DG DemoNet Validation – Central Voltage- and Reactive-Power-Control in Distribution Networks

[1]Schwalbe R.; [2]Prüggler, W.; [1]Bletterie, B.; [1]Tremmel W.; [1]Brunner, H.; [3]Herb, F.; [3]Nenning, R.; [4]Abart, A.; [5]Pointner, R.; [6]Einfalt, A.;

[1] AIT Austrian Institute of Technology, Electric Energy Systems; [2] Vienna University of Technology, Energy Economics Group; [3] Vorarlberger Energienetze GmbH; [4] Energie AG Oberösterreich Netz GmbH; [5] Salzburg Netz GmbH; [6] Siemens AG Austria

roman.schwalbe@ait.ac.at

ABSTRACT

The integration of renewable distributed generation (DG) in medium voltage (MV) distribution networks can cause unacceptable voltage rise at the feeding branch. The conventional solution to avoid overvoltage is grid reinforcement, which can make the integration of additional DG non-economically. Coordinated voltage control (CVC) strategies utilising the on-load-tap-change-capability (OLTC) of the central transformer and the capability of generators to provide reactive power (Q) and curtail active power (P) can help maintaining the voltage within the limits and enable a high share of DG at significant less costs [1]. Currently the control algorithm developed within this project is validated in a field trial in two Austrian distribution grids to demonstrate the savings in voltage band when applying CVC.

CONTROL MECHANISM [2]

- **LEVEL Control:** Calculate set point for OLTC's automatic voltage controller (AVC) to keep all voltages within the allowed limits while minimizing the amount of tap changes
- **RANGE Control:** Optimize voltage range of critical nodes (spread between highest and lowest) to fit into allowed voltage band by reducing the voltage drop on the line impedance by controlling DG's Q – and in second instance limiting the DG's P

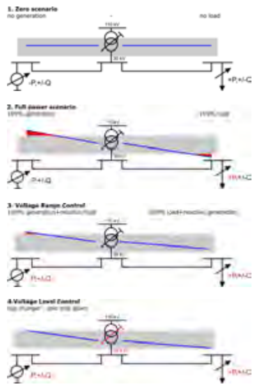

Fig. 1. Level and range control impact

CONTROL LOOP

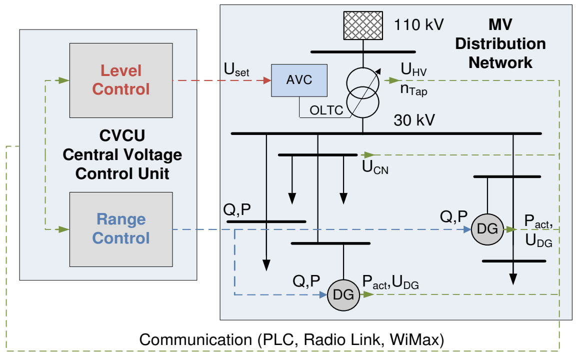

Fig. 2. Controller receives actual grid measurements and calculates set values for AVC and DG's Q

PRELIMINARY OPERATION RESULTS [3]

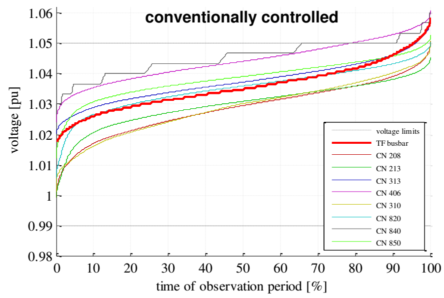

Fig. 3. Duration curves of grid voltage measurements in substation "Lungau" during 72 conventionally controlled days with line drop compensation active: Used voltage band: 1.00 – 1.06pu; Needed 20,2 tap-changes per day

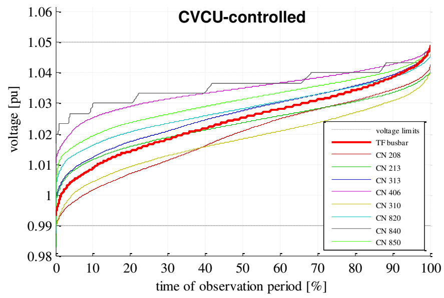

Fig. 4. Duration curves of grid voltage measurements in substation "Lungau" during 66 CVC days with level control mode 'minimum-tapping': Used voltage band: 0.99 – 1.05pu; Needed 14.9 tap-changes per day

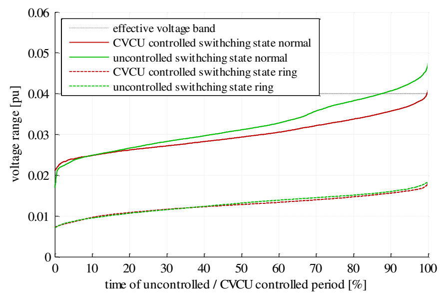

Fig 5. Dependency of voltage range on topology in substation "Lungau": all four curves show one week, weeks with the same switching state area adjacent: Grid voltage ranges significantly depend on the grid's switching state

VALIDATION TECHNIQUE [3]

- Coordinated voltage control objective: Minimise grid voltage range
- Operate grid voltages in level control mode 'lower-limit' or 'upper-limit' to demonstrate the gain in available voltage band
- Comparison between conventional controlled, distributed controlled and coordinated controlled grid voltage ranges is done by daily switching between these control modes.
- Topology changes and status of critical nodes, DGs and transformer have to be considered when analysing data
- Calibrated power quality measurement devices are used for grid voltage measurement

ECONOMIC VALIDATION

- Distribution Voltage regulator is the most economical solution for radial grids (one feeder)
- Additional cost were observed due to underestimated cost of ICT and system integration
- Choice of ICT solution is most crucial regarding economic performance

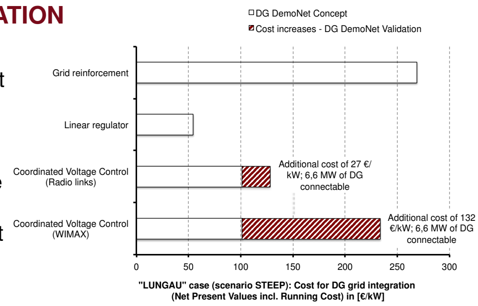

Fig 6. Calculated cost values for DG grid integration comparing the projects "DG DemoNet Concept" and "DG DemoNet Validation" in the grid case "LUNGAU". Significant extra cost are evident for a "WIMAX" communication solution

[1] W. Prüggler, F. Kupzog, B. Bletterie, H. Brunner, „Active grid integration of distributed generation utilizing existing infrastructure more efficiently - an Austrian case study", in Electricity Market, 2008. EEM 2008. 5th International Conference on European, 2008.
[2] M. Stifter, B. Bletterie, H. Brunner, D. Burnier, H. Sawsan, F. Andren, R. Schwalbe, A. Abart, R. Nenning, F. Herb, R. Pointner, "DG DemoNet validation: Voltage control from simulation to field test", Innovative Smart Grid Technologies (ISGT Europe), 2011.
[3] R. Schwalbe, M. Stifter, B. Bletterie, A. Abart, R. Pointer, F. Herb, "DG DemoNet: Impact of volt/var control on increasing the voltage band reserve – results from field trial validations", 22nd International Conference on Electricity Distribution (CIRED), 2013.

SUMMARY AND OUTLOOK

- **Operating coordinated voltage control** in substation "Lungau" saved 26% of tap-changes compared to the conventionally controlled operation
- **Operating distributed voltage control** in substation "Nenzing" reduced voltage range even without utilising the DG's reactive power
- **Final results** of savings in voltage band will be available after validation phase finished at the end of June 2013
- **Economic validation** shows that economic performance of DG DemoNet concepts strongly depends on grid topology and ICT solutions