ESC-GS EG ACPPM

PRELIMINARY REPORT ON

SYSTEM NEEDS THAT REQUIRE ADVANCED CAPABILITIES FOR GRID STABILITY

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AGENDA

01 Need for new capabilities to maintain stability

- / Phase jump power and amplitude jump power
- / Inertia power
- / Stability
- / Protection and operational needs in Distribution grids

02 Basic characteristics of grid-forming power park module

03 Characteristics needed according to the Operational Network Codes

System Needs that require advanced capabilities for grid stability

NEED FOR NEW CAPABILITIES TO MAINTAIN STABILITY

- For obtaining stability, 2 preconditions have to be fulfilled:
  1) An instantaneous compensation of a sudden imbalance of active and reactive power caused by a disturbance.
  2) The stable and well-damped voltage and frequency behaviour of the system as a result of the stable and well-damped voltage and frequency control loops of the power generation modules.
- Precondition 1 requires grid forming capabilities to provide phase jump power and amplitude jump power.
- Precondition 2 requires inertia power as well as the appropriate design of the control loops for FSM, LFSM and voltage control.

System Needs that require advanced capabilities for grid stability

PHASE JUMP POWER AND AMPLITUDE JUMP POWER

The provision of phase jump power and amplitude jump power with an instantaneous response is required:

/ to ensure instantaneous active power balance in case of load or generation changes,

/ to provided instantaneous short circuit current,

/ to provide harmonic and asymmetric loads and

/ to provide sufficient voltage stability to allow for grid following inverters to operate.

System Needs that require advanced capabilities for grid stability

INERTIA POWER

In [2] the ENTSO-E Project Inertia Team quantifies the need for additional inertia

/ to ensure RoCoF values remain within acceptable limits.

Another effect of inertia power is crucial:

/ The creation of a system frequency which is reflecting the actual mismatch of active power in the system

/ Inertia power has to adapt the internal frequency depending on the active power exchange with the network

[2] Project Inertia Team, "ENTSO-E, FREQUENCY STABILITY IN LONG-TERM SCENARIOS AND RELEVANT REQUIREMENTS", https://eepublicdownloads.azureedge.net/clean-documents/Publications/ENTSO-E%20general%20publications/211203_Long_term_frequency_stability_scenarios_for_publication.pdf, 2021.

STABILITY

- To ensure a stable power system operation, the provision of phase jump power and inertia power, together with the provision of FSM and LFSM must operate in a stable manner.
- If a large share of power generation modules behave in a similar way, the sum of generation modules has a direct effect on the grid. There is a direct feedback loop between the generation module and the grid.
- If a large share of power generation modules behave in a similar way, the system behaviour of such a system can be simulated and modelled in a simplified way in which one power generation module supplies only a single load
- Therefore, a closed loop setup representing the relevant grid disturbance scenarios to be considered shall be used when testing the stability of
  - LFSM
  - voltage control loops and
  - if applicable (e.g. for PPMs) the control loops for amplitude jump power, phase jump power and inertia power.

PROTECTION AND OPERATIONAL NEEDS IN DISTRIBUTION GRIDS

- Grid-forming generation (synchronous as well as converter based) pose challenges to DSOs
  - Interaction with tap changers
  - Reactive power exchange
  - Behaviour during fault
  - Islanding risk and possibly resulting risks to safety of persons

  - So far neither detailed preliminary study nor real scale demonstrator of a distribution system equipped with a significant share of grid-forming generators has been performed and tested.

  - This must be considered when connecting grid forming PGM to DSO grids, especially on LV and within the MV grid.

BASIC CHARACTERISTICS OF GRID-FORMING POWER PARK MODULE

- **Creating system voltage and contribution to fault level**

  - A grid-forming PPM behaves like a voltage source behind an impedance. The dynamics of the internal voltage magnitude and angle is limited, and lags the grid dynamics.
  - As a consequence, stabilizing and equalizing currents occur between the grid voltage and the internal source voltage of the grid forming PPM.
  - Fast current limitation prevents currents above rated values .
    - The current limitation is designed in a way to maintain synchronism.

BASIC CHARACTERISTICS OF GRID-FORMING POWER PARK MODULE

- **Provision of electrical inertia (Contribution to Inertia)**
- **within the design limits**
  - The internal voltage's frequency behaviour following an active power unbalance is proportional to this active power unbalance after a finite time
  - A fast current and active power limitation prevents a power supply outside the design limits or an excessive charge/discharge of the inherent energy storage.
    - The current and power limitation is designed in a way to maintain synchronism.
- **within dedicated energy storage**
  - Additional electrical inertia might be provided by a dedicated energy storage

CHARACTERISTICS NEEDED ACCORDING TO THE OPERATIONAL NETWORK CODES

- The characteristics needed in abnormal state of the grid (see SOGL Art. 18) have to be analysed in a system with a majority of PPMs
- The expert group sees the solution of all those topics as a subject for an ENTSO-E forum because experts in restoration issues and owners and operators of SPGMs, synchronous condensers or SVCs are not involved in this expert group.
- Future chapter 5 of this paper will give an overview of expected problems in the final report.

ADDITIONS PLANNED FOR THE FINAL REPORT

- Chapter 4: Gap Analysis of Connection Codes
- Chapter 5: Which technologies can provide these services?
- Chapter 6: Compliance Verification and Performance Monitoring
- Chapter 7: Roadmap for delivering capabilities
- Chapter 8: Recommendations for future work
- Chapter 9: Summary