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SIMULATION OF HIERARCHICAL UNIT COMMITMENT WITH UNCERTAIN WIND POWER GENERATION

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ABSTRACT

Proposes a hierarchical unit commitment (HUC) model based on the concept of RUC to improve the system security of power systems with high wind power penetration by balancing system reserve capacity against security. To prevent over-conservative solutions, HUC divides the wind power output into two intervals based on confidence levels, and uses different scheduling strategies for different intervals of wind power output. Three types of reserves, generation reserve, short-term ramping reserve, and transmission reserve, are proposed to enhance the robustness of the scheduling solutions. The generation reserve guarantees sufficient online generation capacity when the wind power generation deviates from the predicted value. The short-term ramping reserve provides sufficient ramping ability to accept rapid fluctuations in wind power output, while the transmission reserve prevents excessive overloading of transmission lines over the wind power output interval. Furthermore, some simplifications are proposed to reduce the computational complexity when considering transmission reserve. The purpose of this system is to construct a HUC model that guarantees system security while legitimately reducing reserve capacity.

Keywords: Hierarchical unit commitment, RUC, uncertainty, wind power, Reserve capacity.

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INTRODUCTION

Wind power is becoming worldwide a significant component of the power generation portfolio. In Europe, several countries already exhibit adoption levels in the range of 5-20% of the total annual demand. In the U.S. an adoption level of 20% is expected by the year 2030. Such a large-scale adoption resents many challenges to the operation of the electrical power grid because wind power is highly intermittent and hard to predict. In particular, unit commitment (UC) and energy dispatch (ED) operations are of great importance because of their strong economic impact (on the order of billions of dollars per year) and rising emissions concerns. Several UC studies analyzing the impact of increasing adoption levels of wind power have been performed recently.

A security-constrained stochastic UC formulation that accounts used for wind power volatility is presented together with an efficient Benders decomposition solution technique. However, the issue of constructing probability distributions for the wind power is not addressed. A detailed closed-loop stochastic UC formulation is reported. The authors analyze the impact of the frequency of recommitment under the production, startup, and shutdown costs. They find that increasing the recommitment frequency can reduce costs and increase the reliability of the system. However, the authors do not near details on the wind power forecast model and uncertainty information used to support their conclusions.

Artificial neural network (ANN) models are used to compute forecasts and confidence interval for the total aggregated power for a set of distributed wind generators. The authors observed that forecasting the aggregated power tends to reduce the overall forecast error because it smoothes out local character variations. A problem with empirical modeling approaches, however, is that their predictive capabilities rely strongly on the presence of persistent trends. In addition, they forget the presence of spatio temporal physical phenomena that can lead to time-varying correlations of the wind speeds at neighboring locations. Such approaches can thus result in wrong medium and long-term forecasts and over- or under-estimated uncertainty levels, which in turn affect the expected cost and robustness of the UC solution.

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In this work, seek to exploit recent advances in numerical weather prediction (NWP) models to perform UC/EP studies with wind power adoption. The use of physical models is popular because consistent and accurate uncertainty information can be obtained. As an example, consider the missing effects of turbulence during night time, which would allow one to obtain much tighter doubt intervals and lower operating costs. These physical effects cannot be captured adequately through empirical modeling techniques. On the other hand, the practical capabilities of NWP models are also limited.

RELATED WORK

François Bouffard et al [4] an electricity market-clearing formulation that can account explicitly for this type of uncertainty and variability. There are several advantages to the use of a stochastic approach over the more conservative deterministic approaches. This has the consequence of permitting the improvement of the economic performance of the market by taking advantage of the freely-available wind power and by falling reserve scheduling and HTG unit commitment costs.

Qianfan Wang et al [5] proposed the chance constraint guarantees the minimum usage of the wind power by setting a risk level, which limits the chance that a large amount of wind power might be curtailed. Studied three different types of polices and compared the wind utilizations by these policies. The results verified that Policy 3 is the most restrictive one. .[6] discussed about principles of Semiconductors which forms the basis of Electronic Devices and Components.

Pappala et al [7] suggested that two approaches for solving the unit commitment problem in order to mitigate the uncertainty stemming from continuous sources of uncertainty (renewable energy or demand forecast error) as well as discrete disturbances (generator and transmission line failures). The stochastic unit commitment model optimizes the expected cost of operation of the system, while the scenario-based security constrained unit commitment model minimizes the cost of system operations while guaranteeing that the system can withstand major contingencies without shedding load.

PROPOSED METHOD

A hierarchical unit commitment (HUC) model is proposed based on the concept of RUC to improve the system security of power systems with high wind

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power penetration by balancing system reserve capacity against security. To prevent over-conservative solutions, HUC divides the wind power output into two intervals based on confidence levels, and uses different scheduling strategies for different intervals of wind power output. Three types of reserves, generation reserve, short-term ramping reserve, and transmission reserve, are proposed to enhance the robustness of the scheduling solutions. The generation reserve guarantees sufficient online generation capacity when the wind power generation deviates from the predicted value. The short-term ramping reserve provides sufficient ramping ability to accept rapid fluctuations in wind power output, while the transmission reserve prevents excessive overloading of transmission lines over the wind power output interval. Furthermore, some simplifications are proposed to reduce the computational complexity when considering transmission reserve. The purpose of this paper is to construct a HUC model that guarantees system security while legitimately reducing reserve capacity.

IMPLEMENTATION

In our model, the proposed generation reserve is provided by generators and delivered by transmission lines. It has to satisfy the load demand with uncertain wind power generation.

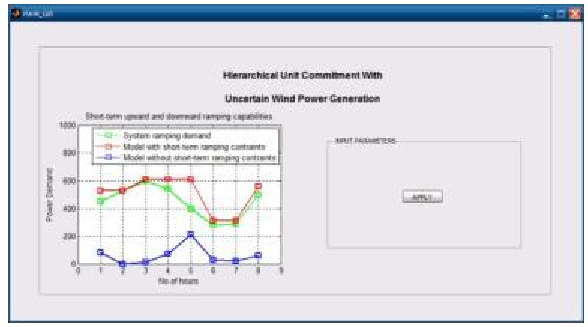

Fig 1 Short-term Upward and Downward Ramping Capability

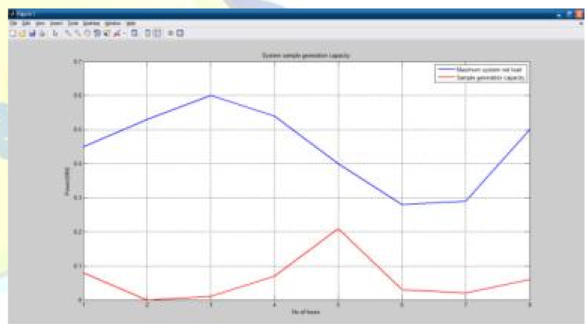

Fig 2 Maximum System Net Load Curve

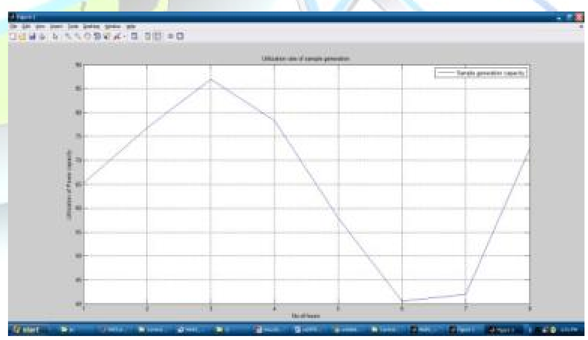

Fig 3 Utilization Rate of Sample Generation

CONCLUSION

Thus, the HUC first divides the wind power output into a high possibility interval and a low possibility interval. Then, the coordination of conventional and emergency power operation is developed in these two intervals. Next, three types of reserves are proposed to deal with the uncertainty from wind power based on its characteristics. Finally, algorithm enhancements including substitution and simplification are proposed to reduce the computational burden. The effectiveness of HUC was evaluated using multiple case studies. Compared with SUC, the HUC is more secure while its economics is just slightly higher than SUC. Compared with RUC, the solvability of HUC is better. If the range of wind power interval for RUC is the same as HUC, system security level for HUC commitment is improved without increasing system cost sharply.

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