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Full Length Article

Efficiency-driven planning for sizing of distributed generators and optimal construction of a cluster of microgrids

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ABSTRACT

The optimal placement and the sizing of various distribution system components have gained extra significance in the recent past as the concepts of smarter distribution systems, distributed generation, and microgrids blossomed. This paper presents two novel techniques for sizing the Distributed Generators (DGs) in a large-sized radial distribution network. The primary strategy is proposed by considering the bi-directional progression of current in the parts of the circuit that occurs because of the presence of newly installed DGs. The subsequent strategy utilizes the active power sensitivity calculations for sizing the DGs. These strategies are applied on the chosen radial distribution systems to size numerous DGs all at once, with the main objective being the improvement of efficiency, by accomplishing minimization of losses and improvement in nodal voltages. Then, the maximum number of self-adequate and highly reliable microgrids is formed in the distribution network utilizing the "Reverse Current Flow" procedure cited in the literature, for the proposed sizing methods. Finally, a sensitivity analysis is performed by varying the rates of infiltration of the DGs to throw light on the suitability of the newly introduced methods of sizing. This analysis gives a set of operational rules for the controller of the smart grid.

1. Introduction

The optimal placement and the sizing of DGs, capacitors, and distributed energy storage devices in smart distribution systems including microgrids have attracted the attention of the research community in the recent past due to the technological progress of the distribution systems. To model a modern distribution system with high efficiency, reduction in energy losses is paramount. In the conventional distribution systems, the generators were placed upstream by the utility, far away from the consumers. Long-distance transmission resulted in greater transmission losses and thus the efficiency of the system was not satisfactory. This disadvantage of the long transmission lines paved the way for the upgradation of the system that encouraged the installation of generators at the customer end. Such a localized supply from the DGs additionally urged the switch over to renewable energy generation, when there arose a need for reduction in carbon discharge levels. Installation of capacitors, storage devices, and protective devices downstream the grid demonstrated that the distribution system could work autonomous of the upstream network. This is the basis for the construction of microgrids. Microgrids can operate in upstream grid-connected mode or in an independent isolated mode. Improved reliability of the overall system consistently turns into an indistinguishable advantagein distribution systems involving microgrids. This research will contribute to the literature by choosing an efficiency-based approach to arrive at optimal sizes for the DGs in the system of consideration. Afterward, multiple microgrids will be constructed by employing a recent approach culled from the literature to ensure the reduced purchase of energy from the substation, emission levels, and improved reliability.

2. Literature review

In the literature the placement of DGs has been dealt with in [1–15] and the placement of capacitors or VAR compensators or FACTS devices in various test systems has been discussed in [2–3,6,10,16–21].Similarly, based on economic constraints, the placement of multiple distributed energy storage devices has formed the core of [22–24]. To place new distributed devices in a chosen distribution system, these works cited in the literature either considered one or more of the following objectives: (a) minimization of transmission losses, (b) minimization of expenditures involved in the

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