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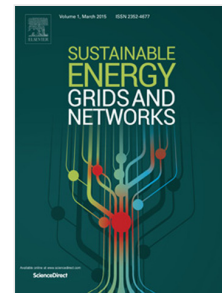
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# Innovative planning method for the construction of electrical distribution network master plans

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**Abstract**—This paper proposes a method to optimize the feeders' routes for medium-voltage distribution grids. The study aims to provide a static model for the construction of master plans and can also be applied to expansion planning. The optimization of the network is performed by a three-stage methodology. The first stage minimizes the total length of the conductors with an adapted simulated annealing algorithm. The secured feeder architecture is directly modelled in the structure of the solution. The second stage performs the balancing of the loads between the feeders in order to respect the different technical constraints. The last stage is the allocation of remote-controlled switches according to the objectives of supply quality. The methodology is applied to a real distribution network of 136 nodes. The complexity of the example is significant because there are no preselected possible routes. Instead of that, all the connections are considered, taking into account the geographical topology of urban areas.

**Index Terms**—Distribution Networks, New Expansion Planning, Optimization, Simulated Annealing.

## NOMENCLATURE

### A. Indexes

$i$	Index of loads (MV/LV substations)
$j$	Index of branches
$k$	Index of areas between two switches
$m$	Index of power lines
$t$	Index of planning years
$w$	Index of feeders

### B. Sets

$\Omega^n$	Nodes of the network
$\Omega^b$	Branches of the network
$\Omega^a$	Areas of the network
$\Omega_j^{lf}$	Loads fed by the branch $j$
$\Omega_k^{la}$	Loads in the area $k$

$\Omega_k^{lf}$	Loads in the same feeder that supplies area $k$
$\Omega_k^{ba}$	Branches in the area $k$
$\Omega_m^{al}$	Areas of the power lines $m$
$\Omega_w^{af}$	Areas in the feeder $w$

### C. Variables

$l_j$	Length of branch $j$
$R_j$	Resistance of conductor of branch $j$ (ohms/km)
$I_j$	Current through branch $j$
$I_j^{max}$	Maximal admissible current through branch $j$
$V_i$	Voltage at load $i$
$n_{rcs}$	Number of remote-controlled switches
$P_{j,t}^{loss}$	Losses of branch $j$ in year $t$
$E_{k,t}^{eens}$	Expected energy not served in area $k$ in year $t$
$P_{k,t}^{epc}$	Expected power cut of area $k$ in year $t$
$SAIDI_k$	System Average Interruption Duration Index of area $k$ (minutes/year/customer)
$SAIFI_k$	System Average Interruption Frequency Index of area $k$ (failures/year/customer)

### D. Parameters

$N$	Number of loads
$N_i^{LV}$	Number of low-voltage customers for load $i$
$M$	Number of power lines
$U$	Nominal voltage level of the network (volts)
$\cos(\varphi)$	Power factor of loads
$P_i$	Maximal active demand of load $i$ (MW)
$P_i^{mean}$	Average active demand of load $i$ (MW)
$P_{max}$	Maximal authorized power per power line (MW)
$V_i^{min}$	Minimal admissible voltage at load $i$
$V_i^{max}$	Maximal admissible voltage at load $i$
$SAIDI^{max}$	Maximal admissible SAIDI
$SAIFI^{max}$	Maximal admissible SAIFI

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