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Performance comparison of Transmission Network Expansion Planning under deterministic and uncertain conditions

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ABSTRACT

Transmission Network Expansion plans determined considering deterministic or uncertain conditions are evaluated under demand and cost scenarios different from the original design scenarios. Performance is measured in terms of minimization of the total expected cost and the range of the operational costs over the new set of assumed scenarios. A test problem for a real network in Brazil is presented to assess the robustness of the expansion plans. It is found that transmission plans considering uncertainty performed better than plans under deterministic conditions both in terms of minimization of the total expected cost and the range of operational costs.

1. Introduction

After deregulation of the Electric Power Sector in the US planning for expansion of generation, transmission and distribution capacities is no longer performed by a vertically integrated utility. In this deregulated environment, the generation sector is competitive and there is open access to the transmission grid. The distribution sector still remains mostly regulated. The transmission network and the electricity markets are managed and dispatched by an Independent System Operator (ISO). In this new environment there is a great deal of uncertainty regarding important parameters needed for Transmission Network Expansion Planning (TNEP) such as: generation cost parameters, siting and characteristics of new generating facilities, demand forecasts over different regions, and generation availability, among others. This high uncertainty imposes additional constraints on the transmission grid [1–3], demanding some degree of transmission capacity over design.

Due to its inherent complexity, TNEP is generally performed assuming deterministic environments. The optimal design of the grid is then based on a fixed deterministic demand and generation cost scenario [4–7]. This demand scenario generally corresponds to peak demand for the system. Since the TNEP under deterministic conditions does not include uncertainties, there is a risk that these expansion plans may not be optimal when realizations different from the assumed deterministic scenario subsequently happen. This is a serious limitation of the TNEP deterministic approach [8,9].

There are two important aspects of uncertainty that the authors of this paper consider that should be included in a decision model: the set of possible values for uncertain parameters and the consequences when these values occur. Uncertain parameters should be defined by a set of possible values with an assigned probability structure. The consequences of the system taking different parameter values should be measured appropriately to identify relevant critical states. The first aspect is included in the proposed models under uncertainty by using scenarios and the second aspect by capturing the consequences of over or under designing transmission capacities in terms of costs [10].

Ignoring uncertainty in the TNEP process may result in the system having a higher total cost due to additional costs in transmission capacity, load curtailment or generation dispatch. In the TNEP models proposed in this paper the objective function representing total cost is the sum of transmission expansion costs, generation costs and load curtailment costs. The generation-dispatch costs are included to capture the effect of different dispatches ordered by the ISO on account of bid-costs variability or generating capacity availabilities causing uncertainty in flows from various generating nodes. The load curtailment cost allows the model to limit the transmission capacities by making an optimal trade off decision between transmission capacity expansion costs and load curtailment cost. For a survey of expansion methods applied to the TNEP under uncertainty see [11].

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