Renewable energy supervision and real time production control in Spain

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1. Introduction

Special regime generation accounts for 27 % (January 2008) of the installed capacity in the Spanish peninsular system in terms of power and has produced 20% of the electrical energy in 2007 and it is expected to increase in the future as foreseen by the Renewable Energies' Plan for Spain [1] complying with European directives [2].

Wind energy requires special attention since it is the biggest and fastest growing share of the special regime generation reaching a total of 13,908 MW installed capacity at the end of the year 2007. Integration of wind power in the electrical system keeping its reliability is an important challenge to system operators due to specific characteristics of this renewable energy.

This paper illustrates the experience of the Spanish System Operator with the special regime generation and the measures carried out to maximize the integration of the wind energy in the system without compromising its security.

Key words: Renewable energy, system operation, voltage dip, control centre, wind power

2. Problems with renewable energy integration

There are various concerns regarding the integration of renewable energy in Spain: transient stability of wind power after voltage dips originated by a correctly cleared fault, power balance viability with high renewable production in the system and voltage control.

A. Behaviour Of Wind Generation During Voltage Dips

The sensitive protection devices installed in the present wind turbines in service in the Spanish electric system are responsible for simultaneous wind power generation losses synchronized to correctly cleared faults. In some cases, protections may trip the wind farm if the voltage at the connection point varies abruptly for more than 10% of the nominal voltage. Certain faults in the Spanish network can generate voltage dips greater that that threshold far away from the short circuit, since the Spanish network is robust and well meshed, impacting in large quantities of wind farms, as shown in Figure 1.

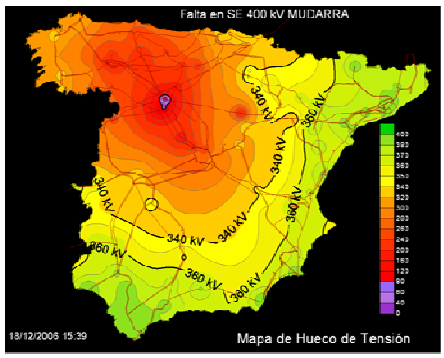

Fig.1. Example of voltage dip propagation due to a fault.

Being aware of this drawback, REE undertook a transient stability study [3] of the response of wind energy generation to voltage dips in order to determine the maximum wind energy production of the Iberian Power System in peak and off-peak periods. The results of the study defined the voltage ride-through requirements and the permissible active and reactive consumption values during voltage dip situations which were then gathered in the grid code.

B. Power Balance Feasibility And Requirement Ratio

Most renewable energy comes from an unmanageable primary resource with great variability and difficulties to be predicted accurately. It implies a higher requirement for conventional manageable generation that has to be scheduled not only for covering the uncertainties of demand behaviour but also to compensate the fluctuations of the special regime generation.

In order to analyze this influence a new variable is monitored: the requirement, defined as the difference between load and wind production. Figure 2 represents the monotonous curve of the requirement ratio (between the maximum and the minimum daily requirement) compared with the monotonous curve of the load ratio (between peak and off-peak daily demand) for 2007. It can be observed that wind energy contributes to steeper manageable generation ramps most of the time, since it is generally at night when the higher wind productions are reached.

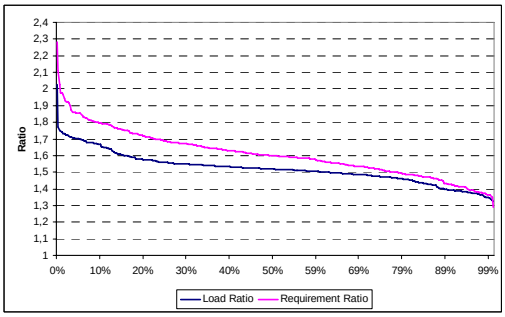

Fig.2. Daily requirement ratio compared to daily load ratio for 2007.

Due to technical minimum power output of generating units, flowing hydro power plants and other reasons there is a requirement ratio over which it is necessary to shut down conventional power generation during off-peak hours to connect it back several hours later in real time to cover the peak demand. Taking into account that special regime generation will not provide ancillary services within the next few years, a minimum amount of manageable production is necessary to be connected to the network, though renewable energy reduction may be unavoidable in certain operating circumstances. The installation of new planning storage-pumps units will reduce the risk of these reductions.

C. Voltage Control

The Spanish regulation currently in force [4] establishes a bonus or penalty depending on the reactive power system factor for the special regime generation. This non-continuous voltage control procedure implies in practice the simultaneous connection/disconnection of capacitors when there is a change in the period (peak, off peak or intermediate) and has lead several times to the tripping of wind generation due to the activation of its over-voltage protections due to the abrupt change in the reactive power pattern.

New continuous voltage control systems and incentives must be developed and introduced in order to avoid voltage control related problems in the network.

3. Control Center for Renewable Energies (CECRE). Maximum Admissible Wind Power Generation in the System (GEMAS)

In June 2006 a new specific control centre for renewable energy (CECRE), mainly focused on wind generation, has been commissioned. The main purpose of the CECRE is to harmonize in real time special regime generation and system security. According to present regulation [3] all production facilities with a total installed power greater than 10 MW must be controlled by a control centre (WGCC) that is directly connected to the CECRE and must be able to comply with CECRE's orders within 15 minutes at any time.

The CECRE complements the operative off-line studies with real time analysis that provide the maximum special regime production that the system is able to integrate without jeopardizing the security conditions. GEMAS (Maximum Admissible Wind Power Generation in the System) is an ad hoc application designed to carry out that calculation simulating every 20 minutes three phase dead faults in the bus bars of 70 different substations using pseudo-dynamic or 'switching studies' with static power flow applications. The wind generation loss is estimated by comparing residual voltage at the wind farm connection buses with the sensitivity of the turbine technology. The production of every wind farm connected to the CECRE is received in real time with the help of the ICCP links to the WGCCs. In case one or several contingencies represent a risk for the system, two separate lineal optimization problems are solved and provide the limitations for each individual wind farm. The goal of the first optimization problem is to maximize the global wind production of the system considering that neither of the contingencies can lead to wind power loss higher that the greater admissible loss of generation in the system. As the result of this problem is not unique, the second optimization loop allows choosing within the possible solutions the one that minimizes the potential wind power losses for all critical and pseudo-critical contingencies. The calculated set points are sent through the EMS system to the WGCCs as established in the regulation [5].

4. Conclusions

The high penetration level of renewable energy in Spain (especially wind power) and its specific characteristics have motivated the creation of the new Control Center for Renewable Energies (CECRE) and the development of new on-line tools (GEMAS) to allow the highest integration of that generation without any risk for the system. Spanish experiences show challenges that system operators have to face in terms of power balance feasibility or voltage control management related to the high proportion of renewable energy in the Spanish generation mix.

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