MULTILEVEL DESIGN APPROACH FOR INDUSTRIAL DISTRIBUTION NETWORK OPTIMIZATION

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ABSTRACT

Optimizing cable cross-sections, trenches and geographical layout is a critical step in the design of MV industrial energy distribution networks. Cable routing for power transfer from the productions units to the distribution substations needs to be designed in a cost-efficient way, to either minimize capital expenditure (CAPEX) or total cost of ownership (TCO). Starting from these considerations, this paper presents a multilevel design approach for MV network optimization. This "all-in-one" algorithm allows selecting appropriate cables and accessories and designing trench cross-sections for network optimization. The working principle, assumptions and inputs data of the approach will be presented and discussed, as well as the results of total cost optimization obtained on real case studies.

KEYWORDS

MV networks; Network design optimization; Cables routing; Cable trench; CAPEX; TCO

INTRODUCTION

The design and implementation of MV distribution networks (i.e. private industrial networks, power farms collector systems) is a long and multistage procedure. It must be performed to guarantee power transfer from energy sources to distribution points, through cables in a cost-efficient manner. To do so, it is important to optimize the cables cross-sections, trenches and the geographical layout in the design procedure. Usually these processes are split in several sub-steps and performed separately by different companies participating in the engineering (cable manufacturer, cable installer, EPC contractor, distribution system operator).

In IEC60287-3-2 standard [1], equations for economic optimization of power cable size are given, by proposing two different approaches: calculation of economic current range for different conductor's sizes and derivation of economic conductor size for a given load. In the literature, integrated optimization methods have been proposed to optimize the economic gain. Kong et al. [2] proposed a multi-objective planning model for open-loop MV distribution networks optimization, to find single-loop optimal paths between network elements. The objectives functions considered by the authors include equipment investments, power losses and outage cost. Najafi et al. [3] presented a method based on loss characteristic matrix for optimizing the location of MV substations and a methodology based on graph theory and GA for optimal locating of the HV substations and MV feeders routing in a real size distribution network. Neagu et al. [4] described an algorithm specifically applied to wind farm cable routing, to optimize the initial cost associated to electrical inter-array cable systems, by considering as objective function the cost associated to the cable price.

In this paper, a multilevel design procedure is proposed, to help operators make enlightened decisions in terms of design of their network architecture. This strategy allows choosing appropriate cables and accessories and designing trench cross-sections in a cost-optimized way. The proposed algorithm allows an "all-in-one" optimization, exploiting synergies between trenches, cables and accessories parameters to optimize the final cost (either CAPEX, TCO or both) for the operator. The proposed paper presents the working principle and required input data, together with the assumptions and strategies applied in the design optimization process. The output results obtained on real case studies will be presented and discussed, together with total cost optimization data.

ALGORITHM DESCRIPTION

Multilevel methodology procedure

The optimization process can be simplied through the iterative process represented on Figure 1:

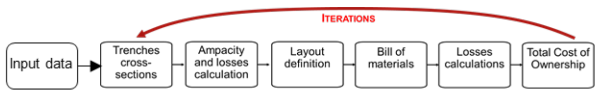

Figure 1: Iterative process optimization

After charging the necessary input data, either a CAPEX or TCO-oriented optimization can be performed through the developed algorithm. Then, for each solution, ampacity and associated losses are calculated. During the optimization process, for each cable line of the defined layout, the algorithm iteratively calculates the optimal solution in terms of CAPEX or TCO and outputs the optimized design and bill of materials, including cables, accessories and trenches, necessary to interconnect the different network elements (Figure 2).

Figure 2: Examples of cables (a), trench (b) and accessories (c) employed as available solutions for the optimization process

Input data

The input data collection, corresponding to the first step of