Comparison of European Interconnection and Operation Requirements for Wind Farms

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Abstract. The necessity to provide clean energy, along with the latest technology developments in the field of wind turbines, have been reflected by building bigger wind farms. This, combined with the integrated operation between wind farms and the grid, involves all the electric system affecting different aspects as transitory stability, voltage regulation, energy reserve management and the electric market. Most UE transmission system operators (TSO) have responded introducing technical regulations for wind farm interconnections. The present paper presents a comparison of grid codes for wind farms (WF), and their operative implications.

Key words

Wind farm, grid code, connection requirements, voltage control, frequency control.

1 Interest of work

The global boom of renewable energies has changed the control needs of electric systems. The firstly developed wind farms (WF) were considered as groups of isolated wind turbines; a local and simple management was enough without complex control systems. The use of fixed speed wind turbines (WT) based on the squirrel cage induction generator was common. Their relative low cost and mechanical simplicity were its main advantages that made it so used.

With the increase of wind power, the squirrel cage induction generator began to have negative impact in the power system stability. This type of generator requires a reactive magnetization current that is taken directly from the grid and is not able to ride through voltage disturbances. In the event of voltage sags most wind farms were tripped off, involving serious problems for the system stability.

The need for more robust systems able to ride through disturbances and participate of the grid stability boosted the incorporation of power electronics and the development of new wind turbine generation concepts, resulting in variable speed wind turbines. Among them, the most common technology used today is the doubly feed induction generator (DFIG). The DFIG is a wound rotor induction generator, in which the stator is connected directly to the grid and the rotor is connected to the grid by means of a back-to-back power converter, responsible for the control of the generator torque. Besides, it can control the production of reactive power, allowing voltage control capability. The power converter is usually rated to 20-30% of the generator power, which implies lower cost than fully rated converters, but having a limited speed range operation.

The new variable speed WT technologies included the use of synchronous generators for full speed range operation using full power converters. Such generators can even allow the reduction or elimination of the mechanical multiplier by using multipolar synchronous machines.

2 Objectives

With all this technological changes and the necessity to maintain the stability in the power systems, Transmission System Operators (TSO) have integrated into their grid codes control requirements for wind farms. Many of them are based on the existing control functions of conventional generating units.

The continuos change of grid codes experienced in the last years, motivate a review including different grid code requirements. This review can be useful for:

- Wind turbine producers and WF developers, giving them an overview about existing requirements and guidance for technology development.

- Countries with a recent interest in wind energy, to attract their attention to the main issues.
- Direct the research work in this direction, responding to the TSO and WF developers needs.

3 Main contribution

In this paper, the grid codes of the countries with more installed wind energy (Denmark, Germany and Spain) and some others with significantly expansion of renewable energies (UK, Ireland and France) are compared. The structure of grid codes and control issues, principally frequency and voltage control, are presented. As well as the principal technological implications.

IEEE is one of the principal references for technical standards. At the end of 80's IEEE published the standard *Guide for Interfacing Dispersed Storage and Generation Facilities with Electric Utility Systems*. It presented the first guidance notes in matter of power quality, equipment protection and safety for distributed networks. At the same time in some countries as Denmark and Germany, distribution companies started to develop some rules for WF connection. Latter at 90's these rules were collected in a national level. Finally in 2002 the *IEEE standard for Interconnecting Distributed Resources with Electric Power System* were published.

Actually each country has a specific regulations concerning WF or is working on them.

Denmark

Energinet.dk responsible of electric transmission system in Denmark, have created a connection code divided in two levels, for connection points above and below to 100kV. In general the control requirements demand the possibility of increase or decrease the active power production [2].

Germany

E.ON the main German utility has been continuously upgrading its Grid Code for high and extra high voltage connections, and more recently Offshore Grid Connections [3].

Spain

In Spain through P.O. 12.3 developed in 2006 the requirements for response to voltage dips of wind power plants setting out. In 1998 were defined with P.O. 1.6 security plans to ensure safe and reliable operation of the system.

UK

In the UK the Energy Networks Association (ENA) and National Grid set out the operational and technical requirements for connection [4]. At the same time, they seek to give WF developers guidelines allowing them to fulfill the requirements of network.

Ireland

In the case of Ireland, the Commission for Energy Regulation (CER) approved the proposed Wind Grid Code the 1st of July of 2004. The Wind Grid Code was produced by ESB National Grid (ESB-NG). The code refers to frequency control settings and regulation margin P-f upwards and downwards [1].

France

In France, the official circular of October 27^{th}, 2006 sets out the operation requirements of a generation unit.

The requirements for grid connection of wind farms differ between countries and each power system has different control necessities as well. In general, all the WF requirements are based on the conventional sources regulations. Although each country has different necessities, the common factor is the need to integrate the wind energy into the system actively, so the WF will be considered as wind power plants unit. And finally this could participate in all the regulation process and support for the grid.

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