

TO Offshore NL

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SUBJECT Requirements for models regarding the harmonic analysis

REPORT   
DECISION

## Introduction

As part of the compliance activities, a harmonic study shall be performed by the OWF to prove compliancy with the harmonic requirements at the connection point. Furthermore, the OWF shall also contribute to the overall harmonic study including an investigation on harmonic stability. This memorandum will state the minimum requirements for the necessary turbine harmonic model.

## Definitions and applicability

The turbine model shall be sufficient accurate to cover the spectra of the:

- Harmonic frequencies
- Interharmonic frequencies;

The definitions of these terms are given in the IEC/TR 61000-3-6 (edition 2, 2008-02)

### harmonic frequency

frequency which is an integer multiple of the fundamental frequency. The ratio of the harmonic frequency to the fundamental frequency is the harmonic order (recommended notation: "h")

### interharmonic frequency

any frequency which is not an integer multiple of the fundamental frequency

NOTE 1 By extension from harmonic order, the interharmonic order is the ratio of an interharmonic frequency to the fundamental frequency. This ratio is not an integer. (Recommended notation "m").

NOTE 2 In the case where  $m < 1$  the term subharmonic frequency may be used.

The turbine models shall be suitable for harmonic studies of single turbine operation as well as multi turbine operation.

## Test report

Each turbine shall comply with the requirements of the IEC 61400-21. Each connected party shall supply a test report of the applied turbine type, covering all subjects mentioned in the sample test report of annex A of the IEC 61400-21.

The test report shall at least contain:

- the harmonic currents ( $I_h$ ), according to tables A.3.1, of order  $1 < h < 51$ ;
- the interharmonics from 75 to 1975 Hz, according to table A.3.2 and

- the higher frequency components from 2.1 to 8.9 kHz.

In case the turbine type test report does not have the information of the above mentioned frequency spectra completely available, an application for derogation can be submitted to TenneT.

### **Harmonic equivalent model**

A model shall be supplied that represents the (integer and inter-) harmonics. As a minimum the model shall be built by a current source equivalent completed with a converter impedance (R, C, L) and the turbine transformer impedance. A single line diagram of a single turbine shall be made available.

### **Harmonic stability grid model**

Furthermore models must be provided which allow an investigation of the frequency-dependent grid impedance in order to ensure harmonic stability. *As part of this investigation the frequency-dependent input impedance (value and phase) of the wind turbines used must be determined in the positive and negative sequence system. The following boundary conditions must be observed here:*

1. **consideration of the active machine response** including controls;
2. **frequency range** up to 2500 Hz;
3. **investigation of different operating points** (full load and idle operation at the respective nominal output factor, as well as fully capacitive and fully inductive reactive power infeed).