



# Trends In Utility-Scale Inverters for Solar PV Projects

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# Trends In Utility-Scale Inverters for Solar PV Projects

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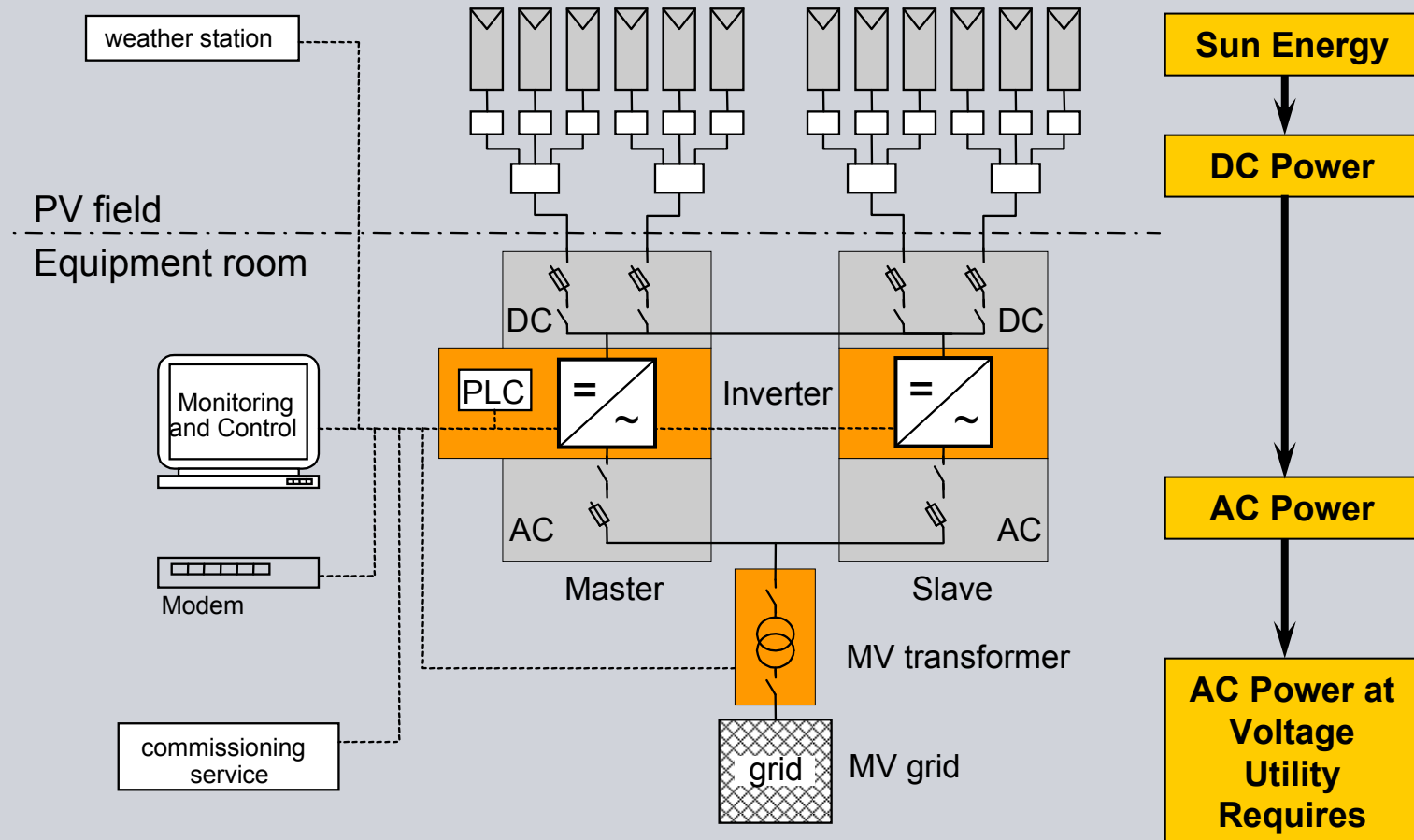


## ▪ **Definitions**

- 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



# 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

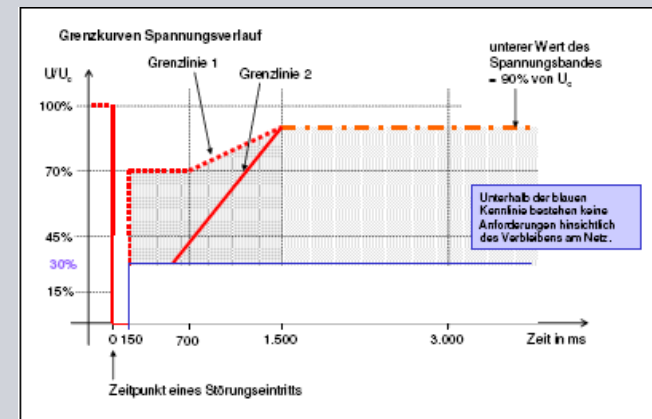
- **Low Voltage Ride Through (LVRT) /  
Fault Ride Through (FRT)**
- **VAR control**
- **Power Regulation**



# Complex transmission grid requirements: LVRT

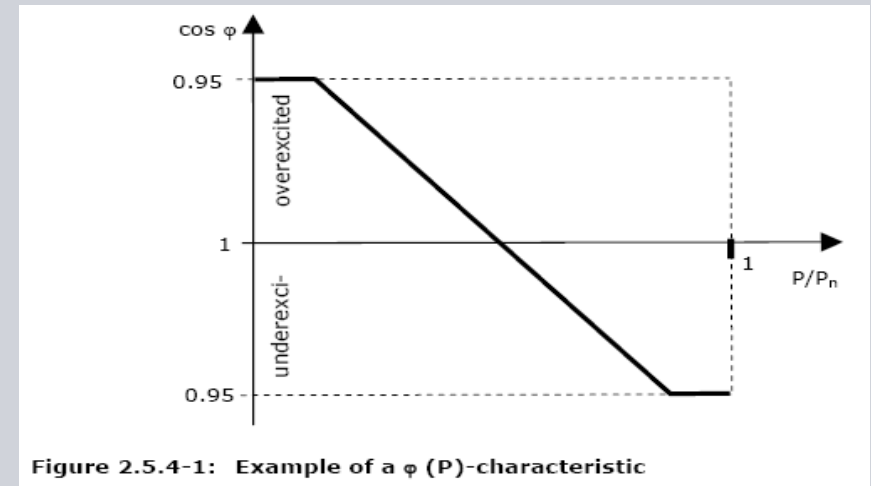
## LVRT:

- 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)



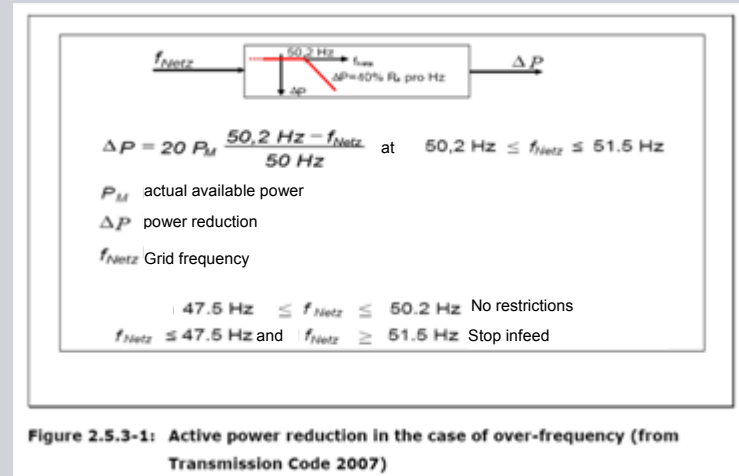
# Complex transmission grid requirements: Power Regulation

## 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

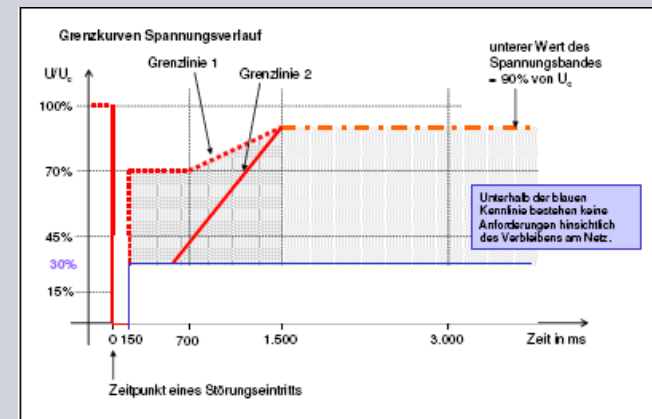
## Reasons:

- 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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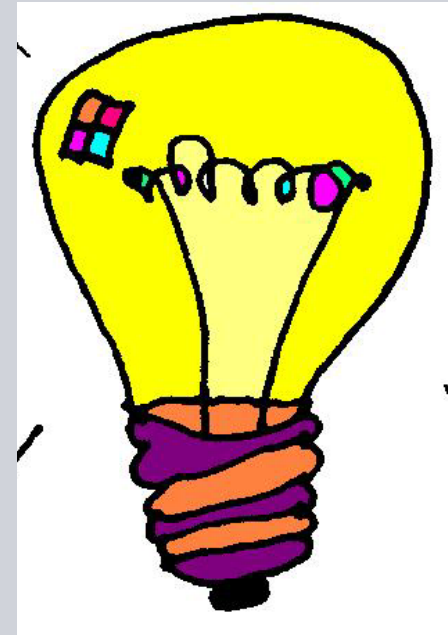
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## Solar PV design challenges

- 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

## 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



# Technological trends in utility-scale inverters: Overall Trend

## 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



# Technological trends in utility-scale inverters>

## Technology Trend

### 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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## Questions & Discussion



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