



14. Symposium Energieinnovation

Increasing the feed-in capability and improving the power quality of low-voltage distribution grids

Markus Meyer, Bastian Maucher

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Technische Universität München
Professur für elektrische Energieversorgungsnetze

Agenda

1. Introduction and project outline
2. Concepts for increasing the feed-in capacity of low-voltage-grids
 - a. Innovative inverter concepts
 - i. Photovoltaic-inverters
 - ii. Unified-Power-Flow-Controller (UPFC)
 - b. Control-strategies
 - i. Autonomous mode
 - ii. Controlled mode
 - iii. Controlled mode with set point
 - c. Communication and data management
3. Conclusion

Introduction

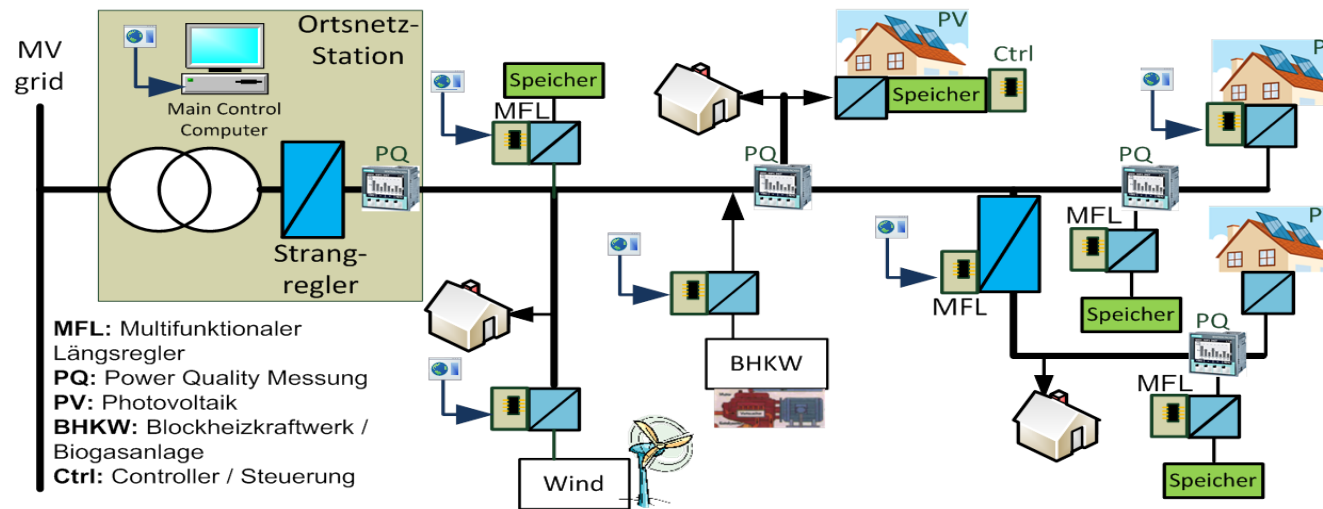
Legal aspects of low-voltage-grid operation:

- standards regulate the quality of the electric power supply
- most important standard: DIN EN 50160
 - grid frequency
 - voltage quality
 - harmonics

Technical aspects:

- increasing number of switched-mode power supplies connected to the grid
- inverter-based power generation connected to low-voltage grids
- inversion of the load flow \Rightarrow top-down vs. bottom-up load flow

Project Outline



- voltage-control / reactive power supply by UPFC
- new PV-inverters contribute to voltage-control and lower reactive power consumption of the grid
- innovative battery charging strategies reduce inverse load-flow
- broadband-powerline-communication offers a reliable and cost-efficient communication between active devices

Inverter Concepts – PV-Inverters

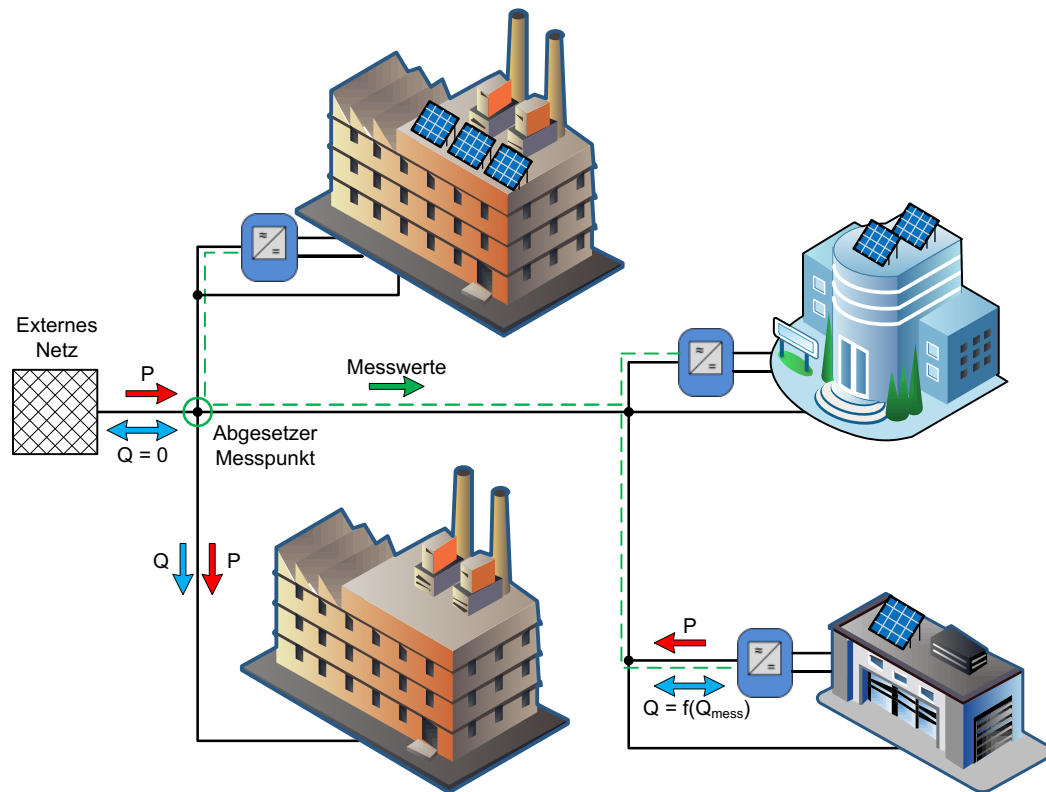
Current technology:

- $Q(U)$; $\cos\phi(P)$ -droop curves
- voltage control on local grid connection point

Innovative concept:

- voltage control on an external grid node
 - decreasing reactive power consumption of industrial enterprises
- decreasing transient time (400 ms to 150 ms)

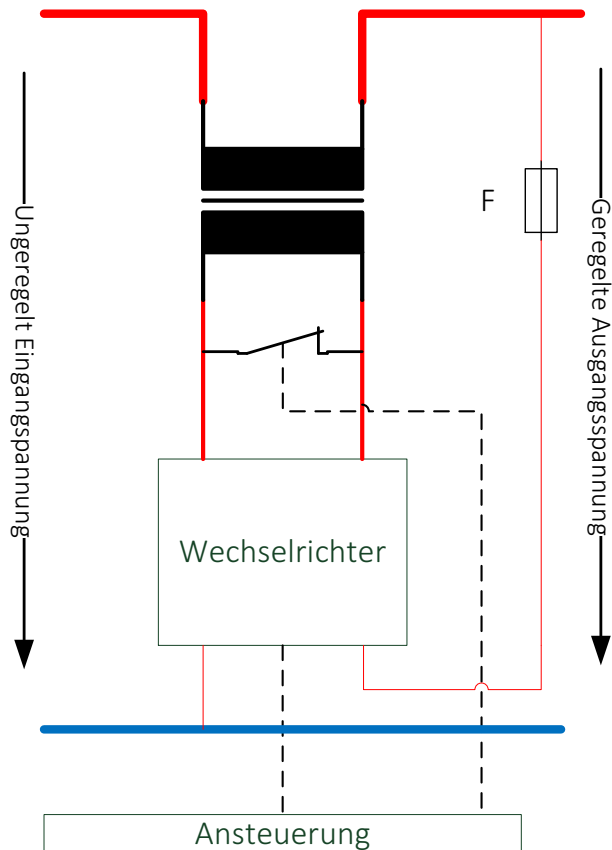
Inverter Concepts – PV-inverter



- industry complex with own PV-generation, connected to the low-voltage grid
- part of active power consumption covered by solar energy

- reactive power compensation device replaced by reactive-power supply of the inverters
- Minimize the reactive power consumption from the grid

Inverter Concepts – UPFC



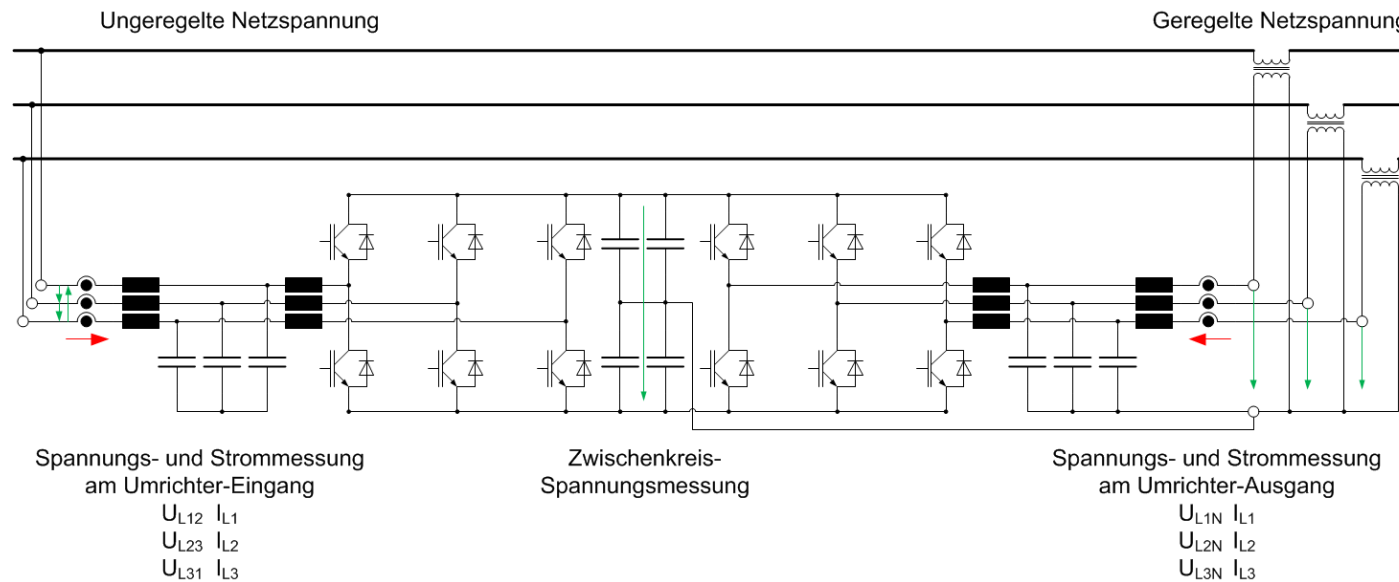
Current technology:

- mechanical load-tap-changer (similar to rONT)
- three phase step-voltage-regulation

Innovative concept:

- inverter-based concept Single-phase balancing of phase-currents/voltages
- stepless voltage regulation
- reactive power supply
- bypass for short-circuit overload and service

Inverter Concepts – UPFC



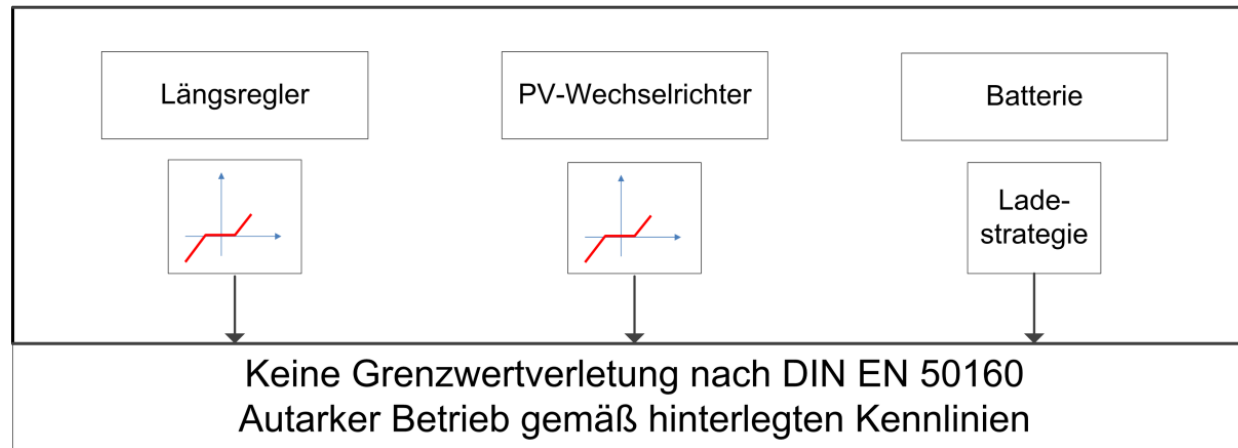
- serial connection of the transformer secondary winding
- phase-independent voltage regulation (magnitude and angle)
- shunt inverter allows additional reactive power supply
- balancing of unsymmetrical grid states
- active/reactive power control over the line
- compensation of harmonics

Control Strategies for Low-voltage Grids

General requirements:

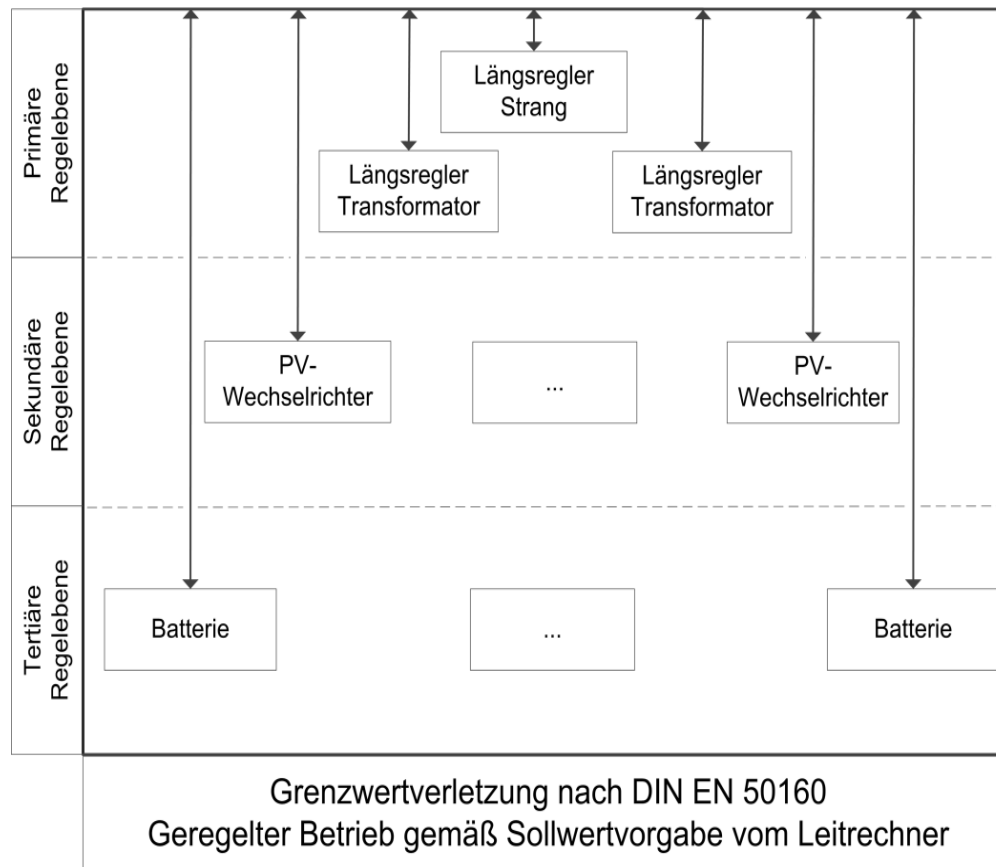
- reliable operation of the controlled grid
 - meeting the constraints due to DIN EN 50160
(voltage band, harmonics)
 - fully automated mode as well as manual mode possible
-
- processing measurement data of different grid nodes
 - detecting violations according to DIN EN 50160

Strategy I: Autonomous Mode



- no detected violation of the limits according to DIN EN 50160
- active utilities (UPFC, PV-inverter) operate according to pre-defined droop-curves and loading strategies

Strategy II: Controlled Mode – Hierarchic Structure



Primary control level: UPFC's:

Strongest influence onto the grid

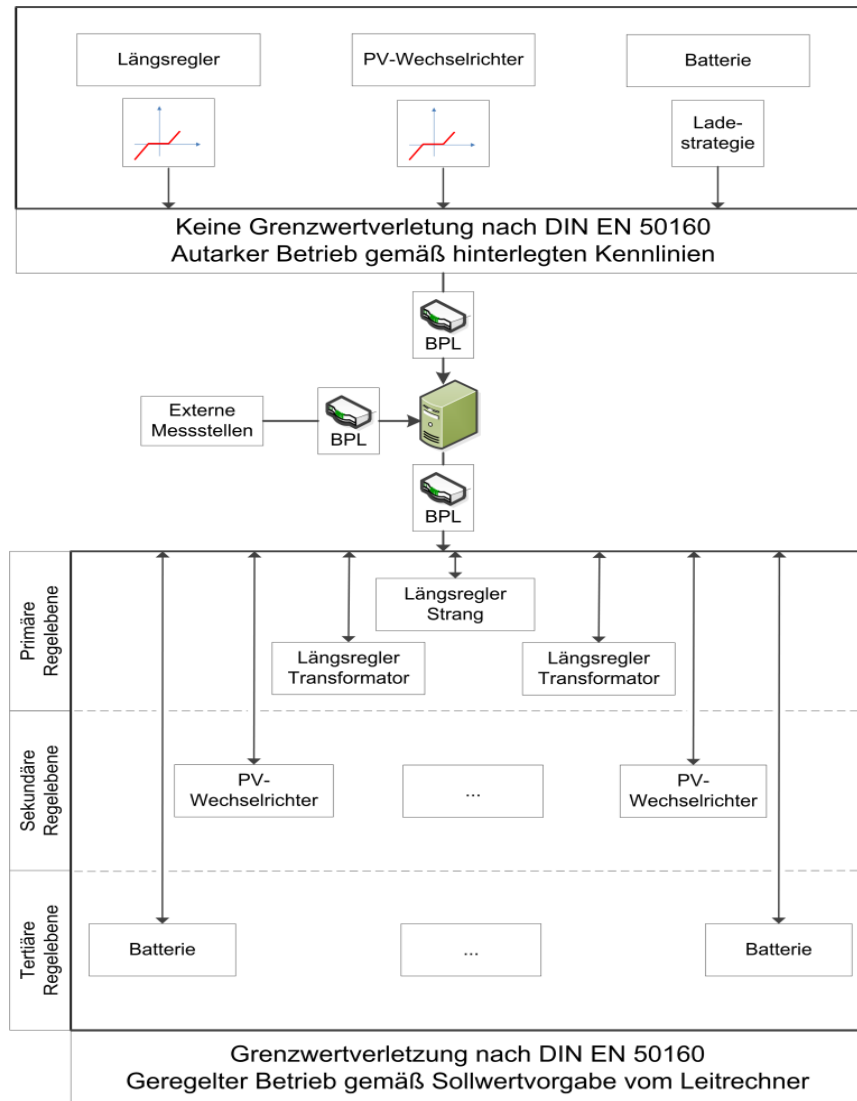
Secondary control level: PV-inverters:

Contribution to the voltage-control by reactive power supply

Tertiary control level: batteries:

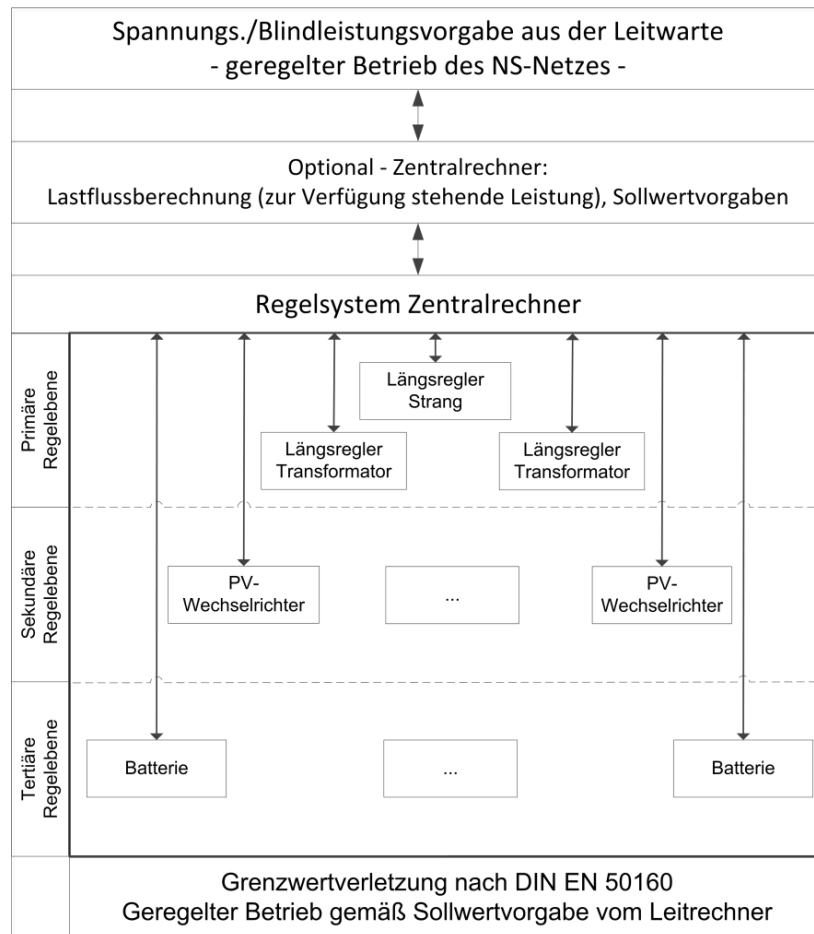
Charging strategies to be changed at last

Strategy II: Transition Autonomous – Controlled Mode



- violation of the limits detected
- Active utilities (UPFC, PV-inverter) operate due to pre-defined droop-curves and loading strategies

Strategy III: Controlled Mode with Set Point

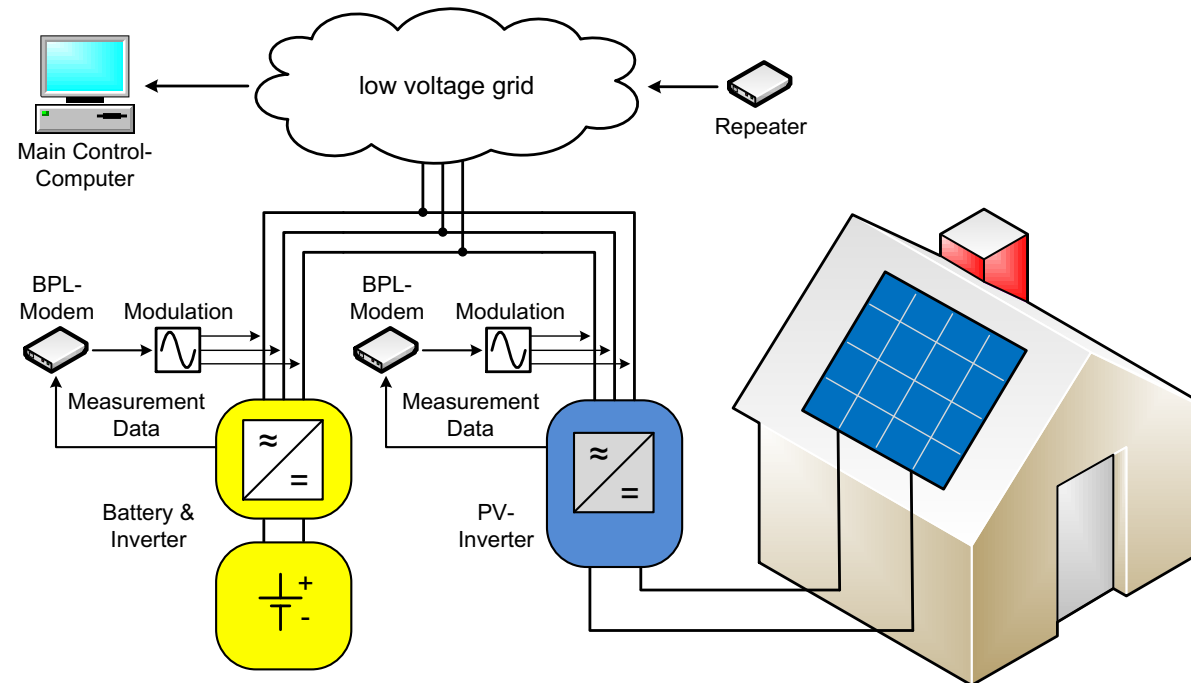


Reactive power-flow-control:

- status feedback of the active utilities
- load flow calculation based on the measurement data
 - remaining reactive power reserve of the low-voltage grid
- Grid operator is able to retrieve a certain amount of active/reactive power

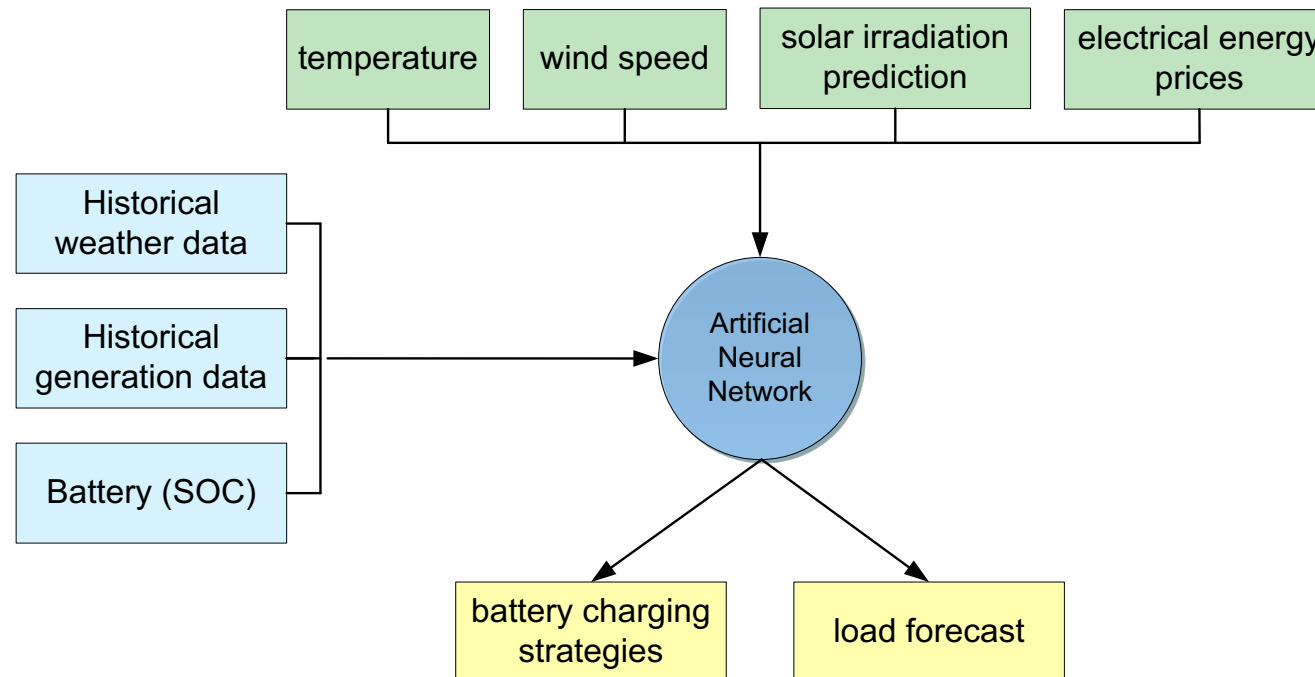
➡ Virtual power plant

Communication – Broad-Band-Powerline-Communication



- measurement data, status reports etc. are converted into high-frequent voltage signals using the electrical grid as its communication infrastructure
- several repeaters are placed at strategic locations

Data Management – Battery-Charging Strategy



- Artificial Neural Network (ANN)
- measured input parameters
- historical input parameters
- statistical/numerical forecasts



Professur für Elektrische
Energieversorgungsnetze



**Thank you
for your attention!**



Gefördert durch:



aufgrund eines Beschlusses
des Deutschen Bundestages