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Transmission Expansion Planning Using TLBO Algorithm in the Presence of Demand Response Resources

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Abstract: Transmission Expansion Planning (TEP) involves determining if and how transmission lines should be added to the power grid so that the operational and investment costs are minimized. TEP is a major issue in smart grid development, where demand response resources affect short- and long-term power system decisions, and these in turn, affect TEP. First, this paper discusses the effects of demand response programs on reducing the final costs of a system in TEP. Then, the TEP problem is solved using a Teaching Learning Based Optimization (TLBO) algorithm taking into consideration power generation costs, power loss, and line construction costs. Simulation results show the optimal effect of demand response programs on postponing the additional cost of investments for supplying peak load.

Keywords: transmission expansion planning; demand response program; TLBO; elasticity

1. Introduction

Installing new devices on an existing power system while ensuring stability and reliability of the power system are the main goals of Transmission Expansion Planning (TEP). This planning is based on load prediction and power supply conditions. From a mathematical view point, TEP is a nonlinear, discrete, and large-scale optimization problem with many equality and inequality constraints. Transmission line planning can be divided into evolutionary, mathematical, and meta-heuristic methods.

The evolutionary method quickly converges to the optimal solution, but for a large scale and complex problem, it can converge to a solution that is far from ideal. One of the first methods for solving the expansion transmission network problem was presented in 1970 by Garver [1]. In this work, the problem is formulated as a load distribution problem; the objective function and the constraints are described by linear functions that neglect Ohmic power loss. Considering the newly added lines, new linear load flow is calculated, and the operation continues until no overload exists in the system. Lattore et al. proposed an evolutionary method in which the transmission line is decomposed into two problems: generation and investment [2]. The investment problem is solved by an evolutionary method, while the generation problem is solved by a known optimization method. In prior studies [3–11], researchers have solved the same problem using the evolutionary method by sensitivity analysis. In each step of the algorithm, the sensitivity index is used for determining the added circuits (lines). The sensitivity index can be generated based on the algorithm implemented in an electrical system like minimum depletion [3], load feeding [4], lowest criteria [6], a lighter version of its own mathematical model [5,7,8], or the optimal load flow [9,10]. In most models, the internal point method is used for solving the linear or non-linear planning problem in each iteration.

One of the first mathematical optimization methods for solving the transmission network expansion is the linear planning technique, in which both the constraints and the objective function