Trends In Utility-Scale Inverters for Solar PV Projects

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Definitions

- Complex transmission grid requirements
- Solar PV design challenges
- Technological trends in utility-scale inverters
- Questions & Discussion
Definition:
Solar PV System

PV generator consisting of solar panels, support structure and DC-cabling

- weather station
- PV field
- Equipment room
- Monitoring and Control
- PLC
- Inverter
- Master
- Slave
- DC Power
- AC Power
- AC Power at Voltage Utility Requires
- Sun Energy
- DC Power
- AC Power
- grid
- MV transformer
- MV grid
- Commissioning service
- modem
Definition: Utility-scale PV plant and inverter

Definition of utility-scale PV plant:
- The installation is ground-mounted
- The plant owner sells energy directly to the electric utility
- Interconnection occurs on medium or high voltage level

Definition of utility-scale inverter:
- Inverter which is used in such an installation
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Complex transmission grid requirements: Overview

- Low Voltage Ride Through (LVRT) / Fault Ride Through (FRT)
- VAR control
- Power Regulation
Complex transmission grid requirements: LVRT

LVRT:

- Only grid requirement from CALISO today (and ONLY if interconnect results show a need for that project site)

- UL 1741 does NOT allow for Low Voltage Ride Through / Fault Ride Through (anti-islanding)
Complex transmission grid requirements: VAR

- **VAR:**
  - VAR 0.95/0.95 NOT required today
  - Only a topic if the interconnect study results show a need for reactive power for that project site
  - Full VAR and Active Voltage Regulation for PV plants is NOT an ISO requirement today (*only recommendations* at ISO and FERC levels)
Complex transmission grid requirements:
Power Regulation

Power Regulation:
- Reduction of real power output of the PV power plant to a certain amount (e.g. set by the grid operator)
- Not a requirement from CALISO yet

Reasons:
- Over-Voltages
- Over-Frequency
- Congestion in the grid
Complex transmission grid requirements: BDEW Guideline in Germany

- Dynamic grid support (fault ride through / FRT)
  → In the event of temporary voltage dips, the inverter does not disconnect from the grid

- Static grid support through reactive power (VAR)
  → Either by fixed or dynamic specification of reactive power by grid operator or control of the reactive power via a characteristic curve

- Power limitation according to EEG §6
  → Grid operators must be able to control the power output of any PV plant

- Frequency-dependent control of the active power
  → With a line frequency of 50.2 Hz or higher, the active power is controlled
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Solar PV design challenges

- 600 VDC vs. 1000 VDC
- UL vs. IEC (Non-UL)
- Container vs. NEMA 3R
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Technological trends in utility-scale inverters
Grid Requirements:

- IEC certified inverters can be parameterized to fulfill the mentioned grid requirements

- Coming up: UL____ (TBD) – Low Voltage Ride Through (LVRT) Electric Grid Support
Overall Trend:

- Larger Project sizes (100 MW, 500 MW, ...)
- Reduce costs in order to reach grid parity
- Over-sizing of Inverter (energy vs. financial optimum / simulation)
- Uptime Guarantees & Service Contracts
Technology Trend:

- 50 C operational temperature without derating
- 1000 V UL approved inverters for “smaller” utility-scale PV plants
- Larger block sizes → reduce costs
- Megawatts in a Box → plug & play → reduce costs and field-installation time
- 1000 VDC to 1200 VDC systems → reduce DC wiring losses and reduce cabling costs
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