PHOTOVOLTAIC POWER SYSTEMS PROGRAMME



PV inverters in a High PV Penetration scenario – Challenges and opportunities for smart technologies

Roland Bründlinger Operating Agent IEA-PVPS Task 14

UFTP & IEA-PVPS Workshop, Istanbul, Turkey 16th February 2011



Contents

- Context
- The role of the PV inverter in a high penetration PV scenario Challenges and opportunities



- PV inverter related activities in the new IEA-PVPS Task 14
- Summary and conclusions



Contents

- Context
- The role of the PV inverter in a high penetration PV scenario Challenges and opportunities



• PV inverter related activities in the new IEA-PVPS Task 14



Summary and conclusions





PV is becoming relevant for electricity supply and grid operation

Today

PVPS

- 17% of electricity generation capacity in EU added in 2009 was PV
- 15 GW new PV capacity installed in 2010 (EPIA estimates)
- 2% of electricity supply (kWh) in Germany from PV
- In certain distribution grid areas, PV generation exceeds local demand
 → reverse power flow



source: EPIA, EWEA, ESTELA, OEA-EU, Platts PowerVision.



PV is becoming relevant for electricity supply and grid operation

Future:

PVPS

- Impressive targets
 - EPIA: 12 % PV in Europe until 2020 – 390 GWp
 - BSW Solar: 10% share in Germany 2020
- High PV penetration is becoming reality
- → "the integration of PV in electricity networks and energy markets has become a major challenge." (Cite from EPIA Solar Generation 6:)



source: Global Market Outlook for Photovoltaics until 2014, EPIA, May 2010.



Technical challenges with high penetration of PV¹

- Challenges & issues at the local distribution level
 - Maintaining voltage quality in the distribution network with high level of PV
 - Increasing levels of distributed generation impact existing protection and distribution infrastructure
 - Lack of information on the state of the distribution network and insufficient communication and realtime data processing
 - Lack of PV visibility and (commercially available) control capability





Technical challenges with high penetration of PV¹

Challenges from an overall system wide perspective

- EPS operation with high level of PV generation
 - At certain penetration levels, PV will be replacing conventional generation
 - Need to improve and extend capabilities of existing power plants (Ramping capability, control parameters)
 - Change of system behaviour during critical situations (e.g. loss of a large generator)
 - Threat due to simultaneous tripping of a large number/capacity of small scale PV systems
 - Loss of inertia today provided by central (rotating) generators
 - Current EMS at the system level are not prepared to operate RES based power systems

¹ Summary conclusions of IEA-PVPS Workshop High Penetration PV – A challenge for Utility Networks? Montreux, Switzerland, April 2010

PVPS



Technical challenges with high penetration of PV¹

Challenges from an overall system wide perspective

- EPS planning with high level of PV generation
 - Current EPS planning tools do not have the necessary capabilities to model power systems with high RE penetration
 - Lack of validated models for RE generation, particularly for inverter based generation (as PV)
 - System planning with high number of small scale generators becomes increasingly complex
 - Lack of high-res, solar resource data



PVPS

PHOTOVOLTAIC POWER SYSTEMS PROGRAMME

帮

Contents

• Context

The role of the PV inverter in a high penetration PV scenario Challenges and opportunities



• PV inverter related activities in the new IEA-PVPS Task 14



Summary and conclusions



The PV inverter as gateway to PV grid integration

- PV inverters
 - play a key role as interface between primary generation and electricity grid
 - Integrate protection and grid monitoring
 - Provide system monitoring and control
 - Offer multifunctional characteristics with modern power electronics
 - Act as interface between grid and local storage





The inverter as interface between PV generation and the grid

- Situation today
 - Sole conversion of DC to AC at unity power factor
 - \rightarrow maximizing conversion efficiency
 - Limitation of additional disturbances
- → Challenges:
 - ➔ Maintain voltage quality in the distribution grid
 - Accommodate increasing amounts of PV capacity



The inverter as interface between PV generation and the grid

- In future high penetration PV scenarios
 - Capable to provide reactive power on demand Q or PF set points, time schedule depending on the voltage at the point of coupling "voltage control"
 - Remote controllability of active and reactive power injection
- Opportunities:
 - Provide voltage support in the distribution grid
 - Increase usable grid capacity ("hosting capacity")



The inverter as interface between PV generation and the grid

- Situation Today
 - Voltage/frequency monitoring
 - Additional passive or active anti-islanding schemes
 - "Disconnection at the first sign of trouble" practice
- → Challenges:
 - Simultaneous loss of a large number/capacity of PV systems due to remote faults in transmission system may jeopardize grid stability
 - Problem: Undefined behavior of PV systems during abnormal grid conditions





The inverter as interface between PV generation and the grid

- In future high-penetration scenarios
 - Static grid support by PV inverters (e.g. power foldback at over frequency situations)
 - Dynamic grid support by PV inverters (Fault-Ride-Through)
 - Behavior of the PV inverters adapted to the requirements of the system operation
- ➔ Opportunities:
 - → PV support fault management in the grid
 - ➔ Grid operators will be able to "rely" on PV during critical situations.

PHOTOVOLTAIC POWER SYSTEMS PROGRAMME

System monitoring and control

Current vs. future requirements for PV inverters

- Situation today
 - PV inverters monitor a broad range of PV and grid parameters – but they are solely used for PV system monitoring
 - No standardized communication interfaces/protocols
 - No link to the grid operation
- → Challenge

PVPS

PV generation not "visible" to the grid operator dispatch centre System monitoring and control

Current vs. future requirements for PV inverters

- In future, high penetration scenarios
 - PV inverter as hub and center for data acquisition, communication and control
 - Standardized communication interfaces and control protocols for easy interconnection

➔ Opportunities:

- PV fully integrated into the EMS of the grid operator
- Optimized direct (local) utilization of PV electricity (grid parity!)





Multifunctional characteristics

- Situation today
 - PV inverters only provide active power to the grid
 - Opportunities of modern power electronics are not fully utilized
- In future high-penetration scenarios
 - PV inverter will become a key component in smart grids
 - Active improvement of quality of supply by filtering/compensation of Harmonics, Phase balancing
 - Virtual inertia
 - Provision of ancillary services to the grid can offer additional value to plant operation



The PV inverter as interface between local storage and the grid Current vs. future requirements for PV inverters

- Situation today
 - Limited to local applications (UPS, backup supply,...)
 - Storage only used for local services
 - ➔ No link to grid operation
- In future, high penetration scenarios
 - Integration of local storage into grid management
 - Power-on-demand
 - Peak shaving/shifting
 - Increased security of supply and provision of ancillary services to the grid
 - Increase hosting capacity of the grid

Contents

- Context
- The role of the PV inverter in a high penetration PV scenario Challenges and opportunities



• PV inverter related activities in the new IEA-PVPS Task 14



Summary and conclusions



IEA PVPS - Task 14 "High-Penetration of PV Systems in Electricity Grids"

Objectives of the 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 systems 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





IEA PVPS - Task 14 "High-Penetration of PV Systems in Electricity Grids"

Key research items:

- PV generation in correlation to energy demand focusing on the consumer behavior to be better linked to the generation profile
- Analyzing and identifying the effects on PV generation to the local grid as well as to the general electricity system
- Smart inverter technology dealing with requirements for inverters at high PV penetration
- Collection of convincing case studies of H-P PV and Simulation models







IEA-PVPS Task 14 Subtask on Smart inverters for high penetration PV

• Objective:

Define inverter technology requirements for successful integration of a high penetration of PV in the electricity grids

- Inverter technology requirements
 Design and topology related issues
- Technical requirements, limits, capabilities What functionality can / needs to be added at certain levels of PV penetration?
- Communication and control related requirements Interfaces, standards and protocols
- The role of the PV inverter as interface between local storage and the grid

Contents

- Context
- The role of the PV inverter in a high penetration PV scenario Challenges and opportunities



• PV inverter related activities in the new IEA-PVPS Task 14



Summary and conclusions





Summary & conclusions

- Growing PV penetration requires the active integration of the installations into grid operation
- PV inverters are the key elements to enable electricity grids for more PV
- New requirements will lead to a big step in technology innovation in the field of PV inverters
- PV inverters with new features
 - Provide system services
 - Contribute to grid support
 - Integrated into grid management
 - → Help to significantly increase the share of PV generation in the electricity grids





Summary & conclusions

- Critical issues
 - Growing complexity and diversity of requirements may create an increasing barrier to effectively apply the potential of new inverter functionalities in practice
 - Important: International exchange of experiences and harmonized standards
- PVPS Task 14 will
 - act as a collaboration platform for international experts on the subject of high penetration PV
 - ➔ Use the worldwide PVPS network to disseminate information on high penetration PV and best practice models.

PHOTOVOLTAIC POWER SYSTEMS PROGRAMME



Thank you very much for your attention!



Contact: Roland Bründlinger AIT Austrian Institute of Technology Energy Department Business Unit Electric Energy Systems Giefinggasse 2, 1210 Wien, Austria roland.bruendlinger@ait.ac.at