

Guidance on Wave 1 Mandatory Technical Trials v1.0

Power Potential

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IMPORTANT – PLEASE READ

Reference

This Power Potential guidance document is to be read in conjunction with the [Power Potential DER Framework Agreement](#) – the contract between UK Power Networks (UKPN) and Power Potential market participants (provider). This is available on the project’s website:

<https://www.nationalgrideso.com/innovation/projects/power-potential>

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Document control

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Contents

Introduction	3
2. Wave 1 Mandatory Trials Test Cases	3
2.1 Reactive Power Service	3
2.2 Active Power Service	3
2.3 Other considerations	3
2.4 Aggregators	3
3. DER Roles & Responsibilities	4
4. Trials Schedule.....	5
Appendix A - Wave 1 reactive power service tests	6
A.1 Response of the DERMS + DERs to simulated step changes in 400kV voltage (sudden voltage change)	6
A.2 Response of the DERMS + DERs to simulated ramp changes in 400kV voltage (slow voltage change).....	8
A.3 Response of the DERMS + DERs to 400kV target voltage set-point changes (stability and sensitivities calculation)	12
Appendix B – Wave 1 active power service test	16
B.1 Response of the DERMS + DERs to MW target set-point changes	16

Introduction

This document provides information and guidance on the nature of the testing to be carried out during the Wave 1 Mandatory Technical Trials.

Distributed Energy Resources (DERs) will only be allowed to participate in the provision of either active or reactive power services once they have undertaken Mandatory Technical Trials. The aim of the Wave 1 Mandatory Technical Trials is to demonstrate that DERs are technically capable of delivering both reactive and active power services when instructed by the DER Management System (DERMS).

2. Wave 1 Mandatory Trials Test Cases

2.1 Reactive Power Service

Specific test methods for this part of the trial are defined separately in Appendix A and include test specifications, data to be recorded and expected results. The reactive power service tests aim to validate the DERs' reactive power responses to simulated 400kV voltage signals in the DERMS. Initially, three different tests (Trial_W1M_Q_01_step, Trial_W1M_Q_02_ramp and Trial_W1M_Q_03_set-point) are expected to be run with an approximate duration of 15 minutes each. Each test needs to be carried out individually for each DER participating in the reactive power service.

In addition to the individual tests, collective tests are also to be run considering a group of DERs. The collective tests will repeat one or two of the aforementioned test cases (to the discretion of the Trial Coordinator and in agreement with the Technical Experts trials team) to prove the virtual power plant (VPP) concept. The collective DER tests are required to assess that the DERMS distributes the total reactive power required at the GSP correctly between a DER's reactive stack.

2.2 Active Power Service

A specific test method for this part of the trial is defined separately in Appendix B and includes test specifications, data to be recorded and expected results. The active power service test aims to validate the DERs' active power response to simulated active power signal requests in the DERMS. One test is expected to be run (Trial_W1M_P_01_set-point) with an approximate duration of 15 minutes. This test needs to be carried out individually for each DER participating in the active power service.

2.3 Other considerations

For this part of the trial, the Platform for Ancillary Services (PAS) interface is not expected to be used and instructions are envisaged to come directly from the DERMS (i.e. using the appropriate DERMS Mandatory Trial web interface).

2.4 Aggregators

Aggregators wishing to participate in the trial will need to complete the Wave 1 Mandatory Technical Trial test cases as detailed in Appendices A and B, for the service they wish to participate

in. High-level steps in the test cases are the same for DERs connected via Remote Terminal Unit (RTU) or via the aggregator route, although specific set-up details may vary.

3. DER Roles & Responsibilities

The DER need to provide a point of contact to cover the responsibilities detailed in the table below to achieve the goals of the Wave 1 Mandatory Technical Trials.

During Mandatory Technical Trials, the DERMS' instructions will be sent by a UKPN's authorised user from a dedicated UKPN's DERMS management web interface. The project Trial Coordinator will ensure that the trials are conducted as per this specification and following the Mandatory Running Schedule communicated to each DER. Support from the project from a dedicated DER Relationship Manager is available to gather and manage all the data required from DER.

Role	Required	Lead/Owner	Responsibilities
DER point of contact	Yes	DER	<ol style="list-style-type: none"> 1. Supplies DER data/parameters before trials to the project Trial Coordinator (or to the project DER Relationship Manager) 2. Monitors the DER's performance during trials 3. The DER point of contact does not have to be present at the plant if the generator can be controlled remotely from a different location 4. In case of test not proceeding as expected for the DER, the point of contact can request to the Trial Coordinator (or DER Relationship Manager) to stop the trial. The test will then need to be rescheduled before the DER can participate in the Optional Technical Trials.

4. Trials Schedule

Wave 1 Mandatory Technical Trials are expected to be carried out over a two-week period. Trial windows are between approximately 2 and 10 hours (total) across two days for the reactive power service for each DER and across one day for the active power service for each DER, as detailed in the Market Procedures document.

The proposed calendar for individual and collective tests is as follows. Each DER will be allocated to one slot for individual testing and to one slot for collective testing if participating in the reactive power service. DER will be allocated to only one slot for individual testing if participating in the active power service.

	Mon	Tues	Wed	Thurs	Fri
Morning (10:00-13:00)	Individual DER	Individual DER	Individual DER	Individual DER	Float
Afternoon (14:00-17:00)	Individual DER	Individual DER	Individual DER	Individual DER	Float
Night (21:00 – 00:00) – Reserved for Q at night DER	Individual DER	Individual DER	Individual DER	Individual DER	Float

	Mon	Tues	Wed
Morning (10:00-13:00)	VPP collective DERs	VPP collective DERs	Float
Afternoon (14:00-17:00)	VPP collective DERs	VPP collective DERs	Float
Night (21:00 – 00:00) – Reserved for Q at night DER	VPP collective DERs	VPP collective DERs	Float

The testing hours in the table above are indicative and specific testing hours will be defined in agreement with the DER. Blocks of three hours for Wave 1 Mandatory Technical Trials are initially suggested to carry out the testing, which allows three sessions per day (morning, afternoon and night). Only one DER will participate on each individual test, where active and reactive power tests will be completed in the individual time slot.

Not all the slots for collective testing will be needed. The project team will evaluate which DER will participate in the trials and when most of the DERs are available to produce results with simultaneous responses from DERs. It is proposed at least one test will be conducted during the day time and one test during the night time, to validate the virtual power plant (VPP) concept.

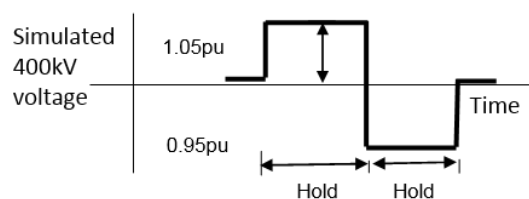
Appendix A - Wave 1 reactive power service tests

A separate test script for each of these test cases will be created to facilitate the process of recording data.

A.1 Response of the DERMS + DERs to simulated step changes in 400kV voltage (sudden voltage change)

Trial test case identifier	Trial_W1M_Q_01_step
Description and purpose	<p>These tests are to verify that the DER working with the DERMS responds correctly (as per test assessment criteria) to a change in the simulated 400kV Grid Supply Point (GSP) input voltage signal. The test requires the application of a step change to the simulated 400kV voltage input signal to the DERMS. The DERMS' 400kV target voltage set-point remains fixed as well as the 400kV dead-band and the 400kV GSP voltage droop setting.</p>
Pre-requisites	<ul style="list-style-type: none"> • The DERMS's mandatory trial interface • The DER's control system is fully integrated with the DERMS and healthy communication to DER is established via RTU or via aggregator route 400 kV signal simulators (functionality in the mandatory trial interface)
Objectives	<ul style="list-style-type: none"> • Verify that the DERMS' response to fast change in simulated 400kV voltage is correct and it issues the correct voltage set-points to DERs (as per test assessment criteria) • Verify that a DER responds to the DERMS' voltage set-point change and delivers expected reactive power output change • Verify that the DERMS calculates settings for each DER within their operating limits • Verify that a DER operates within limits
Test steps	<ol style="list-style-type: none"> 1. Ensure all data recorders are working 2. Ensure liaison between a DER's point of contact and the DERMS, UKPN's and NGENSO's control rooms is in place 3. Ensure the DERMS is initially set for reactive power service delivery and the DER is in operation 4. Apply a simulated 400kV GSP signal to the DERMS replacing real signal with value equivalent to real signal 5. Step the simulated 400kV signal to 1.05pu (within 1s) 6. Hold the simulated 400kV signal until stable, the DER's output is stable and any tap-changer action complete (2 minutes) 7. Step the simulated 400kV signal to 0.95pu (within 1s) 8. Hold the simulated 400kV signal until stable, the DER's output is stable and any tap-changer action complete (2 minutes) 9. Step the simulated 400kV signal back to current real value as received from the UKPN PowerOn Inter-Control Centre Communication Protocol (ICCP) link 10. Switch back the DERMS's 400kV input signal to the PowerOn 400kV real time measured signal 11. Switch back to original operating condition (i.e. p.f. mode) –

stop reactive power service



Data to be collected

The following data can be recorded and submitted by DERs to the project (provision of this data is not compulsory but would support analysis of the trials):

- MW - Active power at the applicable measurement point
- Mvar - Reactive power at the applicable measurement point
- kV- Voltage at controlled busbar, usually the connection point
- kV - Voltage set-point received from the DERMS
- Hz - System frequency to allow synchronising of data (if available, or other appropriate time reference)

The following data must be recorded by the DERMS/UKPN systems:

- MW - Active power at the DER connection point
- Mvar - Reactive power at the DER connection point
- MW - Active power at the 132kV side of 132/400kV transformers at relevant GSP (recorded by NGENSO)
- Mvar - Reactive power at the 132kV side of 132/400kV transformers at relevant GSP (recorded by NGENSO)
- kV - Voltage at relevant DER connection point / controlled busbar
- kV - Voltage received from 400kV relevant GSP (volt select, to be overpassed by simulated signal)
- [] - Sensitivity value used by DERMS to calculate DER voltage target set-point
- Hz - System frequency to allow synchronising of data (if available, or other appropriate time reference)

Issued instruction:

- % - GSP 400kV dead-band instruction
- kV/Mvar – GSP 400 kV droop instruction
- kV – GSP 400kV target voltage instruction
- kV - Injected simulated GSP 400kV voltage change
- kV- Voltage set-points sent from DERMS to DER
- Mvar – DERMS expected Q volume to be delivered at the point of connection from each DER
- Mvar – DERMS requested Q volume to be delivered at the GSP

- Mvar – DERMS GSP availability (lead/lag)

The following data must be recorded by NGESO:

- MW - Active power at the 132kV side of 132/400kV transformers at the relevant GSP
- Mvar - Reactive power at the 132kV side of 132/400kV transformers at the relevant GSP
- kV - Voltage at 400kV at the relevant GSP (volt select parameter at the relevant GSP busbar)
- Hz - System frequency to allow synchronising of data (if available, or other appropriate time reference)

Criteria of assessment

- An appropriate proportion of the full reactive capability of the DER is delivered within specified time
- The change in the DER's reactive output commences within specified time of the application of the receipt of revised set- point
- Any oscillations settle to within 5% of the final voltage value within specified time of the application of the received revised set-point by the DER
- The final steady state reactive value according to the slope characteristic is achieved within specified time of the application of the received revised set-point by the DER
- If 400kV simulated measurement signal increases, the DER is expected to decrease its lag Mvar output and / or increase its lead Mvar output (absorb Mvar)
- If 400kV simulated measurement signal decreases, the DER is expected to decrease its lead Mvar output and / or increase its lag Mvar output (inject Mvar)

Additional learning

- Reactive change seen at the GSP aligns with prediction (i.e. sensitivity of GSP flow to the DER's actions)

A.2 Response of the DERMS + DERs to simulated ramp changes in 400kV voltage (slow voltage change)

Trial test case identifier

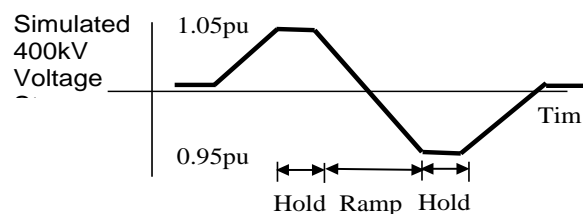
Trial_W1M_Q_02_ramp

Description and purpose

These tests are to verify that the DER working with the DERMS responds correctly (as per test assessment criteria) to changes in the simulated 400kV GSP input voltage signal. The tests require the application of a progressively increasing ramp to the simulated 400kV GSP

	<p>voltage input signal to the DERMS. The DERMS's 400kV target voltage set-point, 400kV dead-band and 400kV GSP droop setting remain fixed.</p>
Pre-requisites	<ul style="list-style-type: none"> • The DERMS's mandatory trial interface • The DER's control system is fully integrated with the DERMS in UK Power Network's systems and healthy communication to DERs established via RTU or via aggregator route • 400 kV signal simulator (functionality in the mandatory trial interface)
Objectives	<ul style="list-style-type: none"> • Verify that the DERMS's response to slow change in simulated 400kV voltage is correct and the DERMS issues the correct voltage set- points to DERs (as per test assessment criteria) • Verify that the DER responds to the DERMS's voltage set-point change and delivers expected reactive power output change • Verify that the DERMS calculates settings for each DER within their operating limits • Verify that the DER operates within limits
Objectives	<ul style="list-style-type: none"> • Verify that the DERMS's response to slow change in simulated 400kV voltage is correct and the DERMS issues the correct voltage set- points to DERs (as per test assessment criteria) • Verify that the DER responds to the DERMS's voltage set-point change and delivers expected reactive power output change • Verify that the DERMS calculates settings for each DER within their operating limits • Verify that the DER operates within limits
Test steps	<ol style="list-style-type: none"> 1. Ensure all data recorders are working 2. Ensure liaison between a DER's point of contact and the DERMS, UKPN's and NGESO's control rooms are in place 3. Ensure the DERMS is initially set for reactive power service delivery and the DER is in operation 4. Apply a simulated 400kV GSP signal to the DERMS replacing real signal with value equivalent to real signal 5. Ramp the simulated 400kV signal to 1.05pu (0.01pu/minute, i.e. 5 minutes)

6. Hold the simulated 400kV signal until stable, the DER's output is stable and any tap-changer action complete (2 minutes)
7. Ramp simulated 400kV signal to 0.95pu (0.01pu/minute i.e. 10 minutes)
8. Hold the simulated 400kV signal until stable, the DER's output is stable and any tap-changer action complete (2 minutes)
9. Ramp the simulated 400kV signal to current real value as received from the UKPN PowerOn ICCP link (0.1pu/minute)
10. Switch back the DERMS's 400kV input signal to the PowerOn 400kV real-time measured signal
11. Switch back to original operating condition (i.e. p.f. mode)– stop reactive power service



Data to be collected

The following data can be recorded and submitted by DERs to the project (provision of this data is not compulsory but would support analysis of the trials):

- MW - Active power at the applicable measurement point
- Mvar - Reactive power at the applicable measurement point
- kV- Voltage at controlled busbar, usually the connection point
- kV - Voltage set-point received from DERMS
- Hz - System frequency to allow synchronising of data (if available, or other appropriate time reference)
- The following data must be recorded by the DERMS/UKPN systems:
 - MW - Active power at the DER's connection point
 - Mvar - Reactive power at the DER's connection point
 - MW - Active power at the 132kV side of 132/400kV transformers at relevant GSP (recorded by NGESO)
 - Mvar - Reactive power at the 132kV side of 132/400kV transformers at relevant GSP (recorded by NGESO)
 - kV - Voltage at relevant DER connection point / controlled busbar

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- kV - Voltage received from 400kV relevant GSP (volt select, to be overpassed by simulated signal)
 - [] - Sensitivity value used by DERMS to calculate DER voltage target set-point
 - Hz - System frequency to allow synchronising of data (if available, or other appropriate time reference)

Issued instruction:

- % - GSP 400kV dead-band instruction
- kV/Mvar – GSP 400 kV droop instruction
- kV – GSP 400kV target voltage instruction
- kV - Injected simulated GSP 400kV voltage change
- kV- Voltage set-points sent from DERMS to DER
- Mvar – DERMS expected Q volume to be delivered at the point of connection from each DER
- Mvar – DERMS requested Q volume to be delivered at the GSP
- Mvar – DERMS GSP availability (lead/lag)

The following data must be recorded by NGESO:

- MW - Active power at the 132kV side of 132/400kV transformers at relevant GSP
- Mvar - Reactive power at the 132kV side of 132/400kV transformers at relevant GSP

Criteria of assessment

- An appropriate proportion of the full reactive capability of the DER is delivered within specified time
 - The change in the DER's reactive output commences within specified time of the application of the receipt of revised set-point
 - Any oscillations settle, to within 5% of the final value within specified time of the application of the received revised set-point by the DER
 - The final steady state reactive value according to the slope characteristic is achieved within specified time of the application of the received revised set-
-

	<p>point by the DER</p> <ul style="list-style-type: none"> • If 400kV simulated measurement signal increases, the DER is expected to decrease its lag Mvar output and / or increase its lead Mvar output (absorb Mvar) • If 400kV simulated measurement signal decreases, the DER is expected to decrease its lead Mvar output and / or increase its lag Mvar output (inject Mvar)
Additional learning	<ul style="list-style-type: none"> • Reactive change seen at the GSP aligns with prediction (i.e. sensitivity of GSP flow to DERs' actions)

A.3 Response of the DERMS + DERs to 400kV target voltage set-point changes (stability and sensitivities calculation)

Trial test case identifier	Trial_W1M_Q_03_setpoint
Description and purpose	<p>These tests are to verify that the DER working with DERMS responds correctly (as per test assessment criteria) to a 400kV target voltage set-point instruction evaluated against the actual 400kV measured voltage. Therefore, it validates the stability of the solution using NGENSO measured signals. The tests require the use of the real 400kV voltage signal input and variation of the DERMS 400kV target voltage set-point. This serves also as a base for validating the sensitivity factors used in DERMS calculations.</p>
Pre-requisites	<ul style="list-style-type: none"> • DERMS mandatory trial interface • DER control system fully integrated with DERMS in UK Power Network's systems and healthy communication to DER established via RTU or via aggregator route
Objectives	<ul style="list-style-type: none"> • Verify stability of the DERMS closed loop performance • Verify that DERMS response to change in 400kV target voltage set-point is correct and DERMS issues the correct voltage set- points to DER (as per test assessment criteria) • Verify that DER responds to DERMS voltage set-point change and delivers expected reactive power output change

	<ul style="list-style-type: none"> • Verify that DERMS calculates settings for each DER within their operating limits • Verify that DER operates within limits
<p>Test steps</p>	<ol style="list-style-type: none"> 1. Ensure all data recorders are working 2. Ensure liaison between DER point of contact and DERMS, UKPN and NGENSO control rooms is in place 3. Ensure DERMS is initially set for reactive power service delivery and DER is in operation 4. Step the 400kV voltage target signal 5% up (e.g. 1.05 p.u. for a 1 p.u. voltage, or 20kV) 5. Hold the 400kV voltage target until stable, DER output is stable and any tap-changer action complete (5 minutes) 6. Step the 400kV voltage target signal 10% down (e.g. 0.95 p.u. for a 1.05 p.u. voltage, or 40kV) 7. Hold the 400kV voltage target until stable, DER output is stable and any tap-changer action complete (5 minutes) 8. Step the 400kV voltage target signal to current real value as received from the UKPN PowerOn ICCP link 9. Switch back to original operating condition (i.e. p.f. mode) – stop reactive power service
<p>Data to be collected</p>	<p>The following data can be recorded and submitted by DER to the project (provision of this data is not compulsory but would support analysis of the trials):</p> <ul style="list-style-type: none"> • MW - Active power at the applicable measurement point • Mvar - Reactive power at the applicable measurement point • kV- Voltage at controlled busbar, usually the connection point • kV - Voltage set-point received from DERMS • Hz - System frequency to allow synchronising of data (if available, or other appropriate time reference) <p>The following data must be recorded by the DERMS/UKPN systems:</p> <ul style="list-style-type: none"> • MW - Active power at the DER connection point • Mvar - Reactive power at the DER connection point • MW - Active power at the 132kV side of 132/400kV transformers at relevant GSP (recorded by NGENSO) • Mvar - Reactive power at the 132kV side of 132/400kV transformers at relevant GSP (recorded by NGENSO)

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- kV - Voltage at relevant DER connection point
 - kV - Voltage received from 400kV relevant GSP (volt select)
 - [] - Sensitivity value used by DERMS to calculate DER voltage target set-point
 - Hz - System frequency to allow synchronising of data (if available, or other appropriate time reference)

Issued instruction:

- % - GSP 400kV dead-band instruction
- kV/Mvar – GSP 400 kV droop instruction
- kV – GSP 400kV target voltage instruction
- kV - Voltage set-points sent from DERMS to DER
- Mvar – DERMS expected Q volume to be delivered at the point of connection from each DER
- Mvar – DERMS requested Q volume to be delivered at the GSP
- Mvar – DERMS GSP availability (lead/lag)

The following data must be recorded by NGESO:

- MW - Active power at the 132kV side of 132/400kV transformers at relevant GSP
- Mvar - Reactive power at the 132kV side of 132/400kV transformers at relevant GSP
- kV - Voltage at 400kV at relevant GSP (volt select parameter at the relevant GSP busbar)
- Hz - System frequency to allow synchronising of data (if available, or other appropriate time reference)

Criteria of assessment

- An appropriate proportion of the full reactive capability of the DER is delivered within specified time.
 - The change in DER reactive output commences within specified time of the application of the receipt of revised set-point
 - Any oscillations settle, to within 5% of the final value within specified time of the application of the received revised set-point by the DER
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- The final steady state reactive value according to the slope characteristic is achieved within specified time of the application of the received revised set-point by the DER
 - If 400kV target voltage set-point increases, DER is expected to increase its Mvar output (lag/inject)
 - If 400kV target voltage set-point decreases, DER is expected to decrease its Mvar output (lead/absorb)

Additional learning

- Reactive change seen at the GSP aligns with prediction (i.e. sensitivity of GSP flow to DER actions)
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Appendix B – Wave 1 active power service test

A separate test script for this test case will be created to facilitate the process of recording data.

B.1 Response of the DERMS + DERs to MW target set-point changes

Trial test case identifier	Trial_W1M_P_01_setpoint
Description and purpose	These tests are to verify that the DER working with DERMS responds correctly to changes in the requested active power volume. The tests require the variation of the DERMS MW request at the DER level.
Pre-requisites	<ul style="list-style-type: none"> • The DERMS mandatory trial interface • DER control system fully integrated with DERMS in UK Power Network's systems and healthy communication to DER established via RTU or via aggregator route
Objectives	<ul style="list-style-type: none"> • Verify that DER responds to DERMS active power set-point change and delivers expected active power output change • Verify that DERMS calculates settings for each DER within their operating limits • Verify that DER operates within limits
Test steps	<ol style="list-style-type: none"> 1. Ensure all data recorders are working 2. Ensure liaison between DER point of contact and DERMS, UKPN and NGENSO control rooms in place 3. Ensure DERMS is initially set for active power service delivery and DER is in operation 4. Step MW target signal 10% up¹ from DER operating condition 5. Hold until stable, DER stable (5 minutes) 6. Restore MW target signal to 0 (delta) 7. Step MW target signal 10% down² from DER

¹ For clarity, please record MW value in absolute terms

² For clarity, please record MW value in absolute terms

	<p>operating condition</p> <p>8. Hold until stable, DER stable (5 minutes)</p> <p>9. Restore MW target signal to 0 (delta)</p> <p>10. Switch back to original operating condition – stop active power service</p>
<p>Data to be collected</p>	<p>The following data can be recorded and submitted by DERs to the project (provision of this data is not compulsory but would support analysis of the trials):</p> <ul style="list-style-type: none"> • MW - Active power at the applicable measurement point • Mvar - Reactive power at the applicable measurement point • kV- Voltage at controlled busbar, usually the connection point • MW – Active power set-point received from DERMS • Hz - System frequency to allow synchronising of data (if available, or other appropriate time reference) <p>The following data must be recorded by the DERMS/UKPN systems:</p> <ul style="list-style-type: none"> • MW - Active power at the DER connection point • Mvar - Reactive power at the DER connection point • MW - Active power at the 132kV side of 132/400kV transformers at relevant GSP (recorded by NGENSO) • Mvar - Reactive power at the 132kV side of 132/400kV transformers at relevant GSP (recorded by NGENSO) • kV - Voltage at relevant DER connection point • s - DERMS expected time for DER to ramp to meet the instructed MW • s- Actual time for the DER to ramp to deliver the instructed MW • Hz - System frequency to allow synchronising of data (if available, or other appropriate time reference) <p>Instruction issued:</p> <ul style="list-style-type: none"> • MW - Active power set-point instruction <p>The following data must be recorded by</p>

NGESO:

- MW - Active power at the 132kV side of 132/400kV transformers at relevant GSP
- Mvar - Reactive power at the 132kV side of 132/400kV transformers at relevant GSP
- kV - Voltage at 400kV at relevant GSP
- Hz - System frequency to allow synchronising of data (if available, or other appropriate time reference)

Criteria of assessment

- An appropriate proportion of the active capability of the DER is delivered within specified time, as instructed
 - The change in DER active power output commences within a specified time of the application of the received MW instruction
 - Any oscillations settle, to within 5% of the final value within specified time of the application of the receipt of revised set-point
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Gallows Hill, Warwick, CV34 6DA

<https://www.nationalgrideso.com/innovation/projects/power-potential>



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