OVERVIEW OF INCREASING THE PENETRATION OF RENEWABLE ENERGY SOURCES IN THE DISTRIBUTION GRID BY DEVELOPING CONTROL STRATEGIES AND USING ANCILLARY SERVICES

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Abstract. Increasing the renewables energy resources in the distribution network is one of the main issues of the distributed system operator due to instability, power quality and feeder capacity problems. This paper proposes a solution for further penetration of distributed energy resources, by combination of control strategies only. Besides the penetration issues, the control strategies will solve power quality problems, voltage unbalance and will increase the immunity of the grid by provision of fault ride through capabilities.

Keywords: ancillary services, control strategy, power quality, voltage unbalance, voltage control

INTRODUCTION

To meet the European 20-20-20 targets, the share of renewable energy needs to be 20% of the total energy use in 2020 [1].This ambitious objective can only be met if the number of distributed renewable energy sources (DRES) at the low voltage (LV) grid will significantly increase and large wind or solar plant farms will be installed at the medium voltage (MV) level. Consequently, distribution system operators (DSOs) face the challenge to connect and integrate an ever increasing amount of renewable energy sources, but still guarantee the high level of power quality to their customers. Grid operators today already face problems to dispatch the distribution grid with the currently installed renewable energy resources RES [2]. Thus, the connection of new production units, including many wind farms, risks to be cancelled (or at the very least significantly delayed) because it requires expensive and time-consuming investments to extend the capacity of the network.

At the low voltage (LV) network, the penetration of DRES is currently limited by emerging voltage unbalance that is caused by the high number of the (mainly) single-phase connected DRES. Moreover, the DSO does not know the DRES locations nor the phase they are connected to which complicates the problem and prohibits a centralized solution [3,4]. In addition to the energy-based electricity markets, on a technical level ancillary services (AS) are needed for the secure operation of the power system [4]. Ancillary services are grid support services required by the transmission or distribution system operator to maintain the integrity and stability of the transmission or distribution system as well as the power quality. These services typically include regulation of frequency, active power reserves, voltage and reactive power control, black start capability and islanding.

A solution to this problem is to add smart control strategies to the inverters of single renewable energy resources RES. The control strategy can be split on two timescales: fast (response time of 1ms) and slow (response time of 1 min and slower) control. The distribution network will be kept stable in the event of disturbances by using the fast control strategy (which is the main focus of this article) that uses local parameters (e.g. voltage, available power) as input. On this short timescale, communication with remote entities is avoided as to maximize the reliability of the system. The slow control, which typically will use communication, will help the system to reach an optimal state.

The DER with high peak power, thus which require three-phase grid-connected inverters. In these inverters, a control strategy can be developed that mitigates voltage phase unbalance by distributing the active power between the phases and also avoid voltage problems. This control strategy enables local voltage control, and the system stability in the event of disturbances will be maintained by using frequency response and the provision of fault-ride through capabilities. Decreasing the voltage unbalance will result in an improved voltage profile allowing a higher penetration of individual RES in the low voltage network and decreasing the network losses.

The fast control strategy will use both local parameters (e.g. voltage and available power measured at the inverter itself) and parameters supplied externally (e.g., measured values of current in the distribution feeder connecting also other DRES). The local control will be targeting voltage unbalance mitigation, over/under voltage control and grid support in case of disturbances and faults. This control strategy thus enables an intelligent control of the voltage profile and improves the reliability of distribution grid in times of disturbances and grid faults.

The fast control strategy will be implemented by combination of two control strategies – the three phase damping control strategy [5] and the voltage-based droop control strategy [6]. By doing so, the voltage unbalance will be mitigated and due to the droops a soft curtailment will be achieved between the different DRES. The soft curtailment will increase the exchange energy from the DRES to grid and will prevent on-off oscillations of the grid voltage [7,8].

CONCLUSIONS

The control algorithms for three-phase-grid connected inverters for DRES to avoid voltage unbalance in LV networks, can easily be implemented for all future DRES implementation. Moreover, the control strategy can be added to existing controllers as well. In this way, by using control strategies only, the power quality and the stability during disturbances in LV will be improved. Furthermore, the loss of energy due to hard curtailment will be decreased which will increase the exchanged energy to the grid. In general the penetration of DRES will increase, without changing of the existing infrastructure of the existing LV-networks which will be cost effective for benefit for DSO's.

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