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DG integrated multistage distribution system expansion planning

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ABSTRACT

In this paper, a framework is presented to solve the problem of multistage distribution system expansion planning in which installation and/or reinforcement of substations, feeders and distributed generation units are taken into consideration as possible solutions for system capacity expansion. The proposed formulation considers investment, operation, and outage costs of the system. The expansion methodology is based on pseudo-dynamic procedure. A combined genetic algorithm (GA) and optimal power flow (OPF) is developed as an optimization tool to solve the problem. The performance of the proposed approach is assessed and illustrated by numerical studies on a typical distribution system.

1. Introduction

Expansion planning of the power distribution systems is one of major activities of distribution utilities to deal with electric power demand growth. Distribution system expansion planning consists of defining facilities to be installed and/or reinforced so that the system serves the forecasted demand at the lowest cost while satisfying operational constraints. Additionally, the system must provide acceptable customer outage profile to ensure that customer reliability requirements are satisfied.

Distribution expansion planning is a highly complex problem, where solution often involves the use of sophisticated mathematical modeling and intensive numerical computation. This problem involves a large number of local optimal solutions and when system size become large, the number of solutions grows exponentially.

Traditionally, distribution expansion planning is solved in two ways:

- *Static approach*, which considers only one planning horizon and determines the location, type, and capacity of new equipment that should be expanded and/or added to the system. In other words, full expansion requirements are determined in one planning period [1–5].
- *Multistage approach*, that defines not only optimal location, type and capacity of investment, but also the most appropriate times to carry out such investments, so that the continuing growth of the demand is always assimilated by the system in an optimal way. Multistage approach refers to expansion of the system in successive plans over several stages, representing the natural course of progression in development [6–12].

The multistage approach, due to the interdependency between stages, is far more challenging to formulate and solve but the solution offers a more useful result. In this paper, we analyze the multistage distribution expansion planning (MSDEP) problem.

Today, power system economic and operation environment has changed as new capacity options are expanded. Distributed Generation (DG) is one of these new options. The introduction of DG in power system changes the operating features and has significant technical and economic advantages. Thus, optimal placement and sizing of DG sources attract active research interests and several works have been done in this area [13–15].

Due to the low investment risk and flexibility, DG can be implemented as a possible solution in distribution system expansion planning [16] to provide more diversity of expansion solutions for distribution utilities. Adding DG sources to the planning options is resulting in challenges in the distribution expansion planning process since the traditional planning approach is now no longer appropriate in this new era. Consequently, expansion planning modeling should now consider not only the substations and feeders but also DG sources in expansion planning alternatives. Therefore, new strategies and models for distribution system expansion planning need to be developed to accommodate this challenge.

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