Testing Guidance (DC, DM, DR)

All assets seeking to pre-qualify as **Eligible Assets** for the **Response Services** will be required to pass testing prior to pre-qualification. For all **Auction Products**, testing will be the responsibility of the **Registered Response Participant** and subject as provided below should be undertaken/verified by an **Independent Technical Expert** (**ITE**). Testing is required at 20Hz or 2Hz depending on the service being tested. Please note that a single duration test can be used for all **Response Services** (i.e., DC, DM and DR) provided the duration test is for the longest duration required by any service, e.g. the duration test of 60 minutes for DR can be used for DM and DC.

NESO will require an **ITE** approval report as part of any submission of an **Eligible Asset** for pre-qualification. The report shall be deemed accepted by **NESO** once submitted. However, should any queries be raised, the **Eligible Asset** shall not be capable of being allocated to a **Response Unit** for participation in the daily auctions until any queries have been satisfied.

Testing shall also be required before the **Maximum Registered Product Capacity** of an existing **Eligible Asset** can be increased.

All example graphs in this Schedule 3 are for illustrative purposes only.

Part 1 - Dynamic Containment Test Requirements

The **Dynamic Containment** tests assess the capability of the **Registered Response Participant** to deliver dynamic response in accordance with a **Response Contract**.

Service description

Dynamic Containment is a fast-acting frequency response service to contain frequency within the statutory range of +/-0.5Hz in the event of a sudden demand or generation loss. The service delivers very quickly and proportionally to frequency deviation.

Table 4- Dynamic Containment Service Specification

Service specification	Details
Deadband delivery	0% (+/- 0.015Hz)
Small linear delivery	Between 0.015Hz and 0.2Hz (maximum of 5% at 0.2Hz)
Knee point activation	+/- 0.2Hz is 5%

Full delivery	+/- 0.5Hz is 100%
Linear delivery knee point	0.2Hz
Full activation	0.5Hz
Full delivery	1s

For more details see: New Dynamic Services (DC/DM/DR) | National Energy System Operator (neso.energy)

Figure 6 – Dynamic Containment Delivery Requirements
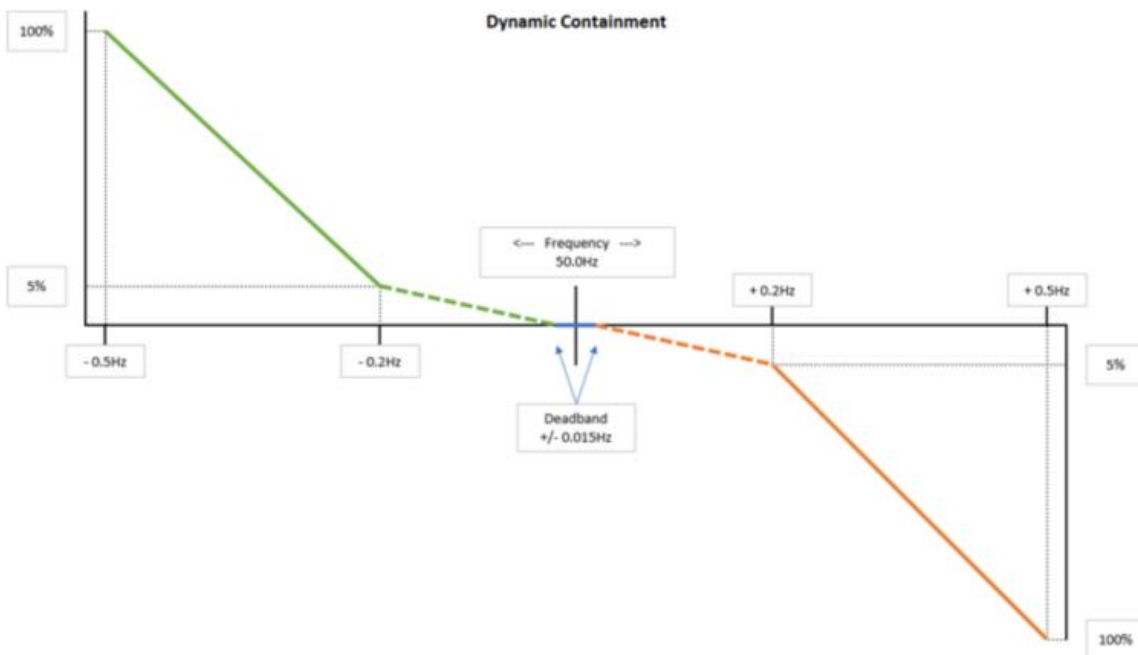
Dynamic Containment Test Requirements

The **Dynamic Containment** tests assess the capability of the **Plant** and **Apparatus** to deliver dynamic response in accordance with the balancing service contract.

Tests 1, 2 and 3 assess response against injected frequency profiles. Test 4 assesses response whilst connected to live system frequency. The frequency profile can be injected either at site or remotely. The minimum sample rate for all tests is 20Hz. See Appendix A for information on test signals.

Test 1 – Step Test

The purpose of Test 1 is to assess the ability of the **Plant** and **Apparatus** to deliver the required response at discreet frequency deviations.

The frequency injections to be used are shown in **Figure 7** and **Table 5** below.

- Each step is sustained for 180 seconds to verify the response.
- The frequency will then be returned to 50Hz for a minimum of 30 seconds, or until the output is stable, before the next injection is applied.
- The minimum sample rate for Test 1 is 20Hz.

Pass Criteria for Test 1

- For Tests 1.1 and 1.2, the **Plant** and **Apparatus** should not provide any response within the deadband. Where there are any non-zero values here these need to be explained by the ITE in the test report using the comments field.
- For tests 1.3 and 1.4 all that is required is a noticeable change in power in the correct direction.
- For Tests 1.5 to 1.12 the active power response within each 3 minute timescale should fall within tolerances shown in
- **Table 6** and shown graphically in **Figure 8.** (Performance monitoring criteria used to calculate tolerance bands)
- A response following a change of frequency should occur before 0.55 seconds.
- Delivery of active power due to a change in frequency should be achieved in the required timescale.
- The Unit should monotonically progress to its required response.
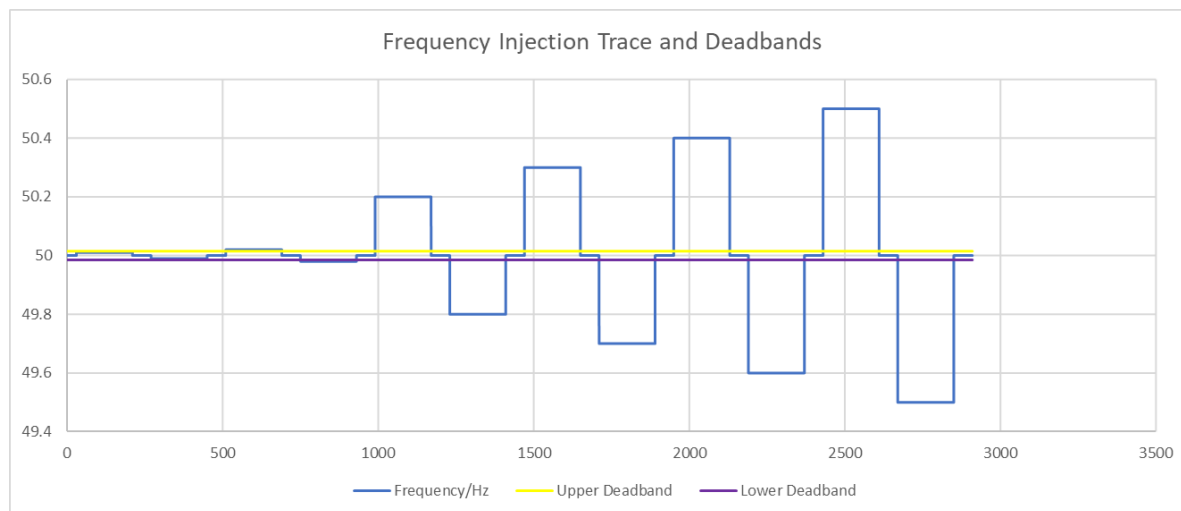
Figure 7 - Test 1

Frequency Injection Trace and Deadbands

Table 5 - Test 1 Frequency Injection Profile corresponding with times

| Test	Parameter	Values					
	Time /s	0	30	30	210	210	240
1.1	Frequency /Hz	50	50	50.01	50.01	50	50
1.2	Frequency /Hz	50	50	49.99	49.99	50	50
1.3	Frequency /Hz	50	50	50.02	50.02	50	50
1.4	Frequency /Hz	50	50	49.98	49.98	50	50
1.5	Frequency /Hz	50	50	50.2	50.2	50	50
1.6	Frequency /Hz	50	50	49.8	49.8	50	50
1.7	Frequency /Hz	50	50	50.3	50.3	50	50
1.8	Frequency /Hz	50	50	49.7	49.7	50	50
1.9	Frequency /Hz	50	50	50.4	50.4	50	50
1.10	Frequency /Hz	50	50	49.6	49.6	50	50
1.11	Frequency /Hz	50	50	50.5	50.5	50	50
1.12	Frequency /Hz	50	50	49.5	49.5	50	50

Table 6 - Test 1 Frequency Injection and expected response value.

For values with an asterisk(*) a noticeable change in power in the correct direction is all that is required.

Test Number	Frequency Step	Expected Response	Allowable Power Tolerance (% of Maximum Contracted)
1.1	50.01	0%	n/a
1.2	49.99	0%	n/a
1.3	50.02	0.135%	*
1.4	49.98	0.135%	*
1.5	50.2	5%	+/- 3%.
1.6	49.8	5%	+/- 3%.
1.7	50.3	37%	+/- 3%.
1.8	49.7	37%	+/- 3%.
1.9	50.4	68%	+/- 3%.
1.10	49.6	68%	+/- 3%.
1.11	50.5	100%	+/- 3%.
1.12	49.5	100%	+/- 3%.

For values with an asterisk (*) a noticeable change in power in the correct direction is all that is required.

Figure 8 Graphical representation of tolerance bands for the expected response at different frequencies – sample data
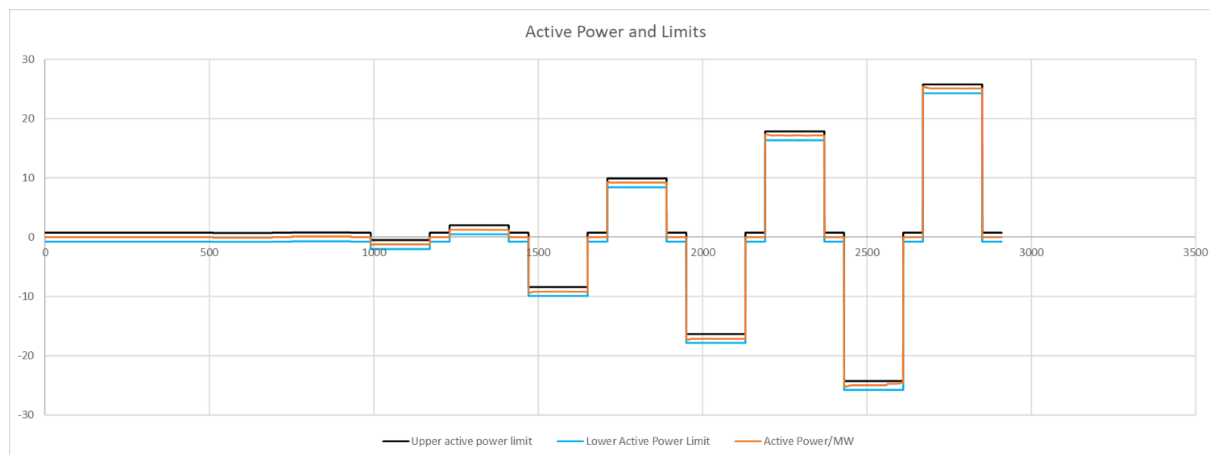
Test 2 – Frequency Sweep Test

Test 2 assesses the performance of the **Plant** and **Apparatus** against a varying frequency over the entire performance envelope.

- The frequency injections to be used are shown in **Table 7** and **Figure 9** & **Figure 10** below..

- The minimum sample rate for Tests 2.1 and 2.2 is 20Hz.

Pass Criteria for Tests 2.1 and 2.2

- For Test 2.1 and 2.2, active power response is within the tolerances in **Figure 11/Figure 12** and *Table 8*. (Performance monitoring criteria used to calculate tolerance bands)

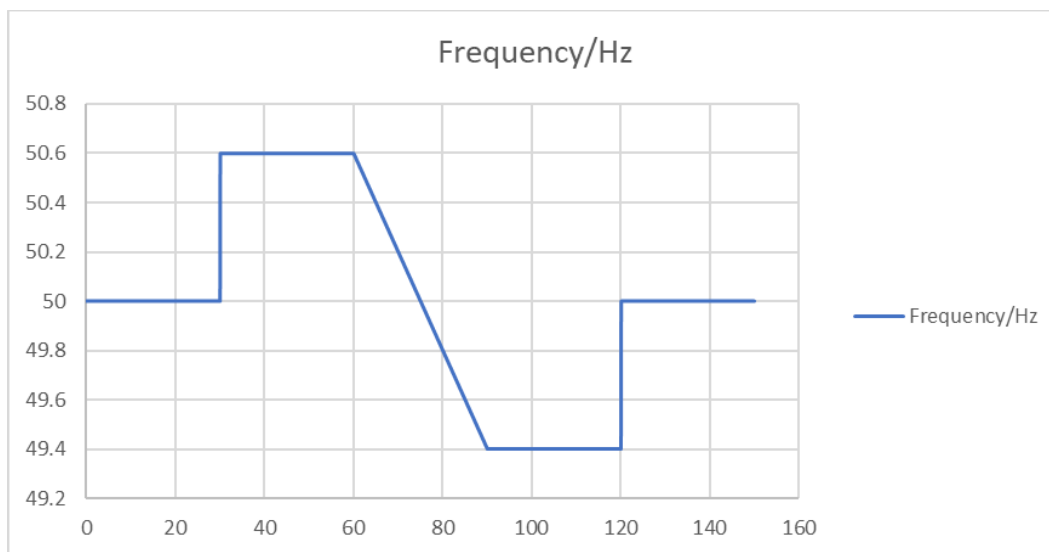**Figure 9 – Test 2.1**

Figure 10 – Test 2.2

Table 7 – Test 2 Frequency Injection Profiles

Time /s	Injected Frequency /Hz	
	Test 2.1	*Test 2.2*
0	50	50
30	50	50
30	49.4	50.6

60	49.4	50.6
65	49.6	50.4
70	49.8	50.2
75	50	50
80	50.2	49.8
85	50.4	49.6
90	50.6	49.4
120	50.6	49.4
120	50	50
150	50	50

Figure 11 - Test 2.1 Tolerance
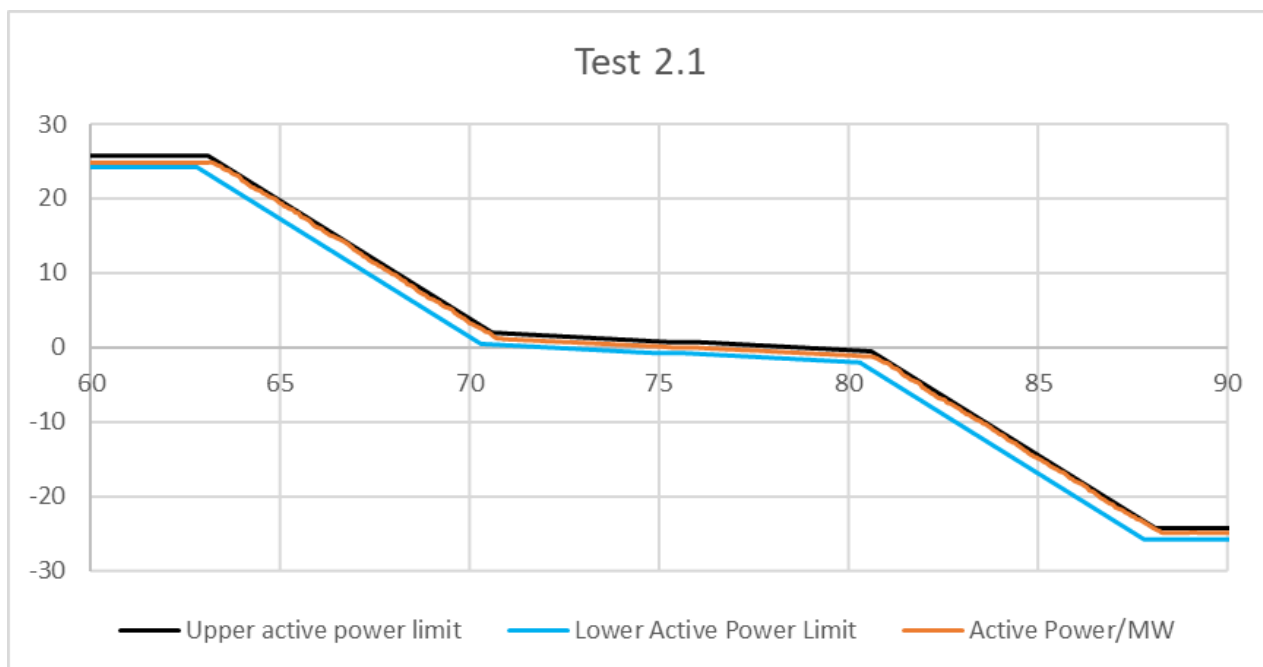
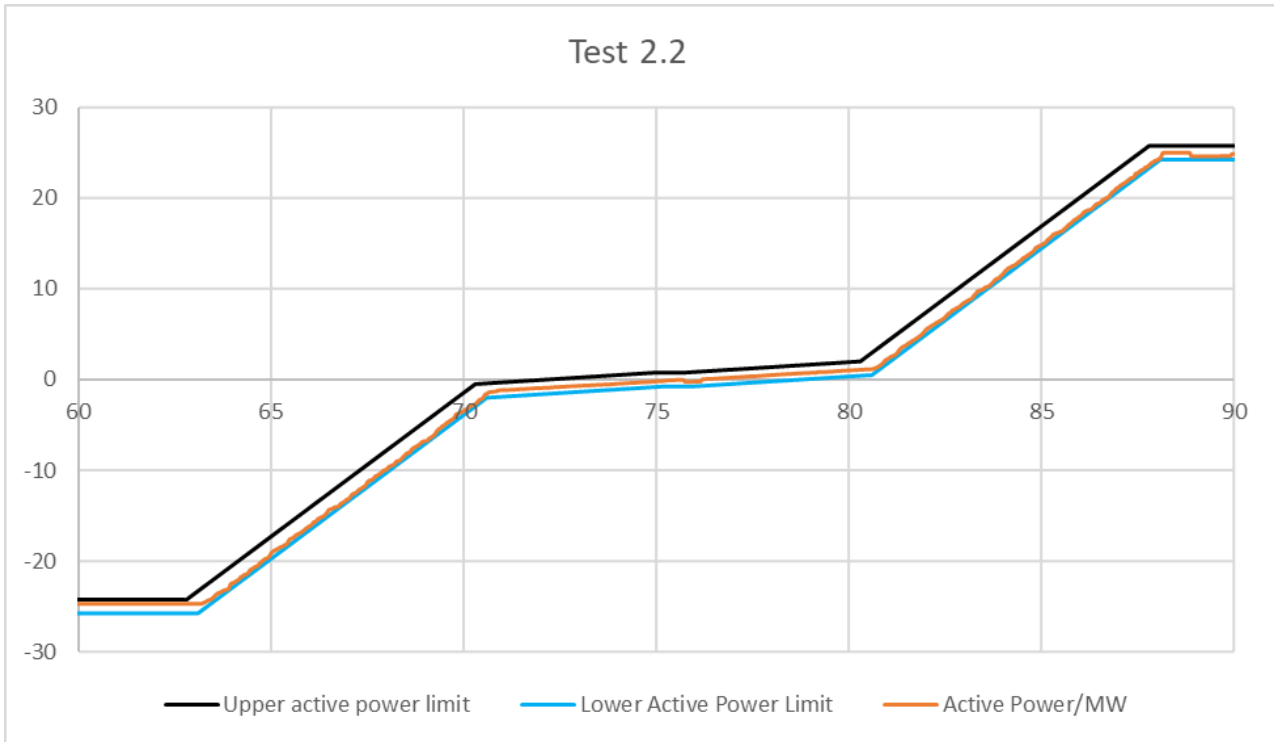**Figure 12 – Test 2.2 Tolerance**

Table 8 – **Test 2.1 and 2.2 Sweep Test tolerances (Without time delay to reach required delivery included)**

Frequency (Hz)	Test 2.1 and Test 2.2	
	Expected Percentage Active Power Response(%)	Tolerance (% of Maximum Contracted)
50.6	100	+/-3%
50.5	100	+/- 3%.
50.4	68.3	+/- 3%.
50.3	36.7	+/- 3%.
50.2	5	+/- 3%.
50.1	2.3	+/- 3%.
50	0	0%
49.9	2.3	+/- 3%.

49.8	5	+/- 3%.
49.7	36.7	+/- 3%.
49.6	68	+/- 3%.
49.5	100	+/- 3%.
49.4	100	+/- 3%.

Test 3 Duration Test

Test 3 assesses the ability of the **Plant** and **Apparatus** to sustain full response for 15 minutes.

- Operation will be tested at ±100% of capability to ensure the system is compliant.
- This is carried out by a frequency step of ±0.6Hz onto the system for 15 minutes.
- The frequency injection profiles are shown in **Figure 13** and **Figure 14** and **Table 9** and **Table 10** below

Pass criteria for test 3:

- The standard deviation of load error at steady state over a 900 second period must not exceed 2.5% of the maximum contracted active power.
- Sustain response for 15 minutes.
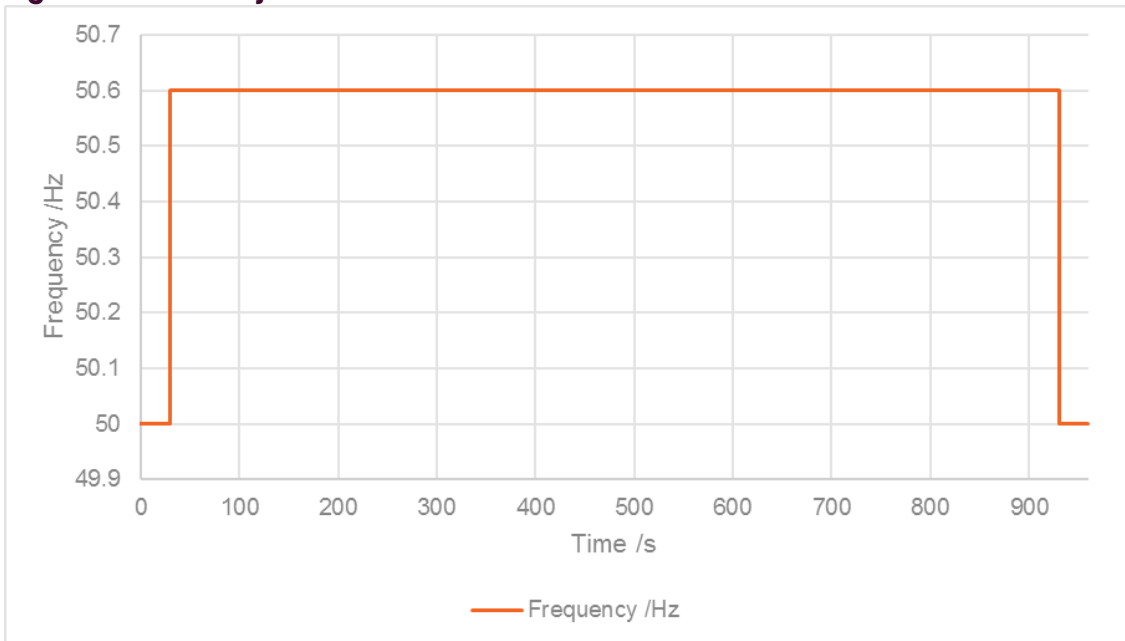
Figure 13 Test 3.1 Injection Profile
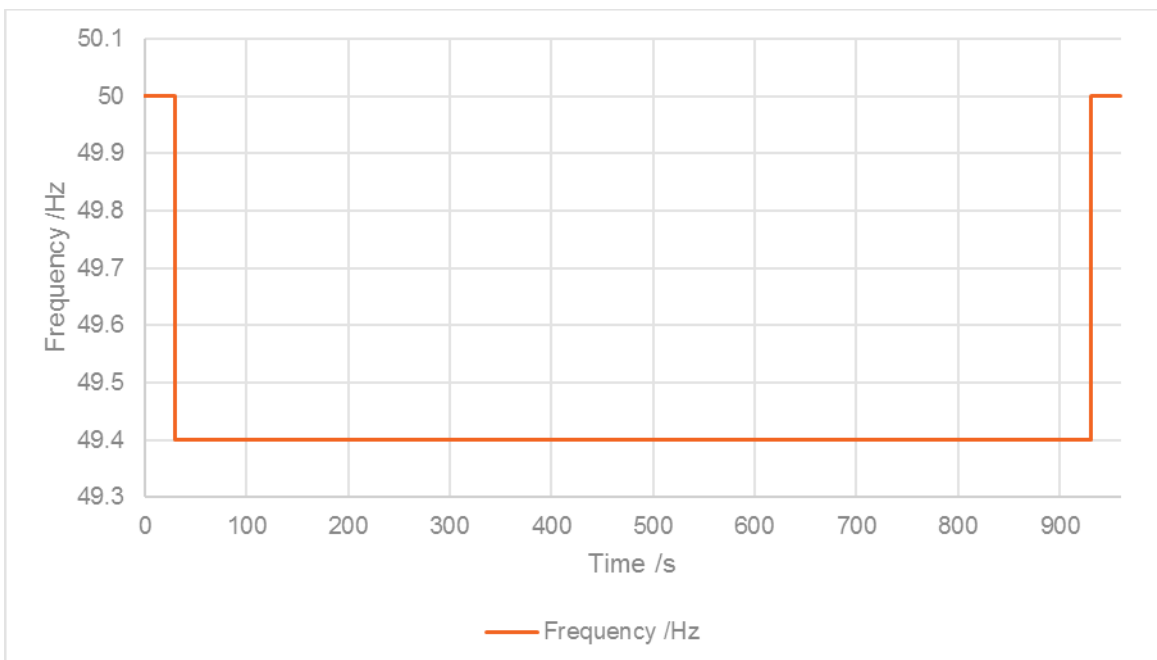

Figure 14 Test 3.2 Injection Profile

Table 9: Test 3.1 Frequency Injection Table Corresponding with times

	Test 3.1 Frequency injection table

Time /s	0	30	30	930	930	960
Frequency /Hz	50	50	50.6	50.6	50	50

Table 10: Test 3.2 Frequency Injection Table Corresponding with times

|	*Test 3.2 Frequency injection table*					
Time /s	0	30	30	930	930	960
Frequency /Hz	50	50	49.4	49.4	50	50

Test 4 – Live System Frequency Response Test

Test 4 assesses the response of the **Plant** and **Apparatus** to system frequency in a live environment. The minimum sample rate for this test is 20Hz and duration is 15 minutes where system frequency and active power response will be recorded. As part of test 4, the **Registered Response Participant** are required to provide evidence that the protection settings are in line with ECC.6.1.2 (frequency) and ECC.6.1.4 (voltage) of the Grid Code.

Pass Criteria for Test 4

- Provide an active power response consistent with the contracted performance within timescales.
- Provide evidence protection setting comply with ECC.6.1.2 (frequency) and ECC.6.1.4 (voltage) of the Grid Code.

Figure 15 – Sample System Frequency
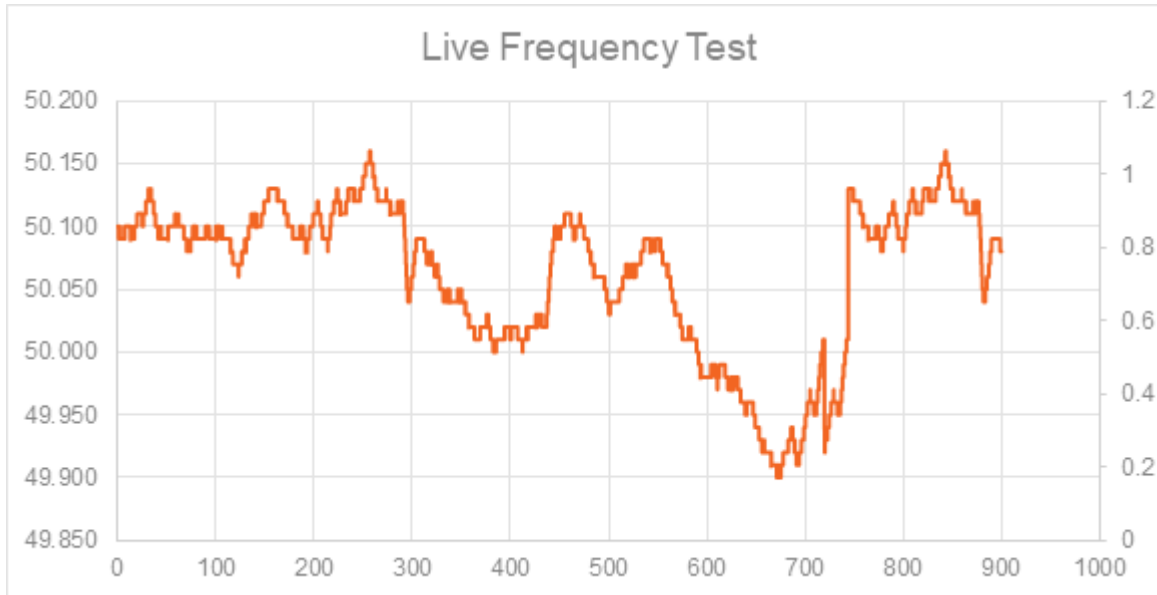
Live Frequency Test

Appendix A – Test Signals

The limits of error and minimum sample rates for testing are shown below in **Table 11**. All success criteria are subject to the stated limit of error/accuracy threshold.

Table 11 - Limits of error and minimum sample rates for Dynamic Service Testing

	Limit of error/ Accuracy threshold	Minimum Sample rate Test 1	Minimum Sample rate Tests 2 and 3
Injection Frequency (Hz)	±0.01 Hz	20Hz	20Hz
Active Power (MW)	Please see pass criteria	20Hz	20Hz
	Limit of error/ Accuracy threshold	Minimum Sample rate Test 4	
Measured System Frequency (Hz)	±0.001 Hz	20Hz	
Active Power (MW)	Please see pass criteria	20Hz	

Simulations / simulated tests are not permitted. Each test submitted must record real time data from the plant and sites under test: The test data submitted must come from the specific site to be contracted; substituted data will not be accepted. Test results must not be changed before submission for analysis.

Test Signals

In ALL cases, the data should record ALL required signals for at least 30 seconds BEFORE the application of the frequency injection signal and for at least 30 seconds AFTER the completion of the test.

For ALL services, the data for the following signals will need to be provided

a) Time
b) Active Power
c) System Frequency or Injected frequency as appropriate
d) Any other relevant signals that may affect the success criteria such as Relay Logic for non-dynamic.

Appendix B – Dynamic Containment Test Data Format

Figure 16 – Sample Dynamic Containment Test Data Format

Provider	Company Name	
Date	xx-xx-xxxx	
Test	1	
Service	Dynamic Containment	
Location	AA	
Site	AA	
Time (s)	Injected Frequency (Hz)	Measured Power (MW)
0	50.00	0.000
0.05	50.00	0.000
0.1	50.00	0.000
0.15	50.00	0.000
0.2	50.00	0.000
0.25	50.50	5.000
0.3	50.50	5.000
0.35	50.50	5.000
0.4	50.50	5.000
0.45	50.50	5.000
0.5	50.50	5.000
0.55	50.50	5.000
0.6	50.00	0.000
0.65	50.00	0.000
0.7	50.00	0.000
0.75	50.00	0.000
0.8	50.00	0.000

- Frequency Injection should be to 2 decimal places
- Measured Power should be to 3 decimal places
- Measured frequency for test 4 should be to 3 decimal places

Further columns can be added to include data for several sites if required.

For Test 4 replace 'Injected Frequency' with 'Measured Frequency'.

Appendix C – Dynamic Containment Test Assessment

- Excel Analysis Tool published with User Guide.

- See Test certificate template in Appendix D for further guidance.

Appendix D – Dynamic Containment Test Certificate Template

Please use this Test Certificate format and submit to NESO, along with the test data and CV of the ITE employed by the prospective response provider.

Prospective Response Provider Company Details

Contracted company name
Primary contact name
Contact number/s
Email address

Contract Details

Contract ID	
Service type	
Asset type, e.g. diesel generator, battery etc	
Unit make up, e.g. single or aggregated	*Describe here what is included in this test e.g. Single asset, group of assets, asset/s being assessed within an existing Unit.*
Aggregation methodology (if appropriate)	
Unit location / ID	
Do any assets associated with this report have a condition in their DNO connection agreement whereby they are signed up to an Active Network management (ANM) Scheme / Flexibility Connection? If yes, please ensure contracted party speaks to their NESO account manager.	
Contract signed date	
Service start date	

Test date

Dynamic Service Details (*example here is for a 5MW Unit*)

Deadband	±0.015Hz
Response / MW	5

Test Results

Further relevant test description/commentary here

Test	Pass Criteria	Pass/Fail	Comment
1.1, 1.2	No delivery within deadband. Where there are any non-zero values here these need to be explained by the ITE in the test report using the comments field.		
1.3,1.4	For Test 1.3 and 1.4 a noticeable change in active power in the correct direction is all that is required.		
1.5-1.12	Active power response within each 3 minute timescale remains within tolerances.	Pass	Note result here (See Figure …)

1.5-1.12	A response following a change of frequency should occur before 0.55 seconds.		
1.5-1.12	Delivery of active power due to a change in frequency is achieved in the required timescale	Pass	
1.5-1.12	The Unit should monotonically progress to its required response	Pass	
2.1 2.2	Active power response is within the allowed tolerances.	Pass	Show in figure below with tolerance bands overlaid.
3	Response is sustained for 15 minutes	Pass	Refer to figures
3	The standard deviation of load error at steady state over a 900 second period must not exceed 2.5% of the maximum contracted active power.	Pass	Standard deviation is assessed from 1 second until 900 seconds after the frequency step.
4	Provide an active power response consistent with the contracted performance timescales.		Figure should show the active power following frequency as expected.

Overall Test Result

Test Result Graphs

Plot frequency injection and active power response vs time for each test.
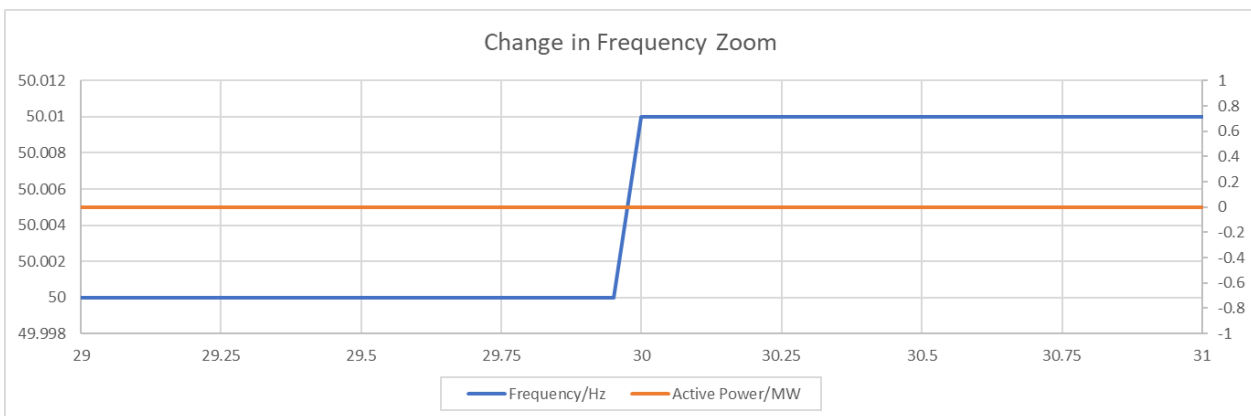
Figure 1 – Test 1 Active Power Response

Active Power and Limits

— Upper active power limit — Lower Active Power Limit — Active Power/MW

Figure 2 – Test 1.1

Change in Frequency Zoom

— Frequency/Hz — Active Power/MW

Figure 3 – Test 1.3

Change in Frequency Zoom
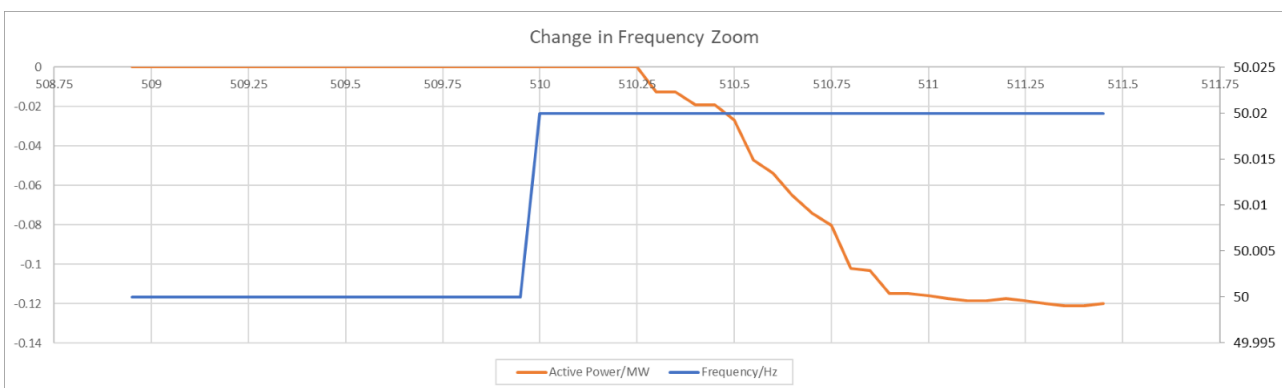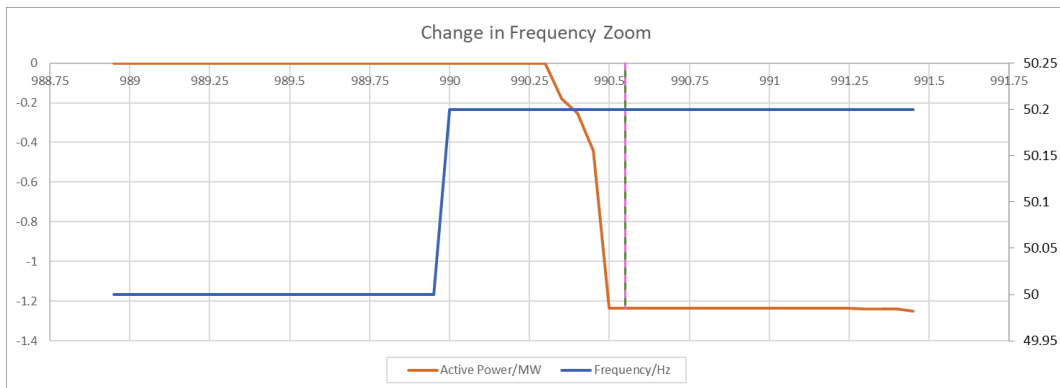
— Active Power/MW — Frequency/Hz
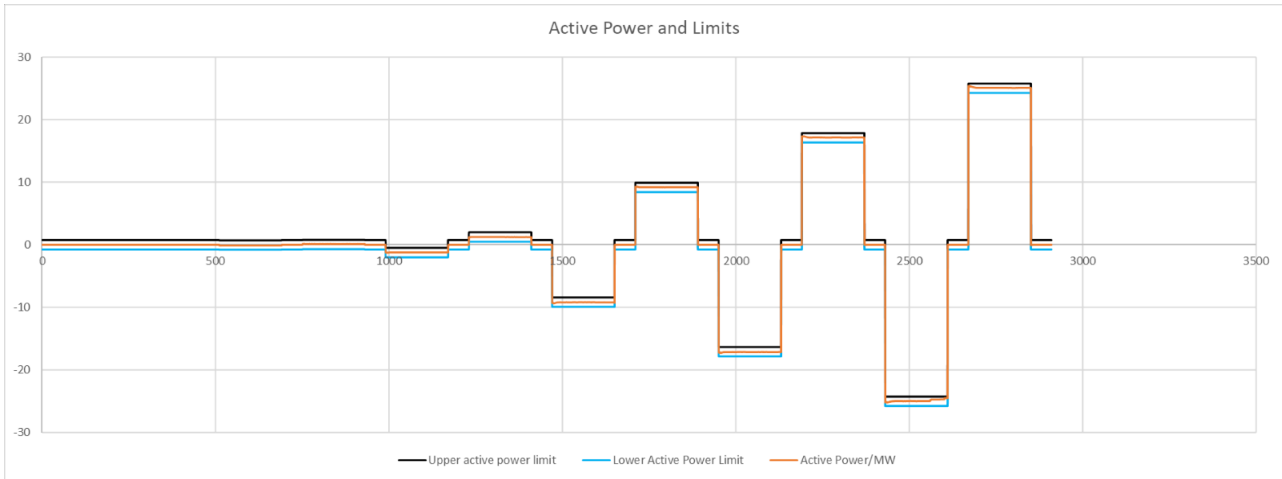
Figure 4 – Test 1.5
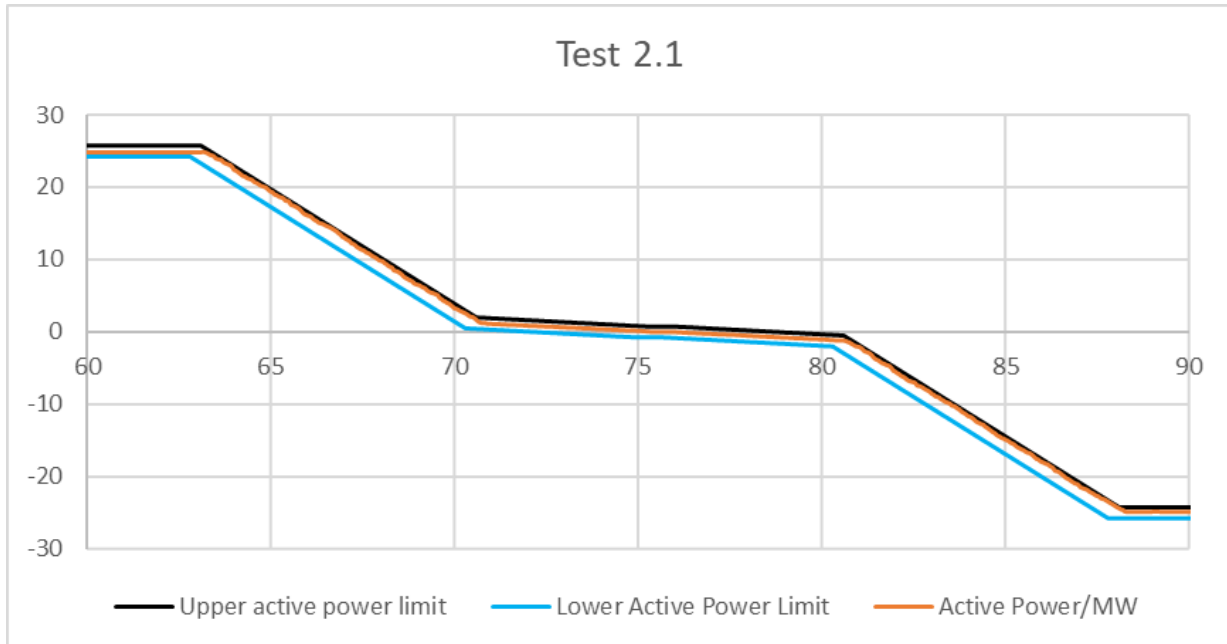

Figure 5 – Test 1.11

Figure 6 – Test 2.1

Test 2.1

Legend: Upper active power limit — Lower Active Power Limit — Active Power/MW

Figure 7 – Test 2.2

Test 2.2

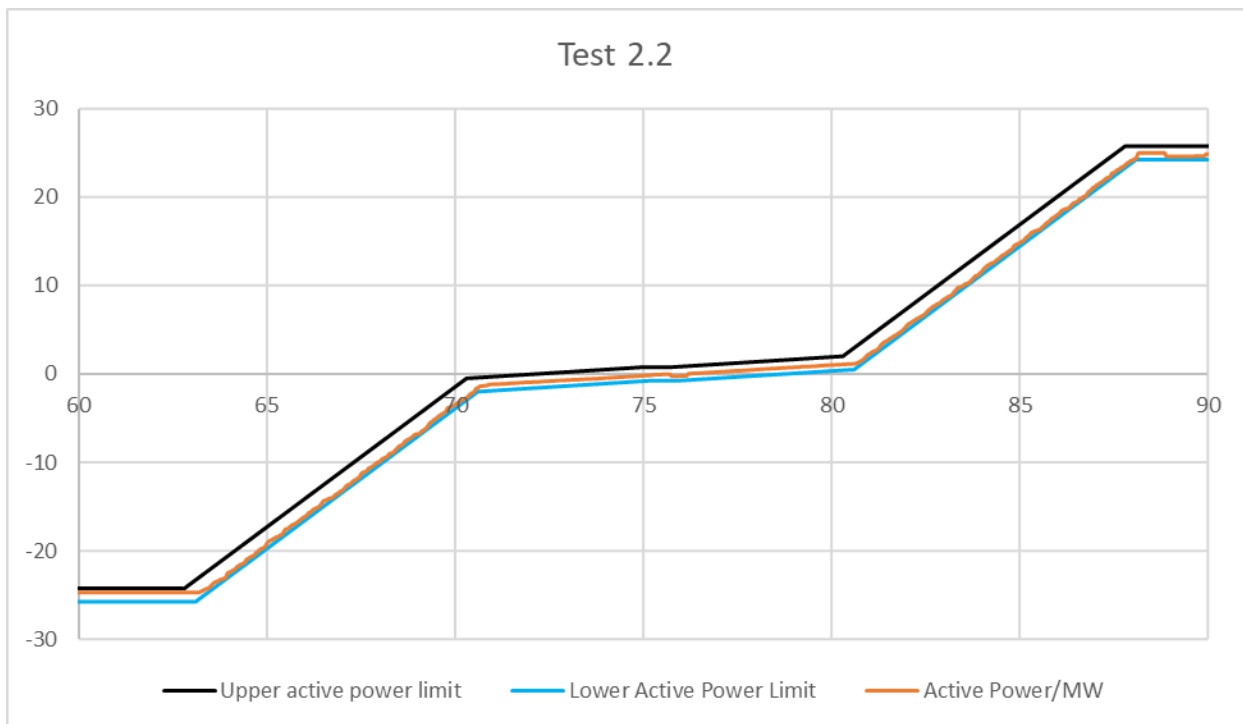Legend: Upper active power limit — Lower Active Power Limit — Active Power/MW

Figure 8 – Test 3.1

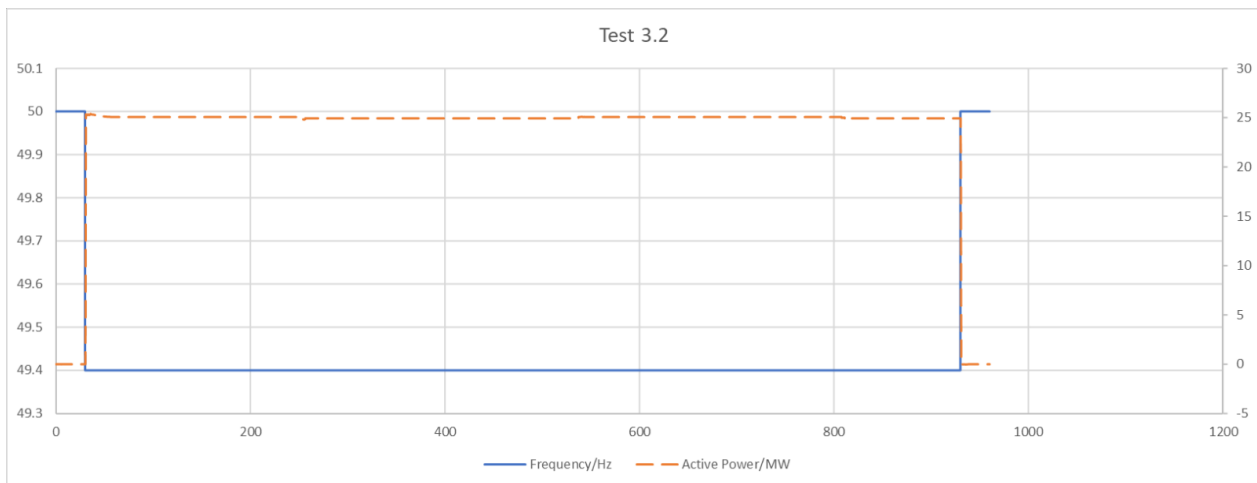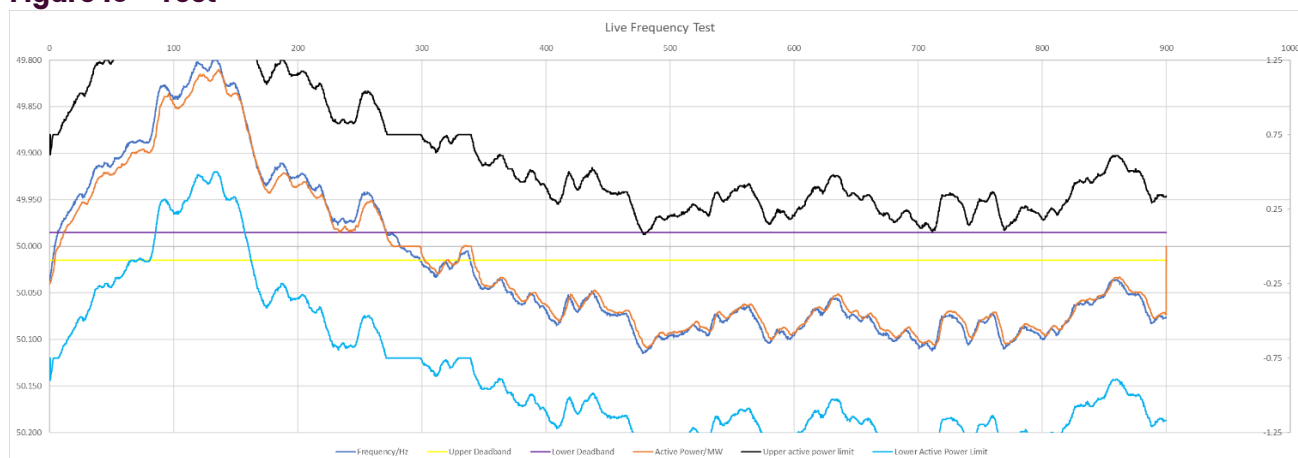**Figure 9 – Test 3.2**

Figure 10 – Test

Live Frequency Test

Independent Technical Expert (ITE) Details

Company name

Primary contact name

Contact number /s

Email address

I / We confirm that I / We the following:

- ☐ **I/We am a/are Independent Technical Expert(s) (as defined in NESO's Response Procurement Documentation;**
- ☐ **I/We have carried out an assessment of the [asset] described above in accordance with the Testing Rules contained in that documentation;**
- ☐ **the above details are, to my/our best knowledge and belief, true, accurate, complete and not misleading; and**
- ☐ **the CV attached of my/our experience is to my/our best knowledge and belief, true, accurate, complete and not misleading.**

Signed:

Date:

Part 2 - Dynamic Moderation Test Requirements

The **Dynamic Moderation** tests assess the capability of the **Registered Response Participant** to deliver dynamic response in accordance with a **Response Contract**.

Tests 1, 2 and 3 assess response against injected frequency profiles. Test 4 assesses response whilst connected to live **System Frequency**. The frequency profile can be injected either at site or remotely. The minimum sample rate for all tests is 20Hz. See Appendix A for information on test signals.

Aggregation/Test Approach

These tests are designed to meet the **NESO** requirement for service validation as well as being equally suitable for all types of **Plant and Apparatus** (both single-site or multi-site) and technology types (generation, storage, demand or a combination of same). The tests also consider how **Registered Response Participants** add to and evolve their aggregated portfolios over time can have additional assets validated.

The dynamic tests can assess the capability of

A single asset

A group of assets

Asset/s to be added to an existing aggregated facility

Test 1 – Step Test

The purpose of Test 1 is to assess the ability of the **Plant** and **Apparatus** to deliver the required response at discreet frequency deviations.

The frequency injections to be used are shown in Figure *17* and Table 12 below.

- Each step is sustained for 180 seconds to verify the response.
- The frequency will then be returned to 50Hz for a minimum of 30 seconds, or until the output is stable, before the next injection is applied.
- The minimum sample rate for Test 1 is 20Hz.

Pass Criteria for Test 1

- For Tests 1.1 and 1.2, the **Plant** and **Apparatus** should not provide any response within the deadband. Where there are any non-zero values here these need to be explained by the **ITE** in the test report using the comments field.
- For tests 1.3 and 1.4 all that is required is a noticeable change in power in the correct direction.
- For Tests 1.5 to 1.8 the active power response within each 3 minute timescale should fall within tolerances shown in Table *13* and shown graphically in Figure *18*.

- (Performance monitoring criteria used to calculate tolerance bands)

- A response following a change of frequency should occur before 0.5 second.

- Delivery of active power due to a change in frequency should be achieved in the required timescale.

- The **Plant** and **Apparatus** should monotonically progress to its required response.
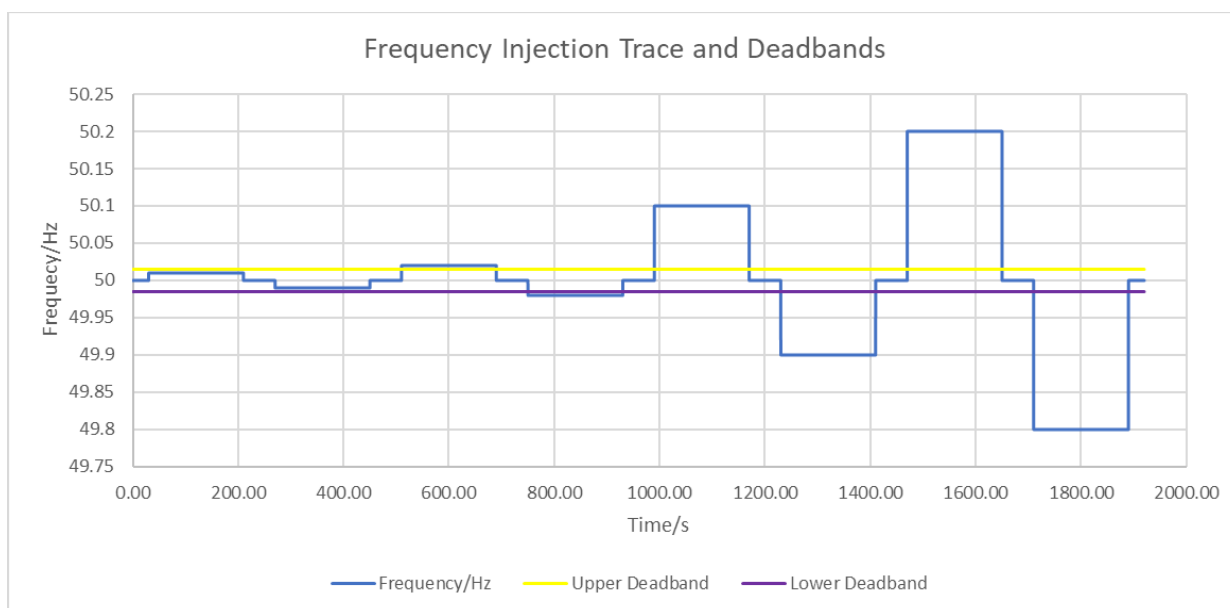
Figure 17 - Test 1

**Table 12 - Test 1 Frequency Injection Profile corresponding with times**

Test	Parameter	Values					
	Time /s	0	30	30	210	210	240
1.1	Frequency /Hz	50	50	50.01	50.01	50	50
1.2	Frequency /Hz	50	50	49.99	49.99	50	50
1.3	Frequency /Hz	50	50	50.02	50.02	50	50
1.4	Frequency /Hz	50	50	49.98	49.98	50	50
1.5	Frequency /Hz	50	50	50.1	50.1	50	50
1.6	Frequency /Hz	50	50	49.9	49.9	50	50
1.7	Frequency /Hz	50	50	50.2	50.2	50	50
1.8	Frequency /Hz	50	50	49.8	49.8	50	50

Table 13 - Test 1 Frequency Injection and expected response value.

Test Number	Frequency Step	Expected Response	Allowable Power Tolerance (% of Maximum Contracted)
1.1	50.01	0%	n/a
1.2	49.99	0%	n/a
1.3	50.02	0.135%	*
1.4	49.98	0.135%	*
1.5	50.1	5%	± 3%
1.6	49.9	5%	± 3%
1.7	50.2	100%	± 3%
1.8	49.8	100%	± 3%

For values with an asterisk (*) a noticeable change in power in the correct direction is all that is required.

Figure 18 - Graphical representation of tolerance bands for the expected response at different frequencies – sample data
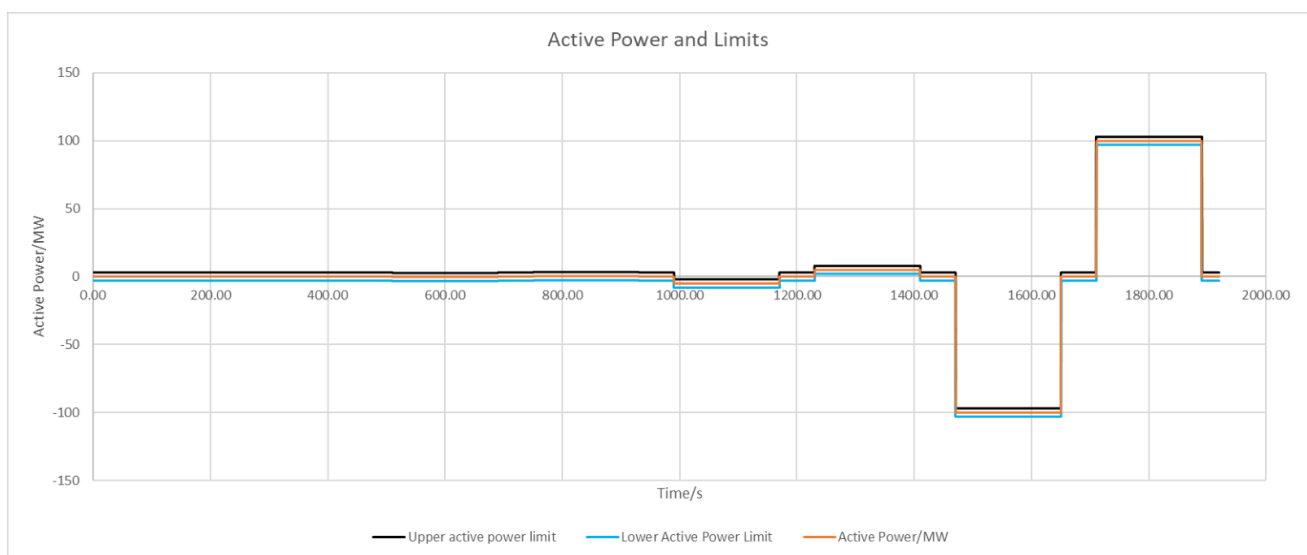
Test 2 – Frequency Sweep Test

Test 2 assesses the performance of the **Plant** and **Apparatus** against a varying frequency over the entire performance envelope.

- The frequency injections to be used are shown in Figure *17* and Figure 19/Figure *20* and Table *14* below.

- The minimum sample rate for Tests 2.1 and 2.2 is 20Hz.

Pass Criteria for Tests 2.1 and 2.2

- For Test 2.1 and 2.2, active power response is within the tolerances in Figure *21* and Figure *22* and Table *15*. (Performance monitoring criteria used to calculate tolerance bands)
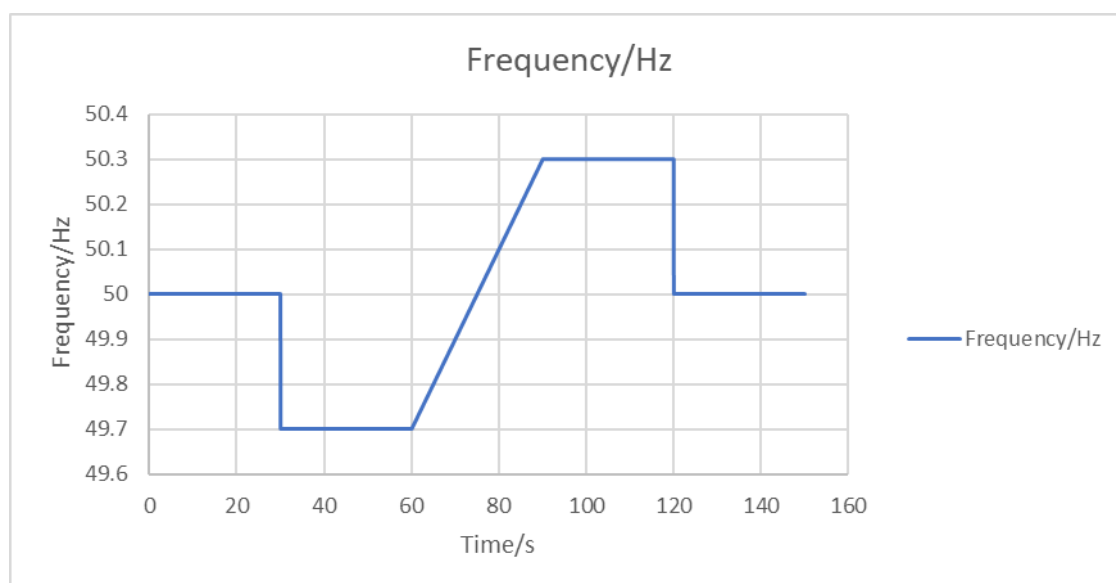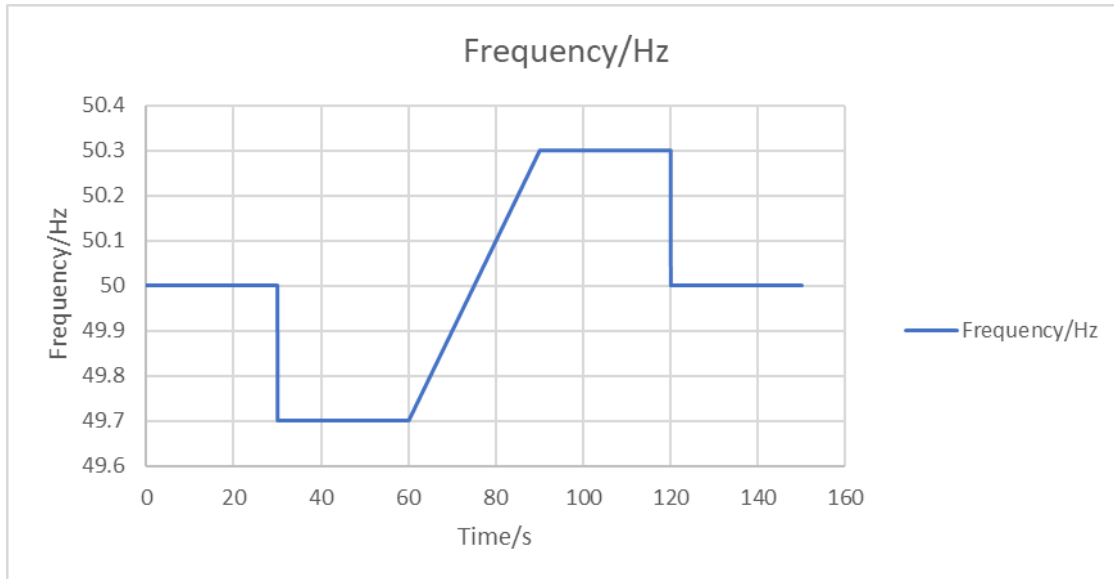
Figure 19 – Test 2.1

Figure 20 – Test 2.2

Table 14 – Test 2 Frequency Injection Profiles

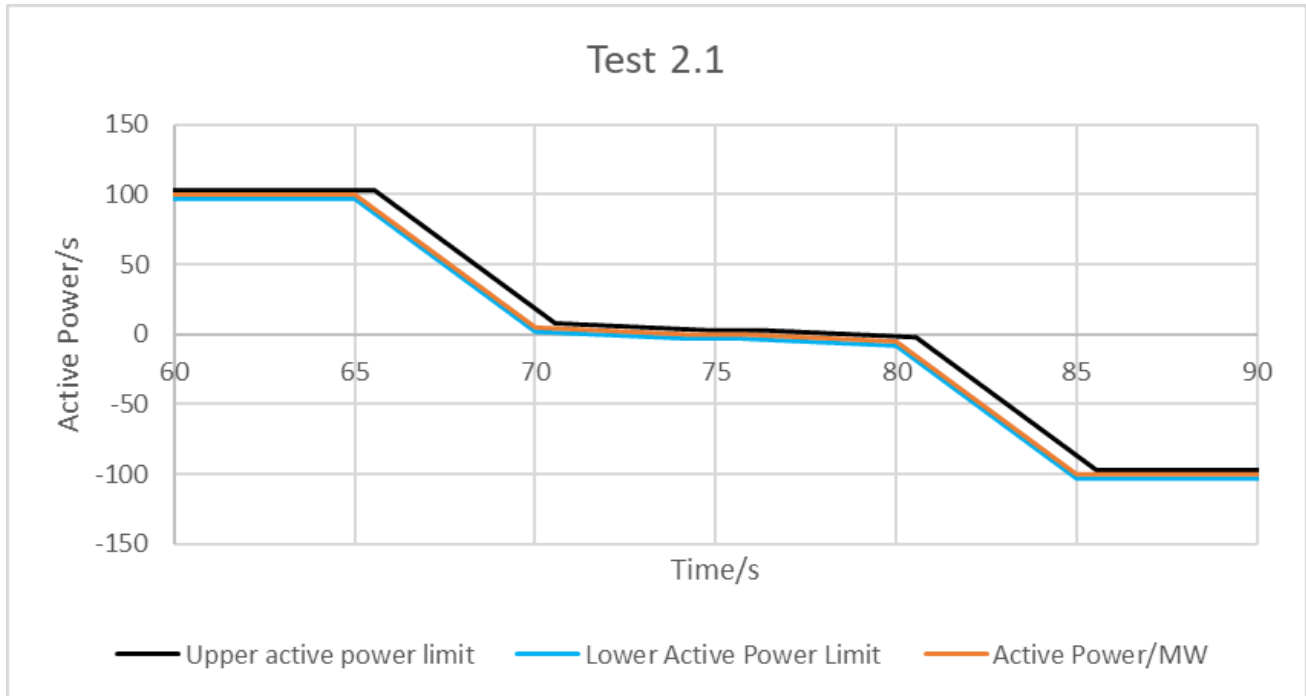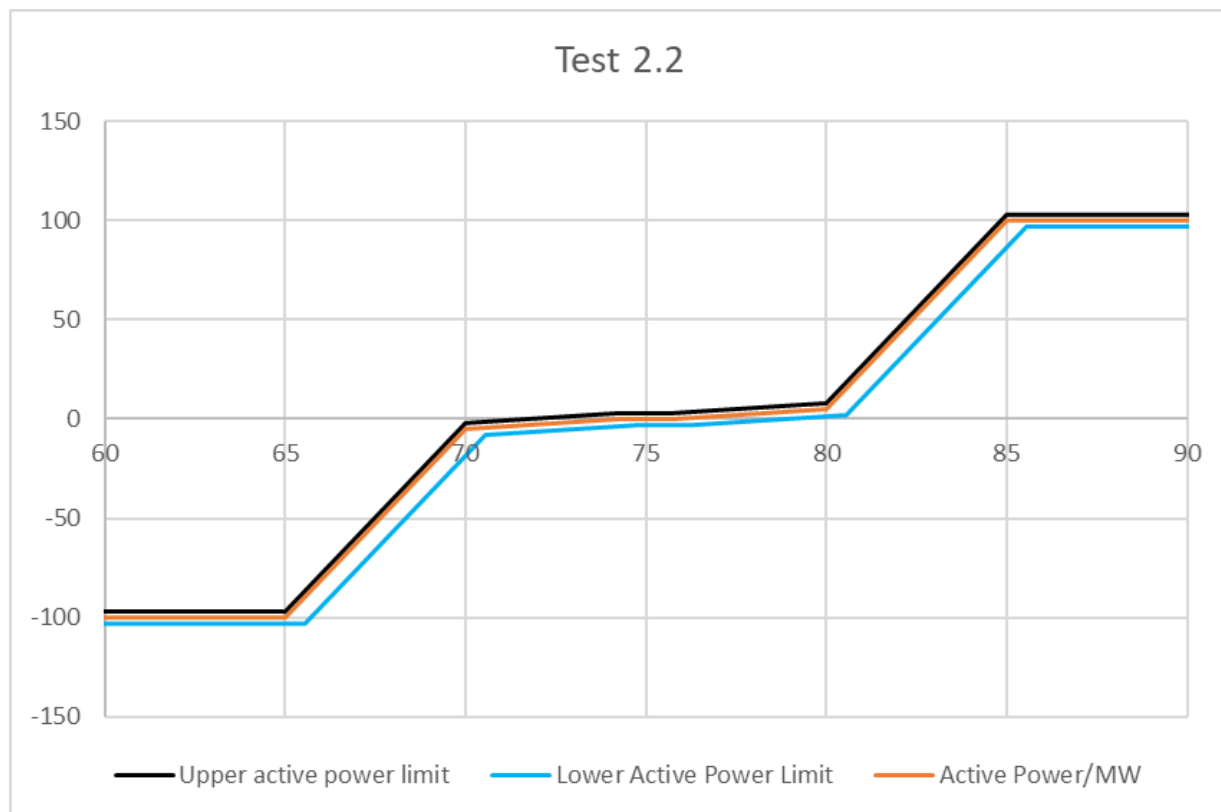| Time /s	Injected Frequency /Hz	
	Test 2.1	**Test 2.2**
0	50	50
30	50	50
30	49.7	50.3
60	49.7	50.3
75	50	50
90	50.3	49.7
120	50.3	49.7
120	50	50
150	50	50

Figure 21 – Test 2.1 Tolerance

Figure 22 - Test 2.2 Tolerance

Table 15 - Test 2.1 and 2.2 Sweep Test tolerances (Without time delay to reach required delivery included)

Frequency (Hz)	Test 2.1 and Test 2.2	
	Expected Percentage Active Power Response (%)	Tolerance (% of Maximum Contracted)
50.3	100	±3%
50.2	100	± 3%
50.1	5	± 3%
50.0	0	0%
49.9	5	± 3%
49.8	100	± 3%

49.7	100	± 3%

Test 3 Duration Test

Test 3 assesses the ability of the **Plant** and **Apparatus** to sustain full response for 30 minutes.

- Operation will be tested at ±100% of capability to ensure the system is compliant.

- This is carried out by a frequency step of ±0.3Hz onto the system for 30 minutes.

- The frequency injection profiles are shown in Figure 23 and Figure 24 and Table 16 and Table 17 below

- Please note that **Registered Response Participants** can reuse existing duration tests for an asset, providing that they are for the same duration or longer and have the same MW value.

Pass criteria for test 3:

- The standard deviation of load error at steady state over a 30-minute period must not exceed 2.5% of the maximum contracted active power.

- Sustain response for 30 minutes.

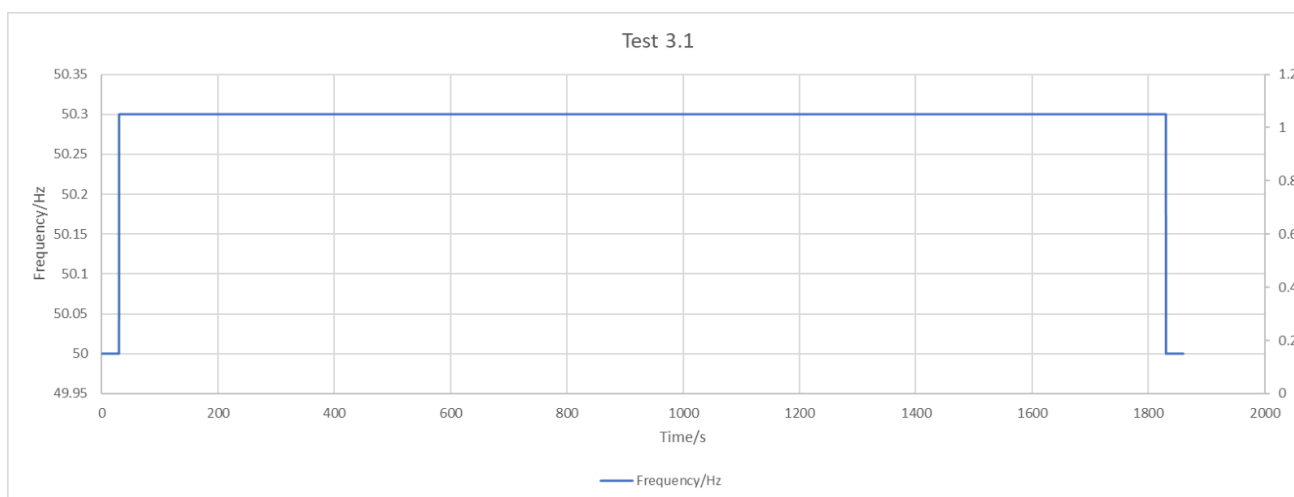**Figure 23 Test 3.1 Injection Profile**
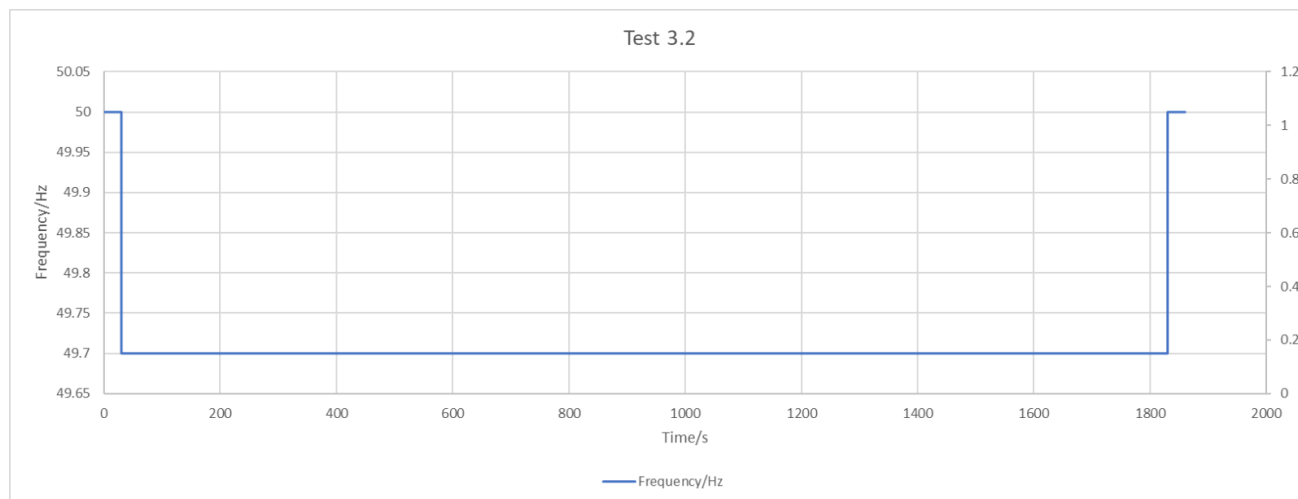
Figure 24 Test 3.2 Injection Profile

Table 16: Test 3.1 Frequency Injection Table Corresponding with times

	Test 3.1 Frequency injection table					
Time /s	0	30	30	1830	1830	1860
Frequency /Hz	50	50	50.3	50.3	50	50

Table 17: Test 3.2 Frequency Injection Table Corresponding with times

|	Test 3.2 Frequency injection table					
Time /s	0	30	30	1830	1830	1860
Frequency /Hz	50	50	49.7	49.7	50	50

Test 4 – Live System Frequency Response Test

Test 4 assesses the response of the **Plant** and **Apparatus** to system frequency in a live environment. The minimum sample rate for this test is 20Hz and duration is 30 minutes where system frequency and active power response will be recorded. As part of test 4, **Registered Response Participants** are required to provide evidence that the protection settings are in line with ECC.6.1.2 (frequency) and ECC.6.1.4 (voltage) of the Grid Code.

Pass Criteria for Test 4

- Provide an active power response consistent with the contracted performance within timescales.

- Provide evidence protection setting comply with ECC.6.1.2 (frequency) and ECC.6.1.4 (voltage) of the Grid Code.

Figure 25 - Sample System Frequency
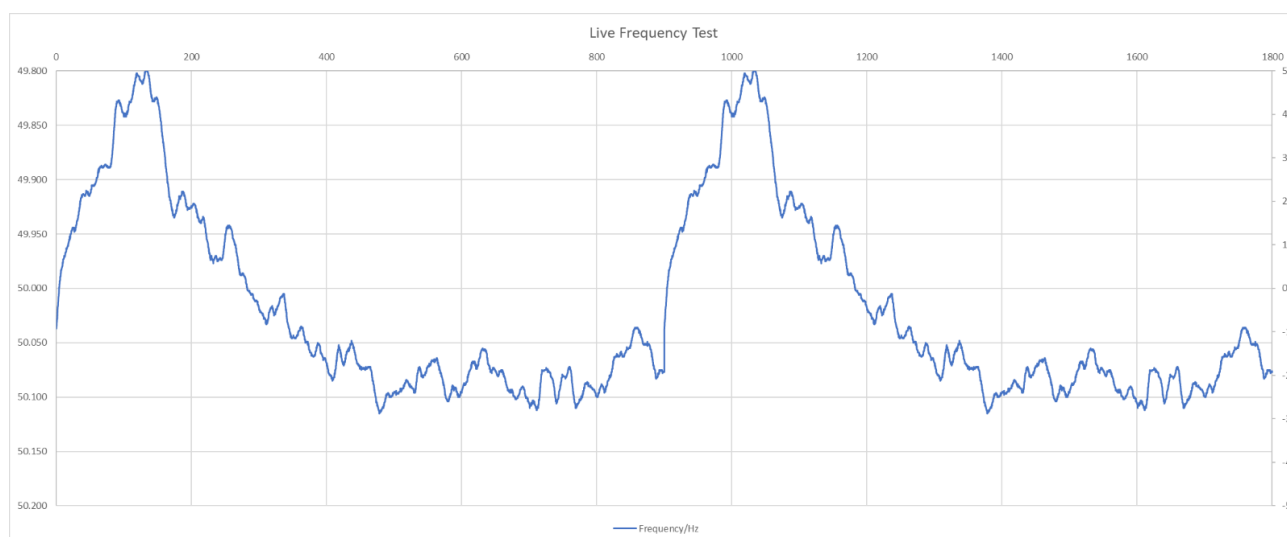
Appendix A – Test Signals

The limits of error and minimum sample rates for testing are shown below in Table *18*. All success criteria are subject to the stated limit of error/accuracy threshold.

Table 18 - Limits of error and minimum sample rates for Dynamic Moderation Testing

	Limit of error/ Accuracy threshold	Minimum Sample rate Test 1	Minimum Sample rate Tests 2 and 3
Injection Frequency (Hz)	±0.01 Hz	20Hz	20Hz
Active Power (MW)	Please see pass criteria	20Hz	20Hz
	Limit of error/ Accuracy threshold	Minimum Sample rate Test 4	
Measured System Frequency (Hz)	±0.001 Hz	20Hz	
Active Power (MW)	Please see pass criteria	20Hz	

Simulations / simulated tests are not permitted. Each test submitted must record real time data from the plant and sites under test: The test data submitted must come from the specific site to be contracted; substituted data will not be accepted. Test results must not be changed before submission for analysis.

Test Signals

In ALL cases, the data should record ALL required signals for at least 30 seconds BEFORE the application of the frequency injection signal and for at least 30 seconds AFTER the completion of the test.

For ALL services, the data for the following signals will need to be provided

    e) Time

    f) Active Power

    g) System Frequency or Injected frequency as appropriate

    h) Any other relevant signals that may affect the success criteria such as Relay Logic for non-dynamic.

Appendix B - Dynamic Moderation Test Data Format

Figure 26 - Sample Dynamic Moderation Test Data Format

Provider	Company Name	
Date	xx-xx-xxxx	
Test	1	
Service	Dymanic Moderation	
Location	AA	
Site	AA	
Time/s	Injected Frequency/s	Measred Power/MW
0	50.00	0.00
0.05	50.00	0.00
0.1	50.00	0.00
0.15	50.00	0.00
0.2	50.00	0.00
0.25	50.30	5.00
0.3	50.30	5.00
0.35	50.30	5.00
0.4	50.30	5.00
0.45	50.30	5.00
0.5	50.30	5.00
0.55	50.30	5.00
0.6	50.00	0.00
0.65	50.00	0.00
0.7	50.00	0.00
0.75	50.00	0.00
0.8	50.00	0.00

- Frequency Injection should be to 2 decimal places
- Measured Power should be to 3 decimal places
- Measured frequency for test 4 should be to 3 decimal places

Further columns can be added to include data for several sites if required.

For Test 4 replace 'Injected Frequency' with 'Measured Frequency'.

Appendix C – Dynamic Moderation Test Assessment

- Excel Analysis Tool published with User Guide.

- See Test certificate template in Appendix D for further guidance.

Appendix D – Dynamic Moderation Test Certificate Template

Please use this Test Certificate format and submit to NESO, along with the test data and CV of the ITE employed by the prospective response provider.

Prospective Response Provider Company Details

Contracted company name	
Primary contact name	
Contact number/s	
Email address	

Contract Details

Contract ID	
Service type	
Asset type, e.g. battery	
Unit make up, e.g. single or aggregated	*Describe here what is included in this test e.g. Single asset, group of assets, asset/s being assessed within an existing Unit.*
Aggregation methodology (if appropriate)	
Unit location / ID	
Do any assets associated with this report have a condition in their DNO connection agreement whereby they are signed up to an Active Network management (ANM) Scheme / Flexibility Connection? **If yes, please ensure contracted party speaks to their NESO account manager.**	
Contract signed date	

Service start date	
Test date	

Dynamic Service Details (*example here is for a 5MW Unit*)

Deadband	±0.015Hz
Response / MW	5

Test Results

Further relevant test description/commentary here

Test	Pass Criteria	Pass/Fail	Comment
1.1, 1.2	No delivery within deadband Where there are any non-zero values here these need to be explained by the ITE in the test report using the comments field.		
1.3,1.4	For Test 1.3 and 1.4 a noticeable change in active power in the correct direction is all that is required.		
1.5-1.8	Active power response within each 3 minute	Pass	Note result here (See Figure …)

timescale remains within tolerances.

1.5–1.8	A response following a change of frequency should occur within 0.5 second.		
1.5–1.8	Delivery of active power due to a change in frequency is achieved in the required timescale	Pass	
1.5–1.8	The Unit should monotonically progress to its required response	Pass	
2.1 2.2	Active power response is within the allowed tolerances.	Pass	Show in figure below with tolerance bands overlaid.
3	Response is sustained for 30 minutes	Pass	Refer to figures
3	The standard deviation of load error at steady state over a 1800 second period must not exceed 2.5% of the maximum contracted active power.	Pass	Standard deviation is assessed from 1 second until 1800 seconds after the frequency step.
4	Provide an active power response consistent with the contracted performance timescales.		Figure should show the active power following frequency as expected.

Overall Test Result

Test Result Graphs

Plot frequency injection and active power response vs time for each test.
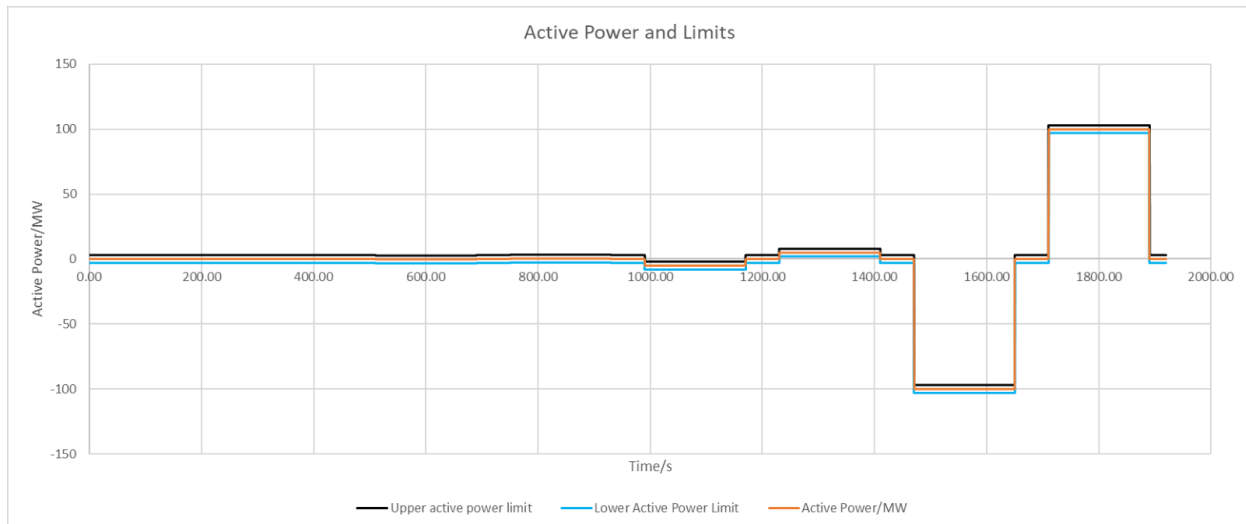
Figure 1 – Test 1 Active Power Response
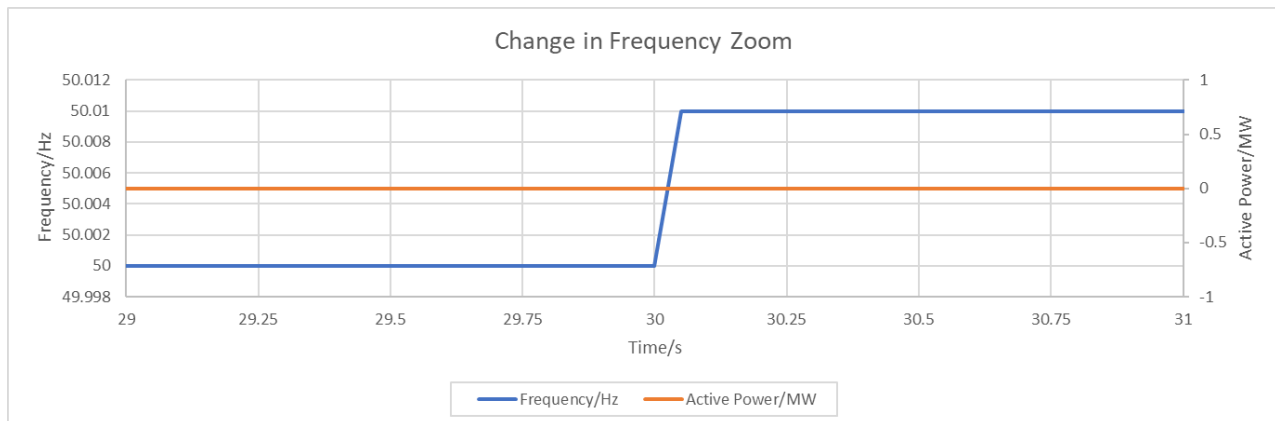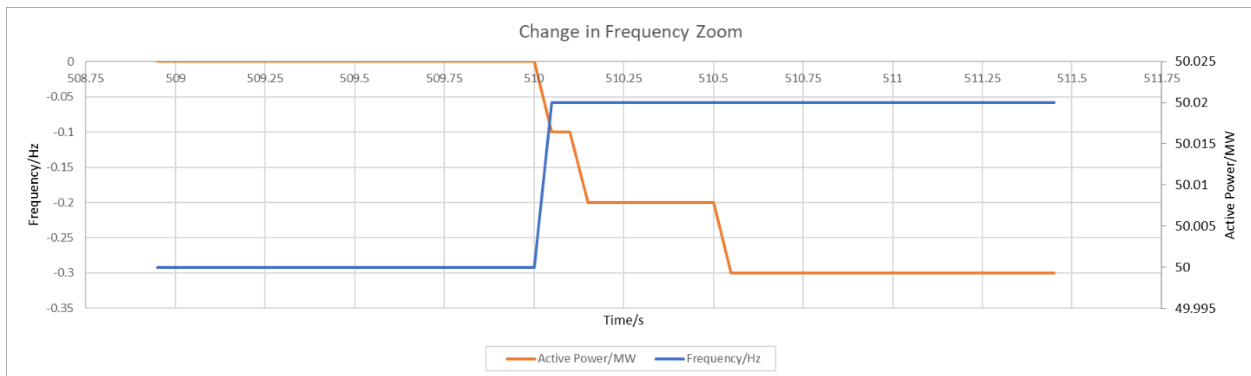

Figure 2 – Test 1.1

Figure 3 – Test 1.3
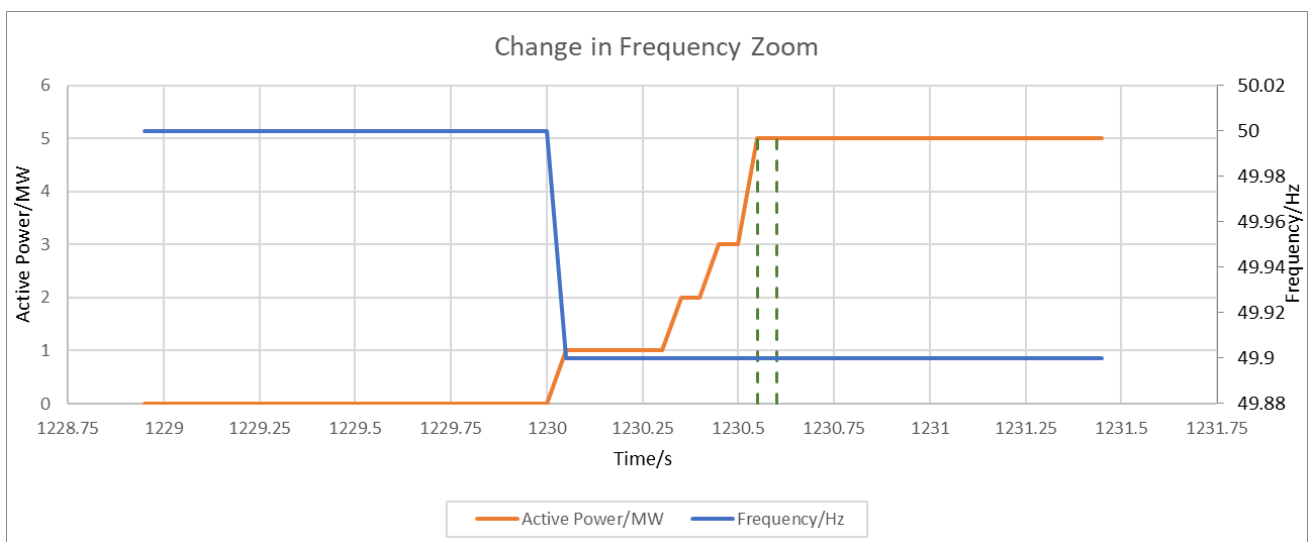
Change in Frequency Zoom

Figure 4 – Test 1.6

Change in Frequency Zoom

Figure 5 – Test 1.7

Change in Frequency Zoom

Figure 6 – Test 2.1

Test 2.1

Active Power/s vs Time/s. Legend: Upper active power limit, Lower Active Power Limit, Active Power/MW

Figure 7 – Test 2.2

Test 2.2

Active Power vs Time. Legend: Upper active power limit, Lower Active Power Limit, Active Power/MW
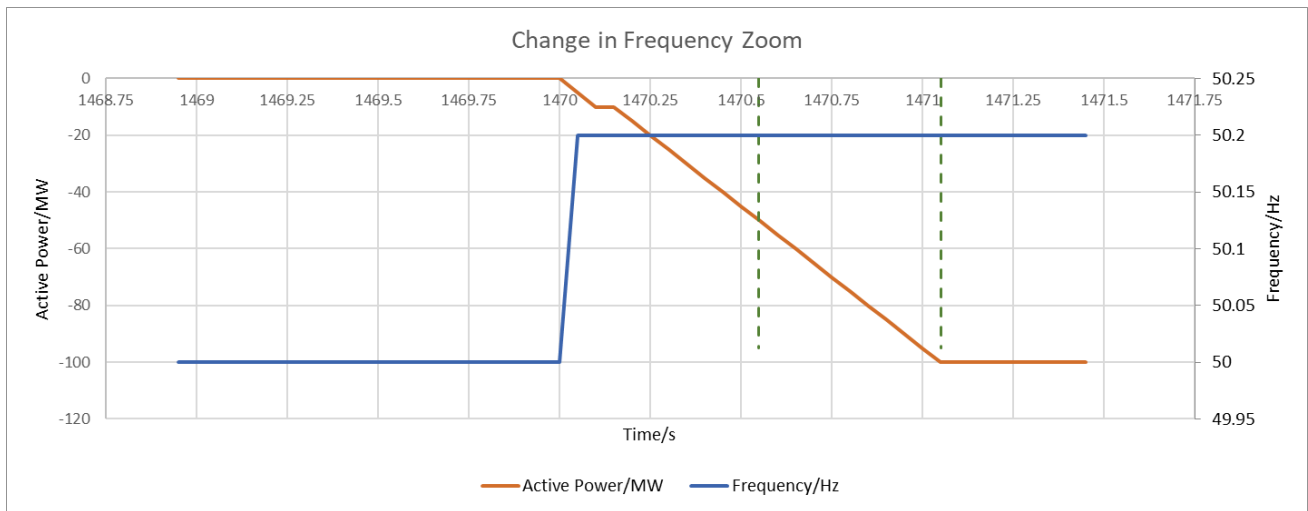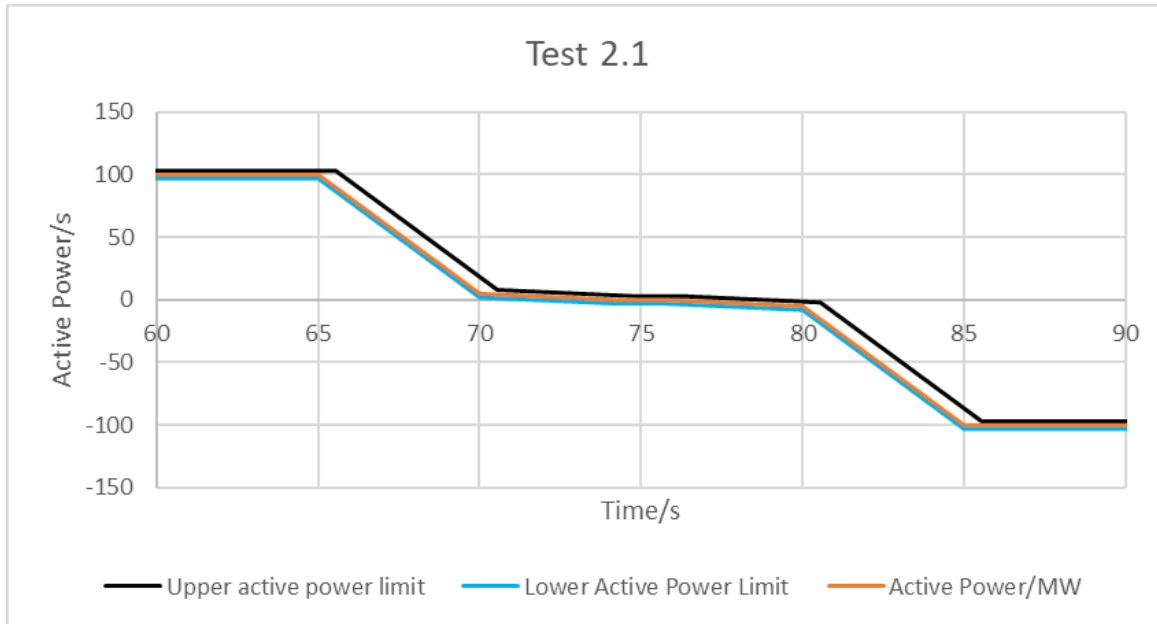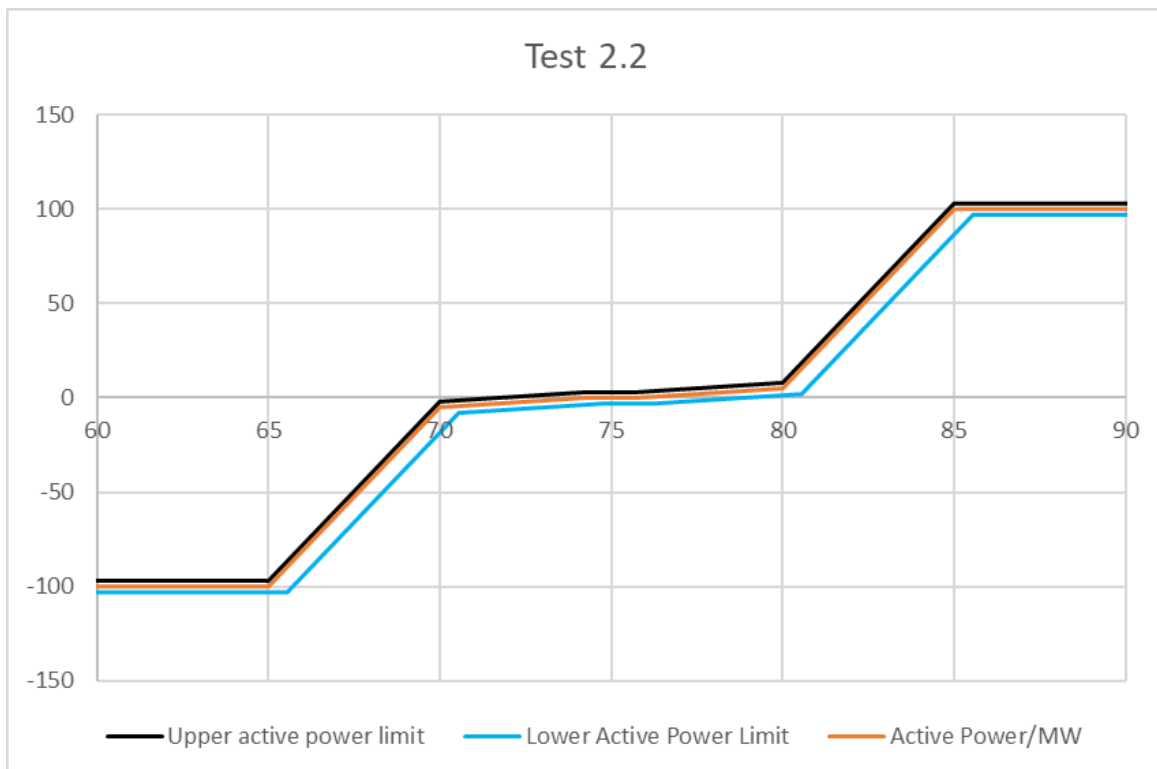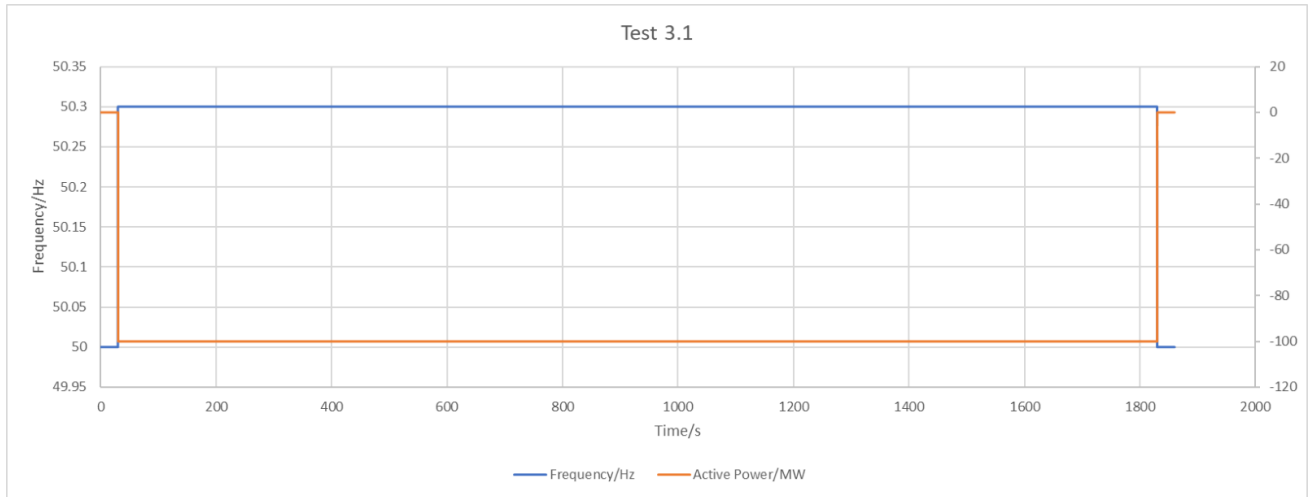
Figure 8 – Test 3.1
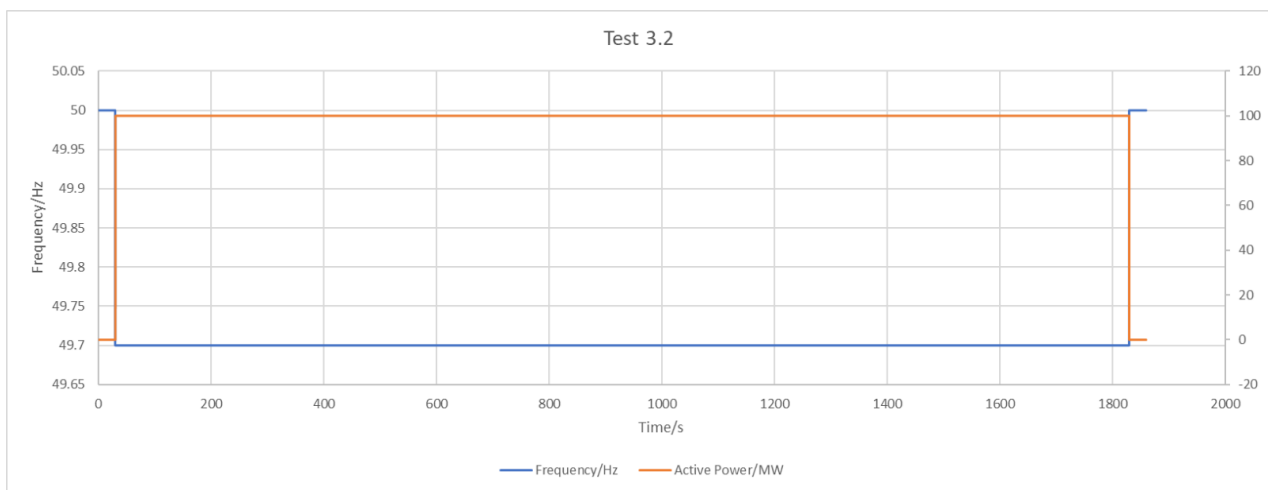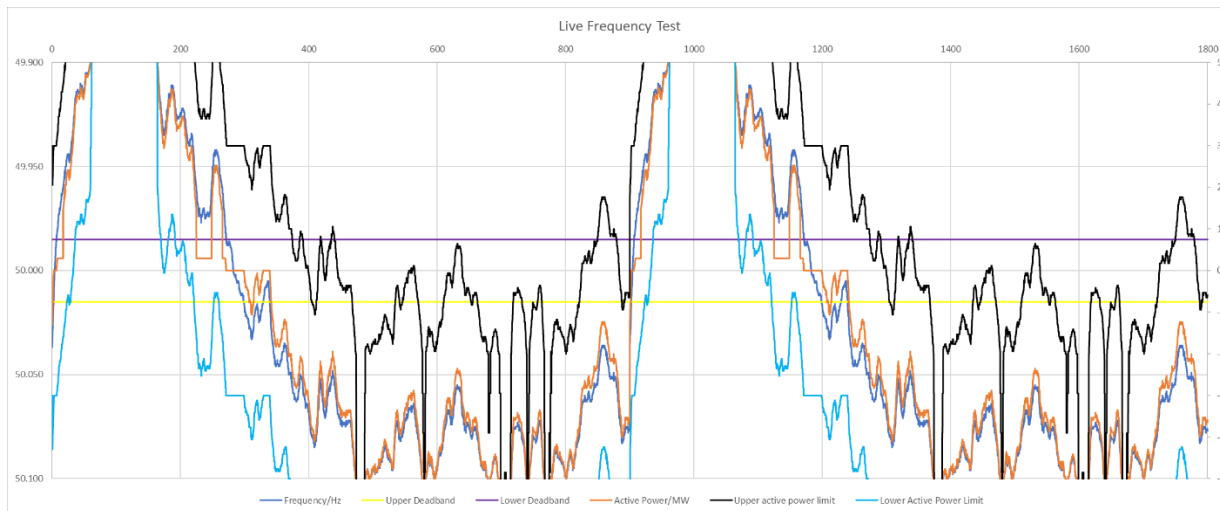

Figure 9 – Test 3.2

Figure 10 – Test 4

Independent Technical Expert (ITE) Details

Company name

Primary contact name

Contact number /s

Email address

I / We confirm that I / We the following:

- ☐ **I/We am a/are Independent Technical Expert(s) (as defined in NESO's Response Procurement Documentation);**
- ☐ **I/We have carried out an assessment of the [asset] described above in accordance with the Testing Rules contained in that documentation;**
- ☐ **the above details are, to my/our best knowledge and belief, true, accurate, complete and not misleading; and**
- ☐ **the CV attached of my/our experience is to my/our best knowledge and belief, true, accurate, complete and not misleading.**

Signed:

Date:

Part 3 - Dynamic Regulation Test Requirements

The **Dynamic Regulation** tests assess the capability of the **Registered Response Participant** to deliver dynamic response in accordance with a **Response Contract**.

Tests 1 and 2 assess response against injected frequency profiles. Test 3 assesses response whilst connected to live system frequency. The frequency profile can be injected either at site or remotely. The minimum sample rate for Test 1 is 10Hz and for Tests 2 and 3 2Hz. See Appendix A for information on test signals.

Aggregation/Test Approach

These tests are designed to meet the **NESO** requirement for service validation as well as being equally suitable for all types of **Plant** and **Apparatus** (both single-site or multi-site) and technology types (generation, storage, demand or a combination of same). The tests also consider how providers adding to and evolving their aggregated portfolios over time can have additional assets validated.

The three dynamic tests can assess the capability of

A single asset

A group of assets

Asset/s to be added to an existing aggregated facility

Test 1 – Duration Test

The two tests described here can be carried out at the individual or group of assets level. These tests confirm the volume of response the **Plant** and **Apparatus** can deliver, and both demonstrate response within the requisite timescales as well as provision of delivery of the **Plant** and **Apparatus** for required period of the service. The sum of the demonstrated outer-envelope responses for each tested **Eligible Asset** in a **Response Unit** (being the aggregated **Registered Quantities**) constitutes (after rounding) the maximum possible **Contracted Quantity** for the **Response Unit**.

The data can be presented with the new tested volume (presented site by site) aggregated by itself, or where adding volume to an existing **Plant** and **Apparatus**, aggregated with the step test data from that existing pre-tested **Plant** and **Apparatus**.

The minimum sample rate for Tests 1.1 and 1.2 is 10Hz.

The frequency injections to be used are shown in Table 19, Figure 27 and Figure 28 below.

Table 19 – Test 1 Frequency Injection Profile

Time (s)	Injected Frequency (Hz)

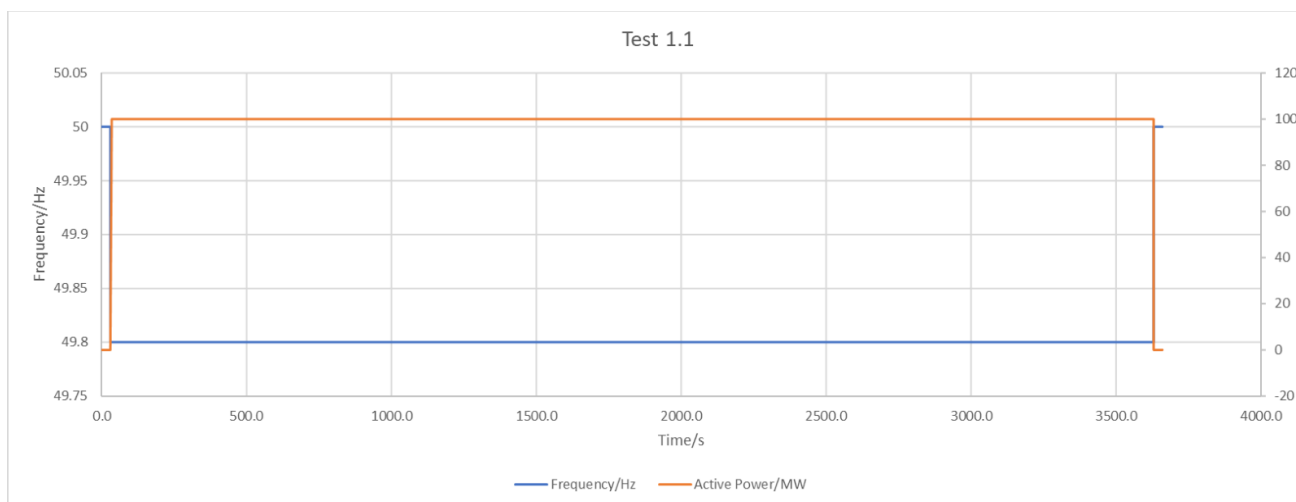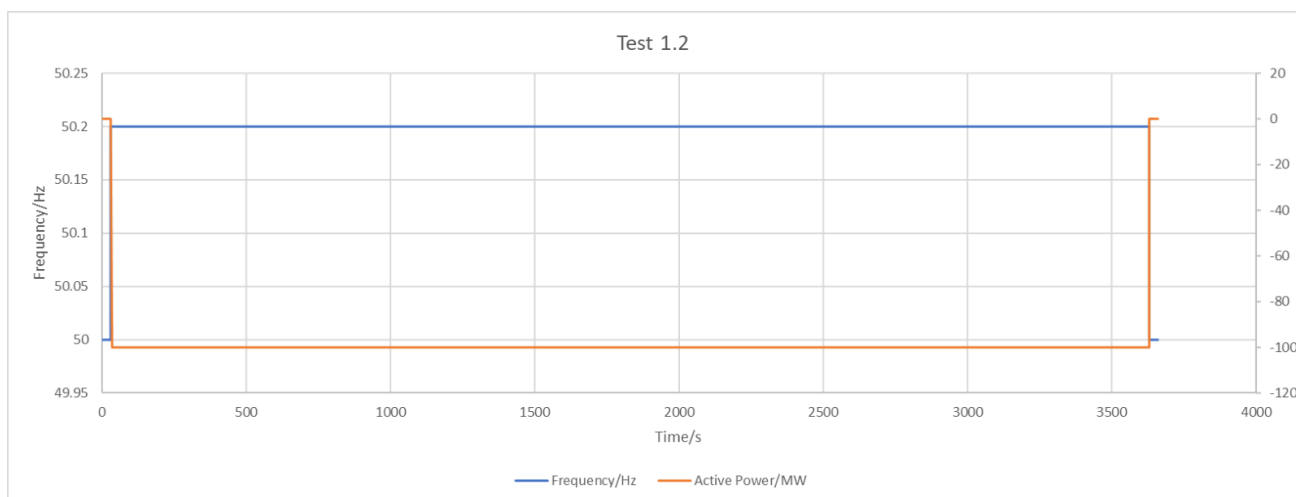|	Test 1.1	Test 1.2
0	50	50
30	50	50
30	49.8	50.2
3630	49.8	50.2
3630	50	50
3660	50	50

Figure 27 – Test 1.1

Figure 28 – Test 1.2

Assessment Criteria for Test 1

Single Asset which will be assessed as part of an aggregated facility

- Record the minimum response achieved within the 10 second to 60 minute timescale.

- How long is the response sustained? (In some cases this may be less than 60 minutes for a single asset which is part of an aggregated asset).

Pass criteria for Unit level (single asset or aggregation)

- The sum of minimum response achieved within the 10 second to 60 minute timescale constitute the total volume of the **Response Unit**. (i.e. the minimum total response achieved within each timescale).

- Delay in response of active power due to a change in frequency is no greater than 2 seconds.

- The **Plant** and **Apparatus** should monotonically progress to its maximum response.

- The standard deviation of load error at steady state over a 60 minute period must not exceed 2.5% of the maximum contracted active power response (standard deviation is assessed from 10 seconds until 60 minutes after the frequency step).

- Sustain response for 60 minutes.

- Please note that **Registered Response Participants** can reuse existing duration tests for an asset, providing that they are for the same duration or longer and have the same MW value.

Test 2 – Response Tests

This test assesses the capability to deliver the following (as applicable where zero deadline applies):

- No response inside the deadband

- Response just outside the deadband

- Proportional response at discreet frequency levels

- Response to changing frequency varying over the entire performance envelope

The minimum sample rate is 2Hz for the response tests.

Aggregation/Test Approach

Test Scenario 1: Where a volume is being tested by itself for validation, the two response tests should be carried out on the asset/s to demonstrate the response of the asset/s for the full range of frequency.

Test Scenario 2: Where a new "in-test" volume is being added to an existing (tested) volume (which it is dependent upon for compliance), the tests would be carried out within an existing aggregated asset that has been withdrawn from the market for the test period.

Table 20 - Test 2 Frequency Injection Profiles

| Time (s) | Injected Frequency (Hz) | | Sub-test reference for assessment |
	Test 2.1	Test 2.2	
0	50	50	
30	50	50	
30	49.99	50.01	a
60	49.99	50.01	a
60	49.98	50.02	b
90	49.98	50.02	b
90	49.9	50.1	c
120	49.9	50.1	c
120	49.8	50.2	d
150	49.8	50.2	d
150	49.7	50.3	e
180	49.7	50.3	f
195	50	50	f
210	50.3	49.7	f

240	50.3	49.7	
240	50	50	
270	50	50	

Figure 29 – Test 2 Injection Profile
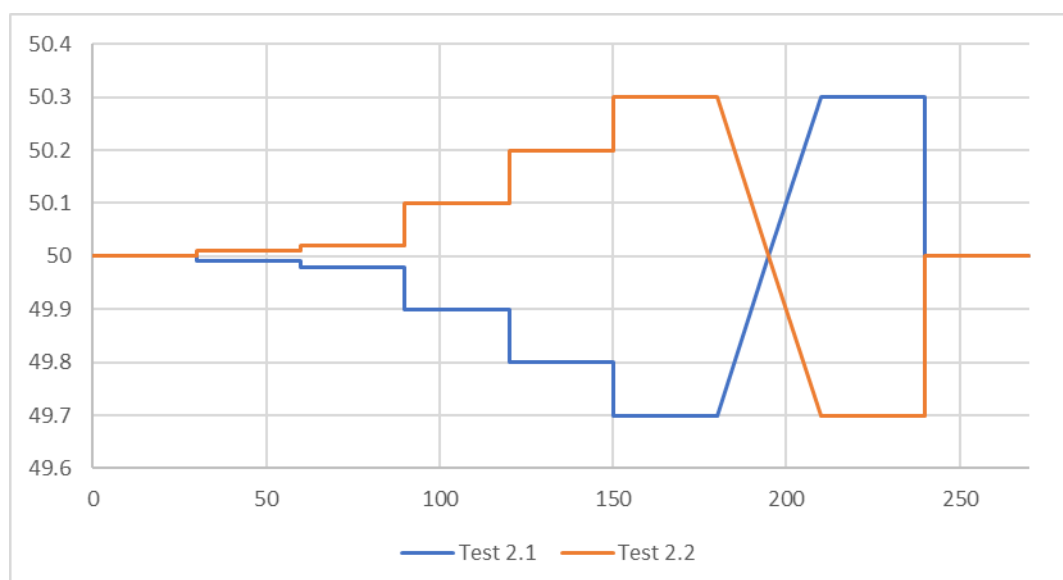
Pass Criteria for Tests 2.1 and 2.2

- For 2.1a and 2.2a the **Plant** and **Apparatus** should not provide any response within the deadband. Where there are any non-zero values here these need to be explained by the ITE in the test report using the comments field.

- Tests 2.1b and 2.2b a noticeable change in power in the correct direction is observed. This test ensures that the **Plant** and **Apparatus** will respond to small frequency deviations outside the deadband.

- For ±0.1Hz, ±0.2Hz and steps ±0.3Hz (Tests c, d and e) the response values achieved are proportional. Also ±0.3Hz sections should reflect total maximum volume from

Test 1. For each 30 second step the minimum response from 10-30 seconds should be assessed against the contracted delivery volume.

- For Test 2.1f and 2.2f, active power response is within the tolerances in **Table 21** (**Figure 30** and **Figure 31**). (Performance monitoring criteria used to calculate tolerance bands).

Table 21 - Test 2 Tolerances (Without time delay to reach required delivery included)

Frequency Deviation (Hz)	Expected Response (Percentage of maximum)	Tolerance (Percentage of Maximum Contracted)
0.01	n/a	n/a
0.02	*	*
0.1	~50**	± 5%
0.2	100	± 5%
0.3	100	± 5%

**At 0.1% the actual expected response is 45.9459% due to linear delivery between 0.015Hz (deadband) to 0.2Hz
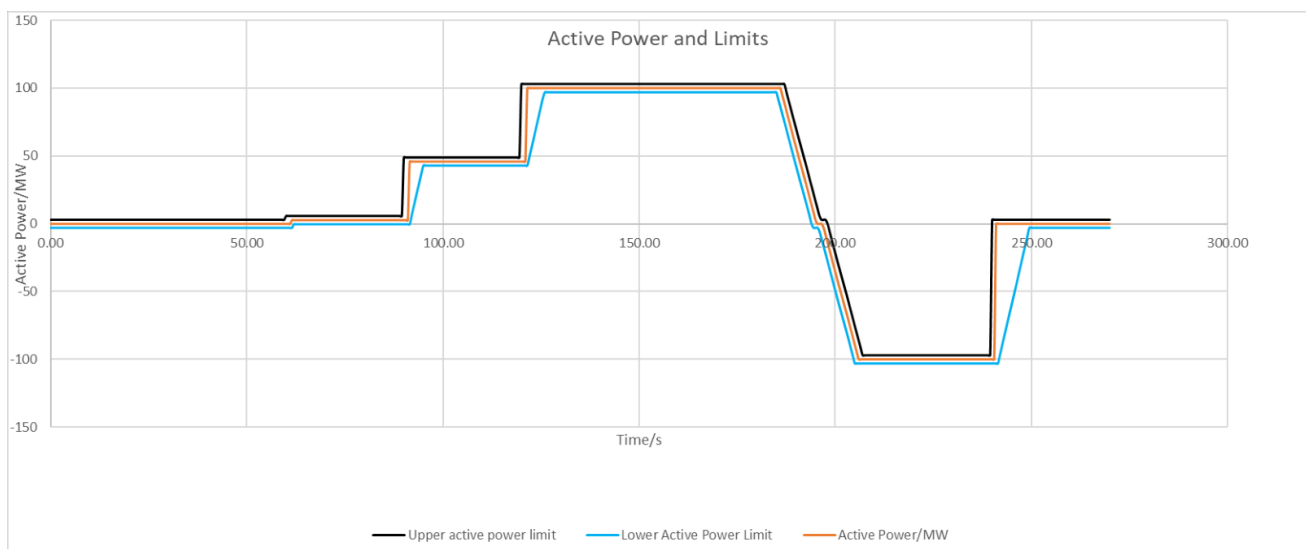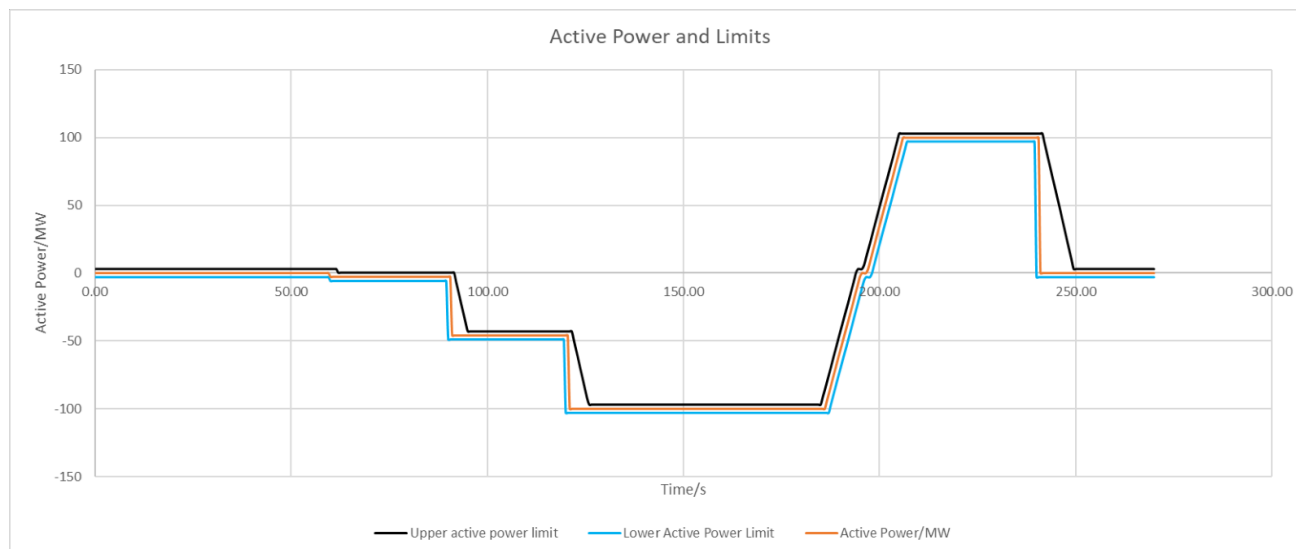
Figure 30 - Test 2.1 Tolerance

Figure 31 – Test 2.2 Tolerance

Active Power and Limits

Test 3 – Live System Frequency Response Test

Test 3 assesses the response of the **Plant** and **Apparatus** to system frequency in a live environment. The minimum sample rate for this test is minimum 2Hz and duration is 1 hour where system frequency and active power response will be recorded. As part of test 3, you are required to provide evidence that the protection settings are in line with ECC.6.1.2 (frequency) and ECC.6.1.4 (voltage) of the Grid Code.

Aggregation

The options for the live test are as follows.

1. A single asset capable of meeting the DR service specification on its own.
2. A group of 'new' assets capable of meeting the DR service specification can be tested simultaneously. These could then contract as a standalone Response Unit or be added to an existing Response Unit.
3. New asset/s to be added to an existing Response Unit can carry out a live test where the new "in-test" assets would be added to the existing Response Unit and run following the system frequency (equivalent of being in-market) for a period of 1 hour. (See Appendix E for further details).

Pass Criteria for Test 3

• Provide an active power response consistent with the contracted performance within timescales.

- Provide evidence protection settings comply with ECC.6.1.2 (frequency) and ECC.6.1.4 (voltage) of the Grid Code.

Figure 32 – Sample System Frequency
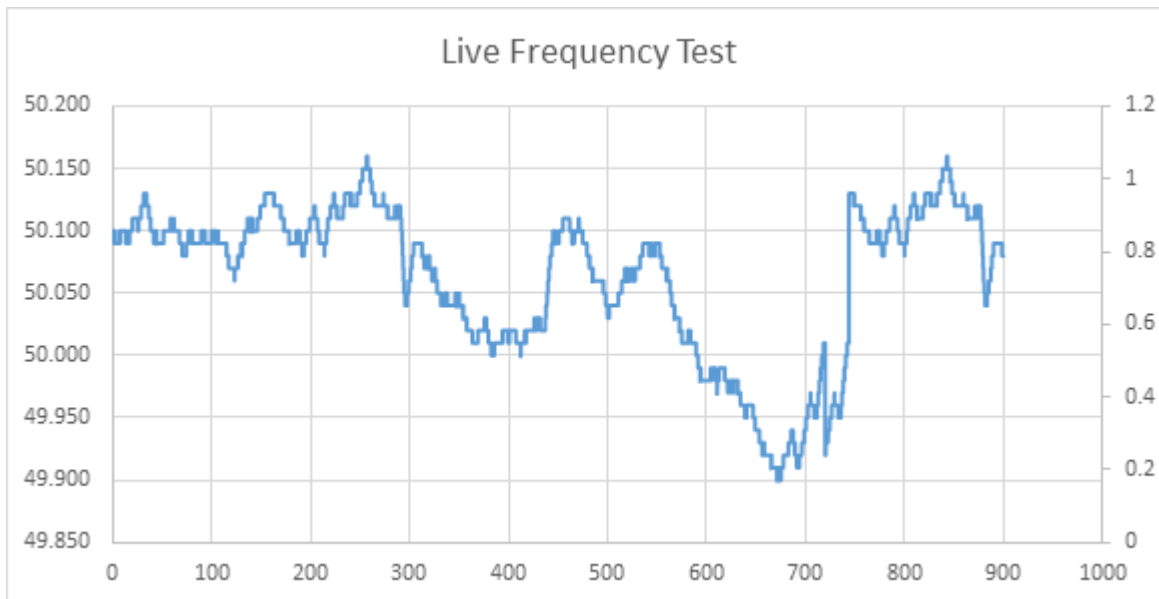
Appendix A – Test Signals

The limits of error and minimum sample rates for testing are shown below in Table 22. All success criteria are subject to the stated limit of error/accuracy threshold.

Table 22 - Limits of error and minimum sample rates for Dynamic Regulation Testing

	Limit of error/ Accuracy threshold	Minimum Sample rate Test 1	Minimum Sample rate Tests 2 and 3
Injection Frequency (Hz)	±0.01 Hz	10Hz	2Hz
Active Power (MW)	Please see pass criteria	10Hz	2Hz

Simulations / simulated tests are not permitted. Each test submitted must record real time data from the plant and sites under test: The test data submitted must come from the specific site to be contracted; substituted data will not be accepted. Test results must not be changed before submission for analysis.

Test Signals

In ALL cases, the data should record ALL required signals for at least 30 seconds BEFORE the application of the frequency injection signal and for at least 30 seconds AFTER the completion of the test.

For ALL services, the data for the following signals will need to be provided

    i)   Time
    j)   Active Power
    k) System Frequency or Injected frequency as appropriate
    l)   Any other relevant signals that may affect the success criteria such as Relay Logic for non-dynamic.

Appendix B - Dynamic Regulation Test Data Format

Table 23 - Sample Dynamic Regulation Test Data Format

Time/s	Injected Frequency/s	Measred Power/MW
0.0	50.00	0.00
0.5	50.00	0.00
1.0	50.00	0.00
1.5	50.00	0.00
2.0	50.00	0.00
2.5	50.30	5.00
3.0	50.30	5.00
3.5	50.30	5.00
4.0	50.30	5.00
4.5	50.30	5.00
5.0	50.30	5.00
5.5	50.30	5.00
6.0	50.00	0.00
6.5	50.00	0.00
7.0	50.00	0.00
7.5	50.00	0.00
8.0	50.00	0.00

- Frequency Injection should be to 2 decimal places
- Measured Power should be to 3 decimal places
- Measured frequency for test 3 should be to 3 decimal places

Further columns can be added to include data for several sites if required.

For Test 3 replace 'Injected Frequency' with 'Measured Frequency'.

Appendix C - Dynamic Regulation Test Assessment

- Excel Analysis Tool published with User Guide.

- See Test certificate template in Appendix D for further guidance.

Appendix D – Dynamic Regulation Test Certificate Template

Please use this Test Certificate format and submit to NESO, along with the test data and CV of the ITE employed by the prospective response provider.

Prospective Response Provider Company Details

Contracted company name	
Primary contact name	
Contact number/s	
Email address	

Contract Details

Contract ID	
Service type	
Asset type, e.g. battery	
Unit make up, e.g. single or aggregated	*Describe here what is included in this test e.g. Single asset, group of assets, asset/s being assessed within an existing Unit.*
Aggregation methodology (if appropriate)	
Unit location / ID	
Do any assets associated with this report have a condition in their DNO connection agreement whereby they are signed up to an Active Network management (ANM) Scheme / Flexibility Connection? **If yes, please ensure contracted party speaks to their NESO account manager.**	
Contract signed date	
Service start date	

Test date	

Dynamic Service Details (example here is for a 5MW Unit)

Deadband	±0.015Hz
Response / MW	5

Test Results

Further relevant test description/commentary here

Test	Pass Criteria	Pass/Fail	Comment
Single Asset which will be assessed as part of an aggregated facility			
1	Record the minimum response achieved within the 10second to 30minute timescale.	N/A	Note result here (See Figure …)
1	Record how long is the response sustained	N/A	Note result here. (Some assets which are part of an aggregated unit may not be able to maintain response for 30 minutes.)
Pass criteria for Unit level (single asset or aggregation)			
1	Delay in response of active power due to a change in frequency is no greater than 2 seconds.	Pass	a response was observed within 2 seconds of the frequency change. This is illustrated in Figure …
1	Record the minimum response achieved within the 10second to 30minute timescale.	Pass	Record result here. Should align with the in-test volume in Table 1.

1	The Unit should monotonically progress to its maximum response.	Pass	Refer to Figures below.
1	The standard deviation of load error at steady state over a 60 minute period must not exceed 2.5% of the maximum contracted active power response.	Pass	Standard deviation is assessed from 10 seconds until 60 minutes after the frequency step.
1	Sustain response for 60 minutes.	Pass	
2.1a 2.2 a	No response within the deadband.	Pass	
2.1b 2.2 b	A noticeable change in power in the correct direction is observed.		
2.1,2 .2 c,d, e	For ±0.1Hz, ±0.2Hz and steps ±0.3Hz (Tests c, d and e) the response values achieved are proportional.	Pass	
2.1c -f 2.2 c-f	Active power response is within the allowed tolerances.	Pass	Show in figure below with tolerance bands overlaid.
3	Provide an active power response consistent with the contracted performance timescales.	Pass	
	Overall Test Result	**PASS**	

Test Result Graphs

Plot frequency injection and active power response vs time for each test.
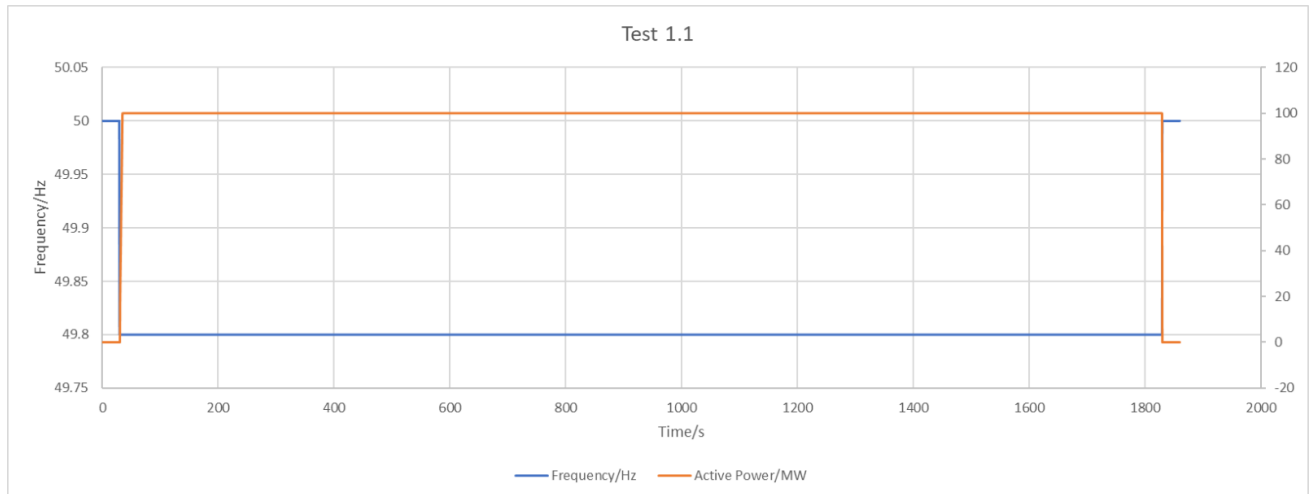
Figure 1 – Test 1.1

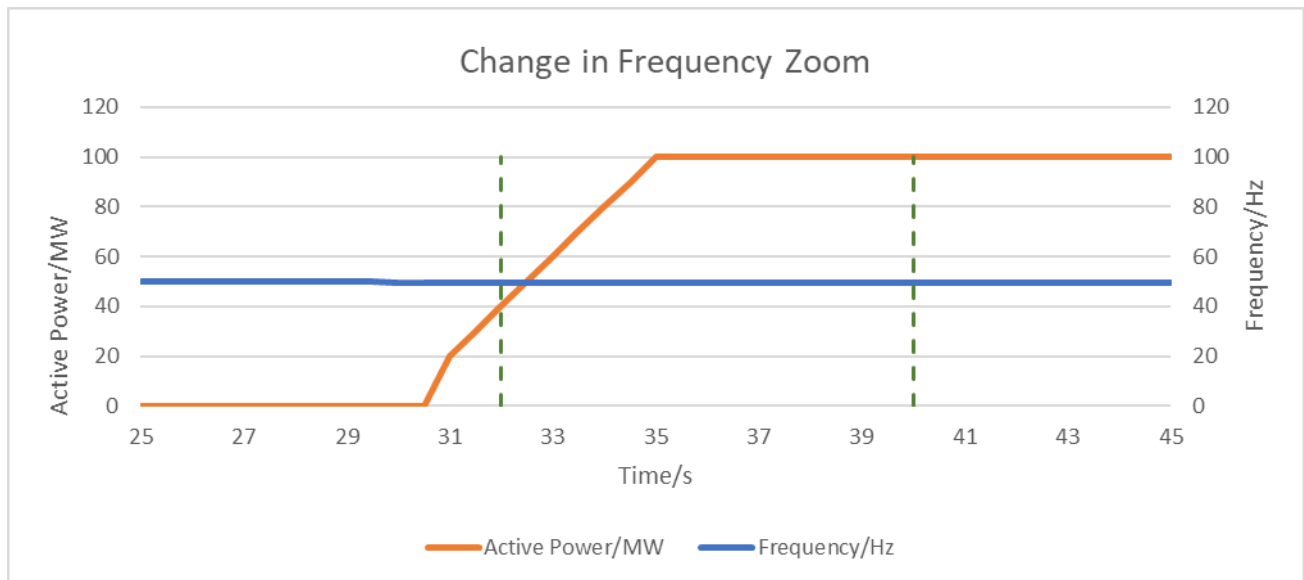### Figure 2 – Test 1.1 Change in Frequency Zoom
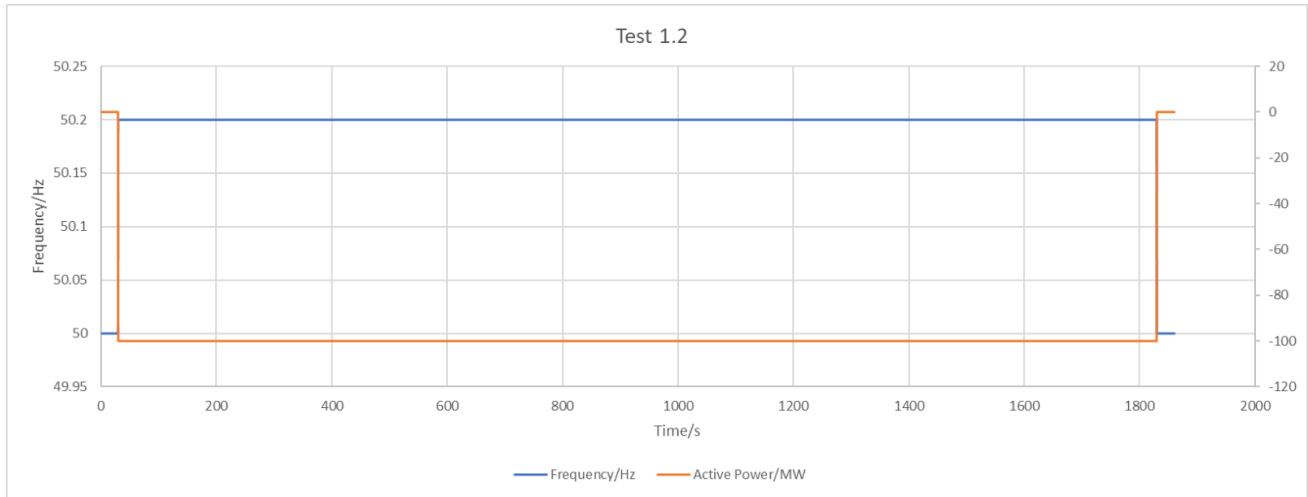
Figure 3 – Test 1.2

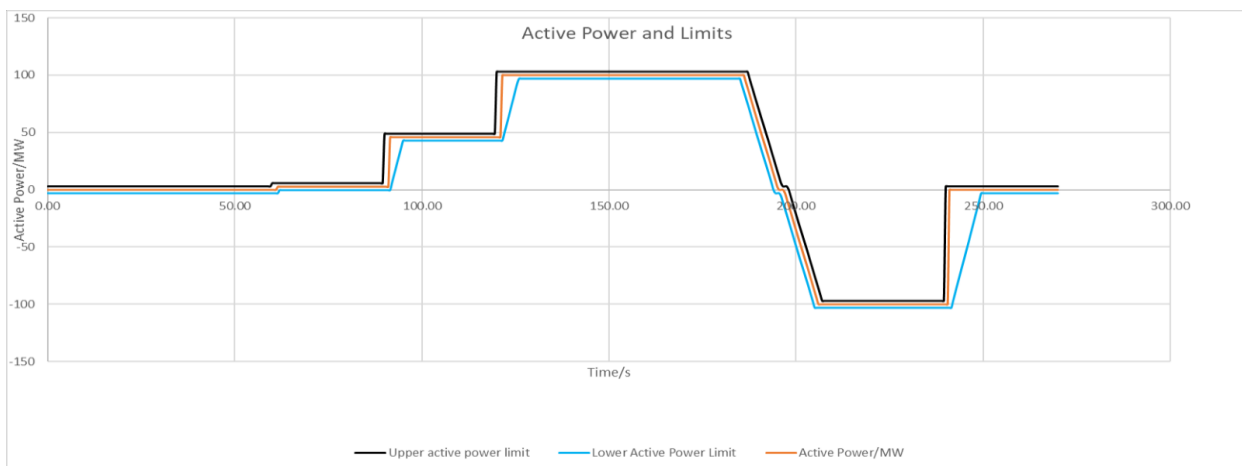
Test 1.2

Figure 4 – Test 2.1
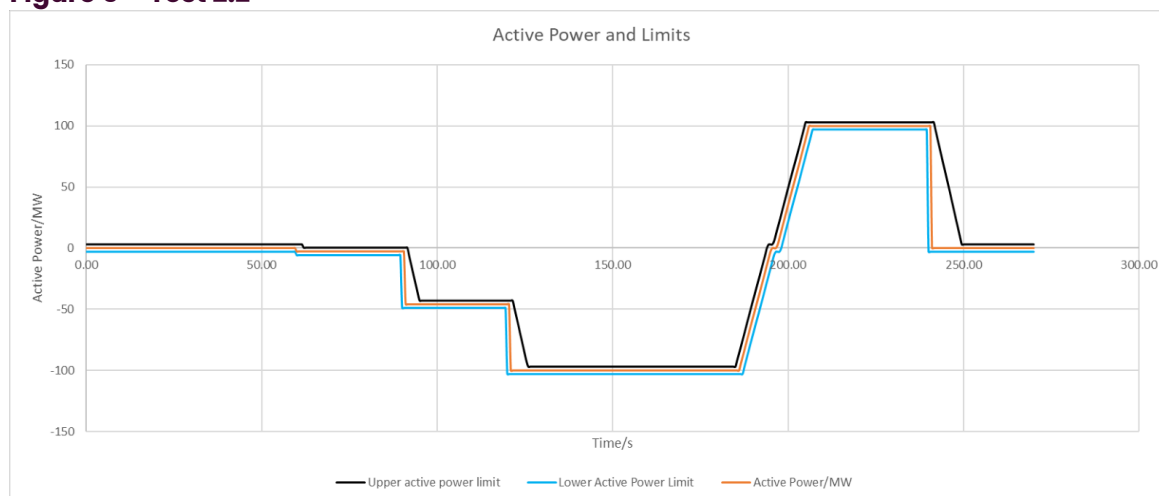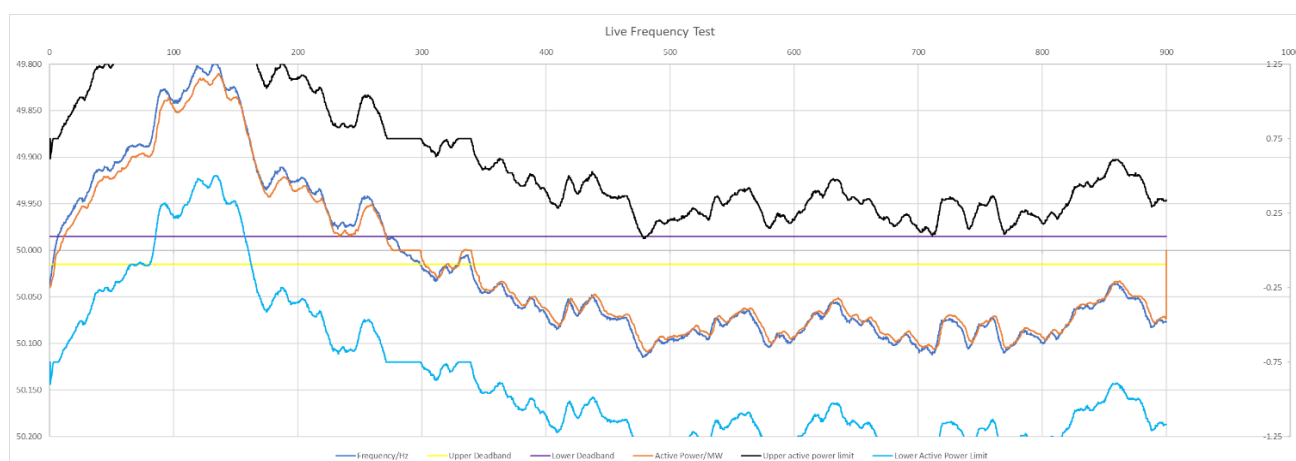
Figure 5 – Test 2.2

Figure 6 – Test 4

Independent Technical Expert (ITE) Details

Company name

Primary contact name

Contact number /s

Email address

I / We confirm that I / We the following:

    (a) **I/We am a/are Independent Technical Expert(s) (as defined in NESO's Response Procurement Documentation);**

(b) **I/We have carried out an assessment of the [asset] described above in accordance with the Testing Rules contained in that documentation;**

(c) **the above details are, to my/our best knowledge and belief, true, accurate, complete and not misleading; and**

(d) **the CV attached of my/our experience is to my/our best knowledge and belief, true, accurate, complete and not misleading.**

Signed:

Date:

Appendix E – Test 3 Approach

The options for the live test are as follows.

1. A single asset capable of meeting DR criteria on its own. The single asset would be run following the system frequency (equivalent of being in-market) for a period of 1 hour

2. A group of 'new' assets capable of meeting DR criteria can be tested simultaneously. The 'new' assets would be aggregated and run following the system frequency (equivalent of being in-market) for a period of 1 hour. This would validate that the volume responds as required to system frequency in a live environment. This group of assets could then contract as a standalone unit or be added to an existing DR Unit.

3. New asset/s to be added to an existing DR Unit can carry out a live test where the new "in-test" assets would be added to the existing DR Unit and run following the system frequency (equivalent of being in-market) for a period of 1 hour. Where the new "in test" assets were being added to a DR Unit already in market, then they should be combined and aggregated with the live "in-market" unit to show the overall portfolio operating as required based on the "in-market" and "in-test" combined volume. The existing portfolio does not need to be withdrawn from market during this test but NESO should be informed.

The test approach, described in option 3 above, would be carried out for an agreed 1-hour period with NESO. This agreement will detail what assets are being added to the portfolio and the expected resulting change from its standard operation. For example, if six assets adding up to a 2MW total were added to a 10MW portfolio, the portfolio would usually be expected to behave like a 12MW portfolio. This validates that the combined volume responds as required against the system frequency in a live environment.

Data submission for this test shall include the frequency, response of the existing portfolio, response of each new asset in the new combined portfolio, and the combined total response of the portfolio.

If testing for Option 3, above, the frequency data and combined "in-test" and "in-market" volume response data would be submitted for validation.

SCHEDULE 6 – INDEPENDENT TECHNICAL EXPERT: DEFINITIONS

Test results for all **Response Services** will be assessed by an **Independent Technical Expert** (ITE) who will prepare a **Test Certificate.**

The following definitions shall apply:

Group means, for any person, another person who is the direct or indirect **Holding Company** of that person and any **Subsidiary** of that **Holding Company**.

Holding Company means, in relation to a company, any other company in respect of which it is a **Subsidiary**.

Independent Technical Expert means an experienced technical expert with expertise in the operation of demand side response (DSR) or generating units or electricity Interconnectors (as the case may be), **Independent** of the prospective response provider, engaged by the prospective response provider at its expense to carry out a technical assessment and prepare a **Test Certificate.**

Independent means, for any technical expert and the applicable prospective response provider, that the technical expert is:

    (a) not in the same **Group** as the prospective response provider; and

    (b) neither engaged on terms, nor party to any other arrangements, which could allow the prospective response provider or any member of its **Group** to exercise undue influence on any assessment of the **Test Certificate** prepared by that technical expert or otherwise compromise the objectivity of any such assessment and test certificate to the **Required Technical Standard**.

Required Technical Standard means, with respect to any assessment and **Test Certificate** prepared by an **Independent Technical Expert** that:

    (a) to the best of the **Independent Technical Expert**'s knowledge and belief all information provided in it is accurate, complete and not misleading; and

    (b) any opinions or forecasts in the assessment have been conservatively prepared on assumptions which it considers to be fair and reasonable.

Subsidiary means a subsidiary within the meaning of section 1159 of the Companies Act 2006 (but relation to an Interconnector, or shareholder in such provider, subsection (1)(a) of that section shall apply as if a "majority of the voting rights" included 50% only of those rights)

Test Certificate means a certificate in the relevant form set out in Schedule 5 prepared by an **Independent Technical Expert**.