Combined Planning of Medium and Low Voltage Grids

Introduction
- Based on a German rural MV grid and all connected LV grids, we compare required investments for MV and LV grids using separate and combined planning approaches

Example Grid and DER Scenario

Combined vs Separate Approach
Separate approach:
- set MV/LV voltage limit as worst-case for every LV grid regardless of position in the MV grid
- Some LV grids have over-voltage

Combined approach:
- first reinforce the MV grid
- use resulting MV voltages as worst-case assumptions for LV
- Voltage is influenced by the distance to the HV/MV substation

CAPEX Assessment
- Measures used to mitigate scenario induced problems: line and transformer replacement, parallel lines, parallel transformers, OLTC
- Combined planning leads to less than half the capex of separate planning
- With combined planning fewer LV grids require reinforcement

Planning principles
- Grid planning is based on two worst-case situations, strong load case and high feed-in case
- Conventionally, the voltage band is separated between the MV and LV grids (Fig. 1)
- The voltage value that divides the available voltage band is called MV/LV voltage limit
- MV/LV voltage limit is varied to analyze the effect of voltage band allocation on the reinforcement capex

Voltage band adjustment
- Separate planning overestimates necessary reinforcement
- Feeder-wise voltage limits lead to capex reduction (denoted as the “capped” approach in Fig. 5, 6)
- Combined planning leads to the lowest capital expenditure

On-Load Tap Changing Transformers
- OLTC greatly reduces capex with separate planning, little effect with combined planning
- OLTC to be used only when an LV grid would otherwise require higher investments

Figure 1: Voltage band allocation between MV and LV grids
- 12 MV feeders, 201 LV grids
- Future DER scenario with 33 MW of PV and 27 MW of wind power
- Subsequent voltage profile plots refer to the marked feeder

Figure 2: Violations in an MV feeder and the connected LV grids due to DER integration, separate (left) and combined (right) calculation

Figure 3: Violations in an MV feeder and the connected LV grids due to DER integration, separate (left) and combined (right) calculation

Figure 4: Grid reinforcement results, separate (left) and combined (right) grid planning

Figure 5: CAPEX for grid reinforcement for the separate, capped and combined planning approaches

Figure 6: OLTC greatly reduces CAPEX with the separate planning, has modest benefits with the capped and combined approaches