Steady-State Reactive Power (SSRP)

System Services Test Procedure

WFPS

Unit Name

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# Document Version History

Revision 3.0 published 12th November 2019

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Version** | **Date** | **Comment** | **Name** | **Company** |
| 0.1 | Insert Date | Minor version (v0.1) - First submission for review and approval | Insert Name | Unit Company Name |
| 1.0 | Insert Date | Revised to version 1.0 following approval by EirGrid, SONI. | Insert Name | Unit Company Name |

# Introduction

**WFPS shall highlight any changes made to this document or approval will be void.**

The WFPS shall submit the latest version of this test procedure template as published on the EirGrid or SONI websites[[1]](#footnote-2).

All yellow sections shall be filled in before the test procedure will be approved. All grey sections shall be filled in during testing. If any test requirements or steps are unclear, or if there is an issue with meeting any requirements or carrying out any steps, please contact [generator\_testing@eirgrid.com](mailto:generator_testing@eirgrid.com) or [generator\_testing@soni.ltd.uk](mailto:generator_testing@soni.ltd.uk) as appropriate.

Where a site consists of two separate controllable WFPS with a single connection point, this will impact on the test procedure outlined below. In this case, the WFPS shall insert active power levels for both wind farms as required to achieve the percentage of registered capacity.

The WFPS representative shall coordinate testing. On the day of testing, suitably qualified technical personnel may be needed at the wind farm to assist in undertaking the tests. Such personnel shall have the ability to fully understand the function of the wind farm and its relationship to the network to which the wind farm is connected. Furthermore, such personnel shall have the ability to set up the control system of the wind farm so as to enable the DS3 System Services test to be correctly undertaken. In addition, the function of the technical personnel is to liaise with NCC, CHCC.

The availability of personnel at NCC, CHCC will be necessary in order to initiate the necessary instructions for the test. NCC, CHCC shall determine if network conditions allow the testing to proceed.

All wind turbines shall be available on the day of the testing unless otherwise agreed with the TSO. Wind conditions need to be sufficient and at a relatively constant level in order adequately perform the test.

Following testing, the following shall be submitted to [generator\_testing@eirgrid.com](mailto:generator_testing@eirgrid.com) or [generator\_testing@soni.ltd.uk](mailto:generator_testing@soni.ltd.uk) as appropriate.

|  |  |
| --- | --- |
| **Submission** | **Timeline** |
| A scanned copy of the test procedure, as completed and signed on site on the day of testing | 1 working day |
| Test data in CSV or Excel format | 1 working day |
| Test report | 10 working days |

# Abbreviations

APC Active Power Control

AVR Automatic Voltage Regulation

AAP Available Active Power

DMOL Defined Minimum Operating Level

HV High Voltage

MEC Maximum Export Capacity

MVAr Mega Volt Ampere – reactive

MW Mega Watt

NCC National Control Centre

CHCC Castlereagh House Control Centre

PF Power Factor

TSO Transmission System Operator

WFCS Wind Farm Control System

WFPS Wind Farm Power Station

WTG Wind Turbine Generator

Leading MVAr Absorbing MVAr from System

Lagging MVAr Producing MVAr

# WFPS Data

|  |  |
| --- | --- |
| WFPS Name | WFPS to specify |
| WFPS Test Co-Ordinator and contact number: | WFPS to specify |
| WFPS Location | WFPS to specify |
| WFPS connection point | HV Bushings of T101 in XX 110kV station |
| WFPS connection voltage | WFPS to specify |
| Installed Turbine type, MW size and quantity | WFPS to specify |
| Contracted MEC | WFPS to specify |
| Registered Capacity | WFPS to specify |
| Limiter applied to Exported MW | WFPS to specify |
| Limiter applied to AAP | WFPS to specify |
| DMOL | WFPS to specify |
| Maximum Leading MVAr at connection point | WFPS to specify |
| Maximum Lagging MVAr at connection point | WFPS to specify |
| Grid Connected Transformer Tap range | WFPS to specify |

**Reactive Power Capability chart at connection point**

|  |  |
| --- | --- |
| The PQ chart is based on | Modelled / Real data  (If the data is based on modelled results the WFPS shall specify the model reference and confirm that this is as submitted to EirGrid / SONI through the connection process) |
| The PQ chart shows the capability at the connection point and accounts for all losses. | Yes / No |
| The PQ chart shows the following.   1. Maximum capability of the WFPS 2. Breakdown of reactive power devices e.g. turbines or STATCOM | 1. Yes / No 2. Yes / No |
| Any further information | WFPS to specify how reactive power capability is achieved i.e. fixed / switched cap banks, STATCOM, etc. |
| Note:   1. The PQ chart will be site specific. 2. Generic PQ charts of turbines will not be accepted. | |

WFPS shall Insert PQ chart

Provide Steady State Reactive Power Capability chart showing the full PQ capability of the WFPS with all key points clearly labelled and displayed.

# System Services

## Steady-State Reactive Power explanation

The definitions referenced in this document are for indicative purposes only. In the event of inconsistency between the definitions in this document and those in the DS3 System Services Agreement, the definitions in the DS3 System Services Agreement shall prevail.

SSRP is defined as the dispatchable reactive power range (QRange) in MVAr that can be provided across the full range of active power output (PRange). For WFPS, PRange may or may not be limited by DMOL.

## Reactive Power Factor calculation

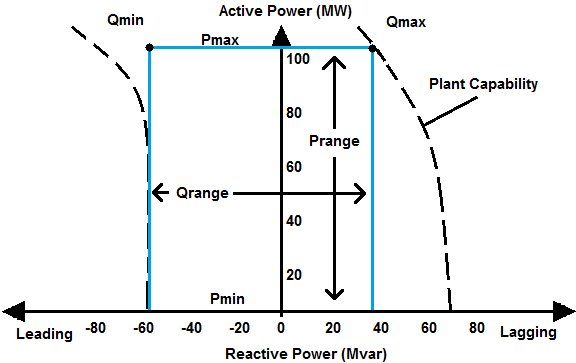


Figure : Example graph showing a unit with reactive capability down to 0 MW.

# Site Safety Requirements

The following is required for the EirGrid, SONI witness to attend site:

|  |  |
| --- | --- |
| Personal Protective Equipment Requirements   1. Site Safety boots 2. Hard Hat with chin strap 3. Hi Vis 4. Arc Resistive clothing 5. Safety Glasses 6. Gloves 7. Safe Pass | 1. Yes / No 2. Yes / No 3. Yes / No 4. Yes / No 5. Yes / No 6. Yes / No 7. Yes / No |
| Site Induction requirements | Yes / No  (If Yes, Unit to specify how and when the induction must carried out) |
| Any further information | Unit to specify |

# Test Purpose, Initial-conditions and Calculations

## Test Purpose

The purpose of this test is to demonstrate the limits of the WFPS reactive power capability curve at the connection point. The test is undertaken at various load levels for both the export of reactive power and for the import of reactive power.

## Initial Conditions

If “No” is answered to any of the following, contact NCC, CHCC and agree next steps in advance of making any corrective actions. If the kV set-point = system voltage at the connection point and WFPS is not producing 0 MVAr, this test may not proceed.

|  |  |
| --- | --- |
| **Conditions** | **Check on day of test** |
| All WTGs are available | # turbines installed: \_\_\_\_  # turbines generating: \_\_\_\_ |
| Generated MW > 60% of Registered Capacity | Generated MW: \_\_\_\_ |
| Grid Connected Transformer Tap range | Tap range: \_\_\_\_ to \_\_\_\_ |
| Size of MVAr step changes agreed with NCC, CHCC Transmission Desk (*e.g.* 5 MVAr) | \_\_\_\_ MVAr |

## MVAr changes and calculations

|  |  |
| --- | --- |
| **Calculation** | **Value** |
| 1kV change in system voltage with Voltage Regulation System slope of 4% (Ireland Only) | \_\_\_\_ MVAr  (WFPS to specify calculation and formula used) |
| 3kV change in system voltage with Voltage Regulation System slope of 4% (Ireland Only) | \_\_\_\_ MVAr  (WFPS to specify calculation and formula used) |
| 1kV change in system voltage with Voltage Regulation System slope of 3% (Northern Ireland Only) | \_\_\_\_ MVAr  (WFPS to specify calculation and formula used) |
| 3kV change in system voltage with Voltage Regulation System slope of 3% (Northern Ireland Only) | \_\_\_\_ MVAr  (WFPS to specify calculation and formula used) |

# Instrumentation and onsite data trending

## Onsite Data Trends

All of the following trends shall be recorded by the WFPS during the test. Failure to provide any of these trends shall result in test cancellation.

|  |  |  |  |
| --- | --- | --- | --- |
| **No.** | **Data Trending and Recording** | **Resolution** | **Check On Day Of Test** |
| 1 | Available active power at the connection point from the prevailing wind in MW, derived by algorithm in the WFCS | WFPS to specify (≥10 Hz) | Yes / No |
| 2 | Actual active power at the connection point from the wind farm in MW | WFPS to specify (≥10 Hz) | Yes / No |
| 3 | Grid voltage measured at the connection point | WFPS to specify (≥10 Hz) | Yes / No |
| 4 | Reactive power measured at the connection point | WFPS to specify (≥10 Hz) | Yes / No |
| 5 | Grid transformer tap position | WFPS to specify (≥10 Hz) | Yes / No |
| 6 | MVAr set-point at the connection point | WFPS to specify (≥10 Hz) | Yes / No |
| 7 | Other signals as required by the unit or by [generator\_testing@eirgrid.com](mailto:generator_testing@eirgrid.com) or [generator\_testing@soni.ltd.uk](mailto:generation-outages@soni.ltd.uk). | WFPS to specify | WFPS to specify |

# Test Steps

## Reactive Power Capability (Importing / Leading MVAr)

The WFPS is brought from 0 MVAr at full output to maximum leading MVAr. Once at maximum leading MVAr, the active power is reduced in steps from max output to 0 MW. Reactive Power set-point is changed to require 0 MVAr response, before the WFPS is released from 0 MW to max output.

| **Step No.** | **Action** | **Time** | **Comments** |
| --- | --- | --- | --- |
| 1 | WFPS begins data recording for all trends noted in Section 8.2, above |  | Operator Name \_\_\_\_\_\_\_\_\_\_\_\_  Date \_\_\_\_\_\_\_\_\_\_\_\_ |
| 2 | WFPS requests permission from NCC, CHCC to proceed with the Reactive Power Capability (Inductive / Leading MVAr) test and confirms the following with NCC, CHCC:   1. MW output of the WFPS 2. APC / Emergency Action is OFF 3. Frequency Response is OFF 4. MVAr (Q) control mode is ON 5. The transformer tap position 6. On Load Tap Changer Mode 7. System Voltage 8. Maximum leading MVAr capability of the WFPS 9. MVAr Export at the connection point |  | 1. \_\_\_\_ MW 2. Status \_\_\_\_ 3. Status \_\_\_\_ 4. \_\_\_\_ Mode 5. Tap # \_\_\_\_ 6. \_\_\_\_ Mode 7. \_\_\_\_ kV 8. \_\_\_\_ MVAr 9. \_\_\_\_ MVAr |
| 3 | WFPS requests NCC, CHCC to decrease the MVAr set-point in steps as agreed in section 7.2 until the wind farm has reached its maximum leading MVAr limit at the connection point |  | -\_\_\_\_ MVAr  \_\_\_\_ kV |
| 4 | WFPS requests NCC, CHCC to reduce the MVAr set-point by a further step |  | WFPS shall remain at maximum lagging MVAr  -\_\_\_\_ MVAr  \_\_\_\_ kV |
| 5 | WFPS requests NCC, CHCC to turn APC / Emergency Action ON and issue a set-point of [insert 90% of Registered Capacity] MW and waits until 1 minute after the set-point has been achieved |  | \_\_\_\_ MW  -\_\_\_\_ MVAr |
| 6 | WFPS requests NCC, CHCC to issue a set-point of [insert 80% of Registered Capacity] MW and waits until 1 minute after the set-point has been achieved |  | \_\_\_\_ MW  -\_\_\_\_ MVAr |
| 7 | WFPS requests NCC, CHCC to issue a set-point of [insert 70% of Registered Capacity] MW and waits until 1 minute after the set-point has been achieved |  | \_\_\_\_ MW  -\_\_\_\_ MVAr |
| 8 | WFPS requests NCC, CHCC to issue a set-point of [insert 60% of Registered Capacity] MW and waits until 1 minute after the set-point has been achieved |  | \_\_\_\_ MW  -\_\_\_\_ MVAr |
| 9 | WFPS requests NCC, CHCC to issue a set-point of [insert 50% of Registered Capacity] MW and waits until 1 minute after the set-point has been achieved |  | \_\_\_\_ MW  -\_\_\_\_ MVAr |
| 10 | WFPS requests NCC, CHCC to issue a set-point of [insert 40% of Registered Capacity] MW and waits until 1 minute after the set-point has been achieved |  | \_\_\_\_ MW  -\_\_\_\_ MVAr |
| 11 | WFPS requests NCC, CHCC to issue a set-point of [insert 30% of Registered Capacity] MW and waits until 1 minute after the set-point has been achieved |  | \_\_\_\_ MW  -\_\_\_\_ MVAr |
| 12 | WFPS requests NCC, CHCC to issue a set-point of [insert 20% of Registered Capacity] MW and waits until 1 minute after the set-point has been achieved |  | \_\_\_\_ MW  -\_\_\_\_ MVAr |
| 13 | WFPS requests NCC, CHCC to issue a set-point of [insert DMOL] MW and waits until 1 minute after the set-point has been achieved |  | \_\_\_\_ MW  -\_\_\_\_ MVAr |
| 14 | At this stage in the test, care should be made not to cause a large change in MVAr by reducing the MW. [Insert additional MW steps as required]. |  |  |
| 15 | WFPS requests NCC, CHCC to issue a set-point of [insert 50% of DMOL] MW and waits until 1 minute after the set-point has been achieved |  | \_\_\_\_ MW  -\_\_\_\_ MVAr |
| 16 | WFPS requests NCC, CHCC to issue a set-point of 0 MW and waits until 1 minutes after the set-point has been achieved |  | \_\_\_\_ MW  -\_\_\_\_ MVAr |
| 17 | WFPS requests NCC, CHCC to increase the MVAr set-point in steps as agreed in section 7.4 until the WFPS is exporting 0 MVAr at the connection point  Note: Section 9.3 may be completed at this stage |  | MVAr output shall be at 0 MVAr  +/-\_\_\_\_ MVAr |
| 18 | WFPS requests NCC, CHCC to issue a set-point of [insert 100% of Registered Capacity] MW and turn APC / Emergency Action OFF and waits until 1 minute after AAP has been achieved |  |  |
| 19 | WFPS ends data recording |  |  |
| 20 | WFPS informs NCC, CHCC that the Reactive Power Capability (Inductive / Leading MVAr) test is complete |  |  |

## Reactive Power Capability (Exporting / Lagging MVAr)

The WFPS is brought from 0 MVAr at full output to maximum lagging MVAr. Once at maximum lagging MVAr, the active power is reduced in steps from max output to 0 MW. Reactive Power set-point is changed to require 0 MVAr response, before the WFPS is released from 0 MW to max output.

| **Step No.** | **Action** | **Time** | **Comments** |
| --- | --- | --- | --- |
| 1 | WFPS begins data recording for all trends noted in Section 8.2, above |  | Operator Name \_\_\_\_\_\_\_\_\_\_\_\_  Date \_\_\_\_\_\_\_\_\_\_\_\_ |
| 2 | WFPS requests permission from NCC, CHCC to proceed with the Reactive Power Capability (Capacitive / Lagging MVAr) test and confirms the following with NCC, CHCC:   1. MW output of the WFPS 2. APC / Emergency Action is OFF 3. Frequency Response is OFF 4. MVAr (Q) control mode is ON 5. The transformer tap position 6. On Load Tap Changer Mode 7. System Voltage 8. Maximum lagging MVAr capability of the WFPS 9. MVAr Export at the connection point |  | 1. \_\_\_\_ MW 2. Status \_\_\_\_ 3. Status \_\_\_\_ 4. \_\_\_\_ Mode 5. Tap # \_\_\_\_ 6. \_\_\_\_ Mode 7. \_\_\_\_ kV 8. +\_\_\_\_ MVAr 9. \_\_\_\_ MVAr |
| 3 | WFPS requests NCC, CHCC to increase the MVAr set-point in steps as agreed in section 7.4 until the wind farm has reached its maximum lagging MVAr limit at the connection point |  | -\_\_\_\_ MVAr |
| 4 | WFPS requests NCC, CHCC to increase the MVAr set-point by a further step |  | WFPS shall remain at maximum leading MVAr  -\_\_\_\_ MVAr |
| 5 | WFPS requests NCC, CHCC to turn APC / Emergency Action ON and issue a set-point of [insert 90% of Registered Capacity] MW and waits until 1 minute after the set-point has been achieved |  | \_\_\_\_ MW  -\_\_\_\_ MVAr |
| 6 | WFPS requests NCC, CHCC to issue a set-point of [insert 80% of Registered Capacity] MW and waits until 1 minute after the set-point has been achieved |  | \_\_\_\_ MW  -\_\_\_\_ MVAr |
| 7 | WFPS requests NCC, CHCC to issue a set-point of [insert 70% of Registered Capacity] MW and waits until 1 minute after the set-point has been achieved |  | \_\_\_\_ MW  -\_\_\_\_ MVAr |
| 8 | WFPS requests NCC, CHCC to issue a set-point of [insert 60% of Registered Capacity] MW and waits until 1 minute after the set-point has been achieved |  | \_\_\_\_ MW  \_\_\_\_ MVAr |
| 9 | WFPS requests NCC, CHCC to issue a set-point of [insert 50% of Registered Capacity] MW and waits until 1 minute after the set-point has been achieved |  | \_\_\_\_ MW  -\_\_\_\_ MVAr |
| 10 | WFPS requests NCC, CHCC to issue a set-point of [insert 40% of Registered Capacity] MW and waits until 1 minute after the set-point has been achieved |  | \_\_\_\_ MW  -\_\_\_\_ MVAr |
| 11 | WFPS requests NCC, CHCC to issue a set-point of [insert 30% of Registered Capacity] MW and waits until 1 minute after the set-point has been achieved |  | \_\_\_\_ MW  -\_\_\_\_ MVAr |
| 12 | WFPS requests NCC, CHCC to issue a set-point of [insert 20% of Registered Capacity] MW and waits until 1 minute after the set-point has been achieved |  | \_\_\_\_ MW  -\_\_\_\_ MVAr |
| 13 | WFPS requests NCC, CHCC to issue a set-point of [insert DMOL] MW and waits until 1 minute after the set-point has been achieved |  | \_\_\_\_ MW  -\_\_\_\_ MVAr |
| 14 | At this stage in the test, care should be made not to cause a large change in MVAr by reducing the MW. [Insert additional MW steps as required]. |  |  |
| 15 | WFPS requests NCC, CHCC to issue a set-point of [insert 50% of DMOL] MW and waits until 1 minute after the set-point has been achieved |  | \_\_\_\_ MW  -\_\_\_\_ MVAr |
| 16 | WFPS requests NCC, CHCC to issue a set-point of 0 MW and waits until 1 minutes after the set-point has been achieved |  |  |
| 17 | WFPS requests NCC, CHCC to decrease the MVAr set-point in steps as agreed in section 7.4 until the WFPS is exporting 0 MVAr at the connection point.  Note: Section 9.3 may be completed at this stage |  | MVAr output shall be at 0 MVAr  +/-\_\_\_\_ MVAr |
| 18 | WFPS requests NCC, CHCC to issue a set-point of [insert 100% of Registered Capacity] MW and turn APC / Emergency Action OFF and waits until 1 minute after AAP has been achieved |  | \_\_\_\_ MW |
| 19 | WFPS ends data recording |  |  |
| 20 | WFPS informs NCC, CHCC that the Reactive Power Capability (Capacitive / Lagging MVAr) test is complete |  |  |

## Establish WFPS Cable Network Charging Capacitance

The steps below establish the charging capacitance of the cable network and balance of plant. These steps may be carried out in between step 17 and step 18 of sections 9.1 or 9.2 above.

|  |  |  |  |
| --- | --- | --- | --- |
| **Step No.** | **Action** | **Time** | **Comments** |
| 1 | WFPS requests permission from NCC and shuts down all WTGs |  |  |
| 2 | WFPS records the MVAr at the connection point |  | \_\_\_\_\_ MVAr |
| 3 | WFPS requests permission from NCC and restarts all WTGs |  |  |
| 4 | WFPS informs NCC, CHCC that Reactive Power Control testing is complete |  |  |

## Return to Standard Settings

The steps below return the WFPS to standard settings at the completion of testing.

|  |  |  |  |
| --- | --- | --- | --- |
| **Step No.** | **Action** | **Time** | **Comments** |
| 1 | WFPS confirms the following with NCC, CHCC:   1. AAP of the WFPS 2. MW output of the WFPS 3. APC / Emergency Action is OFF 4. Frequency Response is ON 5. Frequency Response is in Curve 1 6. AVR (kV) control mode is ON 7. The transformer tap position 8. On Load Tap Changer is in Automatic mode 9. System Voltage 10. kV Set-point = system voltage at connection point 11. Voltage slope setting = 4% 12. MVAr Export at the connection point |  | 1. \_\_\_\_ MW 2. \_\_\_\_ MW 3. Status \_\_\_\_ 4. Status \_\_\_\_ 5. Curve \_\_\_\_ 6. \_\_\_\_ Mode 7. Tap # \_\_\_\_ 8. \_\_\_\_ Mode 9. \_\_\_\_ kV 10. \_\_\_\_ kV 11. \_\_\_\_% 12. \_\_\_\_ MVAr |
| 2 | WFPS informs NCC, CHCC that Reactive Power Control testing is complete |  |  |

# Comments and Sign-off

|  |
| --- |
| **Comments:** |
| WFPS Witness signoff that this test has been carried out according to the test procedure, above.  Signature: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Date: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ |
| EirGrid, SONI Witness signoff that this test has been carried out according to the test procedure, above.  Signature: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Date: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ |

1. <http://www.eirgridgroup.com/> or <http://www.soni.ltd.uk/> [↑](#footnote-ref-2)