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Combined Planning of Medium and Low Voltage Grids

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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

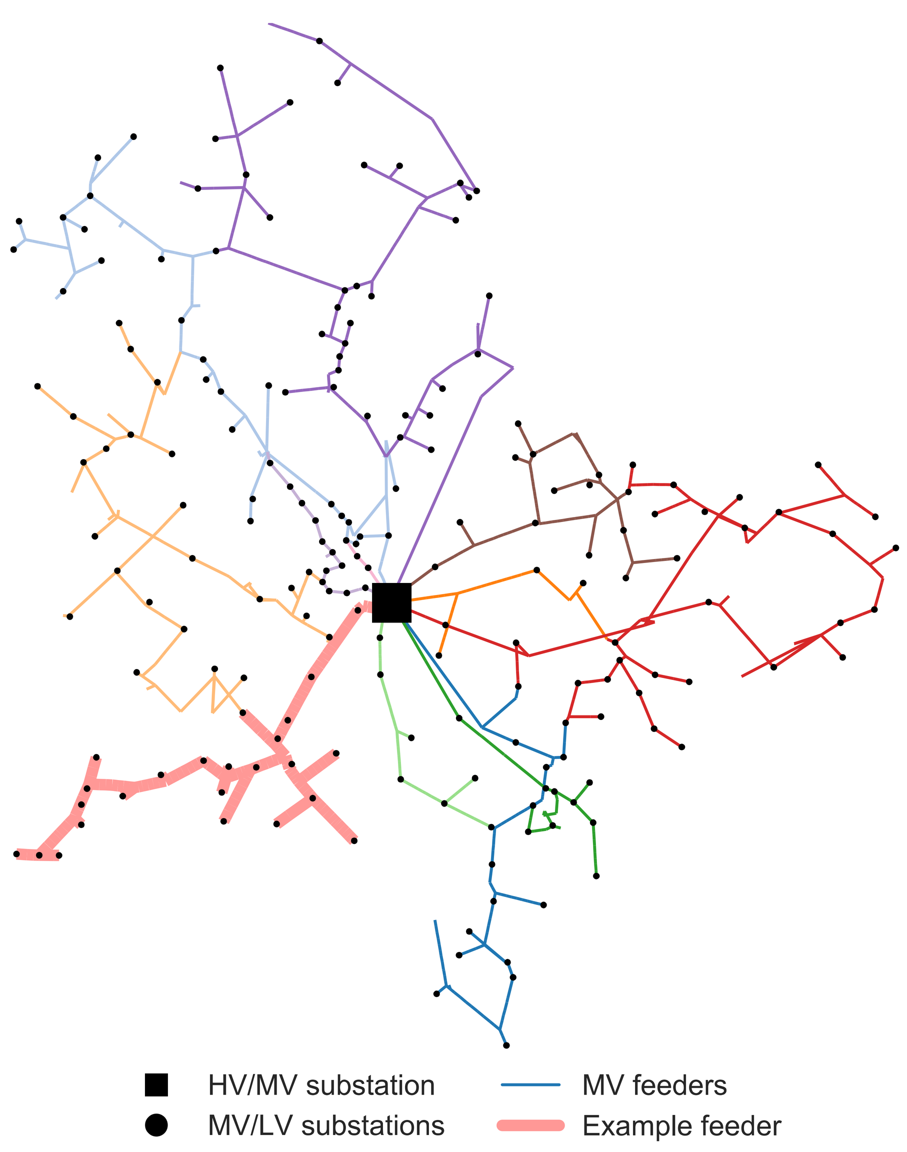

Figure 2: Considered MV grid, example feeder marked in red

- 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

Planning principles

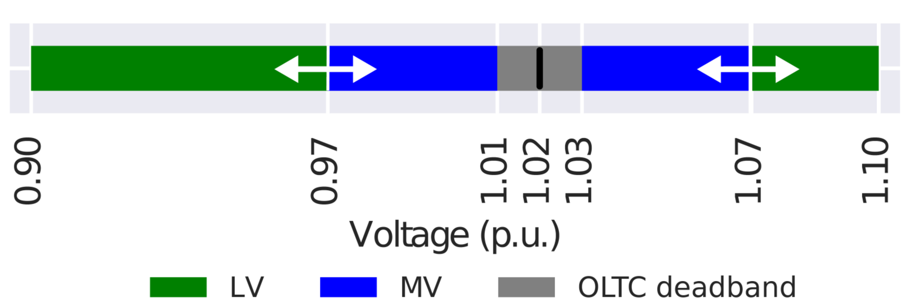

Figure 1: Voltage band allocation between MV and LV grids

- 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

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

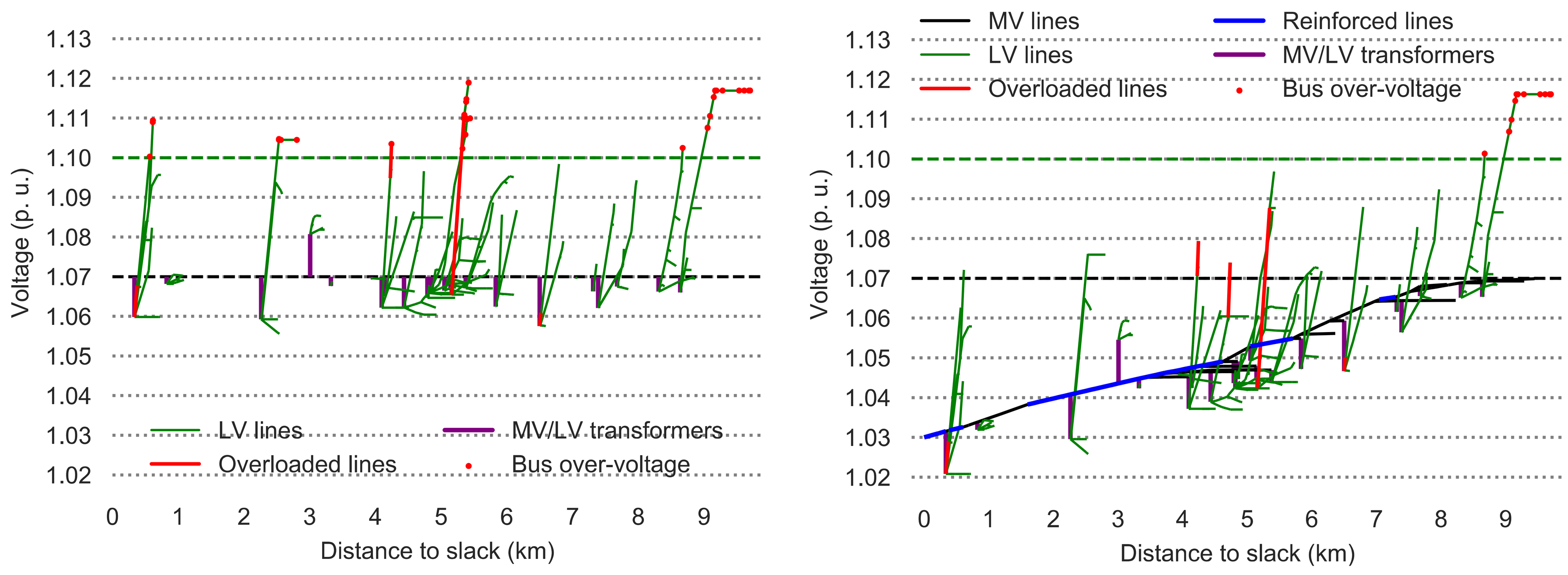

Figure 3: Violations in an MV feeder and the connected LV grids due to DER integration, separate (left) and combined (right) calculation

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

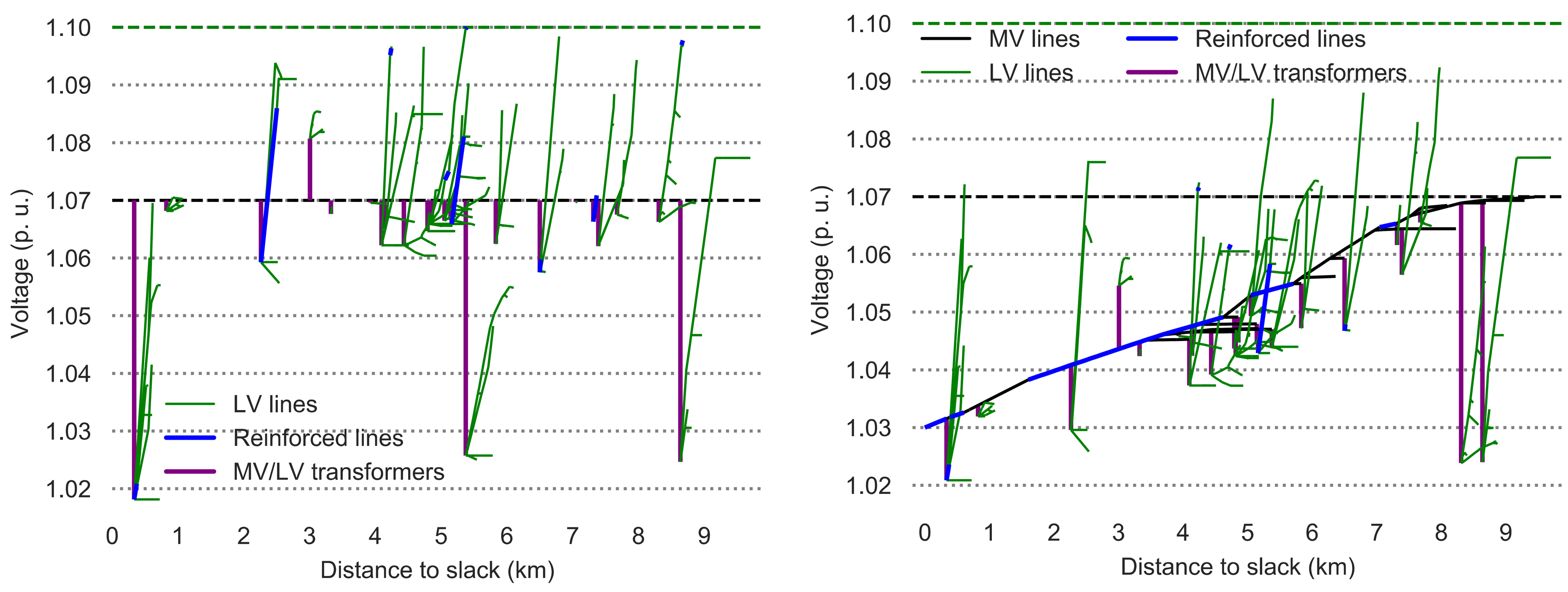

Figure 4: Grid reinforcement results, separate (left) and combined (right) grid planning

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

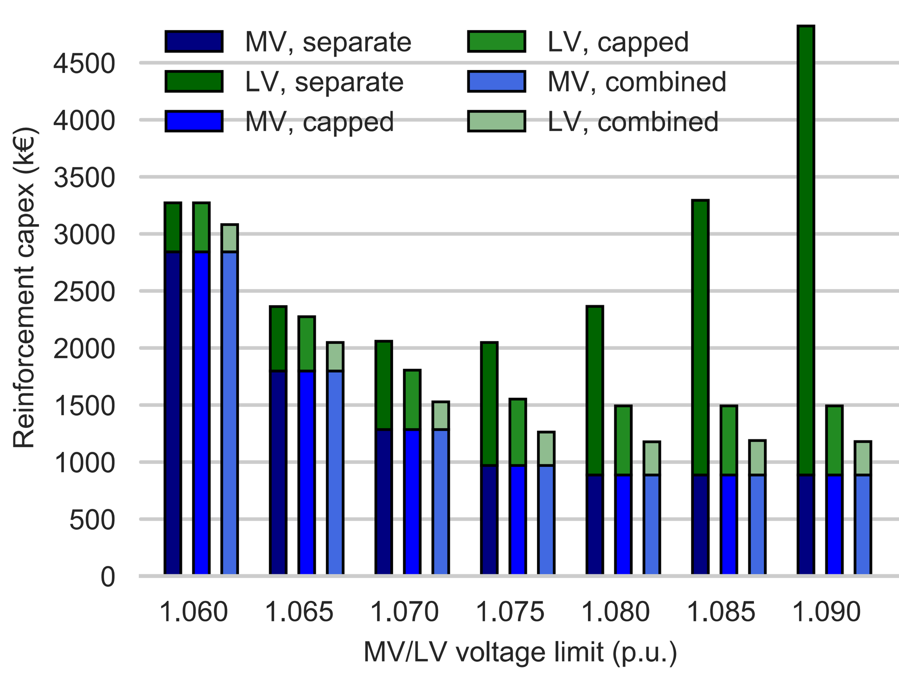

Figure 5: CAPEX for grid reinforcement for the separate, capped and combined planning approaches

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

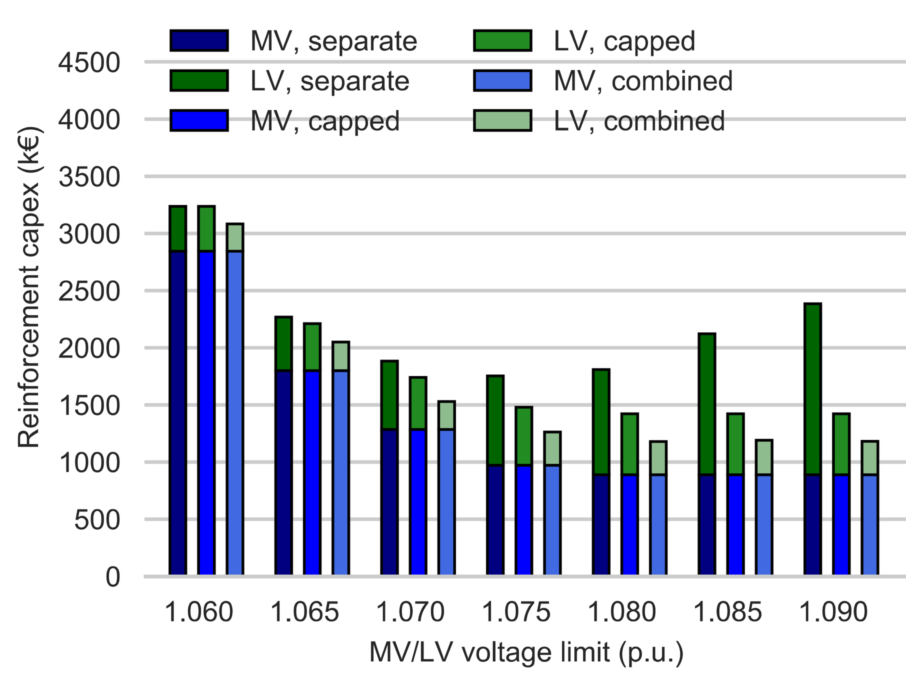

Figure 6: OLTC greatly reduces CAPEX with the separate planning, has modest benefits with the capped and combined approaches

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