IEA PVPS Task 14
High penetration PV in Electricity Grids

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

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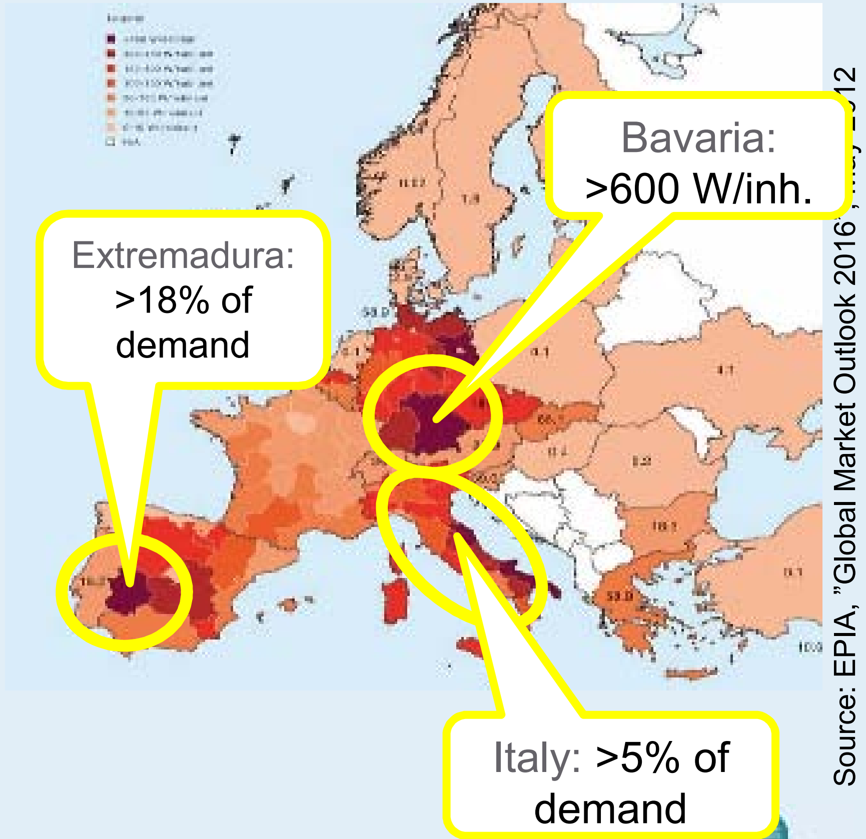
High Penetration of PV in Electricity Grids

- 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

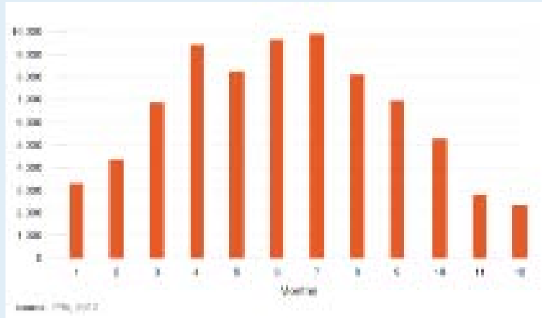
- PV penetration levels >100% are already leading to issues in some regions
- With installations growing in the GW range/year grid constraints will become crucial for further deployment of PV.

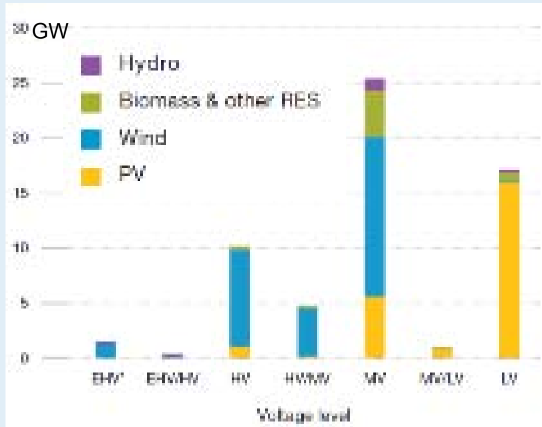


Source: EPIA, "Global Market Outlook 2016 … 2012

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



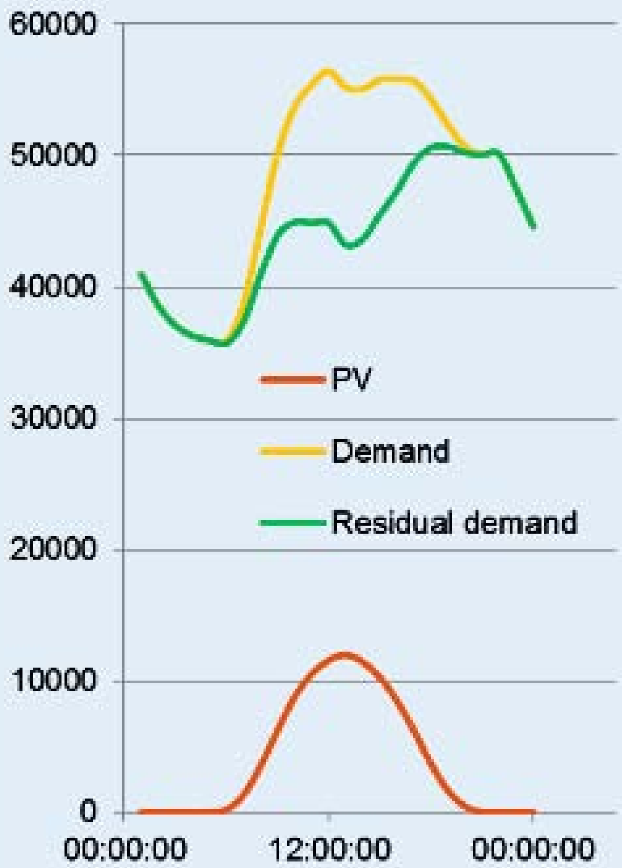


Source: EPIA based on DGS figures

RES capacity in Germany connected to different network levels

Characteristics of PV power generation Positive effects for the grid

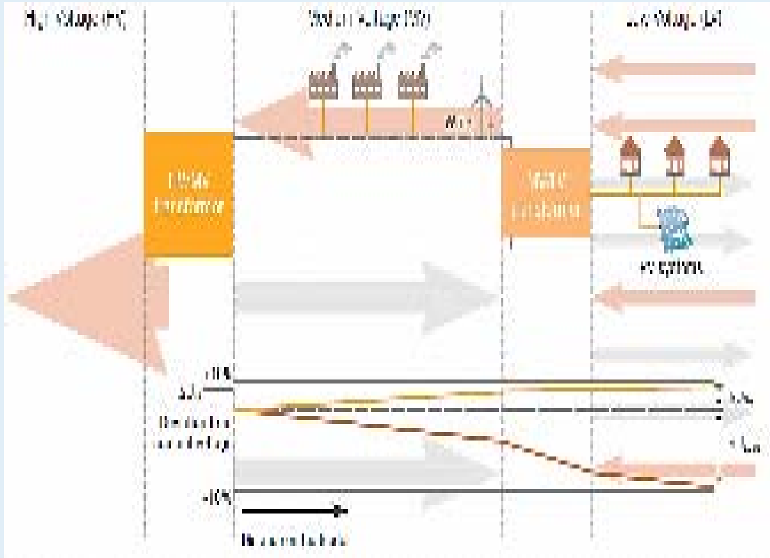
- PV production frequently meets times of high load in networks
- Reduction of network losses due to more local generation and therefore decreased power transmission
- More transmission capacity opens space for other transmission services
- Active network services from multifunctional photovoltaic inverters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

2 Associations

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

- http://www.iea-pvps.org/index.php?id=58

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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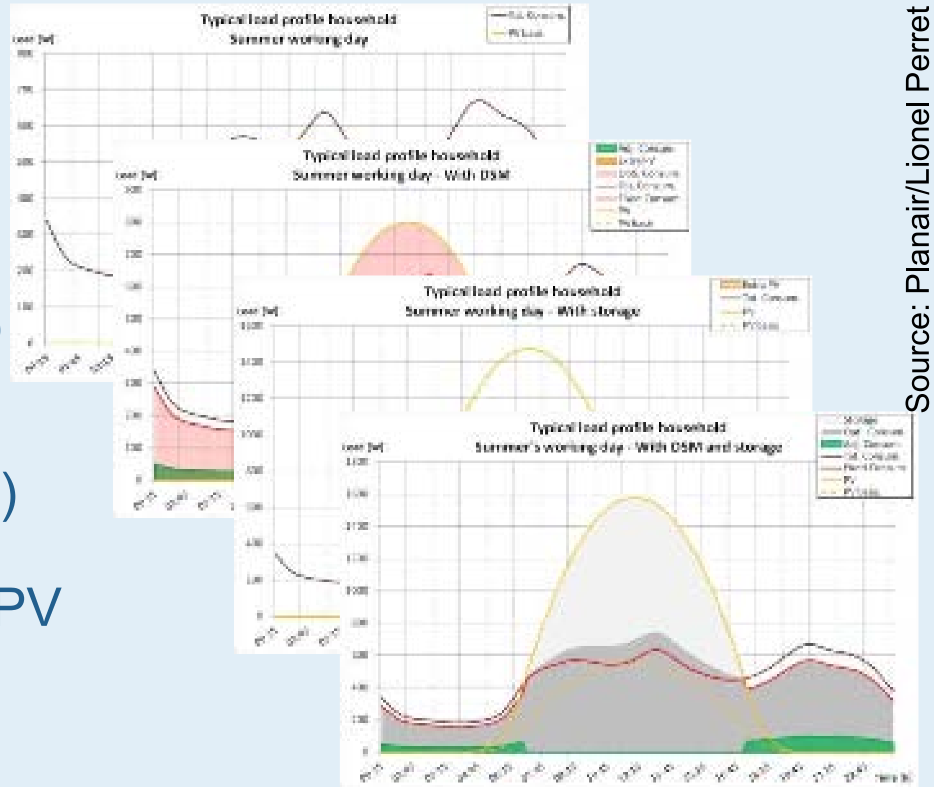
Task 14 – Results
Energy Management with PV

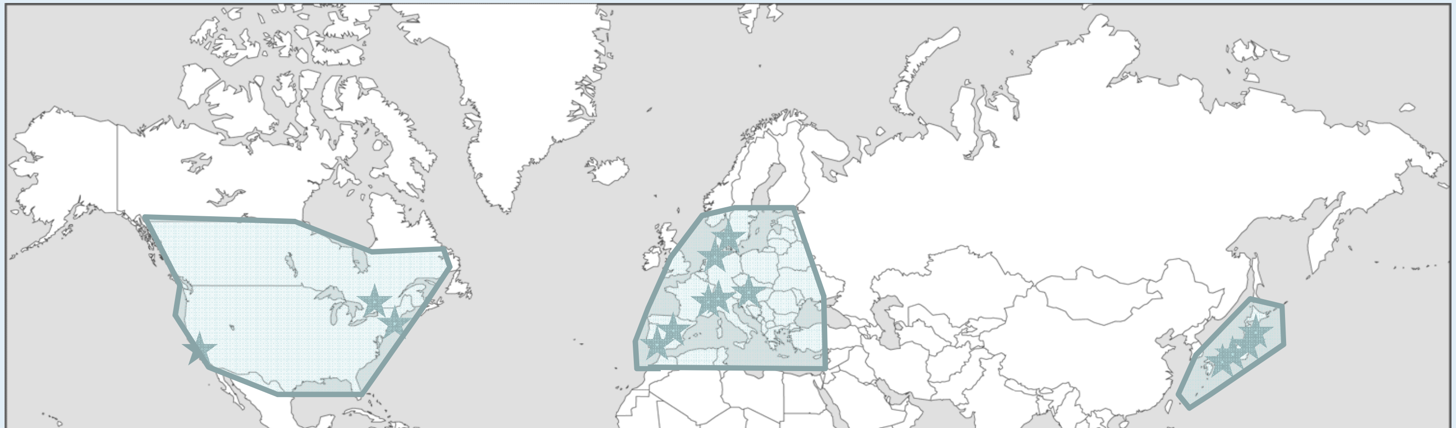
- Case studies for PV integration
  - Base case PV 4.5kWh/d
  - Integration with DSM PV 6.5kWh/d (+45%)
  - Integration with Storage system PV 12kWh/d (+165%)
  - Integration with DSM and Storage system PV 12.9kWh/d (+185%)



Source: Planair/Lionel Perret

Task 14 – Results
PV forecast: state of the art

- **3 regions: USA, Europe and Japan**



Source	Location of validation	Time step and forecast time	Uncertainty % of persistence	Uncertainty RMSE (relative or absolute)
DLR (DE)	Southern Spain	1 h, day 1		DNI: 50 – 64% rmse
CanmetENERGY (CAN)	Canada, USA	1 h, day 1 – 2	57%	
JWA (JP)	Japan	30 Min, 1h.		140 W/m^2
MeteoSwiss (CH)	Switzerland	-	-	-
Univ. Oldenburg / Meteocontrol (DE)	Switzerland Southern Spain Canada, Spain	1 h, day 1	65% 61% [2] 57% [2]	42 % rmse 21 % rmse
Univ. Jaen (ES)	Southern Spain	1 h, day 1	72% [2]	
DTU IMM (DK)	Denmark		68% [2]	
AIST / Waseda (JP)	Japan	1 h, day 1		100 W/m^2
Univ. GIFU (JP)	Gifu	1 h		64% rmse
UCSD (USA)	San Diego, 4 days	30 sec. 5 min.	50% 75%	
Bluesky Wetteranalyse (A)	Switzerland	1 h, day 1	65%[2]	
Irsolav (ES)	Spain	1 h, day 1		18 – 35% rmse
Meteotest (CH)	Switzerland	1 h, day 1	72% [2]	41 – 50% rmse
Weather Analytics (USA)	-	-	-	

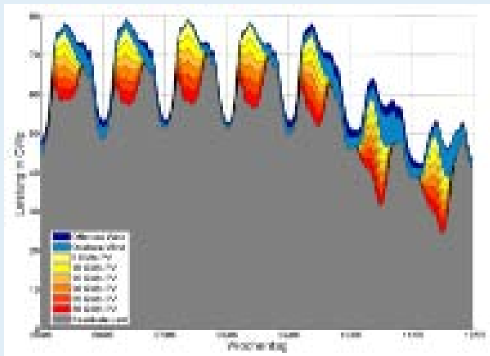
Source: Jan Remund, Meteotest

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

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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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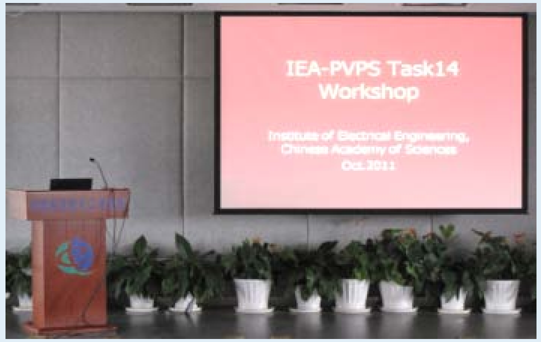
Task 14 – dissemination and interaction with key stakeholders

- 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

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

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

M. Braun, T. Stetz, R. Bründlinger, C. Mayr, K. Ogimoto, H. Hatta, H. Kobayashi, B. Kroposki, B. Mather, M. Coddington, K. Lynn, G. Graditi, A. Woyte and I. MacGill

ABSTRACT

1. INTRODUCTION

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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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