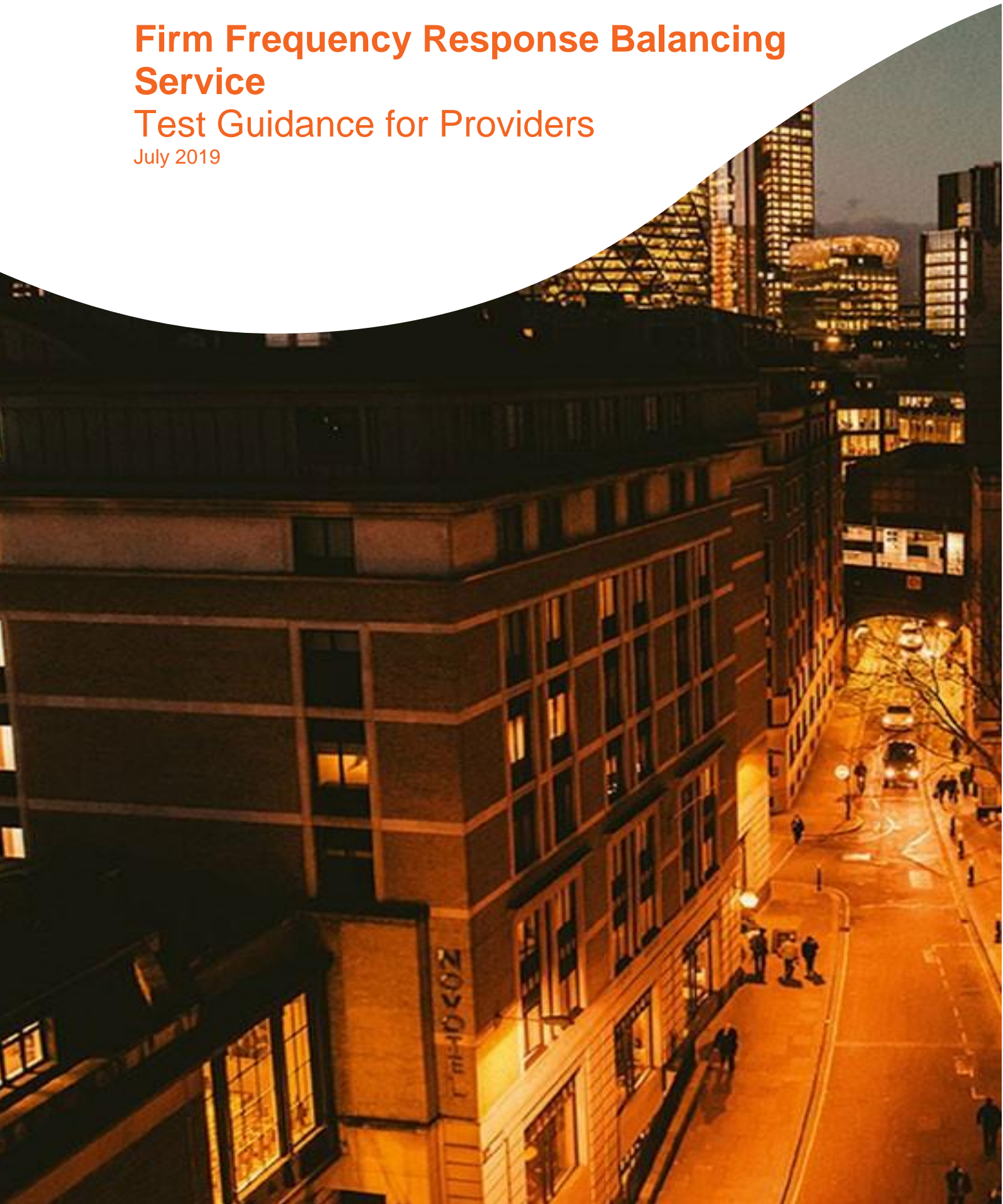# nationalgrid**ESO**

Firm Frequency Response Balancing Service
Test Guidance for Providers

July 2019

Foreword

This document aims to provide guidance to Firm Frequency Response (FFR) providers to National Grid. This document covers the testing requirements for pre-qualification assessment and reproving of this service. The tests outlined in the document are to verify that the requirements of the service specified in contract documents can be met. For any further enquires or questions, contact your Account Manager or:

E-mail   commercial.operation@nationalgrid.com

Telephone   +44 (0) 1926 654611

The test results will be assessed by an Independent Technical Expert (ITE). (See Appendix A)

To complete the pre-qualification requirement, the following information must be submitted to National Grid Electricity System Operator (NGESO):

•   The test data, in the format outlined in Appendix C or F

•   A report from the ITE, in the format outlined in Appendix E or H

•   A CV, setting out the qualifications and experience of the ITE

Contents

1

Test Requirements

Service description

FFR is the change in active power delivered as a response to a change in system frequency. This change in active power could either be from its initial state or a predicted demand level (baseline). FFR can be non-dynamic or dynamic as follows:

Non-Dynamic (also referred to as Static) frequency response is typically a discrete service triggered at a defined frequency deviation.

Table 1– Response Timescale for a Non-Dynamic Service

Contracted Response	Delivery timescale
Secondary timescale	30s – 30min

Figure 1- Example of a Non-Dynamic Response to a Varying Frequency
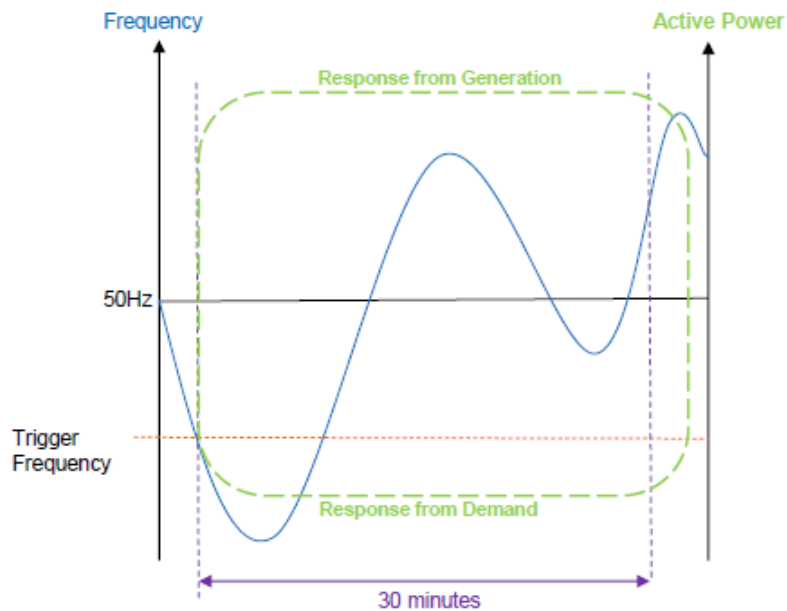
Dynamic frequency response is a continuously provided service used to manage the normal second-by-second changes on the system.

Table 2- Response Timescales for a Dynamic Service

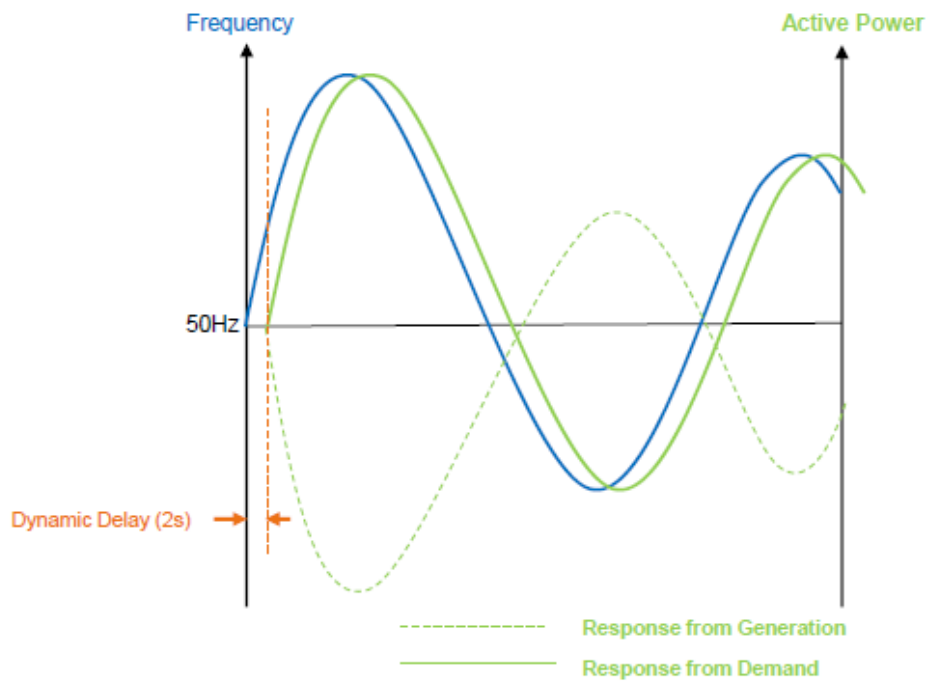| Contracted Response	Delivery timescale
Primary timescale	10s – 30s
Secondary timescale	30s – 30min
High Frequency timescale	10s – 30min (minimum)

Figure 2 - Example of a Dynamic Response to a Varying Frequency

Non-Dynamic FFR Test Requirements

The non-dynamic low frequency test is designed to assess the capability of the provider to deliver the contracted Service described above.

The frequency profile can be injected either at site or remotely. The minimum sample rate for the Test is 1Hz. See Appendix B for information on test signals.

The injected frequency profile used in testing is shown in **Table 3** and **Figure 3** and where the trigger frequency is 49.7Hz.

Table 3 - Frequency Injection Profile for Low Frequency Non-Dynamic Response Testing

Time (s)	0	30	40	80	90	120	420	450	750	780	1080	1110	1410	1440	1740	1770	2010	2100
Injected Frequency (Hz)	50	50	49.72	49.72	50	49.5	49.5	49.8	49.8	49.6	49.6	50.2	50.2	50.4	50.4	50	50	50

Figure 3 – Frequency Injection Profile for Low Frequency Non-Dynamic Response Testing
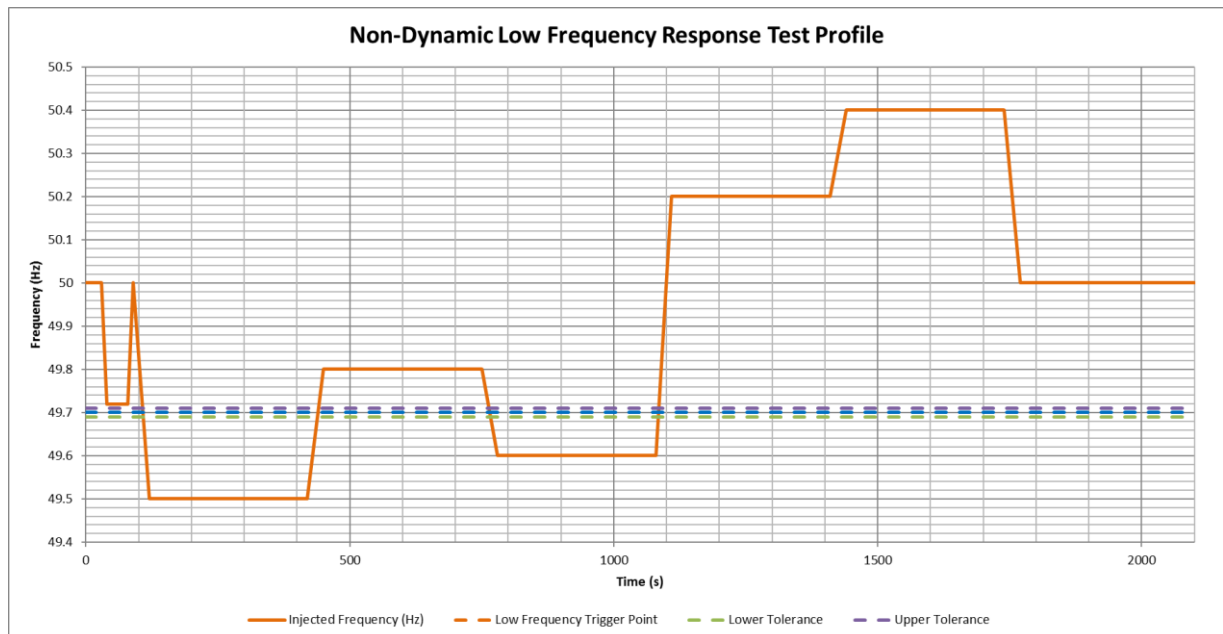
The initial frequency dip to 49.72Hz aims to prove that the relay will not activate (hence no response) if the frequency drops to just above 49.7Hz. During the sweep from 50Hz to 49.5Hz, the relay should trigger at 49.7Hz (±0.01Hz). Once the relay has triggered, full response should be reached within 30 seconds and be sustained for a further 1770 seconds (30 minutes after relay trigger) regardless of the varying frequency injection.

Pass Criteria for Non-Dynamic Test

- An acceptable frequency injection profile is used (See **Table 3**/**Figure 3**).

- The relay (or equivalent) activates at the correct contracted trigger frequency and within the permitted tolerance (±0.01Hz).

- Sustain the response for the 30 minutes. Response volume is assessed as the minimum response observed from 30 seconds to 30 minutes following relay trigger.

- The standard deviation of active power error over a 30 minute period must not exceed 2.5% of the contracted active power change. (Standard deviation is calculated from 30 seconds to 30 minutes following relay trigger).

Aggregation

Where the non-dynamic unit being tested is made up of more than one asset, the test described above can be carried out as follows.

1. Each asset tested and assessed separately with the minimum test volume being added to the unit. This approach can also be used when adding new asset/s to an existing unit.

2. Test carried out on each asset timestamped then results aggregated for assessment.

3. Test all assets within the unit simultaneously.

Dynamic FFR Test Requirements

The dynamic frequency response tests assess the capability of the service provider to deliver dynamic response in accordance with the balancing service 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 1Hz. See Appendix B for information on test signals.

Aggregation/Test Approach

These tests are designed to meet the NGESO requirement for service validation as well as being equally suitable for all types of FFR units (both single-site or multi-site units) 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 3 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 Tests

The two tests described here can be carried out at the individual or group of assets level. These tests confirm the volume of the asset/s for Primary, Secondary and High services, and both demonstrate response within the requisite timescales as well as provision of delivery of the asset/s for required period of the service. The sum of the demonstrated outer-envelope responses for each tested asset in an FFR Unit constitute the total volume of the FFR 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 unit, aggregated with the step test data from that existing pre-tested unit.

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

The frequency injections to be used are shown in **Table 4**, **Figure 4** and **Figure 5** below.

Table 4 - Test 1 Frequency Injection Profile

Time (s)	Injected Frequency (Hz)	
	Test 1.1	Test 1.2
0	50	50
30	50	50
30	49.5	50.5
1830	49.5	50.5
1830	50	50
1860	50	50

Figure 4 - Test 1.1

Injected Frequency (Hz)

Figure 5 - Test 1.2

Injected Frequency (Hz)

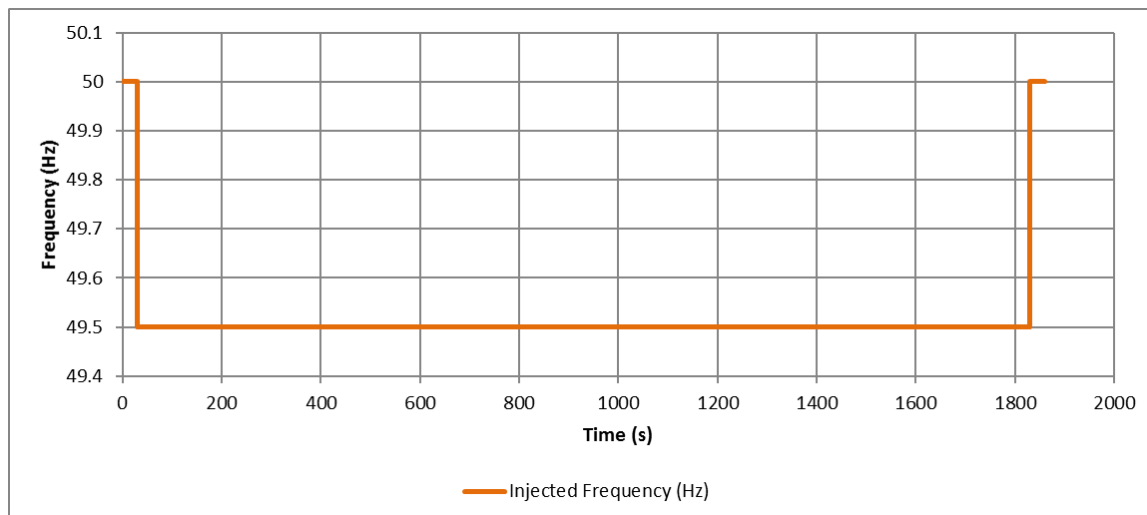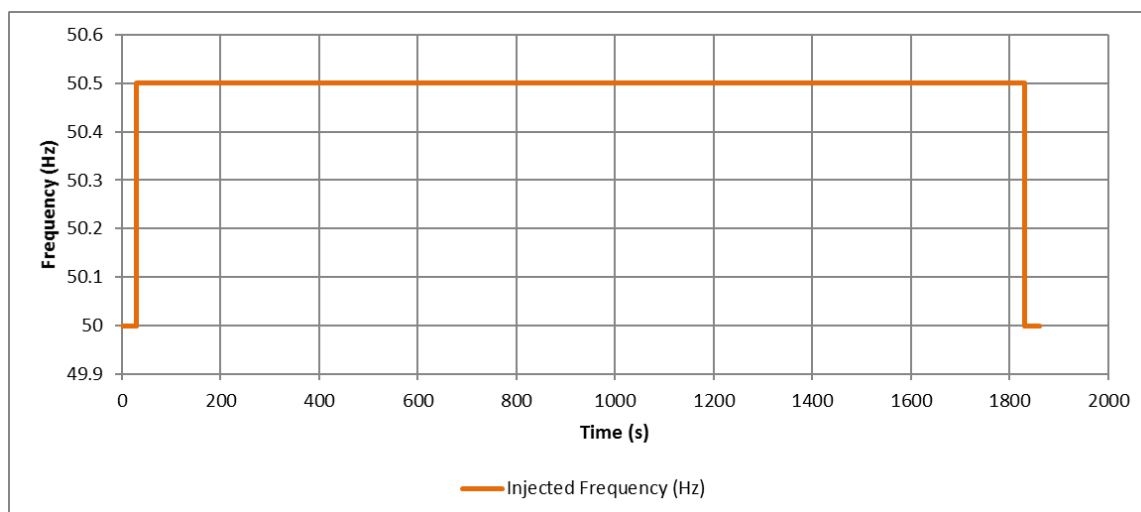## Assessment Criteria for Test 1

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

• Record the minimum of the sampled values of active power response within primary, secondary and high frequency timescales (i.e. the minimum response achieved within each timescale).

• How long is the response sustained? (In some cases this may be less than 30 minutes for a single asset which is part of an aggregated unit).

Pass criteria for Unit level (single asset or aggregation)

• The sum of the minimum of the sampled values of active power response within primary, secondary and high frequency timescales constitute the total volume of the FFR 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 Unit should progressively change to its maximum response.
- 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 response.

  (Standard deviation is assessed from 10 seconds until 30 minutes after the frequency step, unless the contracted values for primary and secondary are different. In this case, standard deviation is assessed from 30 seconds until 30 minutes after the frequency step.)

- Sustain response for 30 minutes.

Test 2 – Response Tests

This test assesses the capability to deliver the following:

- 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 1Hz 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 unit that has been withdrawn from the market for the test period.

Table 5 - Test 2 Frequency Injection Profiles

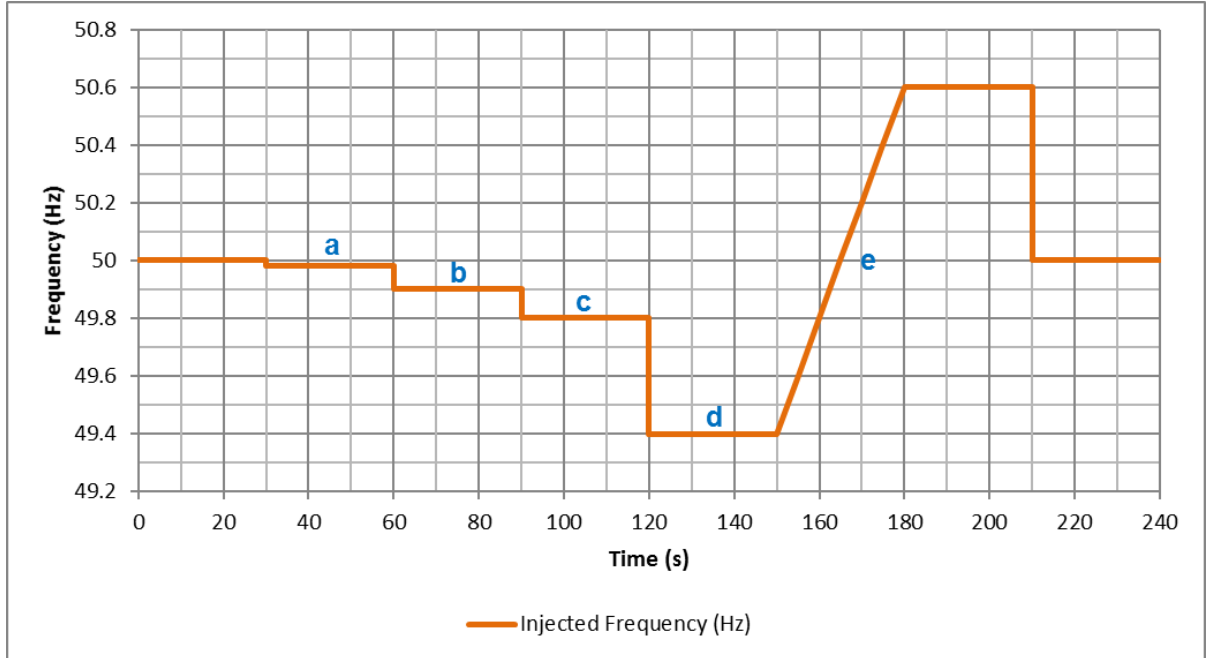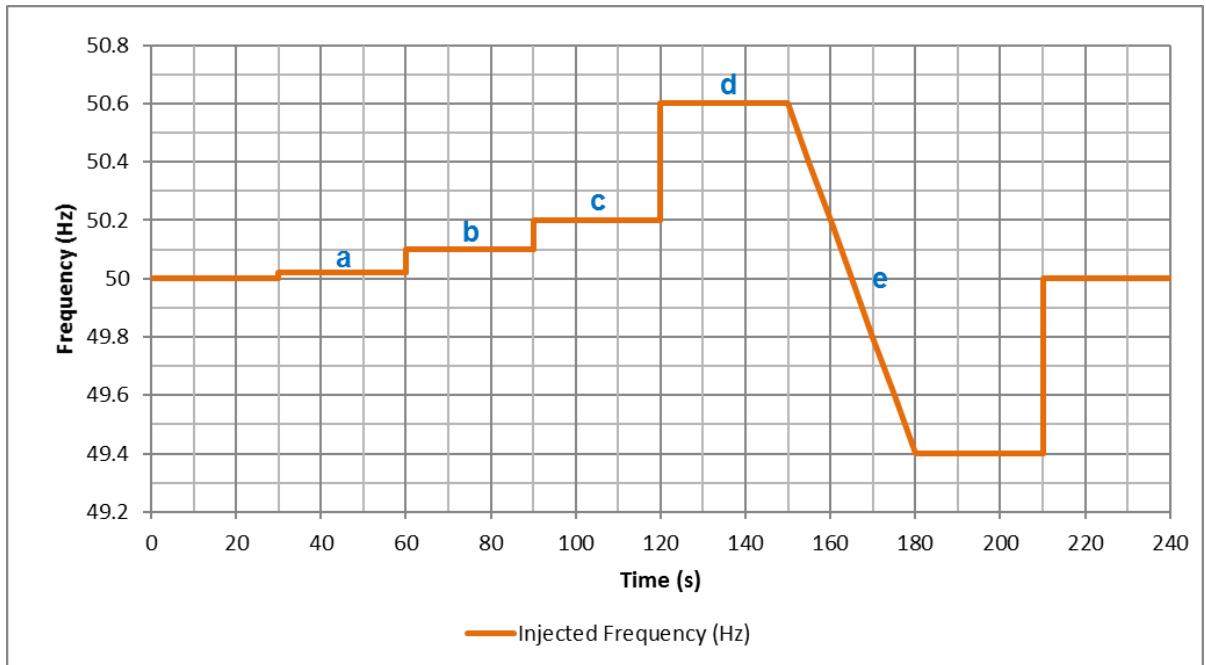| Time (s)	Injected Frequency (Hz)		Sub-test reference for assessment
	Test 2.1	Test 2.2	
0	50	50	
30	50	50	
30	49.98	50.02	a
60	49.98	50.02	a
60	49.9	50.1	b
90	49.9	50.1	b
90	49.8	50.2	c
120	49.8	50.2	c
120	49.4	50.6	d
150	49.4	50.6	d
155	49.6	50.4	e
160	49.8	50.2	e
165	50	50	e
170	50.2	49.8	e
175	50.4	49.6	e
180	50.6	49.4	
210	50.6	49.4	
210	50	50	
240	50	50	

Figure 6 - Test 2.1

Figure 7- Test 2.2

Pass Criteria for Tests 2.1 and 2.2

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

- For ±0.1Hz, ±0.2Hz and steps ±0.6Hz (Tests b, c and d) the primary/high response values achieved are proportional. Also ±0.6Hz sections should reflect total maximum volume from Test 1. For each 30 second step the minimum response from 10-30seconds should be assessed against the contract table. See **Table 6** (**Figure *8*** and **Figure *9***) for tolerances.

- For Test 2.1e and 2.2e, active power response is within the tolerances in ***Table 7***.

Table 6 - Test 2 b, c and d Tolerances

Test	Frequency Deviation (Hz)	Expected Response (Percentage of maximum)	Tolerance (difference between expected and measured)
2.1b, 2.2b	0.1Hz	20	5%/-4%
2.1c, 2.2c	0.2Hz	40	5%/-3%
Derived from Tests b,c and d	0.3Hz	60	5%/-2%
	0.4Hz	80	5%/-1%
2.1d, 2.2d	0.5Hz	100	5%/-0%

Figure 8 - Allowable Power Tolerance for a Negative Gradient Active Power Response
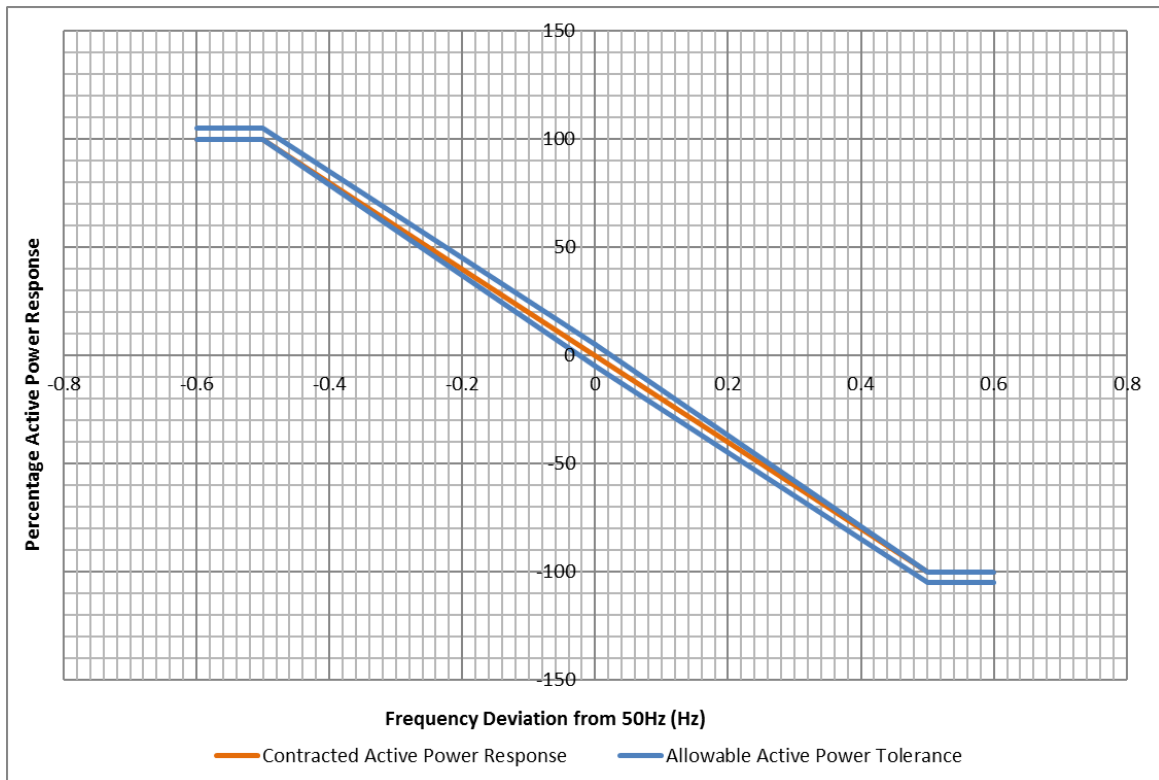
Figure 9 - Allowable Power Tolerance for a Positive Gradient Active Power Response
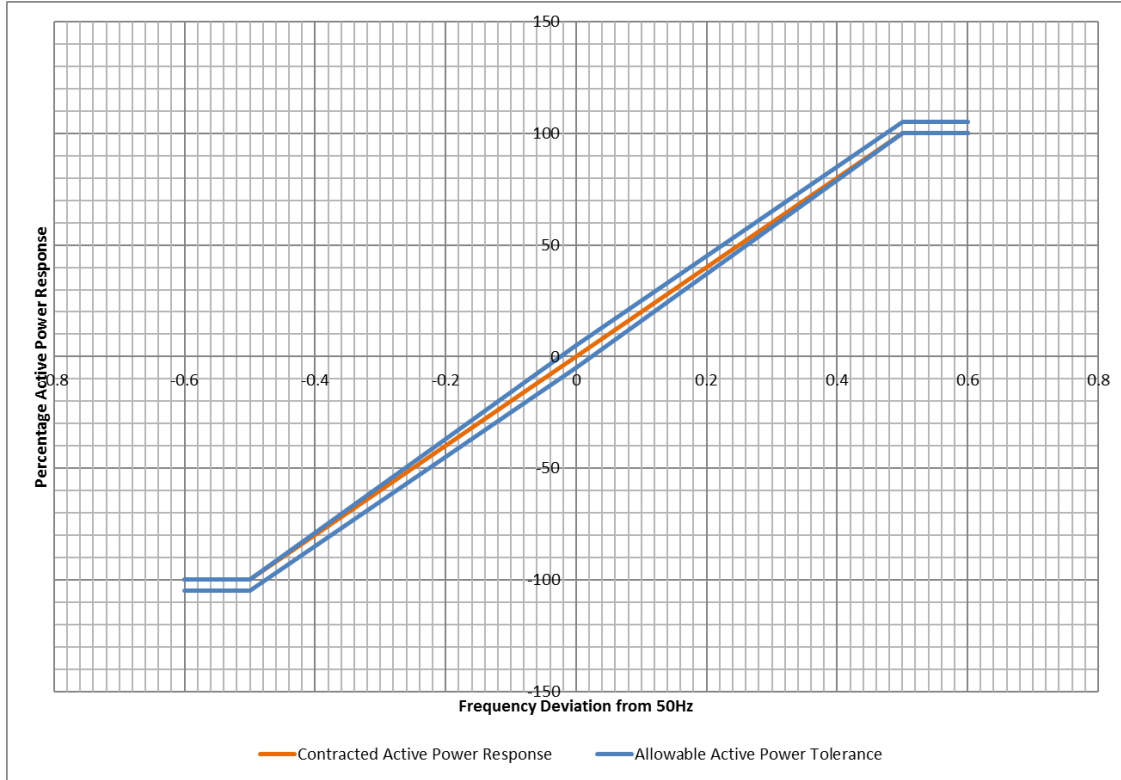
Table 7 - **Test 2.1e and 2.2e Sweep Test tolerances**

| Time (s) | Test 2.1e | | Test 2.2e | |
| | **Negative Active Power Gradient** | | **Positive Active Power Gradient** | |
	Expected Percentage Active Power Response	Tolerance	Expected Percentage Active Power Response	Tolerance
152.5	100	-0%/+5%	-100	-5%/+0%
154.5	84	-0.8%/+21%	-84	-21%/+0.7%
155	80	-1%/+21%	-80	-21%/+1%
157.5	60	-2%/+21%	-60	-21%/+2%
160	40	-3%/+21%	-40	-21%/+3%
162.5	20	-4%/+21%	-20	-21%/+4%
165	0	-5%/+21%	0	-21%/+5%
167.5	-20	-5%/+20.2%	20	-20.2%/+5%
170	-40	-5%/+19.3%	40	-19.3%/+5%
172.5	-60	-5%/+18.4%	60	-18.5%/+5%
175	-80	-5%/+17.6%	80	-17.6%/+5%
177.5	-100	-5%/+16.7%	100	-16.7%/+5%
179.5	-100	-5%/+0%	100	-0%/+5%

Figure 10 - Test 2.1e Tolerance

Figure 10 - Test 2.1e Tolerance

Figure 11 - Test 2.2e Tolerance

Figure 11 - Test 2.2e Tolerance
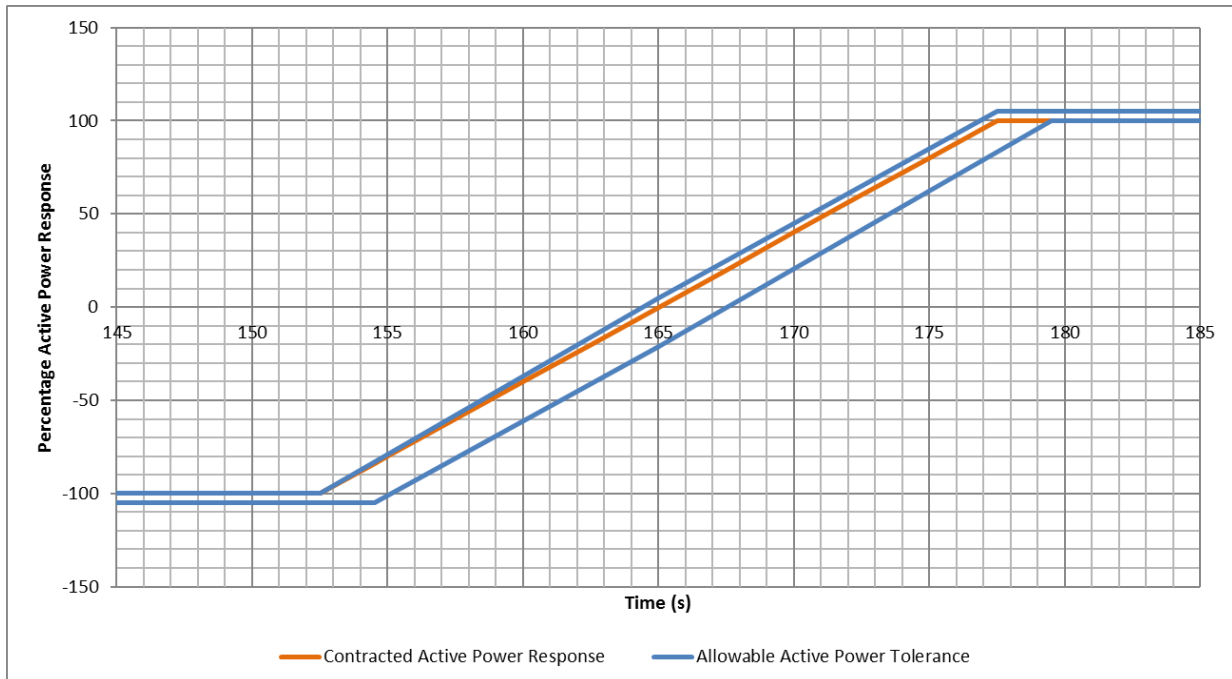
Test 3 – Live System Frequency Response Test

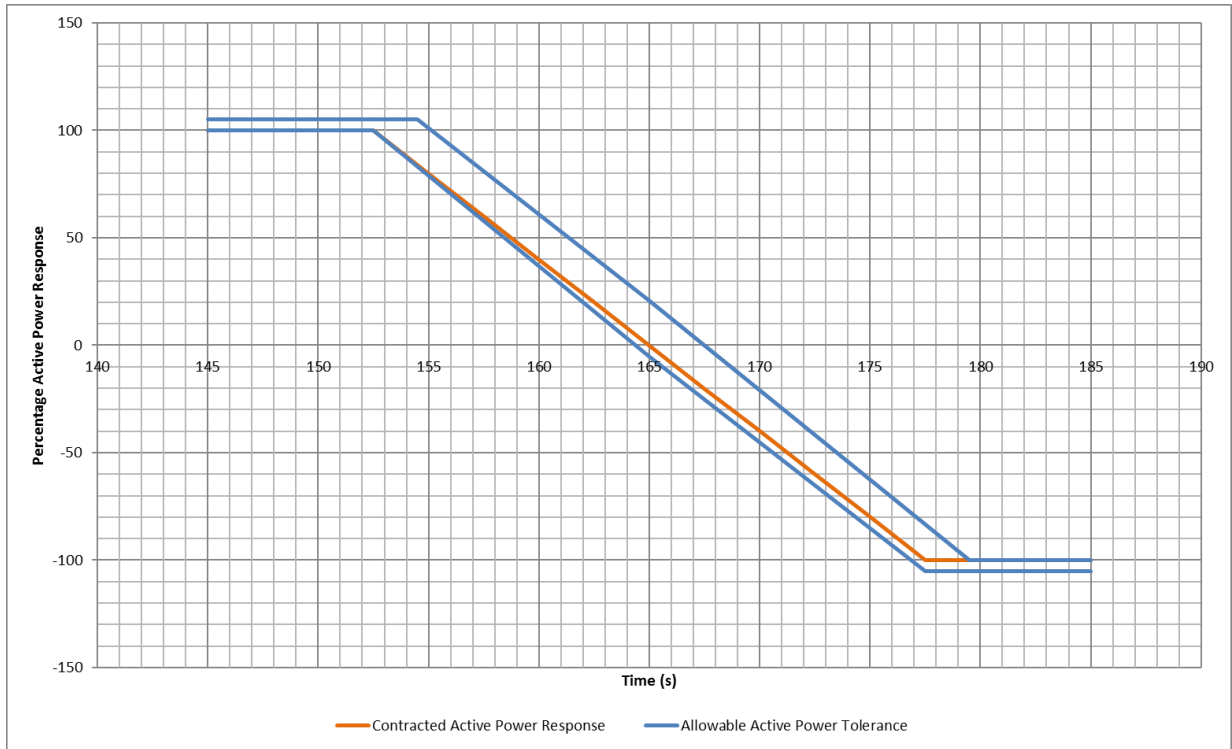This test aims to confirm that the FFR Unit responds as required to system frequency in a live environment. The minimum sample rate for this test is 1Hz and duration is 1 hour where system frequency and active power response will be recorded.

Aggregation

The options for the live test are as follows.

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

Pass Criteria for Test 3

- Provide an active power response consistent with the contracted performance within Primary, Secondary and/or High frequency response timescales.

Figure 12 - Sample System Frequency
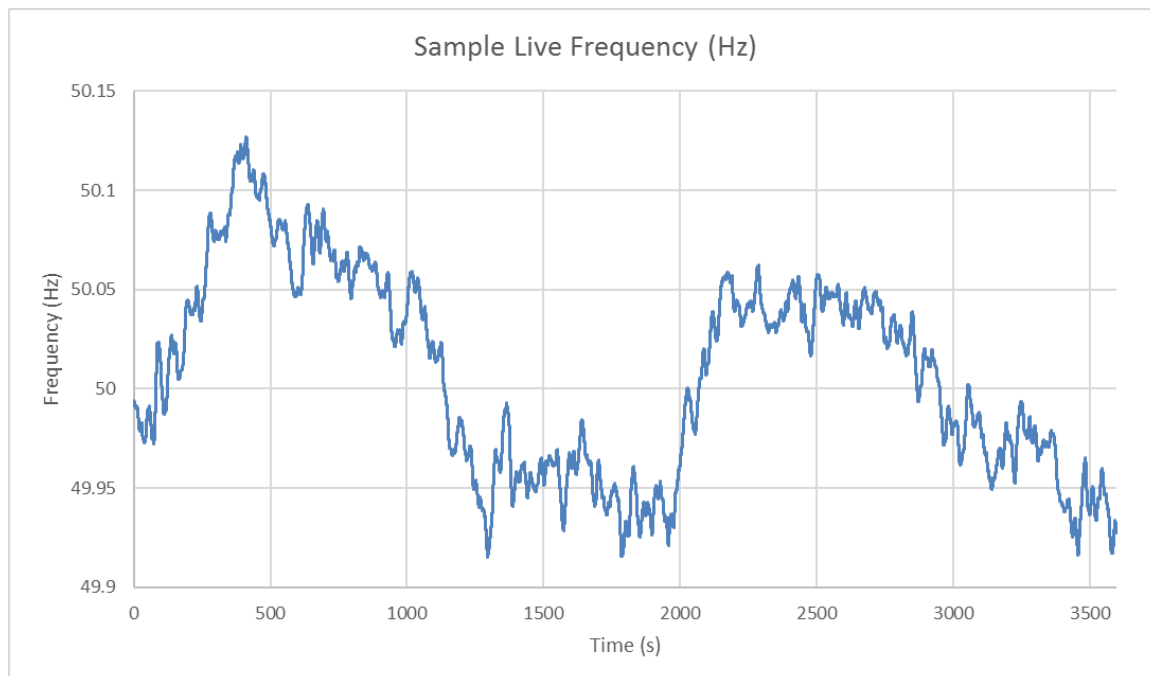
A

Appendices

Appendix A - Independent Technical Expert (ITE)

The FFR test results 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 form set out in Appendix E (non-dynamic) or Appendix H (dynamic) prepared by an **Independent Technical Expert**.

Appendix B – Test Signals

The limits of error and minimum sample rates for testing are shown below in **Table 8** for Non-Dynamic and **Table 9** for Dynamic. All success criteria are subject to the stated limit of error/accuracy threshold.

Table 8 - Limits of error and minimum sample rates for Non-Dynamic Service Testing

	Limit of error/ Accuracy threshold	Minimum Sample rate
Frequency (Hz)	±0.01 Hz	1Hz
Active Power (MW)	Please see pass criteria	1Hz

Table 9 - 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
Frequency (Hz)	±0.01 Hz	10Hz	1Hz
Active Power (MW)	Please see pass criteria	10Hz	1Hz

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 much 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 C - Non-Dynamic Test Data Format

Table 10- Sample Non-Dynamic Test Data Format

Provider	Company Name		
Date	xx-xx-xxxx		
Test	1		
Service	Low Frequency Non-Dynamic Secondary Response		
Location	AA		
Site/Group/Plant	A		
Time	**Injected Frequency (Hz)**	**Measured Power (MW)**	**Relay**
0	50.000	0.000	0
1	50.000	0.000	0
2	50.000	0.000	0
3	50.000	0.000	0
4	50.000	0.000	0
5	50.000	0.000	0
6	50.000	0.000	0
7	50.000	0.000	0
8	50.000	0.000	0
9	50.000	0.000	0
10	50.000	0.000	0
11	50.000	0.000	0
12	50.000	0.000	0
13	50.000	0.000	0
14	50.000	0.000	0
15	50.000	0.000	0
16	50.000	0.000	0

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

Appendix D – Non-Dynamic Test Assessment

Paste test results in to Non-dynamic Excel Analysis Tool – published with User Guide.

Check results against Pass Criteria

- 'An acceptable frequency injection profile is used'.

- The relay (or equivalent) activates at the correct contracted trigger frequency and within the permitted tolerance (±0.01Hz).

- Sustain the response for the 30 minutes. Response volume is assessed as the minimum response observed from 30 seconds to 30 minutes following relay trigger.

- The standard deviation of active power error over a 30 minute period must not exceed 2.5% of the contracted active power change. (Standard deviation is calculated from 30 seconds to 30 minutes following relay trigger).

See Test certificate template in Appendix E for further guidance.

Appendix E – Non-Dynamic Test Certificate Template

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

Prospective Response Provider Company Details

Prospective Response Provider 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	
Aggregation methodology (if appropriate)	
Unit location / ID	
Test date	

Static Service Details

Contracted MW	
Contracted response time	30 seconds
Contracted duration	30 mins
Trigger Frequency Setting	49.7Hz

Test Results

Pass Criteria	Pass / Fail	Comment
An acceptable frequency injection profile is used.	Pass / Fail	
The relay operating point of the plant/unit(s) occurs at the correct contracted trigger frequency and within the permitted tolerance (±0.01Hz).	Pass / Fail	See Figure 1 for sample showing close up of the frequency at which relay operates
The response is sustained for 30 minutes.	Pass / Fail	

Pass Criteria	Pass / Fail	Comment
The standard deviation of active power error over a 30 minute period does not exceed 2.5% of the contracted active power change.	Pass / Fail	Insert test SD value here
Response volume is assessed as the minimum response observed from 30 second to 30 minutes following relay trigger	Pass / Fail	Can be shown in Figure 2 below.
Overall Test Result	**Pass / Fail**	**<Confirm volume validated by test>**

Figure 1 – Relay Operation (sample, to be replaced with test data)
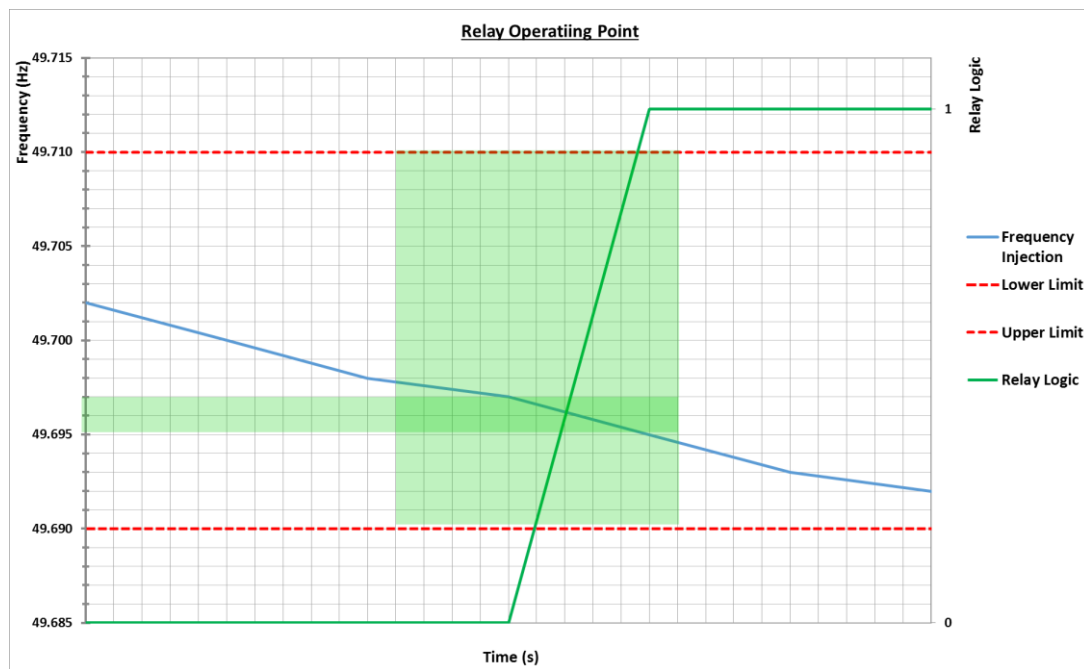
Figure 2 – Overall Response (sample, to be replaced with test data)

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 Appendix A of the NGESO's prevailing Testing Guidelines);

(b) I/We have carried out an assessment of the [asset] described above in accordance with the testing guidelines set out in the Testing Guidelines;

(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 F - Dynamic Test Data Format

Figure 13 - Sample Dynamic Test Data Format

Provider	Company Name	
Date	xx-xx-xxxx	
Test	1	
Service	Dynamic FFR PSH	
Location	AA	
Site/Group/Plant	A	
Time	Injected Frequency (Hz)	Measured Power (MW)
0	50.000	0.000
0.1	50.000	0.000
0.2	50.000	0.000
0.3	50.000	0.000
0.4	50.000	0.000
0.5	50.000	0.000
0.6	50.000	0.000
0.7	50.000	0.000
0.8	50.000	0.000
0.9	50.000	0.000
1	50.000	0.000
1.1	50.000	0.000
1.2	50.000	0.000
1.3	50.000	0.000
1.4	50.000	0.000
1.5	50.000	0.000
1.6	50.000	0.000

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

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

Appendix G – Dynamic Test Assessment

Dynamic Excel Analysis Tool published with User Guide.

See Test certificate template in Appendix H for further guidance.

Appendix H– Dynamic Test Certificate Template

Please use this Test Certificate format and submit to NGESO, 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, e.g. Static or Dynamic	
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	
Contract signed date	
Service start date	
Test date	

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

Deadband	±0.015Hz
Primary response MW	5
Secondary response MW	5
High response MW	5

Test Results

Further relevant test description/commentary here

Table 1 – Contracted vs Actual Response Values

Frequency Deviation (Hz)	Tolerance	Primary (MW)		Secondary (MW)		High (MW)	
		Contracted	Actual	Contracted	Actual	Contracted	Actual
0.1Hz	5%/-4%	1.0	1.0	1.0	1.0	-1.0	-1.0
0.2Hz	5%/-3%	2.0	2.0	2.0	2.0	-2.0	-2.0
0.3Hz	5%/-2%	3.0	3.0	3.0	3.0	-3.0	-3.0
0.4Hz	5%/-1%	4.0	4.0	4.0	4.0	-4.0	-4.0
0.5Hz	5%/-0%	5.0	5.0	5.0	5.0	-5.0	-5.0

(Actual values populated from results of Test 1 and Tests 2a, b and c)

Test	Pass Criteria	Pass/Fail	Comment
Single Asset which will be assessed as part of an aggregated facility.			
1	Record the minimum of the sampled values of active power response within primary, secondary and high frequency timescales (i.e. the minimum response achieved within each 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	The sum of the minimum of the sampled values of active power response within primary, secondary and high frequency timescales constitute the total volume of the FFR unit. (i.e. the minimum total response achieved within each timescale).	Pass	Record result here. Should align with the in-test volume in Table 1.
1	The Unit should progressively change to its maximum response.	Pass	Refer to Figures below.
1	The standard deviation of load error at steady state over a 30 minute period must not exceed	Pass	Standard deviation is assessed from 10 seconds until 30 minutes after the frequency step, unless the contracted

Test	Pass Criteria	Pass/Fail	Comment
	2.5% of the maximum contracted active power response.		values for primary and secondary are different. In this case, standard deviation is assessed from 30 seconds until 30 minutes after the frequency step.
1	Sustain response for 30 minutes.	Pass	
2.1a 2.2a	A noticeable change in power in the correct direction is observed.	Pass	
2.1,2.2 b,c,d	For ±0.1Hz, ±0.2Hz and steps ±0.6Hz steps, the primary/high response values achieved are proportional.	Pass	For each 30 second step the minimum response from 10-30seconds should be assessed against the contract values and inserted in Table 1. See Test Guidance for tolerance table.
2.1e 2.2e	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 within Primary, Secondary and/or High frequency response timescales.	Pass	Figure should show the active power response 'following' frequency as expected. Include a plot where the frequency axis has been reversed and both vertical axes (response and frequency) have been scaled to be consistent with the contract table. Without considering delays, both plots should match and any anomalies can be observed and further investigated/explained.
	Overall Test Result	**PASS**	

Test Result Graphs

Plot frequency injection and active power response vs time for each test.

Figure 1 –

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 Appendix A of the NGESO's prevailing Testing Guidelines);

(b) I/We have carried out an assessment of the [asset] described above in accordance with the testing guidelines set out in the Testing Guidelines;

(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 I - Test 3 Approach

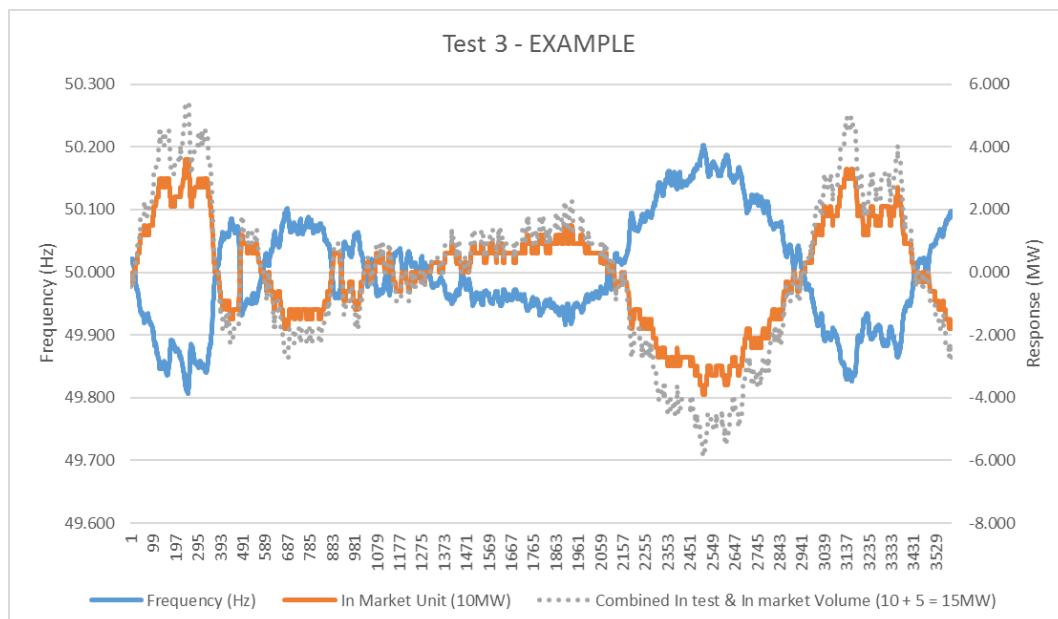The options for the live test are as follows.

1. A single asset capable of meeting dynamic FFR 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 dynamic FFR 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 FFR Unit.

3. New asset/s to be added to an existing FFR Unit can carry out a live test where the new "in-test" assets would be added to the existing FFR 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 FFR 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 NGESO should be informed.

The test approach, described in option 3 above, would be carried out for an agreed 1-hour period with NGESO. 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.

An ideal dataset example for a volume by itself (10MW) or a combined volume (15MW, with 10MW "in-market" volume combined with 5MW "in-test" volume) is shown in **Figure 14**. If testing for Option 3, above, the frequency data and combined "in-test" and "in-market" volume response data would be submitted for validation.

Figure 14 - Test 3 Example

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