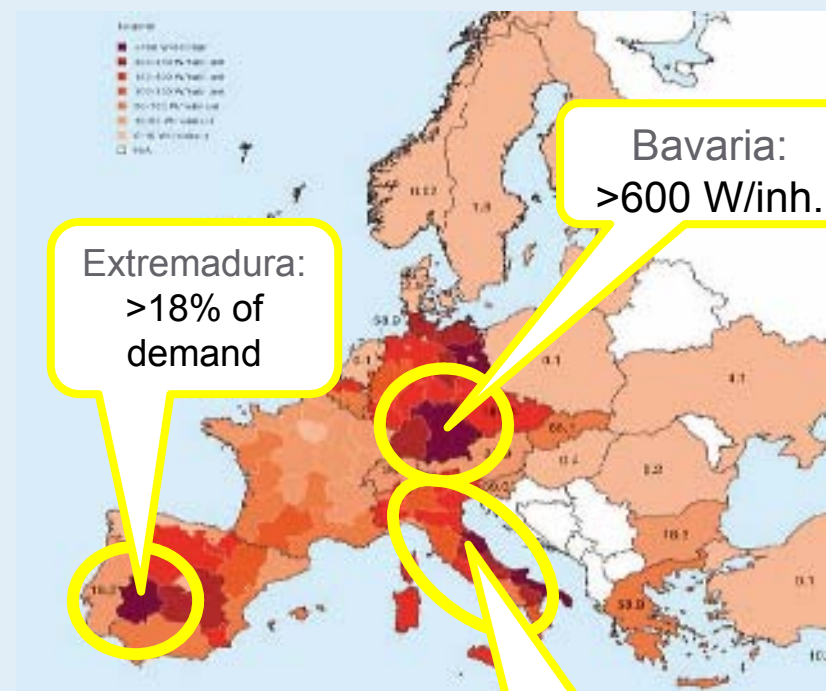
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High Penetration of PV in Electricity Grids

- PV is unevenly distributed
- Few countries account for around 75% of the global capacity installed *(01/2012)
 - DEU ~ 24,8 GW
 - Italy ~ 12,5 GW
 - JAP ~ 4,7 GW
 - ESP ~ 4,2 GW
 - USA ~ 4,2 GW
- PV penetration levels >100% are already leading to issues in some regions
- With installations growing in the GW range/year grid constraints will become crucial for further deployment of PV.



Source: EPIA, "Global Market Outlook 2016", p. 12

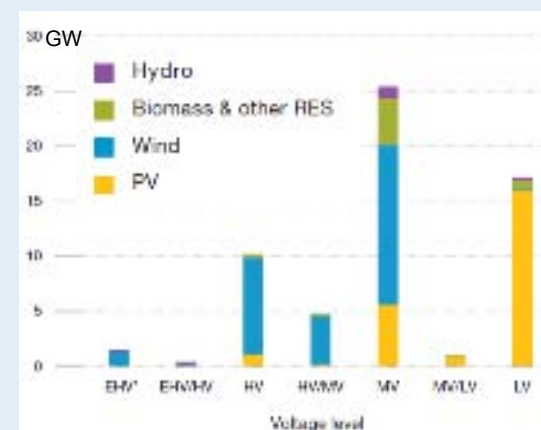




Characteristics of PV power generation

PV specific features

- Variable generation
 - Daily profile
 - Seasonal profile
 - Variability
- Typical system size
 - High number of small scale (residential) installations -> aggregation
 - Also large scale installations in high-irradiation locations
- Connection predominantly at LV grid - Inverter connection
- Frequently linked to buildings



RES capacity in Germany connected to different network levels

Source: EPIA based on DGS figures

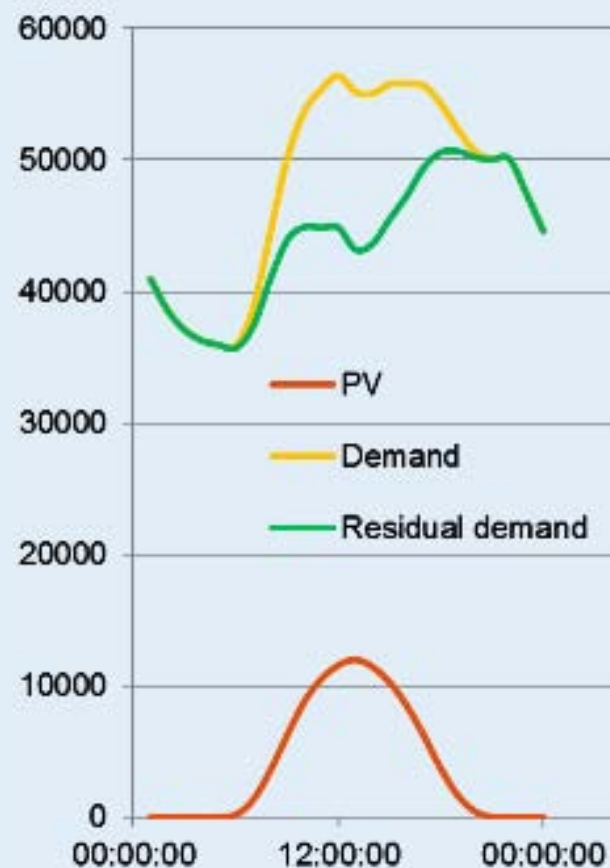




Characteristics of PV power generation

Positive effects for the grid

- PV production frequently meets times of high load in networks
- Reduction of network losses due to more local generation and therefore decreased power transmission
- More transmission capacity opens space for other transmission services
- Active network services from multifunctional photovoltaic inverters can support the local network management



Source: EPIA, Task 14 Workshop Kassel, May 2012

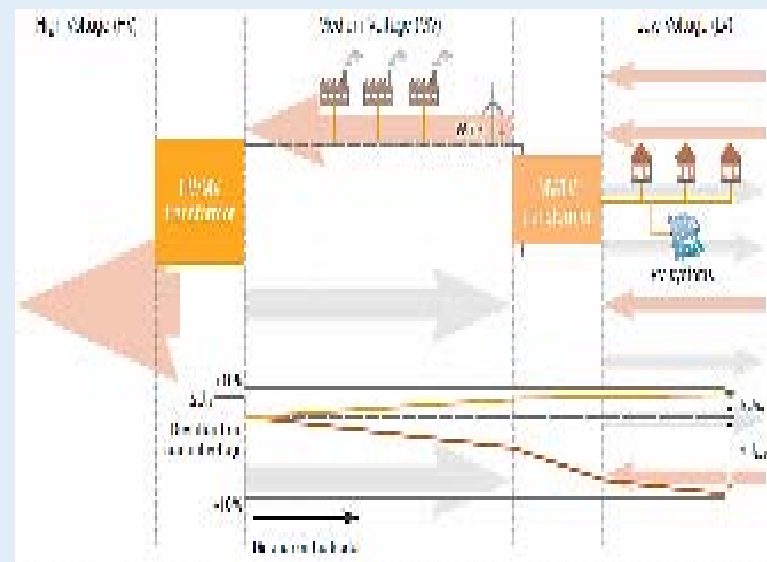




Characteristics of PV power generation

Critical issues for grid integration

- Additional powerflows
 - additional loading of grid components
 - grid extension required (transformers & lines)
- Reverse power flows
 - voltage rise in distribution grids
 - grid reinforcement and voltage control devices required
- Grid stability (frequency and voltage)
 - Current protection and control settings often cause additional destabilization in abnormal situations and limited support in normal operation
 - traditional/conventional power system has to guarantee stability



Source: EPIA 2012 based on AIT figures

→ Smart PV integration required !!!





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Task 14: Overall objectives of this international collaboration

- Promote the use of grid connected PV as an important source in electric power systems also on a high penetration level where additional efforts may be necessary to integrate the dispersed generators in an optimum manner.
- Develop and verify mainly technical requirements for PV and electric power systems to allow for high penetrations of PV systems interconnected with the grid
- Discuss the active role of PV systems related to energy management and system control of electricity grids
- Reduce the technical barriers to achieve high penetration levels of distributed renewable energy systems on the electric power system





Task 14

Outcomes

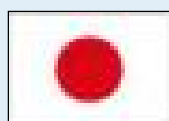
- Provide access to more transparent technical analyses in order for industry, network operators, energy planners as well as authorities in the energy business to decide on steps to be taken and strategies to be developed on a sound basis.
- provide comprehensive international studies for high penetration PV
- Prepare Reports, (Utility) Workshops and further dissemination activities to provide objective and neutral high-quality Information...





Task 14 High Penetration of PV Systems in Electricity Networks

14 Countries



- Utilities/DNOs
- Industry/Manufacturers/Consultancies
- Applied research
- Universities
- Agencies

2 Associations

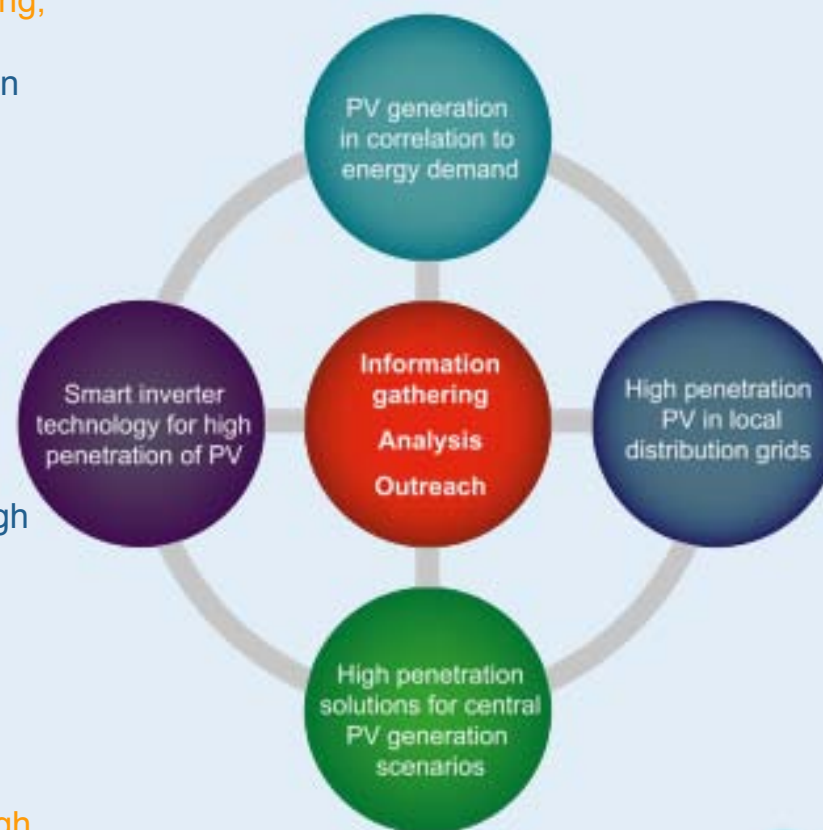




IEA PVPS - Task 14

Organization and structure

- **Cross Cutting Subtask: Information Gathering, Analysis and Outreach:**
Collect and share state of the art information amongst the various tasks.
- **Subtask 1: PV generation in correlation to energy demand: Switzerland**
Show how with better prediction tools and optimized local energy management, PV penetration can be improved.
- **Subtask 2: High penetration in local distribution grids: Germany**
Identify and interpret the role of PV in distribution grids and impact analyses of high PV penetration
- **Subtask 3: High penetration solutions for central PV scenarios: Japan**
PV integration from the total power system view point, including forecasting, power system operation and augmentation
- **Subtask 4: Smart inverter technology for high penetration of PV: Austria**
Technology, technical requirements and standards as well as system integration aspects for inverters with High Penetration PV





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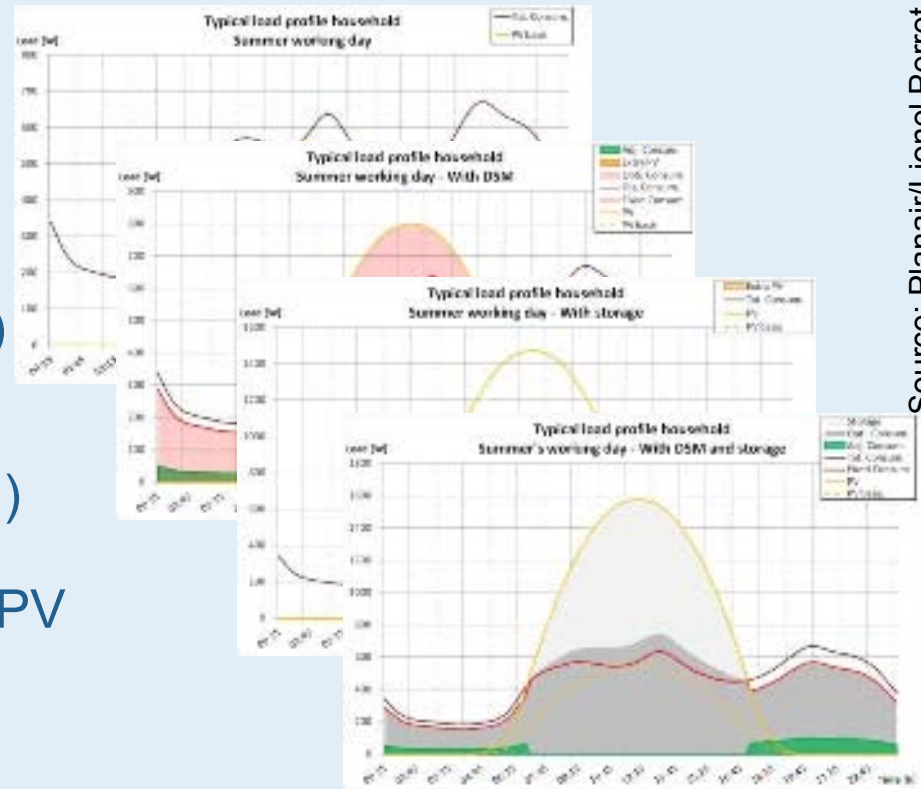




Task 14 – Results

Energy Management with PV

- Case studies for PV integration
 - Base case
PV 4.5kWh/d
 - Integration with DSM
PV 6.5kWh/d (+45%)
 - Integration with Storage system
PV 12kWh/d (+165%)
 - Integration with DSM and Storage system
PV 12.9kWh/d (+185%)



Source: Planair/Lionel Perret

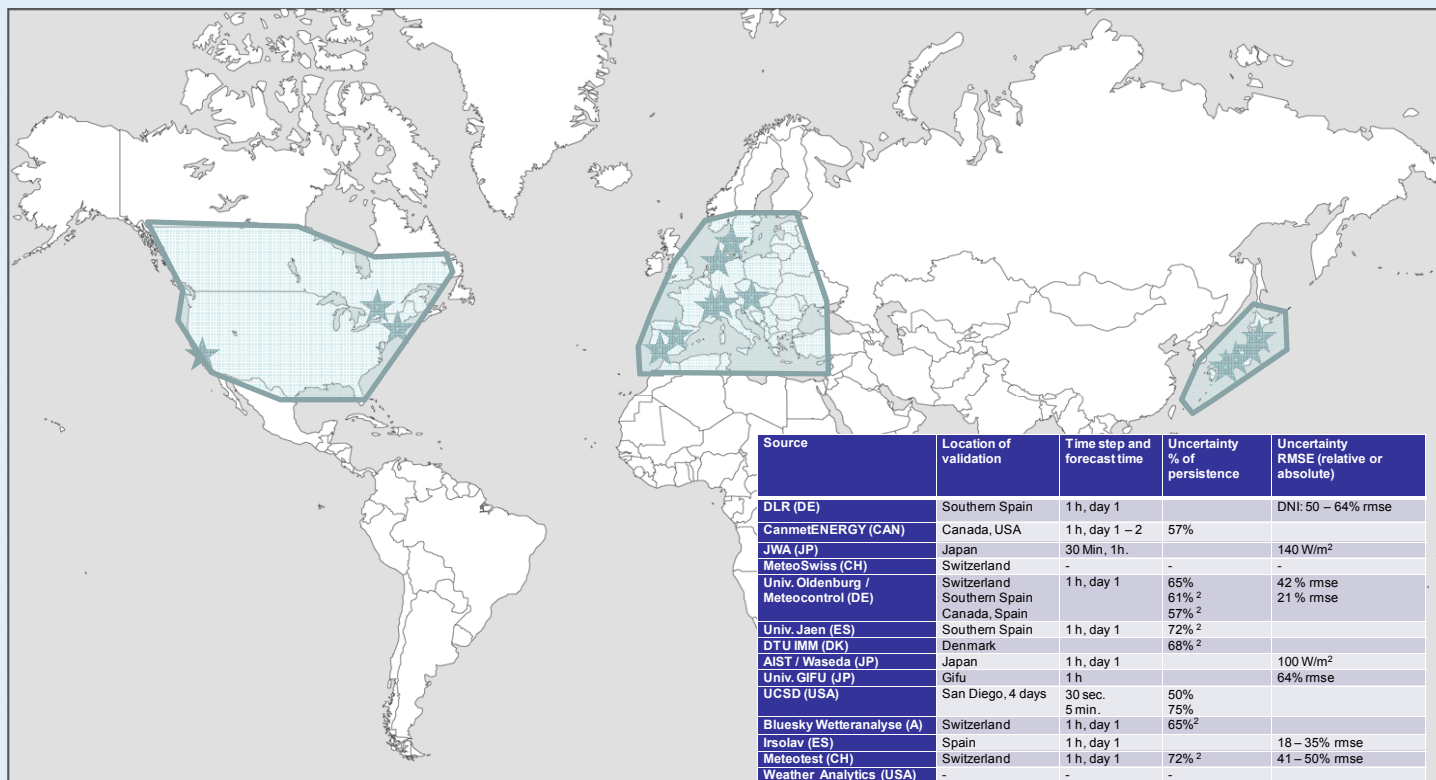




Task 14 – Results

PV forecast: state of the art

- 3 regions: USA, Europe and Japan



Source: Jan Remund, Meteotest





Task 14 – Results

High Penetration Case Studies

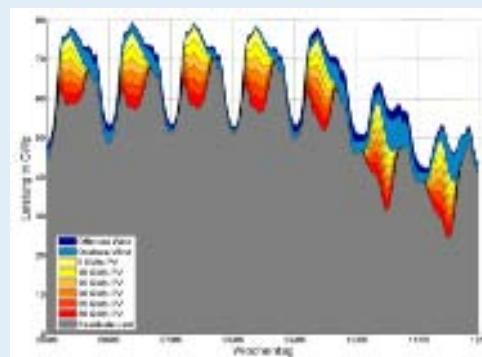
- Distribution grid case studies
 - Germany
 - USA
 - Belgium
 - ...
- Overall power system studies
 - Japan
 - USA
 - Italy
 - ...



Source: E.on Bayern/Fraunhofer IWES



Source: SMUD/NREL



Source: Y.M. Saint Drenan/Fraunhofer IWES



Source: NREL





Task 14 – Results: Current vs. future requirements for PV inverters

- Support Voltage Control
Reactive power provision for voltage support
→ reduces grid extension costs significantly
- Support Frequency Control
automatically reduce active power with frequency deviations
(Over Frequency Response)
→ Integrate harmonized frequency stabilization functions!
- Remote dispatch
control PV generation to a specified % of nominal power rating
(Remote Dispatch for security actions)
→ Standardized control and communication interfaces required
- LVRT Fault Ride Through: Supply reactive current during grid faults,
→ No disconnection during grid faults





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Task 14 – dissemination and interaction with key stakeholders

- Successful series of Task 14 High Penetration PV Workshops:
 - Sept. 2010: Joint Task 1/14 workshop EUPVSEC/ WCPEC in Valencia
 - Dec. 2010: Task 14 workshop, Golden, CO, U.S.A. Hosted U.S. DoE, NREL and SEPA
 - May 2011: Task 14 utility workshop, Lisbon, Portugal, Hosted by EDP
 - Oct. 2011: Task 14 Utility and Research workshop, Beijing, China, hosted by the IEE, Chinese Academy of Sciences
 - May 2012: Task 14 High penetration PV workshop, Kassel, Germany, Hosted by SMA
 - Oct. 2012: Task 14 High penetration PV workshop, Tokyo, Japan, hosted by NEDO
- Presentations available at www.iea-pvps.org





Task 14 – Public visibility

- Task 14 poster presentations at the main conferences (European PVSEC/ WCPEC, IRED Conference)
- Presentations and visuals by Task 14 experts
- Task 14 Journal publications
- Supporting activities: High Penetration PV workshop at IRED Berlin Dec 2012

PVPS

Bringing Together International Research On High Penetration PV In Electricity Grids – The New Task 14 Of The IEA-PVPS Programme

PROGRESS IN PHOTOVOLTAICS: RESEARCH AND APPLICATIONS
Prog. Photovolt. Res. Appl. 2011
Published online in Wiley Online Library (wileyonlinelibrary.com). DOI: 10.1002/pip.1254

PAPER PRESENTED AT 26TH EU PVSEC, HAMBURG, GERMANY 2011

Is the distribution grid ready to accept large-scale photovoltaic deployment? State of the art, progress, and future prospects

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ABSTRACT

The installed capacity of photovoltaic (PV) systems has already increased at a much faster rate than the development of grid codes to effectively and efficiently manage high penetration of PV within the distribution system. In a number of countries, PV penetrations in some regions are now raising growing concerns regarding integration. Management strategies vary considerably by country—some still have an approach that PV systems should behave as passive as possible, whereas others demand an active participation in grid control. This variety of grid codes also poses challenges in learning from “best practices”. This paper provides a review of current grid codes in some countries with high PV penetrations. In addition, the paper presents a number of country-specific case studies on different approaches for improved integration of PV systems in the distribution grid. In particular, we consider responses applicable to using active and reactive power control that can reduce or defer expensive grid reinforcement while supporting higher PV penetrations. Copyright © 2011 John Wiley & Sons, Ltd.

KEYWORDS
photovoltaic; grid integration; distributed generation; grid codes; case studies; auxiliary services

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1. INTRODUCTION

In 2009, the globally installed photovoltaic (PV) capacity was about 54 GW [1]. Driven by significant policy incentives in some countries and cost reductions in PV systems, the annual global PV installation rate has since rocketed, leading to a worldwide installed PV capacity approaching 40 GW in 2010 [1]. In this period of extraordinary industry growth, some national markets have emerged as global leaders for the installation of new PV systems. Some expert assessments estimate that this industry growth may continue to grow over the coming years as shown in Table I.

This paper is a joint work of Germany, Austria, Japan, USA, Italy, Belgium, and Australia that represent a total market share in 2010 of more than 70%.

In contrast to conventional power plants and wind energy conversion, PV systems are typically connected to low-voltage (LV) and medium-voltage (MV) systems. In part this reflects the inherent scalability of PV technologies (grid-connected system sizes can vary from hundreds of watts to hundreds of megawatts) and its ready integration into the built environment. In addition, the nature of policy support in some countries, which emphasizes distributed applications. In Germany, for example, up to 80% of the

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Summary

- Task 14 supports PV integration on high penetration levels
 - Provide access to more transparent technical analyses
 - Provide guidelines and best practices for industry, network operators, energy planners as well as authorities in the energy business to decide on steps to be taken and strategies to be developed.
 - Provide comprehensive international studies for high penetration PV
- Prepare Reports, Workshops and dissemination activities to provide objective and neutral high-quality information
- Develop key methodologies for
 - PV Power Forecast
 - Active management and control of grid integrated PV
 - Grid interconnection studies
 - Technical standards and interconnection requirements
- **Reduce the technical barriers to achieve high penetration levels of PV on the electric power system.**





Thank you very much for your attention

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