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Probabilistic model for distributed generation expansion in distribution power network

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Abstract. In this paper a probabilistic model is presented to optimize the expansion of distributed generation in the electricity distribution network. The Monte Carlo technique is used to obtain probability distributions of the desired variables, such as: power flows, output power of distributed generators, costs, etc. The analysis of the results leads to optimized criteria for the expansion of distributed generation (DG) in distribution networks.

Key words

Probabilistic model, Monte-Carlo, expansion generation, renewable energy, optimization.

1 Introduction

The development of distributed generation, primarily associated with renewable energy, is related to several important topics such as the need for greater flexibility of the electrical system, new legislative and economic scenarios, price of energy and environmental impact of the generation of electricity (green house effect).

Renewable generators are intermittent due to its primary energy sources, like wind or solar radiation. But not only renewable energy sources are uncertain, also the future costs of fuels and technologies and the energy demand itself.

The presence of distributed generation has significant effects on the performance of distribution networks: reverse flows, increased contribution to short circuit currents, voltage levels and the deterioration of the protection systems and its coordination.

Electrical distribution systems are beginning to face a period of major changes which are going along with long periods of rates of return. Therefore, there is an increasing need for the development of planning tools able to efficiently address the growing uncertainty that characterizes the current situation.

Until now the main focus of the planning tools was given to deterministic methods and very few authors have considered any uncertainty in their models. This contrasts with the fact that risk management or the management of uncertainty is a very important issue for the utilities and system operators. In order to exploit the opportunities ahead, it is necessary to find an efficient way to minimize the risks and uncertainties.

Recently, several authors address the planning of generation expansion from a deterministic perspective. Kuri *et al.* [1] propose an architecture to optimize the planning of distributed generation by emphasizing the risks and uncertainties. Keane *et al.* [2] propose a methodology for determining the optimal location of distributed generators along the distribution network. Krahl *et al.* [3] present a method for assessing and minimizing the costs of distributed generation networks.

In recent years, there were proposed models based on probability distributions. In Repo *et al.* [4] the short-term planning of a distribution network is discussed, taking into account the stochastic behavior of Distributed Generation units. Marmidis *et al.* [5] show a method for the optimal location of wind turbines in a wind farm, based on Monte Carlo Simulation. Bouffard *et al.* [6] formulate a short-term electricity market-clearing problem with stochastic security, considering non-dispatchable, stochastic wind generation. It is pointed out that stochastic operation planning allows more wind power in the network, without sacrificing security. Haesen *et al.* [7] present a robust planning methodology for integration of generators in distribution networks.

In section 2 the algorithm based on the Monte Carlo technique used in the probabilistic model is exposed. In section 3, the probabilistic optimization model is described, which represents the expansion of distributed generation in an electricity distribution network. In section 4 results are presented. In section 5 the additional information given by the probabilistic model compared to