Transmission surplus capacity based power transmission expansion planning

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A B S T R A C T

A power transmission expansion planning model with consideration of transmission surplus capacity and network load factor is presented. With traditional planning model, some transmission lines will operate on high load factors due to ignorance of the load levels of transmission lines. This may lead to network congestion or degrade the dispatch flexibility of future network. Traditional planning model has put more emphasis on investment cost rather than other aspects such as operation environment, transmission benefit, etc. The transmission expansion planning model in the paper aims to maximize network transmission surplus capacity and optimize network load factor distribution with least investment. Chaos Optimal Algorithm (COA) is introduced to solve this nonlinear integer planning optimization problem for its advantage of stochastic and ergodic searching characteristics. The effectiveness of proposed model and methodology is tested with two typical systems.

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1. Introduction

Transmission expansion planning is a kind of nonlinear discrete integer optimization problem with consideration of linear and nonlinear constraints [1]. Long term transmission expansion planning is generally carried out in the form of either in centralized or competitive frameworks and can be classified as two groups: static transmission planning and dynamic (multistage) transmission planning [2]. The static transmission expansion problem that takes transmission power losses into account under centralized environment is proposed in [3]. The nonlinear characteristics of the losses in the transmission network are transformed into a linear format. Network expansion investment is regarded as the main objective to be optimized in most transmission expansion planning models [4]. And power transfer capability is often an important technical index in transmission expansion planning. A probabilistic planning method to assess the risk of increasing utilization degree of transmission capacity in existing network is presented in [5]. The available transfer capability measures the further power transfer capability in network and is useful to guide power transactions for all participants [6]. Transmission capacity shortage may result in undesired serious consequences such as load shedding, blackout, market manipulation, increase of congestion cost and O&M cost and so on [7]. Continuing load growth could erode reliability margins and deregulation will further sharpen this situation.

A mixed-integer linear programming formulation for the long term transmission expansion in competitive pool-based electricity market is introduced in [8]. It considers investment cost and weights the aggregate social welfare according to different levels of demand scenarios. Transmission capacity expansion is assumed not to cause excessive transmission congestion or endanger the system reliability in power market environment [9]. The power transfer capability will be deeply explored by operators and the transmission capacity management is vital to ensure system operation safety under deregulated environment [10]. Besides, transmission expansion planning suffers from a lot of uncertainties, such as generation expansion uncertainty, load forecast uncertainty, environmental changes, etc. Therefore, the network expansion planning is required to have adequate capacity and adaptability to deal with uncertainties.

Transmission surplus capacity is an additional capacity over normal power transmission capacity of the network. It represents power transmission reserve capacity to some extent and is helpful to evaluate network transmission capacity increment effect. Adequate transmission surplus capacity could ensure the implementation of power transaction and enhance the operation level to withstand system disturbances. Network load factor distribution betterment could improve system operation environment and mitigate some heavy loaded branches effectively. To obtain global optimization of network load factor improvement, proper mathematical model should be adopted to select the most effective transmission lines. Conventional planning approach such as the