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The optimal automation level of medium voltage distribution networks

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ABSTRACT

This paper proposed a new methodology for determining the optimal level of investments in medium voltage (MV) distribution network (DN) automation. The problem of network automation is complex, non-linear and discrete optimization problem of enormous dimensions and it is not possible directly apply appropriate optimization procedures. The proposed methodology is based on heuristic combinatory search algorithm with simultaneous consideration scenarios with different types of automation equipment: local automation and remote control. The basis of the proposed procedure is real fault management procedure on the base of which the appropriate estimation of benefits for different network automation scenarios is done. The essence of the algorithm for determining the optimal solution is decomposition of an optimal automation problem with different types of automation equipment to sub problems of network automation with one type of equipment. The proposed methodology has been tested on real network of the city of Belgrade. Obtained results have proven that the proposed methodology is a powerful tool for the determination of the optimal level of investments in the automation of MV DN.

1. Introduction

One of the most important reasons for introducing the automation of network is more efficient fault management. This reduces average outage duration per consumer in medium voltage (MV) distribution network (DN) in case of faults. It reduces costs due to unsupplied energy and improves network reliability. This altogether brings a higher quality of customers power supply and increased income to distribution utilities. The following equipment is considered for network automation [1–3]: (1) fault detectors (directional and no directional) with local and/or remote fault indication; (2) local automation: (reclosers, autosectionalisers, changeovers) and (3) remote controlled switches on control centers with Supervisory, Control and Data Acquisition (SCADA) and Distribution Management System (DMS).

The development of DN automation has been diverse. Distribution utilities differentiate by area, number of consumers and their significance, load density, climate conditions, type of the network (cable, overhead and mixture), treatment of DN neutral nodes and available budget. The majority of distribution utilities begun their automation of DN with local automation [4,5]. Later on, after a decrease in prices of telecommunications, utilities that have dominant city cable network started to introduce remote control (England [6], Italy [7], France [3]), while utilities with predominant rural overhead network kept local automation (Belgium, Finland, Norway [8]). Further reduction of telecommunication price levels brought even more intensified use of remote control, even in rural networks. In rural networks, remote control is introduced most frequently in specific situations when it is necessary to increase reliability on interconnected feeders, as well as feeders which supply important customers. Moreover, even in city networks, which usually supply important customers, elements of local automation in order to increase reliability (Italy). Finally, most utilities are introducing modern control centers with full DMS functionality and additional power application [9], which is enabling utility optimal capacities management (France [3], Italy [7]). Based on all previously mentioned facts it is obvious that there is no clear concept of automation for specific types of networks, but rather a specific solution in each single case. This imposes demand for development of appropriate algorithms for determining the optimal automation level for each particular DN [1–3].

The determination of the optimal level of network automation is complex, non-linear and discrete optimization problem of enormous dimensions and it is not possible directly apply appropriate optimization procedures. Different methods are used to deal with a growing concern in power utilities [10] regarding quantitative justification of the increase in reliability due to the placement of

Abbreviations: AS, autosectionaliser; CB, circuit breaker; CO, changeover; DN, distribution network; ENSI, energy not supplied index; LFD, local fault detector; MV, medium voltage; NOS, normally opened switch; RCB, remote circuit breaker; RCL, recloser; RCS, remote controlled switch; RFD, remote fault detector; RNOS, remote normally opened switch; SAIDI, system average interruption duration index.

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