Assessment of Power Quality Characteristics of Wind Farms

A. I. Estanqueiro, *Member, IEEE,* J. O. Tande and J. A. Peças Lopes, , *Senior Member, IEEE*

Abstract—**In this paper the main parameters to assess the power quality of grid embedded wind farms are presented. International standards to assess and quantify the power quality of grid connected wind turbines exist for some years now, and are here extrapolated to wind farms aggregates when possible being the correspondent methodologies identified in the document. Recently, the grid code requirements posed a novel challenge to this technologic area, particularly since they were issued with national or local objectives and without particular normalized global concerns. The form how the international standards are evolving in order to cope both with the power systems industry local requirements, but also with the global wind turbine manufacturers principles is addressed in the paper.**

Index Terms— **power quality, wind energy, wind turbines, voltage dip.**

I. Introduction

This paper presents the existing normalized and uniform parameters and methodologies that ensure consistency and accuracy in the assessment and presentation of power quality characteristics of grid connected wind turbines (WTs). These methodologies have been prepared to be applied by the several parties involved in the wind industry, namely: the WT manufacturer striving to comply with well-defined characteristics; the WT purchaser in specifying the equipment characteristics; the WT operator, planner or regulator who may be required to verify that stated, or required power quality characteristics are met and also determine the impact of a WT on the power system quality of service; finally it may also be useful to the planner or regulator of the electric network who needs to determine the grid connection required for a WT.

The currently existing power quality standard for wind turbines, issued by the International Electrotechnical Commission (IEC), IEC61400-21: "Measurement and assessment of power quality characteristics of grid connected wind turbines", Ed 1, 2001 [1] defined the parameters that are characteristic of the wind turbine behavior in terms of the quality of power, and also provides recommendations to carry out measurements and assess the power quality characteristics of grid connected WTs. Although the standard mainly describes measurement methods for characterizing single wind turbines, there are methodologies and models developed that enable, for well pre-defined conditions, to extrapolate the single turbine unit parameters to the typical quality characteristics of wind farms.

Recently, several Transmission System Operators (TSOs) have developed grid codes [2] for wind turbines and/or wind farms. These generally resemble requirements to wind farms that are very similar to those of any other power stations. The new requirements were challenging for the wind turbine industry, but it responded as requested by the TSOs. The largest problem seems to be the fact that the grid codes were issued to respond to national and regional grid characteristics that, by their intrinsic nature, are typically non-general and local-dependent thus prevent from a normalized standard approach [3].

II. Wind Power Quality Characteristics

When the IEC 61400-21 standard was developed as published, the assessment of the WT's power quality was, in its essence, the assessment of the turbines voltage quality. The reason for this was that at the time of developing the standard, the wind turbines were mainly connected to the distribution grid, and the basic concern was their possible impact on the voltage quality and not on power system operation. This has changed with the development of large wind farms that may form a significant part of the power system. In consequence, today's wind turbines are able to control the power (active and reactive) delivered both in transient and steady state, they can cope with power ramp requirements and they have ride through fault (RTF) capability. They may even contribute to the primary frequency control, but then on the cost of dissipating energy. To this, IEC 61400-21 is currently under revision to provide procedures for assessing these new wind turbine characteristics. One may state that today's wind farms are more like conventional power plants, and in that respect quite different from the wind turbine installations from the end of the last century. Such recent technical advances allow for large global wind power penetration and also attractive for island systems.

Nevertheless, wind farm developers still face some resistance from the utilities to connect their independent power plants to the existing grid. The wind, being a spatially dispersed renewable source of energy, still induces a negative reaction

Ana I. Estanqueiro is with INETI – National Institute for Engineering, Technology and Innovation, Estrada do Paco do Lumiar, 22, Lisbon, Portugal. (Ph: 351210924773; fax: 351217127195; e-mail: ana.estanqueiro@ineti.pt).

J.O Tande is with SINTEF Energy Research, Norway

J. A. Peças Lopes, is with INESC-Porto and Faculdade de Engenharia da Universidade do Porto, Portugal.

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