Simplified wind turbine models for wind energy integration into power systems

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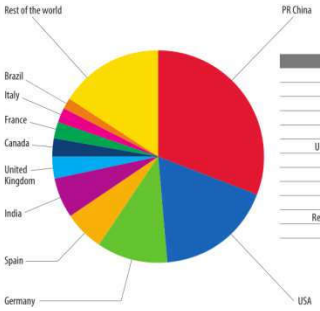
Abstract

This paper analyses the boundaries of simplified (also known as generic or standard) wind turbine models used to represent the behaviour of wind turbines in order to conduct power system stability studies. Specifically, the response of recent generic wind turbine models that are currently being developed by the International Standard IEC 61400-27 is compared to the real response of a wind turbine based on experimental tests carried out on a Type III wind turbine. This International Standard, whose Technical Committee was convened in October 2009, is focused on defining generic simulation models for both wind turbines (Part 1) and wind farms (Part 2). The results of this work show that the response of a simplified model submitted to voltage dips is in good agreement with the complex response of the real wind turbine. Therefore, this paper contributes to the increase of the usability of this simplified simulation models intended for power system stability analysis.

Keywords: generic wind turbine model, IEC 61400-27, power system stability, variable speed wind turbines.

I. Introduction

During the last few years, Renewable Energy Sources (RES) have experienced a rapid development. Among the different types of RES, wind energy can be considered as the most promising technology to produce the largest share of renewable electricity needed to meet EU's 2020 targets. In the case of Spain, around 21% of the electric demand has been covered with wind energy during 2013 and 2014, representing the second largest contribution to electricity generation, only exceeded by nuclear power. Similar figures are found in Portugal or Denmark, where wind energy covered around 24% and 30% of electricity consumption in 2014, respectively (in line with the values observed in 2013 as well).



Country	MW	% SHARE
PR China*	114,763	31.0
USA	65,879	17.8
Germany	39,165	10.6
Spain	22,987	6.2
India	22,465	6.1
United Kingdom	12,440	3.4
Canada	9,694	2.6
France	9,285	2.5
Italy	8,663	2.3
Brazil**	5,939	1.6
Rest of the world	58,275	15.8
Total TOP 10	**311,279**	**84.2**
World Total	**369,553**	**100**

Figure 1. Total cumulative wind capacity installed in a global basis [1].

Even one day in 2014, wind energy reached 89% of instantaneous penetration in Portugal. From a global point of view, in 2014 a new record of more than 51 GW installed in a single year was achieved, bringing the global total capacity close to 370 GW, Figure 1 [1]. Furthermore, following the moderate scenario suggested by the Global Wind Energy Council, this amount is expected to be doubled in 2020, [2].

In order to properly integrate this considerable amount of wind energy into power systems, the effect that wind power generation has on the dynamic performance of the power system has to be analysed in detail [3]. For this purpose, grid operators —both Transmission System Operators (TSOs) and Distribution System Operators (DSOs)— need dynamic simulation models of wind turbines and wind farms for conducting power system stability studies [4]–[7]. Unlike synchronous machine-based generators, majority of wind generator models have not been universally standardised and validated. Therefore, wind turbine manufacturers have developed specific models to study the electrical and mechanical behaviour of their generators with the highest level of accuracy [8], [9]. Nevertheless, such level of detail is not suitable for stability studies of large power systems due to several reasons. For example, the considerable amount of input data needed by these detailed models, the high