Electric Power Systems Research 80 (2010) 1375–1383

Contents lists available at ScienceDirect

Electric Power Systems Research

journal homepage: www.elsevier.com/locate/epsr

Secure and economic management of a power system in the presence of wind generation

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ARTICLE INFO

Article history:
Received 22 September 2009
Received in revised form 18 January 2010
Accepted 16 May 2010
Available online 20 June 2010

Keywords:
Minimum load curtailment
Level of penetration reserve
Security
Uncertainty
Unit commitment
Wind power generation

ABSTRACT

Nowadays, large-scale integration of wind power is a challenge in terms of the minimization of the insecurity risk, that is, of the expected cost associated with the expected load not served. In fact, when there is an elevated proportion of wind power, the electrical power quality in the sense of continuity of supply may be low, since energy from wind power cannot be dispatched in the classical sense and its output varies as weather conditions change. However, continuity of supply may also be undermined by other uncertain factors, such as the occurrence of random events like line outages, generator failures or sudden demand variations. Assuming the insecurity risk as a part of the overall expected cost for a secure management of a deregulated power system, this paper proposes a DC formulation of an AC Economically correct Secure Economic Dispatch (EcSED), modified also for the introduction of uncertain Wind Power Generation (WPG) sources. Finally, simulations were carried out in order to investigate how the above overall expected cost changes, as a function of varying penetration levels and varying installation locations of a WPG plant.

1. Introduction

A prevailing factor in the operation of a power system is the desire to maintain system reliability, whereas the cost of operating the power system is simultaneously minimized. System reliability is referred to the overall ability of the system to perform its function, and system reliability assessment embeds both system adequacy and system security. Adequacy relates to the existence of sufficient facilities within the system to satisfy consumer load demand or system operational constraints, and it is therefore associated with static conditions, which do not include system disturbances. On the contrary, security instead relates the ability of the system to respond to disturbances arising within the system itself [1].

The need for power system reliability evaluation has nowadays become a major concern also in the presence of new renewable energy sources, in general not-programmable, such as wind, solar and wave, which replace some of the energy generated by programmable fossil-fired stations. The non-programmable production of renewable plants is related to the uncertain nature of the primary sources, mainly wind and sun. For this reason, even over a short period, e.g. on the day before, power production of a renewable plant can only be forecasted, whereas it will be known exactly only in real-time. This uncertainty, together with real-time load variation and system contingencies, leads to a higher level of insecurity of the power system.

As a consequence of such insecurity, the system operator must increase reserve margins [2], adopt generation rescheduling strategies to counteract the effects of estimation errors and of the next possible contingencies, and finally update old tools for power system security analysis. If the above actions are not performed, black-out episodes might take place, such as the one that occurred in northern Germany, on November 2006 [3]. To this end, several papers [4–8] and practical applications used security-constrained-optimal-power-flow (SCOPF) to determine preventive/corrective actions to improve the security of the system.

Within this context, the paper outlines a proposal of SCOPF in the presence of wind generation in a deregulated power system, based on the main aim of maintaining a high quality level of supply at the minimum overall cost. This minimum overall cost was computed as the sum of the power system security cost [9], of the rescheduling cost in pre-contingency state and of the expected cost owing to a post-contingency generation power change. Power system security cost was taken into account by means of the insecurity risk [10–19], defined as an expected cost, as a function of the minimum load curtailment [12,13,15–19] needed to move the system operating point from an emergency to a restorative state. Preventive/corrective actions against the violation of any operating constraint were implemented, among which generation rescheduling, in either the pre- or the post-contingency state, curtailment of

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doi:10.1016/j.epsr.2010.05.005