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Modelling and Topology Optimisation of Medium Voltage CPES - Synthetic Dutch Case Study

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***Abstract*—This work seeks to reduce the severity of congestion in the medium voltage (MV) cyber-physical systems (CPES) by optimising the network topology in line with seasonal variations in the supply and demand of electricity. To this aim a two-stage reconfiguration algorithm is proposed. In the first stage, the positions of the normally open switches within the network are optimised in to adjust the power flow therein. These optimised positions are subsequently used in the second stage to calculate the network variables. The first stage is implemented as a mixed-integer linear program (MILP) optimisation in Python, whereas the second stage consists of a Newton-Raphson calculation in DIgSILENT PowerFactory software package. The benefit of network reconfiguration is that it is a short-term and low-cost solution which can be implemented by a distribution system operator (DSO) without relying on other external parties. The presented case study addresses the need of seasonal reconfigurations to accommodate for the manual operation of the switches present within a synthetic model of MV CPES, which is implemented inspired from CPES in the Netherlands. The application of the algorithm significantly reduces the frequency by which reconfiguration actions can be performed. Furthermore, the algorithm is able to consistently reduce congestion within the analysed synthetic CPES, completely removing it or reducing its severity. It also outperforms two alternative optimisation options implemented in PowerFactory with regard to the objective function value. Those being an iterative exploration of meshes and a genetic algorithm.**

***Index Terms*—Congestion, Optimisation, Reconfiguration, Distribution CPES, MILP.**

NOMENCLATURE

Sets

$\mathcal{F}$	the set of phases (A, B, C)
$\mathcal{N}$	the set of nodes present within the network
$\mathcal{L}$	the set of lines present within the network
$\mathcal{T}$	the set of considered time steps

Indexes

ϕ, ψ	Phase $\phi \in \mathcal{F}$ and $\psi \in \mathcal{F}$
n, m	nodes n $\in \mathcal{N}$ and m $\in \mathcal{N}$
mn	line mn $\in \mathcal{L}$
t	time step t $\in \mathcal{T}$
λ	λ-th block for the piece-wise linearization of $P^2_{mn,\phi,t}$ and $Q^2_{mn,\phi,t}$

Constants

N	total number of nodes within the network
M	a large number (M $>> V^{max,sqr}$)

Parameters

$R'_{mn,\phi,\psi}$	the transformed line resistance (where $R'_{mn,\phi,\psi} = R_{mn,\phi,\psi}\angle\theta_\psi - \theta_\phi$)
$X'_{mn,\phi,\psi}$	the transformed line reactance (where $X'_{mn,\phi,\psi} = X_{mn,\phi,\psi}\angle\theta_\psi - \theta_\phi$)
$\overline{I}_{mn}$	Maximum current limit for line mn
$P^D_{m,\phi,t}$	Active power demand
$Q^D_{m,\phi,t}$	Reactive power demand
$\widetilde{V}_{m,\psi,t}$	approximation of the voltage magnitude
$\widetilde{P}_{mn,\phi,t}$	approximation of the active power through line mn
$\widetilde{Q}_{mn,\phi,t}$	approximation of the reactive power through line mn
$\rho_{mn,\lambda}$	slope of block λ for the piece-wise linearization of $P^2_{mn,\phi,t}$ and $Q^2_{mn,\phi,t}$
$\overline{\Delta}_{mn,t}$	maximum length of the block for the piece-wise linearization of $P^2_{mn,\phi,t}$ and $Q^2_{mn,\phi,t}$
$V^{min,sqr}$	minimum value of the square of the voltage magnitude
$V^{max,sqr}$	maximum value of the square of the voltage magnitude

Variables

$P^L_{mn,\phi,t}$	Active power losses of branch between nodes m and n
$Q^L_{mn,\phi,t}$	Reactive power losses of branch between nodes m and n
$V_{m,\phi,t}$	Voltage magnitude at bus m
$V^{sqr}_{m,\phi,t}$	Square term of the voltage magnitude at bus m
$P_{mn,\phi,t}$	Active power of branch m-n
$P^{sqr}_{mn,\phi,t}$	Square of the active power of branch m-n
$Q_{mn,\phi,t}$	Reactive power of branch m-n
$Q^{sqr}_{mn,\phi,t}$	Square of the reactive power of branch m-n
$P^S_{m,\phi,t}$	Active power supply at bus m
$Q^S_{m,\phi,t}$	Reactive power supply at bus m
$\Delta^P_{mn,\phi,t,\lambda}$	λ used for the piece-wise linearization of $P^2{}_{mn,\phi,t}$
$\Delta^Q_{mn,\phi,t,\lambda}$	λ used for the piece-wise linearization of $Q^2{}_{mn,\phi,t}$
$P^+_{mn,\phi,t}$	(+) component of the piecewise linearization of $P^2_{mn,\phi,t}$
$P^-_{mn,\phi,t}$	(-) component of the piecewise linearization of $P^2{}_{mn,\phi,t}$
$Q^+_{mn,\phi,t}$	(+) component of the piecewise linearization of $Q^2_{mn,\phi,t}$
$Q^-_{mn,\phi,t}$	(-) component of the piecewise linearization of $Q^2{}_{mn,\phi,t}$
x_{mn}	State of switch position for branch m-n, with $x_{mn} \in 0, 1$
$\eta_{mn,\phi,t}$	Slack variable for the calculation of the voltage difference between nodes
$P^{sqr,switch}_{mn,\phi,t}$	Square of the active power for branch m-n, taking into account the switch position
$Q^{sqr,switch}_{mn,\phi,t}$	Square of the reactive power for branch m-n, taking into account the switch position

I. Introduction

The electrification of moder society keeps increasing, e.g., growing number of electric vehicles (EVs) and heat pumps. Besides, it has proven imperative that the electricity which is used, is generated in a sustainable manner. The most prominent examples that facilitate this are photovoltaic (PV) installations and wind farms.

Contrary to traditional resources connected to the electricity network, most of these resources tend to be placed and operated in a distributed manner. This also leads to their common designation as Distributed Energy Resources (DERs). Subsequently, this results in an increase in the demand for transport capacity within the LV and MV networks of a CPES. However, this demand cannot always be met, leading to congestion within these networks. Congestion occurs when the demand for electrical transport capacity surpasses its availability. On a technical level, congestion problems can usually be described as voltage variations which exceed the designated limits and/or overloading problems of lines and cables, meaning that the loading is close to or exceeding the thermal limits [1].

If a situation of congestion occurs within the LV or MV networks, it is the responsibility of the distribution system operator (DSO) to resolve it. Traditionally, the DSO could either use long-term solutions, like network reinforcement or network reconfiguration (taking several years to implement), or short-term solutions like re-dispatch to resolve congestion. More recently, as the role of the distribution system and subsequently the DSOs is becoming more active, market methods can also be used, which include dynamic tariffs and the distribution grid capacity market [1]. However, most system operators in the Netherlands are still not able to prevent congestion. This is evident from numerous studies performed on the behalf of DSOs [2] [3] [4] [5]. Unless something is done, these occurrences will likely only get worse due to the projected increases in the penetration of DERs.

One of the solutions proposed over recent years to help resolve this problem is the use of network reconfiguration in a more active manner (e.g. day-ahead or even real-time reconfiguration [6]). The problem of distribution network reconfiguration is a highly complex, combinatorial, non-differentiable, non-convex, mixed-integer nonlinear program (MINLP) optimisation problem, due to the binary status of the switches and nonlinear three-phase power flow equations [7] [8] [9]. Solving an optimal reconfiguration in a deterministic manner is computationally expensive. In [6] the problem becomes infeasible in practical terms with just three operations. Approximations are made to the problem formulation such as a MILP formulation in [10] or utilising meta-heuristics as in [11] and [12]. To ensure the applicability of network reconfiguration in day-ahead or real-time, there is also continued work on the efficiency of algorithms meant to solve the reconfiguration, as in [13] and [14].

However, for each of these sources, there is an important problem, when considering, for instance, challenging projected conditions, like in the theoretical future scenarios in the Netherlands. For CPES reconfiguration, it is important that the switching actions can be carried out within a short amount of time and over the entire network. The only feasible way in which this can be implemented is by the presence of remotely-operable switches.

In short, long-term reconfiguration is not solving the problem and short-term reconfiguration is not possible. However, there appears to be little consideration for network reconfiguration between these timescales, like seasonal reconfiguration. This would greatly reduce the number of switching actions, allowing for short-term implementation. This work seeks to add to the existing literature and resources with the following contributions:

- Modeling a MV distribution CPES based on futuristic conditions in Netherlands, in the Python.
- Add possible actions that the DSO can take to remove or reduce congestion, by introducing a two-stage network reconfiguration algorithm on a seasonal timescale (a winter and summer configuration, to be exact).

The remainder of this paper will go into further detail, starting with the developed methodology in Section II. Next, in Section III, the analysed case study is introduced and the scenario used for testing the developed methodology is presented. Finally, the results and the discussion thereof are presented in Section IV, followed by the final conclusions in Section V.

II. Methodology

In order to optimise the network topology, a network reconfiguration algorithm has been constructed. A graphical representation of the algorithm can be found in Fig. 1. First, the relevant network parameters need to be imported. Second, the pre-processing consists of cleaning up the data and placing it in a usable format. An important assumption made within this work is that there are no parallel lines present within the considered network. If this does occur, the lines are aggregated to a single line with equivalent impedance and current carrying capabilities. This last action can only be taken if the characteristics of the parallel lines are similar.

Additionally, a line is usually connected to a switch at both ends. However, due to the manual operation of the switches, minimising the amount of switching actions is preferred. As such only one switch is considered per line. This can be done, assuming that the impedance value of the line is relatively low compared to the other values in the system. Finally, there are usually different kinds of switches present within the network, such as circuit breakers, load-break-disconnectors and disconnectors. However, the circuit breakers are for safety purposes and the disconnectors tend to be relatively old and difficult to operate (according to a Dutch DSO), which would impose additional constraints on the switching actions. As such, only

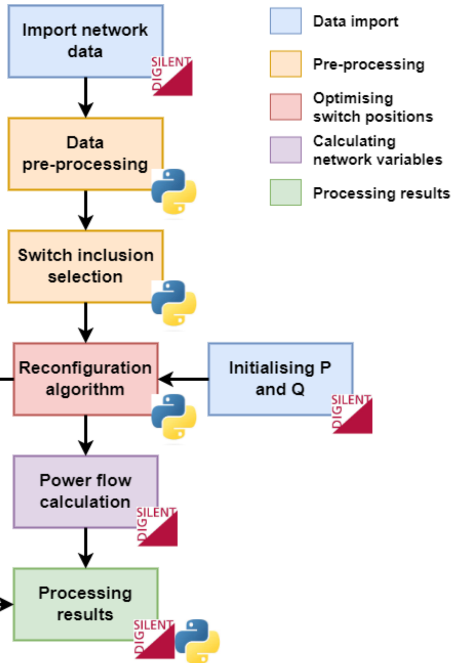

Fig. 1. Flow diagram of the full reconfiguration algorithm. The logos represent the environment in which the respective block is implemented, either in Python or DIgSILENT PowerFactory.

the load-break-disconnector types will be considered for the purpose of reconfiguration.

Next is the switch inclusion selection. Considering all switches within the network for half a year (either winter or summer) is computationally too intensive to be carried out by the available hardware (an HP ZBook Studio G5 laptop). Additionally, the DSO will have certain switches which they do not consider for the purpose of reconfiguration, because they are hard to reach or already rather old for example. Thus, a selection will be made of which switches to consider inside the reconfiguration algorithm. The method for the switch selection is as follows. First, a random half-day of the year is selected. The network data for this day is used as input for the network reconfiguration algorithm, which is subsequently run. All switches are considered by the algorithm during this run. The result will be a list of the switches altered by the algorithm, which will be reasonable candidates to be considered within the final implementation of the reconfiguration algorithm. The same process can be repeated for as many iterations as desirable. In the case of this work, the process was repeated until a list of 25 different switches was obtained.

Then there is the reconfiguration algorithm which would ideally be formulated as an MINLP, as this represents the grid the most accurately. However, it is currently not possible for this work to use a solver capable of solving an MINLP of the size required for an MV distribution network in a deterministic manner. As such, a different approach has been conceived. The complete reconfiguration algorithm will be formulated as a two-step approach. First, a MILP formulation is used to optimise the switch positions within the network. Next, the positions of the switches are updated in a DIgSILENT PowerFactory model of the network [15] and the values of the network variables are calculated using a Newton-Raphson calculation.

The reconfiguration algorithm formulation is in part based on the work in [16], but alterations have been made to suit the purposes of this work. The objective function of the reconfiguration algorithm is formulated as the minimisation of the active power losses in all branches [13] [17], as in (1). This objective is bounded by several constraints, starting with the active and reactive power losses as in (2) and (3). The power balance also needs to be maintained, as implemented in (4) and (5), for the active and reactive power respectively. The value of x, which represents the switch position, is limited to 0 (the switch is opened) and 1 (the switch is closed) in (6). Next is the voltage magnitude drop between different nodes, implemented as in (7). In order to ensure that the voltage drop between two nodes, of which the line between them is open, is not the same as a common copper plate value, the voltage slack variable (η) is introduced, defined as in (8). In the case that a line between two nodes is opened ($x = 0$), the value of η will be limited to an arbitrarily large number, allowing the voltage drop between the two nodes to take on the required value. If the line is closed ($x = 1$), η will be equal to zero. To ensure that the voltage magnitude within the network is still limited to the operating constraints of the DSO, a voltage limit constraint is introduced in (9). A similar constraint is formulated for the current in (10). Distribution systems are operated as a radial network, as this keeps the protection of the network simple [18] and it reduces the short-circuit current [19]. The radiality constraint is implemented in (11), which combined with (4) and (5), ensures the radiality of the network [19]. Finally, the terms $P^{sqr}_{mn,\phi,t}$ and $Q^{sqr}_{mn,\phi,t}$ in (7) will need to be approximated, which is achieved using a piece-wise linear representation implemented using (12) to (23).

$$min \left\{ \sum_{mn \in \mathcal{L}, \psi \in \mathcal{F}, t \in \mathcal{T}} P^L_{mn,\psi,t} \right\} \tag{1}$$

$$\begin{aligned} P^L_{mn,\phi,t} = x_{mn} \sum_{\psi \in \mathcal{S}} \frac{1}{|\widetilde{V}_{m,\psi,t}||\widetilde{V}_{m,\phi,t}|} \\ (R'_{mn,\phi,\psi}\widetilde{P}_{mn,\phi,t}P_{mn,\psi,t} + R'_{mn,\phi,\psi}\widetilde{Q}_{mn,\phi,t}Q_{mn,\psi,t} \\ + X'_{mn,\phi,\psi}\widetilde{P}_{mn,\phi,t}Q_{mn,\psi,t} - X'_{mn,\phi,\psi}\widetilde{Q}_{mn,\phi,t}P_{mn,\psi,t}) \end{aligned} \tag{2}$$

$$\begin{aligned} Q^L_{mn,\phi,t} = x_{mn} \sum_{\psi \in \mathcal{S}} \frac{1}{|\widetilde{V}_{m,\psi,t}||\widetilde{V}_{m,\phi,t}|} \\ (-R'_{mn,\phi,\psi}\widetilde{P}_{mn,\phi,t}Q_{mn,\psi,t} + R'_{mn,\phi,\psi}\widetilde{Q}_{mn,\phi,t}P_{mn,\psi,t} \\ + X'_{mn,\phi,\psi}\widetilde{P}_{mn,\phi,t}P_{mn,\psi,t} + X'_{mn,\phi,\psi}\widetilde{Q}_{mn,\phi,t}Q_{mn,\psi,t}) \end{aligned} \tag{3}$$

$$\sum_{km\in\mathcal{L}} x_{km}P_{km,\phi,t} - \sum_{mn\in\mathcal{L}} x_{mn}\left(P_{mn,\phi,t} + P^{L}_{mn,\phi,t}\right) + P^{S}_{m,\phi,t} = P^{D}_{m,\phi,t} \quad (4)$$

$$\sum_{km\in\mathcal{L}} x_{km}Q_{km,\phi,t} - \sum_{mn\in\mathcal{L}} x_{mn}\left(Q_{mn,\phi,t} + Q^{L}_{mn,\phi,t}\right) + Q^{S}_{m,\phi,t} = Q^{D}_{m,\phi,t} \quad (5)$$

$$x_{mn} \in \{0,1\} \quad (6)$$

$$V^{sqr}_{m,\phi,t} - V^{sqr}_{n,\phi,t} + \eta_{mn,\phi,t} = 2\sum_{\psi\in\mathcal{S}}\left(R'_{mn,\phi,\psi}P_{mn,\psi,t} + X'_{mn,\phi,\psi,t}Q_{mn,\psi,t}\right) - \left(R'^{2}_{mn,\phi,\phi} + X'^{2}_{mn,\phi,\phi}\right)\frac{P^{sqr}_{mn,\phi,t} + Q^{sqr}_{mn,\phi,t}}{\widetilde{V}_{m,\phi,t}} \quad (7)$$

$$|\eta_{mn,\phi,t}| \le M(1 - x_{mn}) \quad (8)$$

$$V^{min,sqr} \le V^{sqr}_{m,\phi,t} \le V^{max,sqr} \quad (9)$$

$$0 \le P^{sqr}_{mn,\phi,t} + Q^{sqr}_{mn,\phi,t} \le V^{sqr}_{m,\phi,t}\overline{I}^{2}_{mn} \quad (10)$$

$$\sum_{mn\in\mathcal{L}} x_{mn} = \mathbf{N} - 1 \quad (11)$$

$$P^{sqr,switch}_{mn,\phi,t} = x_{mn}P^{sqr}_{mn,\phi,t} \quad (12)$$

$$Q^{sqr,switch}_{mn,\phi,t} = x_{mn}Q^{sqr}_{mn,\phi,t} \quad (13)$$

$$P^{sqr,switch}_{mn,\phi,t} + Q^{sqr,switch}_{mn,\phi,t} \approx \sum_{\lambda=1}^{\Lambda}\rho_{mn,\lambda}\left(\Delta^{P}_{mn,\phi,t,\lambda} + \Delta^{Q}_{mn,\phi,t,\lambda}\right) \quad (14)$$

$$P^{+}_{mn,\phi,t} + P^{-}_{mn,\phi,t} = \sum_{\lambda=1}^{\Lambda}\Delta^{P}_{mn,\phi,t,\lambda} \quad (15)$$

$$Q^{+}_{mn,\phi,t} + Q^{-}_{mn,\phi,t} = \sum_{\lambda=1}^{\Lambda}\Delta^{Q}_{mn,\phi,t,\lambda} \quad (16)$$

$$P_{mn,\phi,t} = P^{+}_{mn,\phi,t} - P^{-}_{mn,\phi,t} \quad (17)$$

$$Q_{mn,\phi,t} = Q^{+}_{mn,\phi,t} - Q^{-}_{mn,\phi,t} \quad (18)$$

$$P^{+}_{mn,\phi,t}, P^{-}_{mn,\phi,t} \ge 0 \quad (19)$$

$$Q^{+}_{mn,\phi,t}, Q^{-}_{mn,\phi,t} \ge 0 \quad (20)$$

$$0 \le \Delta^{P}_{mn,\phi,t,\lambda} \le \overline{\Delta}_{mn,t} \quad \lambda = 1...\Lambda \quad (21)$$

$$0 \le \Delta^{Q}_{mn,\phi,t,\lambda} \le \overline{\Delta}_{mn,t} \quad \lambda = 1...\Lambda \quad (22)$$

$$\rho_{mn,\lambda} = (2\lambda - 1)\overline{\Delta}_{mn,t} \quad \lambda = 1...\Lambda \quad (23)$$

III. Case study and test scenario

The case study for this work is a distribution grid for a large city in the Netherlands, for which real data has been provided by one of the Dutch DSOs. The network is rated at 10.5 kV and consists of 143 substations, connected by a total of 153 lines. The substations will also be referred to as nodes, as the model is considered on this level. To conform to the radiality constraint, 11 lines need to be open at any given time during operation. Of the 153 lines, 150 can be considered for the purposes of the reconfiguration as they have load-switch-disconnectors at both ends. Using the switch selection process described in the methodology, 25 lines have been selected, including 10 of the initially open lines from the base topology.

A future scenario has been formulated for the network, representing a prediction of the load and generation during the year 2030. A total load increase of 13.6% is assumed compared to the data provided by the DSO for 2021 [20] [21]. The scenario also accounts for projected capacity increases of PV installations by the DSO, as well as an increase in EV usage based on work from [22]. The scenario is considered for the third week of the year, meaning a winter period is analysed. Note that grid reinforcement or forms of flexibility by the producers and consumers are excluded from the considerations made. That means that the formulated scenario can be considered to be a worst-case scenario.

The presented reconfiguration algorithm will be compared with two alternative options available in DIgSILENT PowerFactory. The options in question are a deterministic variant, where an iterative exploration of the meshes (IEOM) is carried out, and a meta-heuristic variant, where a genetic algorithm (GA) is used. It should be noted that it is not possible to perform a switch selection in PowerFactory, similar to the one used for the reconfiguration algorithm. As such, both IEOM and GA will consider every switch within the network.

Each method will be compared based on a number of parameters of interest. Those being the total active power losses for the considered time frame, the number of switching actions required to change the topology, the number of lines which experience congestion at any point during the considered time frame, the total occurrences of congestion (or whenever a single line is experiencing congestion for a single time step) and the average and maximum size of the encountered congestion (expressed in percentage of line current overloading compared to the rated value).

IV. Results

The congestion encountered in the network using its base topology is highlighted in Fig. 2. A total of 11 lines are experiencing congestion during the considered time frame, with the maximum overloading equal to 81.58%. The overloading is largest around areas of peak demand, referring to the morning between 7 and 9 AM and the afternoon between 5 and 8 PM.

When utilising the network reconfiguration algorithm, a total of 6 switching actions ate needed to update the topology. Once updated, the encountered congestion within the network changes, as is shown in Fig. 3. It is apparent from the figure that the congestion has been greatly reduced in the optimised topology. The total occurrence of congestion has been reduced, as is evident from the lower density of peaks within the heat map. Additionally, the maximum value of the congestion has been reduced to 55.91%.

A more detailed description of the parameters of interest is found in Table I. From the table, it is possible to observe that almost all parameters are improved upon, bar the number of lines which experience congestion. The total occurrences of congestion within the network have dropped by 40.24% when using the optimised topology from the reconfiguration algorithm. Additionally, the objective function value has also improved, dropping by 7.08%.

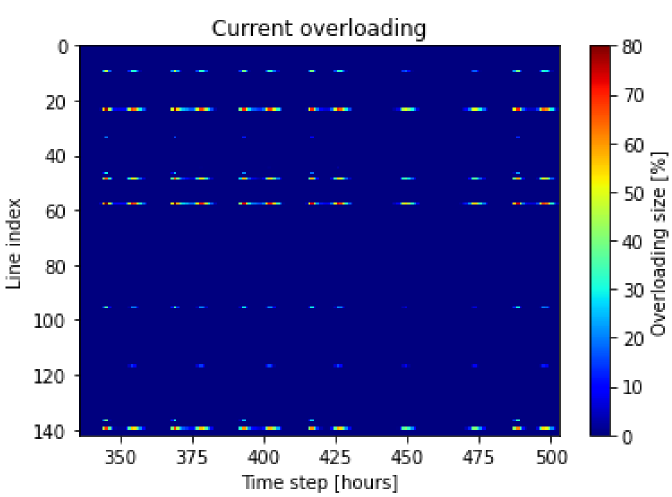

Fig. 2. Visualisation of the considered distribution network, including the switches opened in the base topology (in red and purple) and the switches which can be opened for the use of reconfiguration (blue).

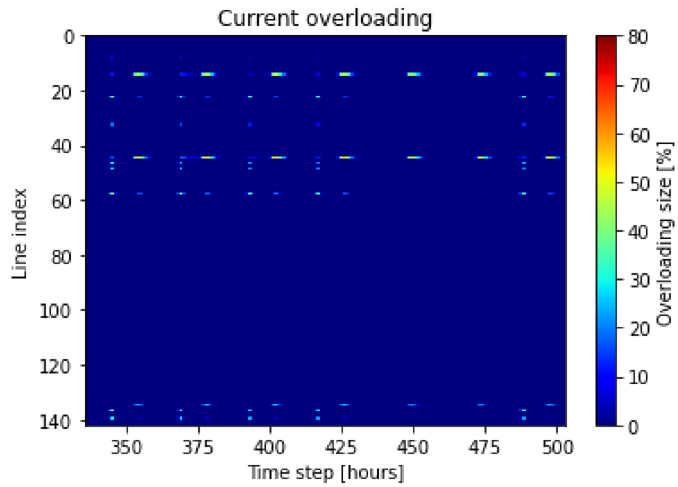

Fig. 3. Visualisation of the considered distribution network, including the switches opened in the base topology (in red and purple) and the switches which can be opened for the use of reconfiguration (blue).

TABLE I

Summary of the results for the analysed scenario. Base refers to the base topology. RA refers to the topology obtained by using the reconfiguration algorithm. IEOM refers to the topology obtained using the iterative exploring of meshes and GA is the solution of the genetic algorithm.

	Base	**RA**	**IEOM**	**GA**
Active power losses [MW]	19.36	17.99	18.52	19.09
Number of switching actions	0	6	6	12
Lines experiencing congestion	11	12	12	14
Occurrences of congestion	507	303	237	562
Average overloading size [%]	25.48	16.88	13.88	22.14
Maximum overloading size [%]	81.58	55.91	41.45	72.22

The topology was also optimised using the two aforementioned algorithms from PowerFactory. The results of utilising these algorithms on the parameters of interest are also shown in Table I. The topology offered by the IEOM also requires 6 switching actions, but the newly opened switches differ compared to the reconfiguration algorithm. The total occurrences of congestion, the average overloading size and the maximum overloading size are actually improved upon when the IEOM is compared to the solution of the reconfiguration algorithm. However, the objective function value of the reconfiguration algorithm outperforms the IEOM.

Finally, the genetic algorithm performs the worst out of the three optimisations. The number of lines which experience congestion and the total occurrence of congestion both increase. Meanwhile, the remaining parameters that are improved, are improved to a lesser extent than the solution offered by the reconfiguration algorithm.

V. Conclusions

The developed reconfiguration algorithm is shown to be able to provide significant improvements with regard to the occurrence of congestion within the network in the short term, reducing the occurrence of congestion by more than 40%.

Other parameters like the active power losses and the average and maximum size of line overloading are also improved upon. Switching operations are relatively cheap compared to grid reinforcement, while still being within the direct control of the DSO. Additionally, the practical application of the reconfiguration algorithm can be used in the short term, as the operation itself is already carried out by the DSO during maintenance for example.

Unfortunately, congestion does still occur, meaning that the reconfiguration algorithm by itself is not enough to remedy the problems encountered within the MV grid. Instead, the reconfiguration algorithm would need to be supplemented by other flexibility sources (such as EVs) and traditional grid reinforcement. However, the direct need and size of these other measures can be reduced by the application of seasonal reconfiguration. In short, network reconfiguration is part of the solution, but it is not the solution itself.

The reconfiguration algorithm is also compared to an iterative exploration of meshes and a genetic algorithm, both implemented in PowerFactory. Overall, each algorithm offers improvements in regard to the severity of the encountered congestion, but the reconfiguration algorithm and the iterative exploration of meshes far surpass the improvements offered by the genetic algorithm. Between the reconfiguration algorithm and the iterative exploration of meshes, the main trade-off is between the flexibility offered by the former to add additional constraints to the optimisation process, while the latter offers a more extensive decision space due to its ability to consider all switches at once. Although the objective function value of the reconfiguration algorithm outperforms the other two algorithms.

Future works will primarily focus on improving upon the objective function formulation to better reflect the intended outcome of network congestion reduction. Additionally, the scalability of the developed algorithm should be improved upon to be able to consider larger networks and time scales. Finally, the current scenarios are not very in-depth and could be defined in a more expansive manner.

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