Transmission and Distribution System Interaction

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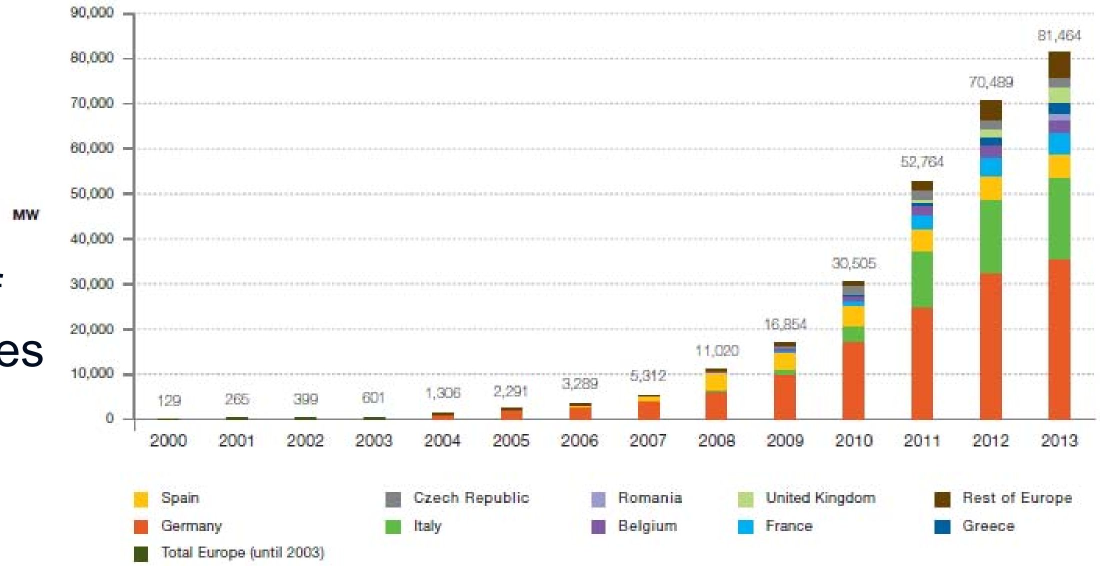
Photovoltaic growth in Europe

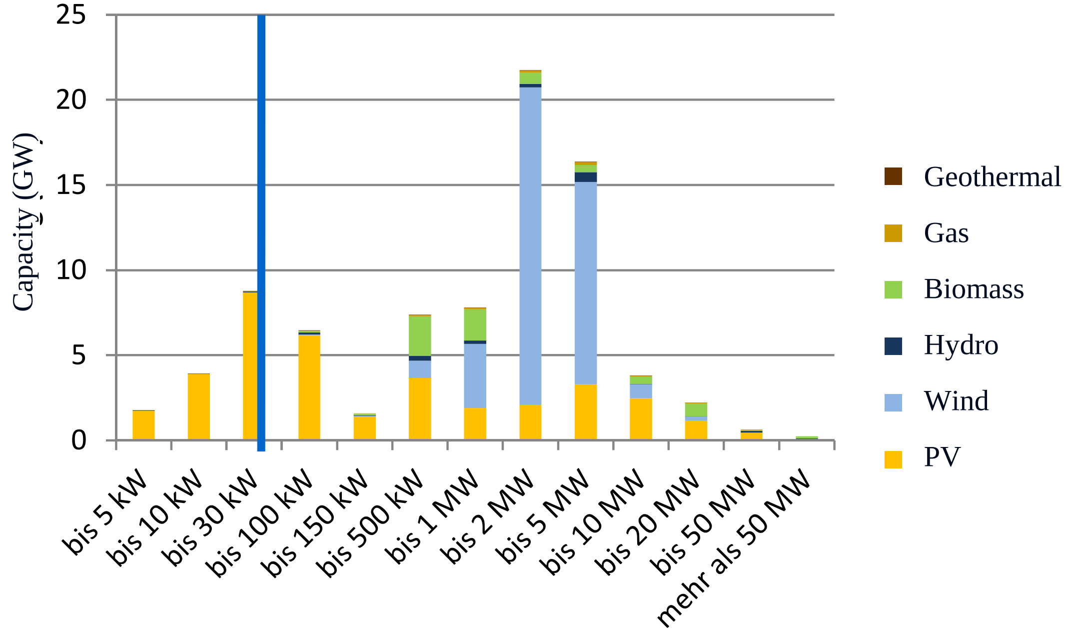
- Massive growth due to:
  - Substantial subsidies
  - Reduced costs for PV
- Heterogeneous distribution of the installed capacity (countries / regions)
- >80 GW (End of 2013):
  - >35 GW in Germany
  - >20 GW in Italy
- Austria: ~630 MW (End of 2013)



Installed PV capacity (End 2013)
(EPIA, "Global Market Outlook for Photovoltaics 2014-2018," 2014)

Special characteristics of PV on the example Germany

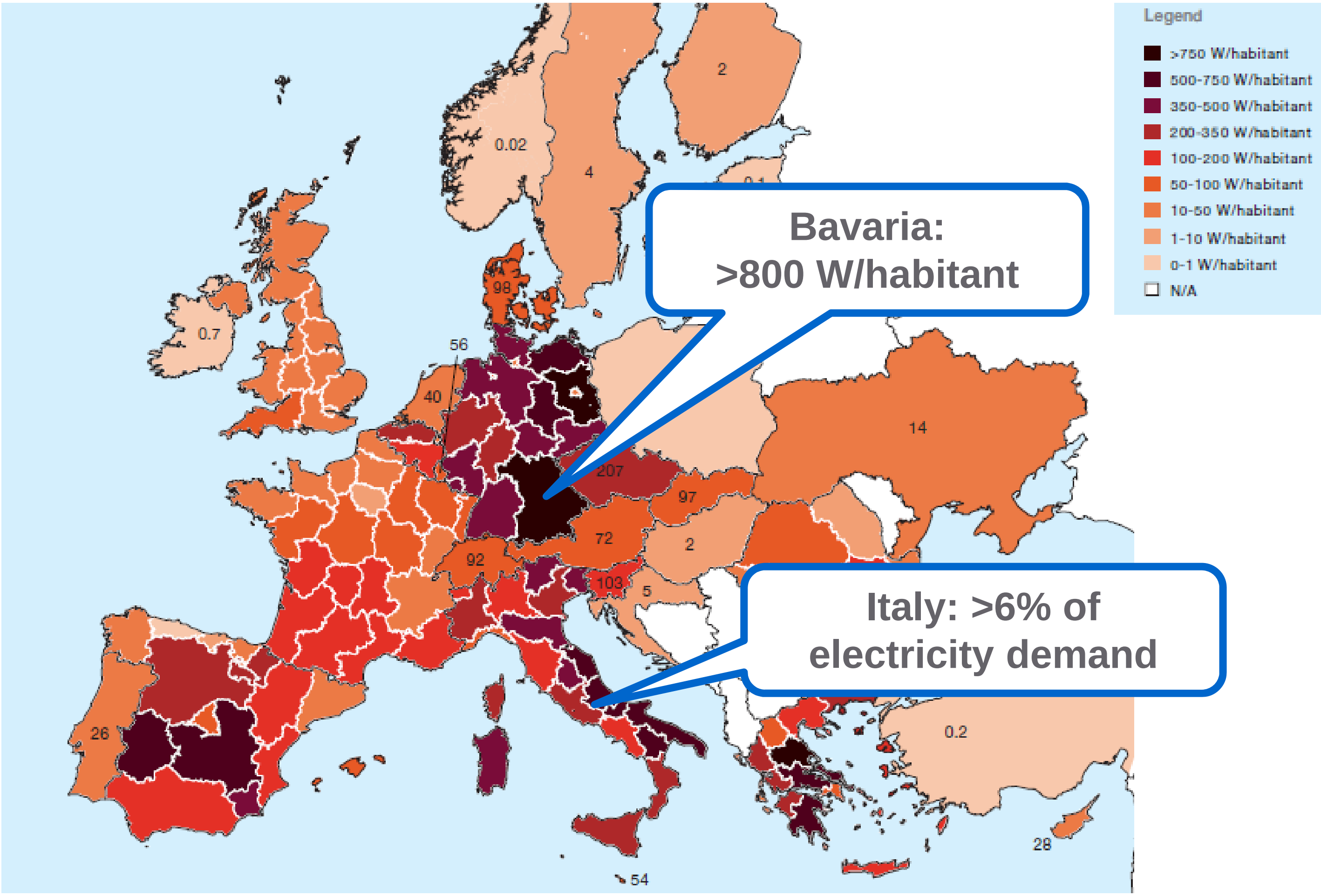
- „15 GW < 30 kW"
- 70 % of the overall capacity is installed in low voltage networks
- Cost efficient network integration is a challenge



Distribution of the installed capacity according unit size (Status 11.2014)
(EnergyMap www.energymap.info)

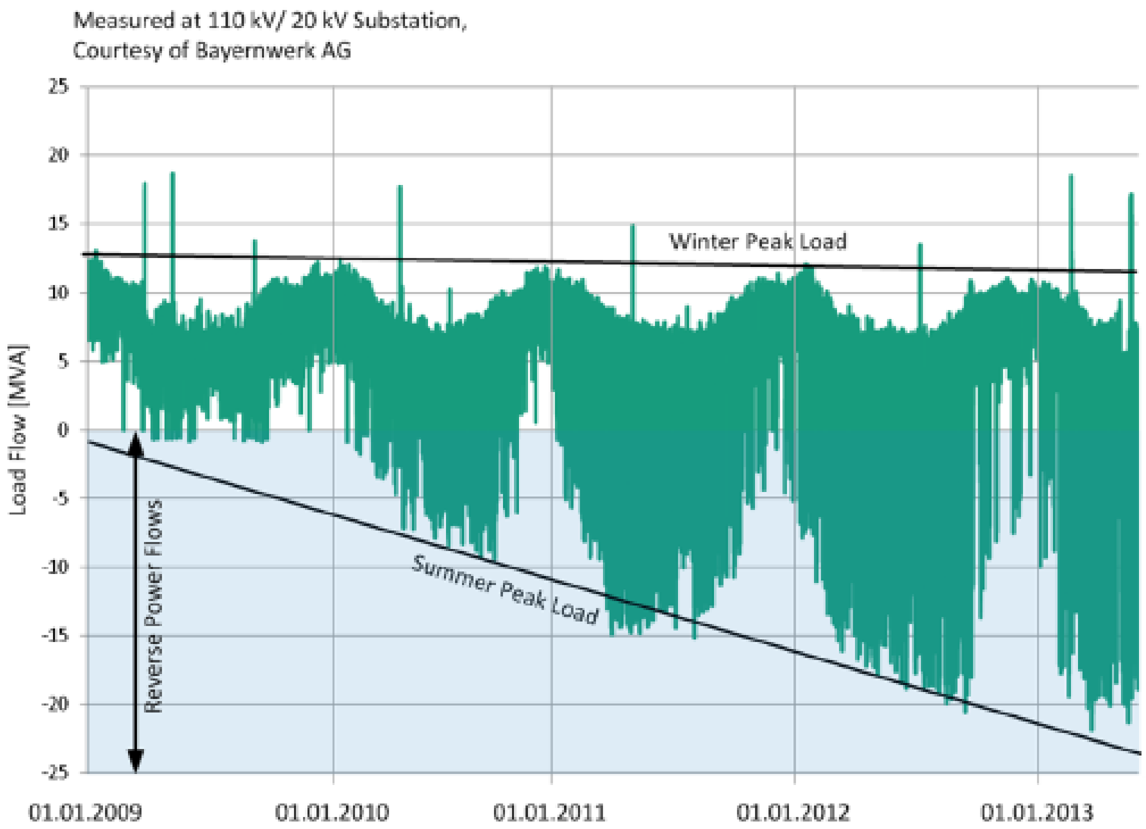
- 90% of all renewable power generation is connected to distribution networks

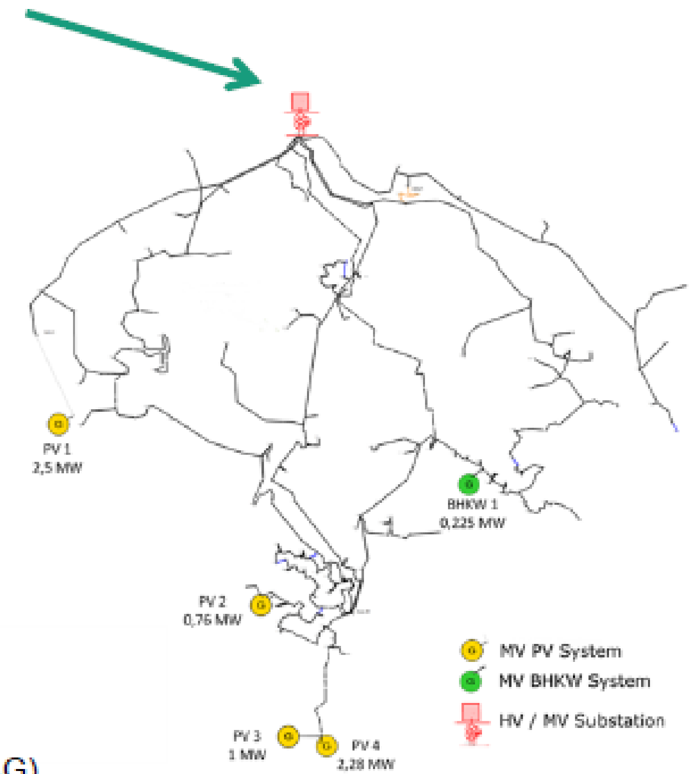
Heterogeneous distribution of installed PV capacity



(Source: EPIA-Global Market Outlook 2013)

Transition from uni- to bidirectional distribution grids





Figures: German MV case study within IEA Task 14 (courtesy of Bayernwerk AG)

(Source: Frauenhofer IWES, 2014)

Development of RES system integration

Massive change from troublemaker being disconnected in case of any problem to troubleshooter supporting grid operation

- Local voltage support
  - Volt/Var Control
  - Extension to Volt/Watt control under discussion
  - Influence of on all voltage levels to be considered
- Frequency control
- Fault ride through (FRT)

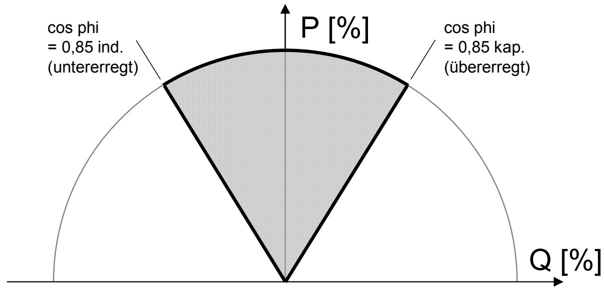
Grid supporting behavior required in different network codes (challenge of defining the right Values)

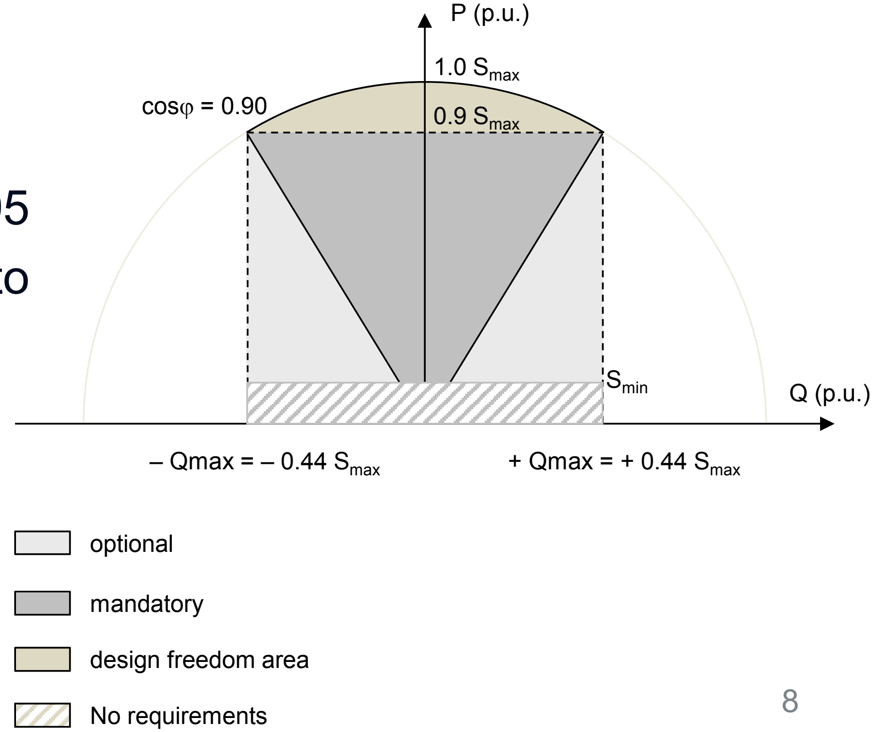
Reactive Power Provision: PQ-Diagram („mandatory “)

- Germany (BDEW and AR4105)
  - Low voltage:
    - No requirements ≤3,68 kVA
    - cosφ 0.95 (≤13.8 kVA) or 0.9 (>13.8 kVA)
  - Medium voltage:
    - up to cosφ 0.9
- Italy (CEI 0-21 8.4.4.2)
  - P = 3-6 kW: “Triangle” with cosφ 0,95
  - P > 6 kW “Rectangle” with cosφ up to 0,90

S_{min}

- CENELEC TS 50549-1 und 2





DG integration in distribution networks on example Germany

- 35% of low voltage network operators and 64% of medium voltage network operators are a affected by network reinforcement
- Investment needs very different depending on region and voltage level
- Innovative planning approaches in conjunction with intelligent technologies can reduce the expected network reinforcement dramatically
  - Reactive power management in network planning
  - Load management in network planning
  - Intelligent network components like OLTC at secondary substation level

Source: Moderne Verteilernetze für Deutschland (Verteilernetzstudie)," Sep. 2014)

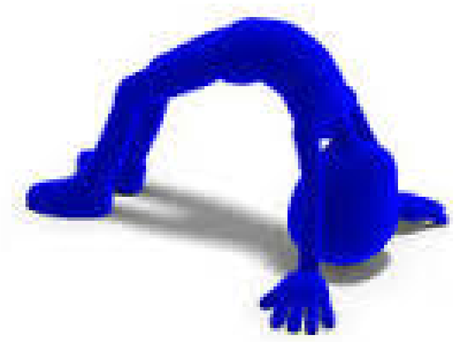
DG integration in distribution networks on example Germany

- Small curtailment of active power can significantly reduce network reinforcement
  - 1% curtailment of annual generation leads to 30% reduction of network reinforcement
  - 3% curtailment leads to save 40% of network reinforcement

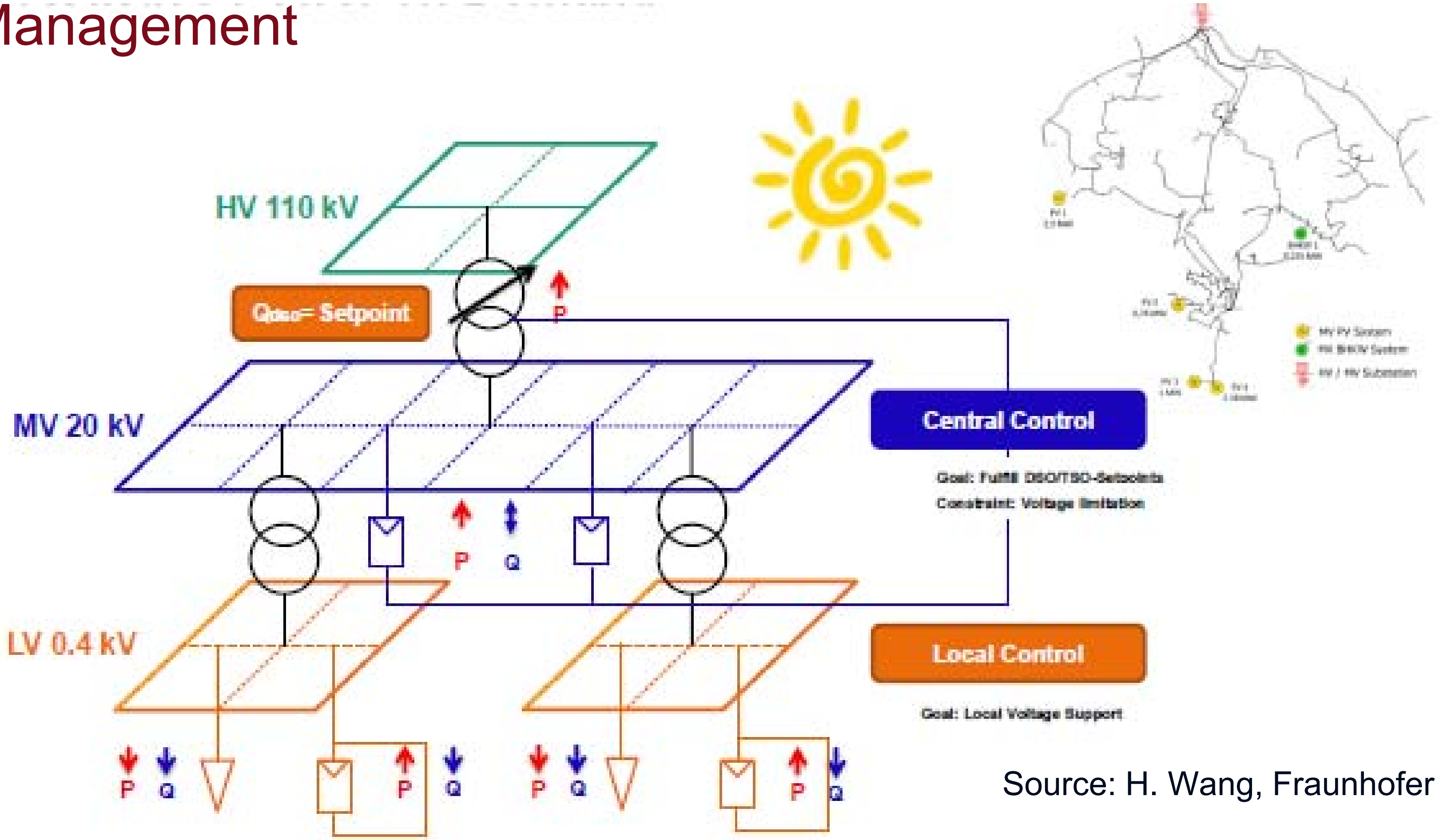
Source: Moderne Verteilernetze für Deutschland (Verteilernetzstudie)," Sep. 2014

Flexibility Provision

- Enabling flexibility at all levels is a key issue for energy and cost efficient integration of DER.
- Possible flexibility resources are at demand level (demand response), generation level (active and reactive power management) and additional electricity storage.
- It is necessary to consider flexibility provision over traditional boundaries from distribution system level (including costumer level) up to transmission system level
  - Vertical integration and
  - Horizontal integration



DSO as Service Provider for the TSO: Reactive Power Management

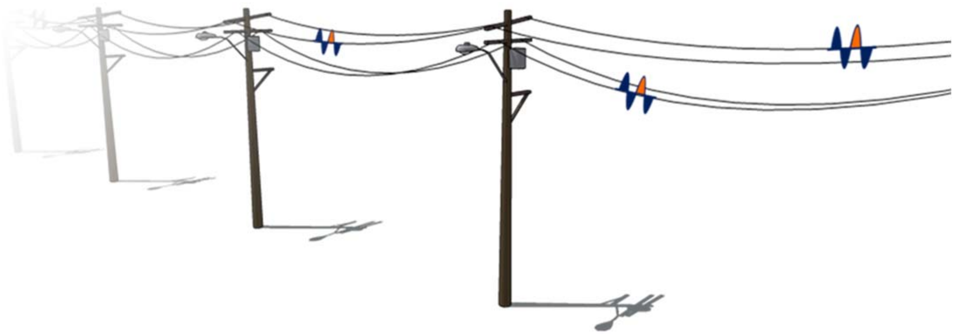


Source: H. Wang, Fraunhofer IWES

- Topic within ISGAN Annex 6, Task 5 on TSO – DSO interaction

Grid and Market

- For gaining benefits the integration of DER in both markets (whole sale, retail, balance…) and grid operation is crucial
- Solutions how to deal with contradicting signals from grid and market need to be developed
- Nevertheless, when developing new integrative control functions it is necessary to consider market design in order to ensure the economic feasible



Issues to be considered

- Coordination of power grid and market issues
- Optimizing voltage band management including reactive power management
- Grid Congestion management by flexibility/demand response
- Integrating flexibilities provided by prosumers and aggregators as an option in reactive power and voltage band management
- Integration of data from the low voltage networks in MV/HV SCADA/DMS systems
- Stability analysis in respect of reactive power flows caused from MV and LV reactive power management
- Influence and interaction of different grid codes: How can the distribution network in practice contribute to deliver ancillary services and are there improvements necessary for the future

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