GRID CODE COMPLIANCE TEST FOR WIND ENERGY FACILITY CONNECTED TO TRANSMISSION OR DISTRIBUTION GRIDS IN SOUTH AFRICA

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1. INTRODUCTION

This document is intended to clarify the Grid Code compliance testing procedure for Wind Energy Facility (WEF) connected to the South African Distribution and Transmission systems. The following tests are required for each WEF:

- Active power management
- Transmission system (TS) or distribution system (DS) voltage requirements
- Signals, communications and control
- Dynamic simulations

All WEF are required to go through full testing of all of these tests unless otherwise agreed with the SO. The tests outlined in this document must be agreed upon by the WEF generator and the SO prior to commencing. Furthermore, the tests are intended to be carried out in the order as outlined in this document, unless otherwise agreed with the SO. It must be noted that Active Power Control must be carried out and successfully passed before any other test is performed.

Scheduling of Grid Code compliance testing:

Contact details are to be exchanged between the designated contacts from Transmission or Distribution and the WEF generator prior to the scheduling of Grid Code compliance testing. These designated contacts will be the primary points of contact between the IPP and Transmission or Distribution throughout the Grid Code compliance process, from scheduling of testing to the carrying out of testing, unless otherwise indicated by either party.

When the WEF generator is satisfied that the WEF is fully compliant with the Grid Code with the exception of any exemptions or derogations approved by NERSA, a request should be sent to SO and the relevant Transmission Network Service Provider (TNSP) or Distributor to schedule a date for Grid Code compliance testing of the WEF. This should be sent no later than three weeks prior to the proposed date of the test.

Along with the test request, the following information should be provided by the IPP:

- Overall single line diagram of the WEF
- Technical data including reactive power capability curve for the wind turbines
- Directions to the WEF
- Site map for the WEF
- Contact details of appropriate personnel on site (if different from designated WEF generator contact)

SO and the relevant TNSP or Distributor will consult with the relevant parties to ensure that the personnel required for testing will be available on the date requested. However, if the necessary personnel are not available on the date requested by the IPP, parties shall agree
on the most appropriate date which is convenient to all. A testing start time is to be agreed with the SO and the relevant TNSP or Distributor one week prior to the scheduled day of testing.

Verification of the wind conditions a week prior to, and a day prior to the scheduled date of Grid Code compliance testing is required to be carried out by the WEF generator and communicated to the SO and the relevant TNSP or Distributor. Insufficient wind conditions may lead to the cancellations of testing up to 1 day prior to testing. Note that at any time prior to, or during Grid Code compliance testing, the SO and the relevant TNSP or Distributor reserve the right to cancel or postpone testing for system security reasons.

**Day of Grid Code Compliance Testing:**

The relevant TNSP or Distributor representative shall witness testing on site, unless otherwise agreed. The TNSP or Distributor representative shall liaise with the SO, in particular the National Control operators and personnel on site to coordinate testing.

Results of the tests consisting of data and graphs should be provided by the WEF generator test coordinator to the SO and the relevant TNSP or Distributor representative in both hard copy and electronic file format.

In addition, the WEF generator is required to prepare a report for tests on the WEF which shall include all tests carried out and the data results collected during testing, along with the raw data from which the data results were extracted. A copy of the WEF generator’s report shall be made available to SO at which point SO will assess compliance in a timely manner.

### 2. ACTIVE POWER MANAGEMENT TEST

**Pre-conditions:**

All wind turbine units (WTUs) should be available for these tests. Wind condition need to be sufficient and at a relatively constant level in order to adequately perform the test. NCC shall approve the proposed sequence of applied values of dispatched power set-points and the period of time that each set-point value of power is maintained.

**General:**

The grid voltage at the high voltage side of the grid connected transformer should be automatically maintained to a value specified at the time by relevant TNSP or Distributor, taking account of AVR voltage droop, regulation of the grid connected transformer and the reactive capability of the wind farm. In this regard, consideration may be given to undertaking the ‘Ramp Rate Tests’ while the Active Power Control Tests are being carried out.
2.1 TEST 1: FREQUENCY SENSITIVE MODE RESPONSE

Description & Purpose of Test:
The WEF shall demonstrate the technical capability to continuously modulate active power over the full operating range to contribute to frequency control and shall verify the steady state parameters of regulations and dynamic parameters, including step change response. The test will require to be simulated by means of injection of a frequency signal into the WEF controller to simulate appropriate changes of frequency.

Pass Criteria:
On completion of the tests, the results should confirm or otherwise compliance with the frequency requirements of WEF grid code clause 4.1 & 4.1.1

The test has been passed, if:
- Activation time of whole full active power frequency response range as a result of step frequency change has been no longer than 30 seconds.
- Non-damped oscillations after the step change response have not occurred;
- The initial delay time has been as small as possible not higher than 2 seconds.
- The minimum time to maintain active power frequency response has been no shorter than 15 minutes; and
- The droop settings and dead band are adjustable according to respective requirements

2.2 TEST 2: ACTIVE POWER CONTROL

Description & Purpose of Test:
The WEF shall demonstrate its technical capability to operate at a load level no higher than the setpoint signals issued by SO or Network Operator.

Pass Criteria:
On completion of the tests, the results should confirm or otherwise compliance with the Active curtailment requirements of WEF grid code clause 4.4 & 4.4.1

The test has been passed, if:
- The load level of the WEF has been kept below the sent setpoint.
- The average value of power is within ±2.5% of set-point value, averaged over the length of time from when the unit should have implemented the setpoint to when the setpoint was changed; or over 10 minutes, whichever is less
- Response required in 10 s or less
- Rate of change of active power no less than the 1 min and 10 min averaged ramp rates as defined by the System Operator.
2.3 TEST 3: RAMP RATE and START-UP TEST

Description & Purpose of Test:
The WEF shall demonstrate the technical capability to ramp up and ramp down according to
certain rates, as defined by the SO. In addition, this test is to demonstrate the ability of the
WEF to start-up from a stopped condition. The two ramp rates issued by the SO detail the
maximum ramp rate average over a period of one minute and a second ramp rate average
over a period of ten minutes. These are ramp rates for increasing load from a stopped
condition to normal operating output and also for decreasing output following initiation of a
stop command, (not Black Start Shutdown). It should be noted that these ramp rates do not
apply for changes in active power as part of the Frequency Response system or, in the case
of downward ramping alone, the sudden decrease in wind speed.

Pass Criteria:
On completion of the tests, the results should confirm or otherwise compliance with the ramp
rate requirements of WEF grid code clause 4.1.1

The test has been passed, if:

• The rate of change of active power no greater than the 1 min and 10 min averaged
  ramp rates as defined by the System Operator.

3. SYSTEM VOLTAGE REQUIREMENTS

Pre-Conditions:
All wind turbine units (WTUs) should be available for the test. Wind conditions need to be
sufficient and at a relatively constant level in order to adequately test this facility.

General:
On the day of the tests, suitably qualified technical personnel will be needed at the WEF to
assist in undertaking the tests. Such personnel shall have the ability to fully understand the
functioning of the WEF and its relationship to the grid to which the WEF is connected.
Furthermore, such personnel shall have the ability to set up the control system of the WEF so
as to enable this grid compliance test to be correctly undertaken. In addition, the function of
the technical personnel will be to facilitate undertaking the tests which shall be carried out in
conjunction with SO.
3.1 TEST 4: AUTOMATIC VOLTAGE REGULATION

Description & Purpose of Test:
The WEF shall demonstrate the technical capability to regulate the grid voltage at the connection point to a value set by SO or relevant Network Operator. Such regulation shall be within the capability of the WEF to regulate the voltage at this point taking account of the short circuit level at the connection point, regulation of the grid connected transformer, the voltage slope (droop) applied to the WEF and the reactive capability of the WEF.

Pass Criteria:
On completion of the tests, the results should confirm or otherwise compliance with the voltage control requirements of WEF grid code clause 4.2.1

The test has been passed, if:
- selected voltage slope settings at any value between 1% and 10% has been applied successfully;
- change in voltage regulation set-point within 20 seconds of receipt of the signal from SO or the relevant Network Operator has been implemented;
- achieve 90% of its steady state reactive power response within 1 second; and
- the actual droop voltage droop concurs with the applied voltage droop setting.

3.2 TEST 5: REACTIVE POWER CAPABILITY

Description & Purpose of Test:
The WEF shall demonstrate its technical capability to operate to the limits of the applicable reactive power capability curves as indicated in figures 3 or 4 of the wind grid code. The test shall be undertaken for both leading (consumption) and lagging (production) reactive power to the WEF. This test should be undertaken at different levels of active power to confirm that the range is within the capability characteristic at the given level of power. The test should be undertaken at the Voltage slope setting of 4%. The grid voltage set-point should be under the control of SO or the relevant Network Operator.

Pass Criteria:
On completion of the tests, the results should confirm or otherwise compliance with the power factor control requirements of WEF grid code clause 4.3

The test has been passed, if:
- The WEF clearly demonstrate that the reactive power capability for both export and import of reactive power at PCC can operate within and up to the limits of the reactive power characteristic as set out in the grid code.
3.3 TEST 6: VOLTAGE EMISSIONS TEST AND HARMONICS TEST

Description & Purpose of Test:
The purpose of this test is to confirm the ability of the WEF to operate within the limits specified by the TNSP or the relevant Distributor. This test shall take place while other grid code compliance tests are being undertaken which are within the normal operating parameters of the WEF. Such measurements shall be undertaken at both WEF voltage and at grid voltage and will be referred to collectively as ‘power quality’ tests.

Pass Criteria:
On completion of the tests, the results should confirm or otherwise compliance with the voltage requirements of WEF grid code clause 4.2

The test has been passed, if:
• The emissions are within limits allocated by the TNSP or the relevant Distributor.

4. SIGNALS, COMMUNICATION AND CONTROL

Purpose and Scope of the Test
The purpose of grid compliance tests of the signals, communications and control systems is to confirm the functionality of each digital and analogue signal between the WEF and Network Operator and vice versa. These tests maybe carried out without actually influencing the WEF during the course of the tests. Their actual influence on the WEF will form part of the individual operational tests such as the Active Power Control test and the Frequency Response test. The scope of the tests is to confirm the functionality and accuracy of the signals received at the WEF control system from Network Operator and also to confirm the functionality and accuracy of the signals received by Network Operator from the WEF. These tests are not intended to check intermediate values of the signals, such as the calibration of signal transducers, as these should be completed during commissioning.

Signals from Network Operator to the WEF are set out in the Grid Code as follows:
• Active Power Control
• Frequency Response
• Voltage Regulation
4.1 Test 7: Signal list from Network Operator to WEF and vice versa

Description & Purpose of Test:
This test is to confirm the functionality and accuracy of analogue and digital signals as outlined in grid code section 8 which refers to Signal list.

Pass Criteria:
The test has been passed, if:
- Confirmation that each analogue signal of the correct magnitude is received by the WEF from Network Operator
- Confirmation that each feedback analogue signal of the correct magnitude is received by Network Operator from the WEF
- Confirmation that each analogue signal of the correct magnitude is received by the Network Operator from the wind farm

5. DYNAMIC SIMULATIONS

5.1 SIMULATION 1: FAULT RIDE THROUGH CAPABILITY

Description & Purpose of Simulation:
The model of the generating unit shall demonstrate its capability to simulate fault ride through capability according to clause 4.5 (3) of the wind grid code.

Pass Criteria:
The simulation has been passed, if:
- The model has demonstrated compliance with clause 4.5 (3) respectively.

5.2 SIMULATION 2: FAST ACTING REACTIVE AND/OR ACTIVE POWER CONTRIBUTION DURING FAULTS

Description & Purpose of Simulation:
The model of the generating unit shall demonstrate its capability to simulate fast acting reactive and/or active power contribution according to clause 4.5 (4) of the wind grid code.

Pass Criteria:
The simulation has been passed, if:
- The model has demonstrated compliance with clause 4.5 (4) respectively.
5.3 SIMULATION 3: POST FAULT ACTIVE POWER RECOVERY

Description & Purpose of Simulation:
The model of the generating unit shall demonstrate its capability to simulate post fault active power recovery according to figure 5 of the wind grid code.

Pass Criteria:
The simulation has been passed, if:
- The model has demonstrated compliance with figure 5.

5.4 SIMULATION 4: POWER OSCILLATIONS DAMPING CAPABILITY

Description & Purpose of Simulation:
The model of the generating unit shall demonstrate its capability to simulate power oscillations damping capability as required by System Operator.

Pass Criteria:
The simulation has been passed, if:
- The model has demonstrated compliance with system operator's requirements.

5.5 SIMULATION 5: SYNTHETIC INERTIAL CAPABILITY

Description & Purpose of Simulation:
The model of the generating unit shall demonstrate its capability to simulate synthetic inertial capability to a low frequency event.

Pass Criteria:
The simulation has been passed, if:
- The model has demonstrated compliance with system operator's requirements.