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Stochastic unit commitment of wind farms integrated in power system

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ABSTRACT

Integration of wind power generation creates new concerns for operation engineers in a power system. Unlike conventional power generation sources, wind power generators supply intermittent power due to uncertainty in parameters of wind such as its velocity. This paper presents probabilistic model for load and wind power uncertainty which can be used in operation planning (with durations up to one or two years). A stochastic model is proposed to simulate the status of units that are directly affected by the load and wind power generation uncertainties.

This paper develops a solution method for generation scheduling of power system, while taking into account the stochastic behavior of the load magnitude and the wind power generation. The stochastic trend in uncertainty of these parameters has been simulated by creating scenarios that can be solved by deterministic methods. Mixed integer nonlinear programming (MINLP) is used for solving deterministic unit commitment problems, the reserve power requirement, load–generation balance, and available wind power constraints. The proposed approach is developed to make decision on fixed state of units operation in different scenarios which can be employed efficiently in unit scheduling of power system. The proposed approach is applied to a 12-unit test system (including 10 conventional units and 2 wind farms). The performance of the proposed approach is more investigated through analysis of its results for two other test systems.

1. Introduction

The introduction of wind energy into conventional utilities creates new concerns for power engineers in a power system. As the amount of wind power generation increases around the world, the concerns increased on its impacts on power system operation and costs. Since wind is an intermittent resource of energy, the development of forecasting tools is extremely valuable to schedulers and dispatchers. Although forecasting tools are becoming more accurate, however integrating large-scale wind power plants into the grid pose challenges, when scheduling for durations not covered by accurate forecasts.

Power system operation covers several time scales, ranging from minutes to days. If a significant amount of new wind generations are added to the power supply, the impacts can extend to each of these time scales. If a wind plant's output could be perfectly forecasted for several days in advance, it would help schedulers to determine which units would need to be committed. In the absence of a perfect forecast, the unit commitment (UC) decision must be made under uncertainty. Consequently, the decision may contain a unit to be committed when it is not needed, and sometimes may not contain a unit for commission while it is needed.

The UC problem is an important optimization task to determine the unit start up and shut down schedules in the scheduling of power system operations. The objective is to minimize the overall system operation cost over the scheduling time period while meeting the system load demands and other constraints. The unit commitment problem is commonly a nonlinear, large-scale, mixed integer combinatorial problem. Various mathematical programming and heuristic based approaches such as dynamic programming, neural networks, simulated annealing, evolutionary programming, constraint logic programming, genetic algorithms, Lagrangian relaxation (LR), branch and bound algorithm, tabu search and particle swarm optimization approaches have been devoted to solve the UC problem [1,2].

The above-mentioned methods solve UC as a crisp problem, although part of UC is imprecise due to the prediction errors. Researchers have considered the uncertainties in imprecise parameters, using one of the two following approaches: fuzzy systems approach [3–10] and stochastic/probabilistic approach [11–22]. Probabilistic and stochastic programming introduce random variables and uncertainty into the conventional linear and nonlinear programs [11]. The randomness and the uncertainty involved are generally represented by a probability density function (PDF) [12]. Many papers have been published to introduce these random

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