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The influence of wind generation on power system reliability and the possible use of hydrogen storages

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ABSTRACT

The aim of this study is to simulate the impact of non-programmable generation sources, in particular wind farms, on the reliability of an electric power system. A probabilistic model has been implemented, to evaluate the influence of wind generation on the amount of secondary/tertiary generating reserve, required in a hydro-thermoelectric system to maintain a certain level of reliability.

A case study, calibrated on the electric system of one of the largest Italian islands, shows the critical issues associated with over-generation events, basically due to an underestimation of wind production. Three possible policies, to be adopted during real-time by the Independent System Operator (ISO) in order to face such events, are simulated and discussed in terms of system reliability and costs for balancing operation.

The use of hydrogen storages, managed by the ISO to cope with over-generation contingencies, is proposed and analyzed in different scenarios of wind penetration, assessing the payback time of the storage devices also considering the economic implications of system reliability.

1. Introduction

In the last decade, the wind power generation installed in the world has grown very rapidly and in the next future it will represent a significant fraction of the total installed renewable capacity. Especially in islanding operation, the uncertainty associated with wind generation, related to the wind speed variability and intermittence, can create serious balancing problems to the Independent System Operator (ISO), who is responsible for system reliability and security.

Assuming, for instance, that new wind generation units are added to an existing hydro-thermoelectric system, the volatility of the production associated with the wind farms requires an oversizing of the secondary and tertiary power reserve margins; such an effect generates additional costs that could even exceed the benefits provided by the use of the renewable source. The problem is, therefore, to estimate which is the relationship between the new installed wind capacity and the operating reserve required to maintain the previous system reliability.

The recent technical literature [1–6] has made large use of probabilistic techniques to assess the reliability of power systems in the presence of intermittent sources. Nevertheless, the use of hydrogen storages to mitigate the over-generation contingencies, due to a strong underestimation of wind production, has not been simulated. Even when storage devices were investigated as a mean to avoid the curtailment of renewable generation, their payback time has never been discussed from the point of view of the Independent System Operator, that means considering in the cash flow analysis the economical value of the reduced load shedding.

This new approach is proposed and applied to a case study, that shows the significant economical impact of three possible different policies, which can be adopted by the ISO to face real-time over-generation events.

2. Power system reliability and Monte Carlo techniques

A large number of variables are involved in the power system's reliability assessment, many of which are affected by aleatory events, such as load levels, wind speed, and accidental failures of generating units or transmission links; furthermore, the presence of a competitive market, which defines the electric system's hourly working point, has to be considered. For this kind of problems, a probabilistic approach, based on sequential Monte Carlo techniques, which have been largely applied in the past for studying the behavior of large electric power systems [7–9], can be more powerful than the analytical methods.

Assuming that a component is fully described by two states ("available" and "unavailable"), Fig. 1 shows an example of an average time series of failure and repair events. Mean Time To Failure (MTTF), Mean Time To Repair (MTTR) and Mean Time Between

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