Optimized Sectionalizing Switch Placement Strategy in Distribution Systems

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***Abstract*—Automation is acknowledged by distribution utilities as a successful investment strategy to enhance reliability and operation efficiency. However, practical approaches that can handle the complex decision-making process faced by decision makers to justify the long-term financial effects of distribution automation have remained scarce. An automated and remote-controlled sectionalizing switch play a fundamental role in an automated distribution network. This paper introduces a new optimization approach for distribution automation in terms of automated and remotely controlled sectionalizing switch placement. Mixed-integer linear programming (MILP) is utilized to model the problem. The proposed model can be solved with large-scale commercial solvers in a computationally efficient manner. The proposed sectionalizing switch placement problem considers customer outage costs in conjunction with sectionalizing switch capital investment, installation, as well as annual operation and maintenance costs. The effectiveness of the proposed approach is tested on a reliability test system and a typical real size system. The presented results indicate the accuracy and efficiency of the proposed method.**

***Index Terms*—Decision making, mixed-integer linear programming, sectionalizing switch placement.**

Nomenclature:

ECOST	System-expected interruption cost of customers due to supply outages.
Inv	Total investment and operating cost of sectionalizing switches.
$L(j,k,f)$	Average load of the kth-type customers located at the jth load point of feeder f.
$\mathrm{CDF}^{d_{ij}^{\mathrm{Switching}}}(i,j,k,f)$	kth-type customers damage function value for the outage duration equal to switching time.
$\mathrm{CDF}^{d_{ij}^{\mathrm{repair}}}(i,j,k,f)$	kth-type customers damage function value for the outage duration equal to the ith fault clearance time (e.g., distribution element repair time).
$\mathrm{IC}(s)$	Sectionalizing device installation cost.
$\mathrm{MC}(s)$	Sectionalizing device annual operation and maintenance cost.
$\mathrm{CI}(s)$	Sectionalizing switch capital investment expenses (e.g., purchase cost, shipment, etc.).
$\lambda(i,f)$	Failure rate of distribution elements grouped together on feeder f (feeder-section, transformer, etc.).
N_f	Total number of feeders.
NC_f	Total number of possible fault locations on feeder f.
NL_f	Total number of load points on feeder f.
CT_f	Total number of customer types.
N_s	Total number of installed sectionalizing switches.
T	Sectionalizing switch life period.
$X(s,f)$	Binary decision variable which is equal to 1 if a sectionalizing switch is installed on the sth location of feeder f.
$C^{d_{ij}}(i,j,k,f)$	Customer damage function continuous decision variable which depends on customer type, duration of interruption d_{ij}, etc.; d_{ij} depends on the number and location of sectionalizing switches.
N	Total number of available switches.
q	Annual load increase rate.
DR	Annual discount rate.

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