Automated use of wired measures in grid planning for solving current and voltage band problems

Power & Energy Student Summit 2019

Automation of grid planning processes

- Development of generalized concepts and algorithms for handling any type of network topology and occurring voltage/current problem
- Calculated solution represents ideally global optimum
- Possibility to calculate global optimum with probabilistic methods, but disadvantages in high computing effort as well as many unnecessary partial results
- Use of heuristic methods for fast solution with sorting out irrelevant partial results, but problems with limited application to many problem cases and difficulties in detection of global optimum in a filtered solution pool (often local optimum!)
- Combination of both solution methods for keeping solution set with heuristic calculations as small as possible, but still including the global optimum and searching best solution of filtered set with mathematical calculations
- Results include technical and economic aspects
- Possibility for searching different optima, such as solution with lowest cost or greatest technical benefit

EU-project CrossEnergy

- Project goal: development of a decision support system (see Fig. 1) for strategic extension of electricity grid at distribution grid level
- THD: energy data and prognosis for load and generation development
- OTH: grid planning with extension measures for current/voltage problems
- UWB: Key figures and status assessment with own load-flow calculation program
- Data platform for communication and in-/output between partners and user
- Left encircled side in Fig.1: overview of system architecture of grid planning tool developed by OTH
- Main program is managing input and output as well as grid extension measures
- User transmit his network and scenario data (load and generation development), then gets back grid extension possibilities with technical and economical key figures

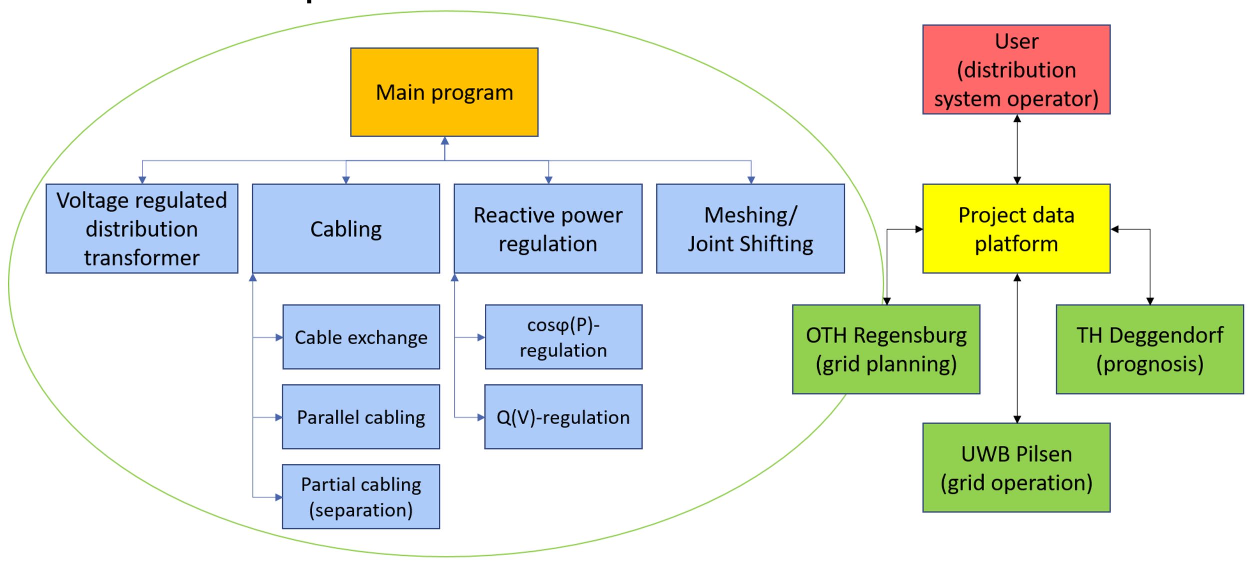

Fig. 1 System architecture of decision support system [1]

[1]: H. Kraus, D. Gschoßmann and O. Brückl, "Automatisierung von Netzplanungsprozessen in der Verteilnetzebene – Q(U)- und cosφ(P)-Blindleistungsregelung als spannungshaltende Netzausbaumaßnahmen", transcript of the conference Zukünftige Stromnetze für Erneuerbare Energien, p. 407-420, Berlin, January 2019.

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Cable exchange

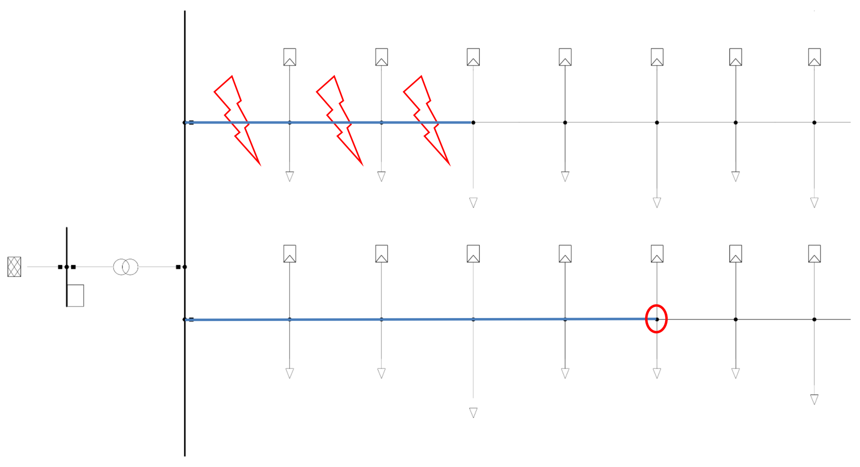

Fig. 2 Visualization of solution path (blue line)

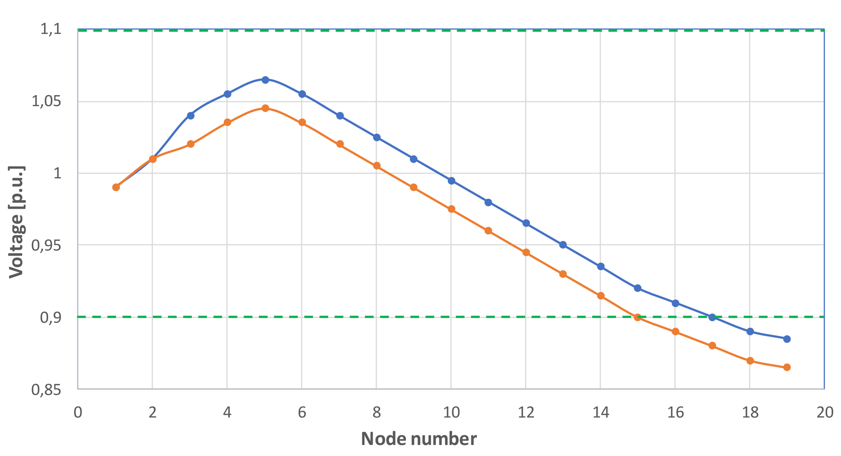

Fig. 3 Voltage band before (blue) and after (orange) cable exchange (without correct sign!)

- For solving current/voltage problem, algorithm reads out solution path (relevant lines) extracted from critical string (Fig. 2)
- Red flashes = current problem
- Red encircled node = voltage problem
- Blue lines = solution path

- High technical efficiency, if changing cable with highest ΔV
- But: if ΔV of changed line has incorrect sign, the problem is getting worse
- Example in Fig. 3: before (blue line) and after (orange line) cable exchange (node 2->3)

- Flow charts for solving current (left side) and voltage (right side) problem (Fig. 4)
- If both problem types occur, always current problem is solved first
- Voltage problem: very necessary to identify type (high or low voltage problem) and analyze the signs of ΔV of the considered lines for solution

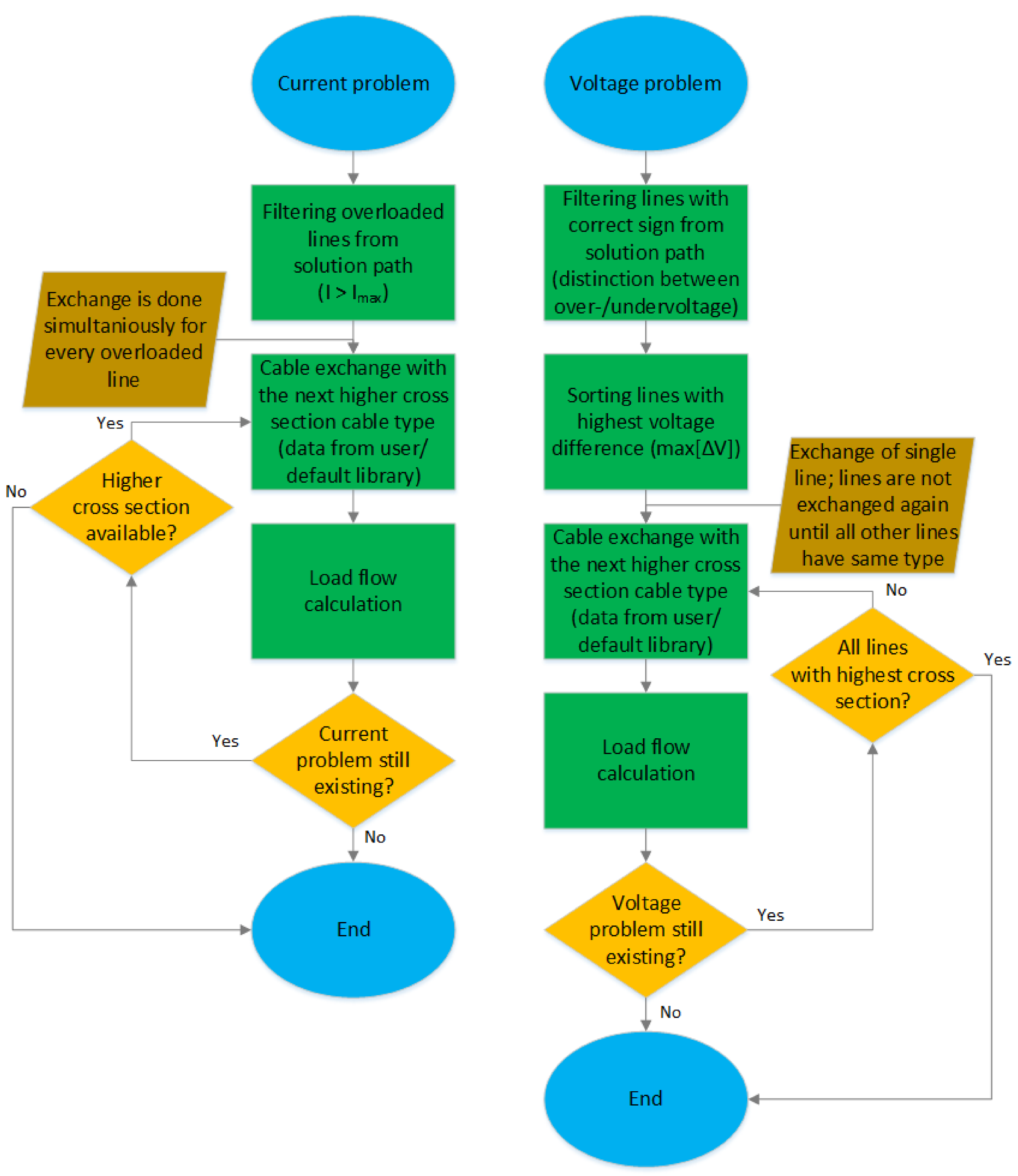

Fig. 4 Flow chart for solving current (left) and voltage (right) problem

Parallel cabling

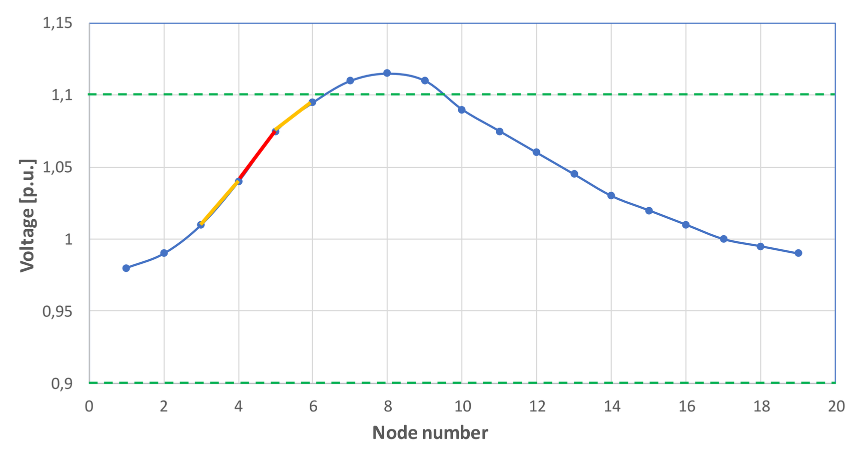

Fig. 5 Voltage band with parallel cabling handling a voltage problem

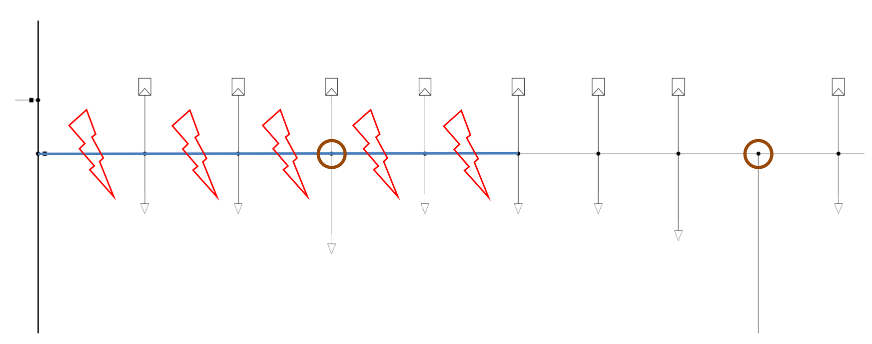

Fig. 6 Parallel cabling with consideration of cable distribution cabinets (encircled nodes)

- Parallel cabling solving a voltage problem (Fig. 5)
- Starting from (red) line with highest correct signed ΔV
- Comparing adjacent (orange) lines, which has higher slope and include it for parallel cable
- Repeating last step until problem is solved or no lines with correct sign are left

- Fig. 6: Parallel cabling considering distribution cabinets (encircled nodes)
- Connection possibilities from busbar to cabinet and from cabinet to cabinet
- Shortest connection, which solves current/voltage problem, is the result
- Try to solve problem with available grid equipment

Summary & Outlook

- Automated grid planning as a tool for system operators to identify future grid extension possibilities related with technical and economical key figures
- Solution for current and voltage problems considering load and generation development scenarios
- Using combination of heuristic and mathematical methods for fast, but optimal result
- Automated grid planning tool as a part of the decision support system developed in the EU-project CrossEnergy
- Concepts and algorithms for cable exchange and parallel cabling
- Solution methods for handling only affected lines up to consideration of cable distribution cabinets
- Automation of grid planning processes represents a big potential for support of network operators
- Overview about grid extension variants with technical and economical key figures and last decision by system operator, which extension is best for his grid
- Many possibilities for enhancement of the tool (like considering land use)

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