



National Grid

CONSULTATION DOCUMENT

CUSC Amendment Proposal CAP001 Frequency Response Imbalance Payments

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1.0 Executive Summary

- 1.1 The Balancing Service of mandatory frequency response is set out and described in Connection Condition 8.1 of the Grid Code. All licensed generators are required to provide mandatory frequency response.
- 1.2 A mechanism was introduced at NETA Go-live which was intended to compensate Generators for imbalance charges incurred under the Balancing and Settlement Code (BSC) when mandatory frequency response was provided. The mechanism (known as imbalance compensation) was discussed and agreed at a sub-group of the Transmission Users' Group (TUG), and was subsequently implemented via the NETA Implementation Scheme in the Mandatory Services Agreements (MSA).
- 1.3 Under NETA, imbalance charges arise for a number of reasons, frequency response provision being just one of them. However, a number of providers raised concerns that the level of imbalance compensation as calculated via the MSA's, did not, in certain circumstances, adequately reflect the actual imbalance charges incurred under the BSC as a result of actual provision of frequency response. As a consequence, some generators indicated their concern in continuing to provide the mandatory service when the costs of provision may not have been adequately compensated.
- 1.4 The mechanism for imbalance compensation, as described within the MSA, was codified into the designated CUSC documentation, which had been scheduled for implementation on 18th July 2001. It had been the intention to propose a CUSC modification to allow the imbalance compensation mechanism to be reviewed under the new Governance arrangements described in the CUSC. However, in view of the announcement to delay CUSC implementation, a CUSC Amendment Proposal could not be raised until CUSC was implemented.
- 1.5 It was thought that, assuming it was found necessary to revise the imbalance arrangements, such a delay would introduce an unnecessary hold-up before the issue regarding imbalance could be considered. Therefore, the proposal to set up an informal working group was suggested. The approach was discussed with Ofgem who were comfortable that an informal 'pre-CUSC' working group was established with a view to National Grid formally proposing a modification at a later date.
- 1.6 Terms of Reference were agreed for the Working Group and further to three working group meetings and associated debate and correspondence, it was the combined view of the Working Group that the mechanism for imbalance compensation should be modified as follows:

- (i) Calculate response energy for each minute of each settlement period using minute average frequency thereby providing a more accurate calculation of a generator's response energy volume;
 - (ii) Calculate assumed response energy by dual linear interpolation between frequency deviation and de-load data in the response capability matrix contained in the MSA thereby removing the need for the use of adjustment factors;
 - (iii) For generating units selected to provide primary and high frequency response the mechanism should continue to use primary and high contract values to calculate response energy, but for primary, secondary and high frequency response, use the average of the primary and secondary contract values to calculate the low frequency response energy thereby improving the approximation of generators actual imbalance; and
 - (iv) Replicate the BSC algebra to calculate a payment to compensate generators for their associated exposure to non-delivery charges.
- 1.6 There was also a fifth issue relating to Frequency Response imbalance on which the Working Group did not reach agreement. This issue was related to the reference price used in the calculation of response delivery i.e. the cost or saved cost of energy production.
- 1.7 The views of this Working Group formed the basis of a CUSC Amendment Proposal (CAP001) that was submitted by National Grid. This Amendment Proposal was presented to the CUSC Amendments Panel on 21 September 2001. The Amendments Panel had been recommended to endorse Amendment Proposal (CAP001) and approve that it be subject to the Urgent Amendment procedure.
- 1.8 At the 21 September 2001 meeting, the CUSC Amendments Panel endorsed Amendment Proposal CAP001 and agreed that the proposal should be treated as urgent subject to a short period of consultation. Further to this meeting, the Authority has given approval (in accordance with CUSC 8.21) for this Amendment to be treated as an Urgent Amendment subject to wider consultation. This document initiates this wider consultation period and invites views on Amendment Proposal CAP001. The consultation closing date is 5 October 2001.

2.0 Introduction

- 2.1 This is a consultation document issued by National Grid under the rules and procedures specified in the Connection and Use of System Code (CUSC) as designated by the Secretary of State. It addresses issues associated with the Mandatory Frequency Response provisions set out in Section 4 of the CUSC.
- 2.2 Further to the submission of Amendment Proposal CAP001 (see Annex 1), and the endorsement of the changes by the Amendments Panel via the Urgent Amendment Procedure, this document seeks views from Industry members relating to the proposed amendment. Such an amendment will result in changes to Section 4.1.3 of the CUSC (as detailed in Annex 2).
- 2.3 This document outlines the nature of the CUSC changes that are proposed for implementation with effect from 21 September 2001. It indicates any relevant issues that arose in the informal, pre-CUSC Working Group discussions and also incorporates National Grid's and the Amendments Panel's views on the way forward concerning this Amendment. Representations received in response to this consultation document will be included in National Grid's Amendment Report that will be furnished to the Authority for their Direction.
- 2.4 This consultation document has been prepared in accordance with the terms of the CUSC. An electronic copy can be found on the National Grid website, at <http://www.nationalgridinfo.co.uk/cusc>.

3.0 Responses to Consultation

- 3.1 Please send your responses to this consultation document to National Grid by no later than close of business 5 October 2001.
- 3.2 Please address all comments to the following e-mail address:
david.friend@uk.ngrid.com

4.0 Amendment Proposal and Working Group Discussion

4.1 The Proposed Amendment Proposal

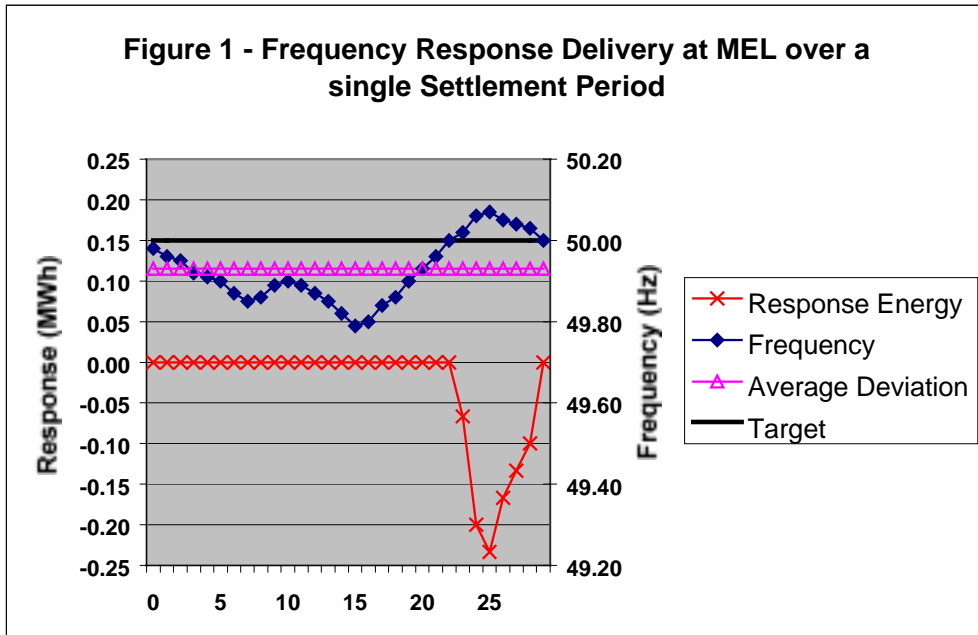
4.1.1 The CUSC Amendment Proposal CAP001 (see Annex 1) as submitted by National Grid is based on the work undertaken by the informal Frequency Response Imbalance Working Group. The Amendment proposes a better approximation of assumed energy imbalance when calculating compensation payments. These improvements to the payment mechanism are:

- Per minute average frequency calculations;
- Detailed interpolation of the response matrix;
- Use of Secondary response values from the matrix; and
- Compensation for non-delivery charges.

Per-minute Response Energy Calculations

4.1.2 The mechanism introduced at NETA go-live calculates response energy within a settlement period based on the net frequency deviation within that period. This is satisfactory where the response capability for a given generator is broadly the same for low and high frequency response i.e. symmetrical. However, where this is not the case, this method can lead to providers being exposed to energy imbalance volumes that are not adequately reflected in the payment mechanism.

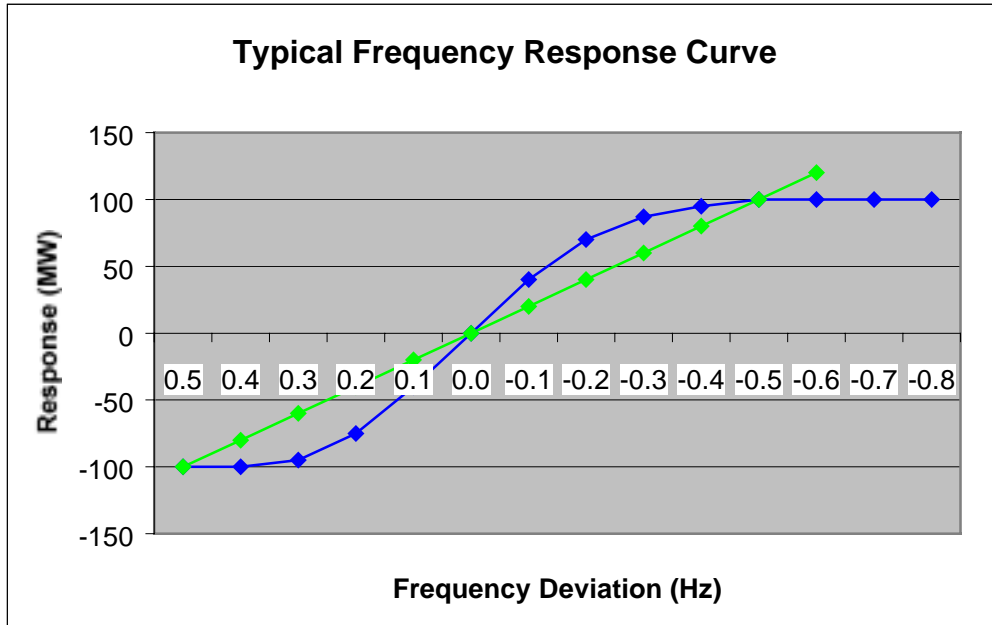
4.1.3 Figure 1 below illustrates a simple example of how this could occur within a single settlement period with a generator operating at maximum export limit (MEL). When at MEL, a generating unit can provide only high frequency response. In the example, no response energy is assumed for the settlement period because the average frequency deviation is negative i.e. a low frequency period. However, if the response delivery is considered to a finer resolution within the period, such a generator will have provided high frequency response energy (reduction in output) for several minutes within the period and will be exposed to SBP for this energy with no imbalance compensation payment.



4.1.4 Calculating response energy for each minute of each settlement period provides a more accurate calculation of a generator’s response energy volume and considerably reduces the margin for error. The assumed response energy volume would be calculated by using the average frequency deviation for each minute. Payment calculations would still be undertaken on a settlement period basis but be based on the sum of the response energy over the 30 minutes.

Dual Linear Interpolation of Response Matrix

4.1.5. The mechanism introduced at NETA go-live uses a simple linear interpolation of the matrix value at a 0.5Hz deviation. As can be seen from the graph below, this simple linear interpolation alone underestimates the assumed response energy. To compensate for this, the mechanism included the use of adjustment factors to scale up the calculated response energy.



- 4.1.6 Adjustment factors of 1.5 for low frequency response and 1.2 for high frequency had been calculated from a sample of 12 generating units based on the de-load data for approximately 75% of full load. Use of these adjustment factors leads to an over or under estimation of the response energy within the imbalance payment mechanism depending on the actual response characteristic of the generating unit and actual frequency deviation.
- 4.1.7 Calculating assumed response energy by detailed linear interpolation of the response capability matrix contained within the contract therefore removes the need for these adjustment factors. On a per minute basis (as described above) the mechanism can take the average frequency in the minute and the de-load of the generator and perform a dual linear interpolation between data points within the matrix.

Use of Secondary Response Values

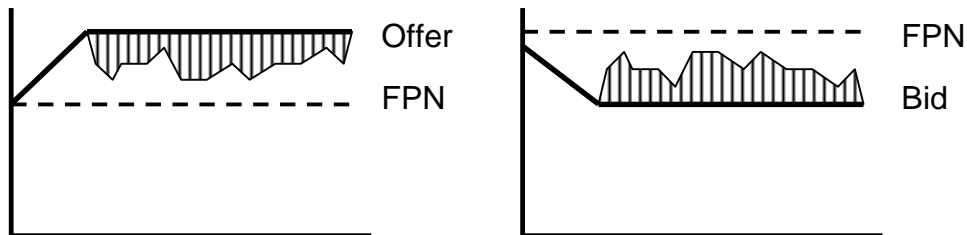
- 4.1.8 The mechanism introduced at NETA go-live uses values of Primary and High Frequency response capability contained within the response matrix. These values by definition reflect the power delivered in response to a change in system frequency within 10 seconds from the time of the frequency deviation.
- 4.1.9 When a generator is selected for Primary and High Frequency response, it was concluded that use of the Primary and High values contained within the matrix, is a fair approximation of the response delivered on a continuing basis. However, when a generating unit is selected for Primary, Secondary and High, the low frequency response energy calculated can be considerably underestimated by using the Primary value alone.

- 4.1.10 It is therefore considered more appropriate to reflect the additional low frequency response power that is delivered after primary response time-scales i.e. 10 seconds. By taking the average of Primary and Secondary values it is possible to more closely approximate actual imbalance arising from the provision of frequency response.

Compensation for Non-delivery Charges

- 4.1.11 In addition to imbalance charges, generators may also be exposed to non-delivery charges whilst providing response following acceptance of a Bid or Offer by the System Operator. No compensation is currently paid for this non-delivery exposure. The algebra for calculating non-delivery is outlined in the BSC and ensures that generators are exposed to the most onerous of SSP/SBP or their Bid/Offer price for a shortfall against a Bid-Offer acceptance. This non-delivery algebra can be simply represented as:

$$\begin{aligned} \text{CNDO} &= \text{Max} \{(\text{Offer} - \text{SBP}), 0\}, \text{ for non-delivery against an Offer} \\ \text{CNDB} &= \text{Min} \{(\text{Bid} - \text{SSP}), 0\}, \text{ for non-delivery against a Bid} \\ \text{CND} &= \text{CNDO} + \text{CNDB}, \text{ for the total non-delivery charge} \end{aligned}$$



- 4.1.12 It is proposed that the algebra for calculating non-delivery contained in the BSC is replicated to calculate a compensation payment for this exposure. The non-delivery charge (CND), can be recalculated based on an expected metered output including response power (CNDR), and a refund (RNDC) be calculated as follows:

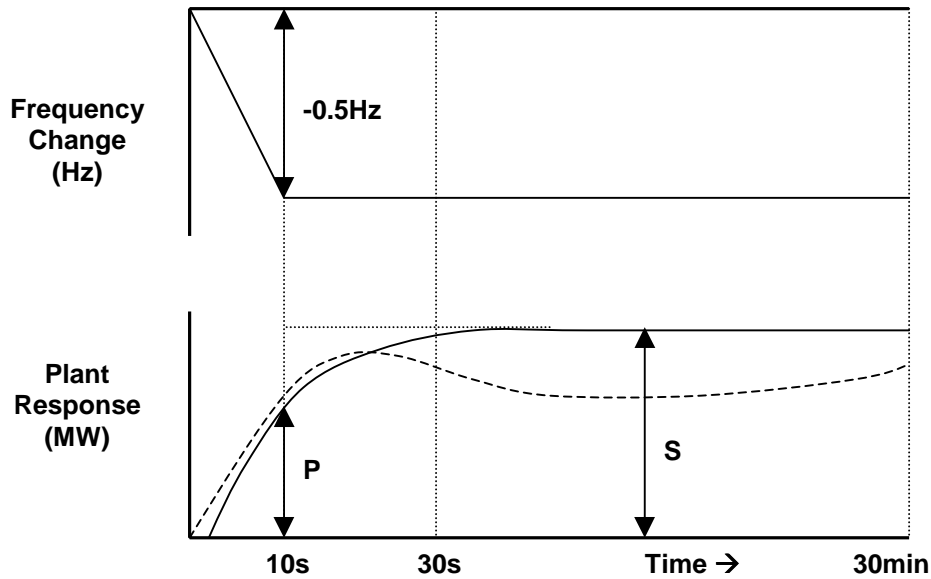
$$\text{RNDC} = \text{CND} - \text{CNDR}$$

4.2 Working Group Views and Discussion

- 4.2.1 There was general agreement within the informal, pre-CUSC Working Group that the proposal as detailed above and in CAP001 would provide a better approximation of the actual imbalance incurred by a generator when providing mandatory frequency response. There was in addition a further issue raised within the Working Group and that was discussed in further detail. This was the issue of frequency response delivery.

Frequency Response Energy Delivery

- 4.2.3 A Working Group member raised an issue with the calculation of response energy for generators when providing Primary response only i.e. no Secondary. The member argued that the definition of Primary response is such that power is delivered within 10 seconds and then sustained for a further 20 seconds. Therefore, when a generator provides only Primary, the current mechanism (and National Grid proposal) may over-estimate the response energy delivered to the system.
- 4.2.4 Following an investigation and presentation by National Grid it was considered that response energy calculations on a per minute basis, using the Primary values contained within the response matrix, would give a reasonable approximation of response energy delivered to the system. The reasoning for this conclusion was that typically generators provide a frequency following service responding to small variations in system frequency. The response delivery is typically in line with a generator's Primary response characteristic because deviations are not usually large enough to use all of this stored primary response. When large deviations occur, response delivery will be over-estimated but these large frequency deviations are relatively uncommon and any payment mechanism should therefore be based around typical conditions.
- 4.2.5 Another Working Group member raised an issue regarding the delivery of Primary and Secondary response. The member argued that when selected for Primary and Secondary low frequency response, the energy delivered would typically be greater than the Primary value currently used.
- 4.2.6 Following an investigation and presentation by National Grid it was considered that this was indeed the case for certain plant. For example, CCGT plant characteristics are such that response energy increases more gradually than coal and oil fired plant but can, for certain plant, provide good response beyond the 10-second response value.



4.2.7 National Grid investigations found that using the Primary value alone could considerably underestimate the low frequency response delivery of certain CCGT plant. Using the Secondary value alone could overestimate the response energy for these generators because the response is not delivered instantaneously with frequency deviation. National Grid proposed that using the average of Primary and Secondary values provided an improved approximation of the actual response energy delivered for low frequency response.

4.2.8 Working Group members were comfortable that this proposal provided a good approximation to actual response energy. However, one member argued that although this did go some way to capture this additional delivered response energy, it may still underestimate response energy for certain plant considered to be good providers of frequency response. This working group member proposed that depending on governor control algorithms, response energy volume should be calculated based on a generating unit's droop parameter (subject to MEL and SEL and time slope). The Working Group member considered that whereas the response matrix shows the response corresponding to de-load levels, the actual response of certain generators may just follow the droop rules (subject to MEL and SEL) regardless of de-load level. This proposal was not considered appropriate by National Grid and other members of the Working Group because the droop parameter does not take into account MEL / SEL or generator de-load value. In addition, the droop parameter alone does not describe the actual response delivery in the temporal sense i.e. the energy delivered within Primary and Secondary time-scales. For these reasons the use of droop parameter alone could considerably overestimate the response energy delivered to the system.

- 4.2.9 There was also discussion regarding the delivery and possible underestimation of high frequency response. National Grid stated that it could see no evidence that high frequency response energy would be understated by the proposed solution. National Grid further argued that the service definition of high frequency response was for delivery within 10 seconds. No additional definition exists beyond this because the System Operator can control frequency back down to target more easily with despatch instructions. There was general agreement within the Working Group regarding this issue with the exception of one member (referenced in 4.2.8).

5.0 Summary of Views

5.1 National Grid Recommendation

5.1.1 National Grid recommends that Amendment Proposal CAP001 is implemented to the time-scales proposed on the basis that it better facilitates achievement of the Applicable CUSC Objective (as set out in Condition 10F in paragraph 1a – the efficient discharge by NGC of the obligations imposed on it by the Act and the Transmission Licence).

5.1.2 This is on the grounds that the Transmission Licence obligates National Grid to purchase ancillary services from the most economical sources available to it having regard to the quantity and nature of the ancillary services. The payment calculations outlined in the CUSC for Frequency Response are based on cost reflective charging principles i.e. based and founded upon actual or estimated costs directly incurred by the provider. The proposed amendment will better facilitate achievement of the applicable CUSC objectives by ensuring providers of mandatory frequency response are appropriately reimbursed for costs directly incurred for providing the service. This in turn will ensure that the most economic sources of mandatory frequency response continue to make their full capability available for despatch by National Grid. In addition, this amendment will help to ensure that providers are not over compensated for providing mandatory frequency response.

5.2 Amendments Panel Recommendation

5.2.1 The majority of CUSC Amendments Panel members agreed with National Grid's views outlined above and proposed that the matter be subjected to a short consultation. This is to seek views on the proposed amendment whether the amendment better facilitates the applicable CUSC objectives.

5.3 Views Invited

5.3.1 National Grid is seeking the views of interested parties relating to this Amendment Proposal CAP001. Views are invited on whether CAP001 will provide a better approximation of assumed energy imbalance exposure and thus better facilitates the applicable CUSC objectives by the following improvements to the payment mechanism:

- Per minute average frequency calculations;
- Detailed interpolation of the response matrix;
- Use of Secondary response values from the matrix; and
- Compensation for non-delivery charges.

Annex 1 – CUSC Amendment Proposal

Amendment Proposal Form

Those wishing to propose an Amendment to the CUSC should do so by filling in this “Amendment Proposal Form” that is based on the provisions contained in Section 8.15 of the CUSC. The form seeks to ascertain details about the proposed Amendment so that the CUSC Panel can determine more clearly whether the proposal should be considered further by a Working Group or go straight to wider National Grid Consultation.

The Panel Secretary will check that the form has been completed, in accordance with the requirements of the CUSC prior to sending it to the Panel. They will then write back to the Proposer, letting him know the Amendment Proposals reference number, and the date on which the Panel will consider the proposal further.

The form should be returned to:

Mark Cox
Panel Secretary
Commercial Development
National Grid Company plc
National Grid House
Kirby Corner Road
Coventry
CV4 8JY

Or via e-mail to:

CUSC.Team@uk.ngrid.com

(Participants submitting this form by email will need to send a statement to the effect that the proposer acknowledges that on acceptance of the proposal for consideration by the Amendments Panel, a proposer which is not a CUSC Party shall grant a licence in accordance with Paragraph 8.15.7 of the CUSC. A Proposer which is a CUSC Party shall be deemed to have granted this Licence.

Proposers Name:

(Name of party making the proposal)

National Grid.

Proposers Representative:

(The name of the person representing the proposer [and his alternate])

Richard Phillips [John Pettigrew]

Organisations Name:

(Organisation on whose behalf the Amendment is proposed)

National Grid are proposing this urgent amendment (CAP001), however, the proposal is based on the recommendations of the informal, pre-CUSC, Frequency Response Imbalance Working Group that was set up to consider revisions to the imbalance compensation mechanism introduced at NETA go-live.

Organisation Address:

National Grid House
Kirby Corner Road
Coventry
CV4 8JY

Capacity in which the Organisation Proposes to make an Amendment:

(CUSC Party, BSC Party, or Other. Other Parties must submit proposed Amendments via "Energy Watch")

CUSC Party

Description of the issue or defect which the proposed Amendment seeks to address:

(This should be in reasonable, but not excessive detail)

Mandatory Frequency Response is an obligation placed on generators under the Grid Code. The payment mechanism for mandatory frequency response was put in place for the commencement of NETA and was intended to be broadly cost reflective. These mechanisms were reviewed and developed for NETA by the R2P2 (Response / Reserve Procurement Principles) sub group of the Transmission Users Group (TUG).

Mandatory Frequency Response payments comprise of:

- De-load payments via bid / offer acceptance;
- Holding payment to cover the cost of a generator holding frequency response;
- Delivery or imbalance exposure payment.

During development of the payment mechanism, it was considered that the mechanism should be simple and not jeopardise the NETA project. In particular, the intention of the imbalance compensation was that on average providers were left neutral over a period of time. It was not intended to be a "value based" principle but to compensate for energy imbalance from actual

provision of frequency response. In light of experience, a number of providers have raised concerns over the imbalance exposure element of the payment. There are 5 potential shortfalls with the current payment mechanism for imbalance exposure:

- Response energy calculations are performed on a settlement period basis. This is adequate where generators are capable of providing equal volumes of energy for both positive and negative deviations of frequency within the period. However, where this is not the case, providers can be exposed to energy imbalance volumes that are not adequately reflected in the current payment mechanism;
- Response energy is calculated by linearly interpolating between zero and the capability at a 0.5Hz frequency deviation. Because this straight-line interpolation underestimates the actual response capability curve, adjustment factors are used to scale up these values. These factors were calculated for typical response providing generators and because they are not reflective of each individual generator may lead to inaccuracies;
- When selected for primary and secondary low frequency response, the energy delivered by the generator may be greater than the primary response contract value currently used in the volume calculation. This may lead to an underestimation of the low frequency response delivered by the generator;
- The payment calculation does not take into account non-delivery charges that generators may be exposed to following the acceptance of Bids and Offers by National Grid and the delivery of frequency response; and
- The payment calculation takes into account the cost or avoided cost of energy production. This is currently calculated from a monthly average of SSP/SBP data in the preceding month. This so-called reference price has proved to be an inadequate proxy for cost of production as it fails to represent with any degree of reflectivity the differences in production cost across the various plant types on the system.

Description of the proposed Amendment and of its nature and purpose:

(This should be in reasonable but not excessive detail)

The nature of the change is to move to a more accurate estimate of actual imbalance. More specifically, four main changes are proposed:

- Per-minute response energy – calculating response energy for each minute of each settlement period would provide a more accurate calculation of a generator's response energy volume in each settlement period. Payment calculations will still be undertaken on a settlement period basis;

- Detailed interpolation of the response matrix – by linearly interpolating between de-load points and frequency deviation data within the response matrix, a more accurate value of response capability can be ascertained. This will remove the need for adjustment factors and the associated inaccuracy of this element of the payment mechanism;
- For generating units selected to provide primary, secondary and high frequency response – calculating the low frequency response energy of a generator using the average of the primary and secondary contract values improves the approximation of a generators actual imbalance; and
- Compensation for non-delivery charges – using the BSC algebra to calculate non-delivery charges it will be possible to calculate a compensation payment based on the volume of response energy delivered.

Although the fifth shortfall highlighted above (i.e. the issue regarding the payment calculation) was discussed and debated in detail by the informal, pre-CUSC, Frequency Response Imbalance Working Group, no agreement as to a way forward regarding this matter was agreed. The CUSC Panel have therefore been invited to consider how this issue may be taken forward (possibly through further discussion/debate at the proposed Balancing Services Standing Group) as part of the recommendations of the Working Group Report.

An indication of those parts of the CUSC which would require amendment in order to give effect to (or would otherwise affected by) the proposed amendment and an indication of the nature of those amendments or effect.

(This should be given where possible)

Section 4.1.3 – calculation of payments and payment formulae. Amendment required to reflect revised payment for frequency response imbalance as outlined above.

Reasons why the Proposer believes that the proposed Amendment would better facilitate achievement of the Applicable CUSC Objectives as compared with the current version of the CUSC with background information in support thereof.

The Transmission Licence obligates National Grid to purchase ancillary services from the most economical sources available to it having regard to the quantity and nature of the ancillary services. The payment calculations outlined in the CUSC for Frequency Response are based on broadly cost

reflective charging principles i.e. based and founded upon actual or estimated costs directly incurred by the provider.

This proposed amendment will better facilitate the efficient discharge of this licence obligation by aligning more accurately payments made with costs incurred, producing greater transparency in the relative costs of service provision. This in turn will ensure that the most economic sources of mandatory frequency response continue to make their full capability available for despatch by National Grid. In addition, this amendment will ensure that providers are not over compensated for providing mandatory frequency response.

An indication of the impact of the proposed Amendment on Core Industry Documents.

(This should be given where possible)

No impact on BSC, Grid Code or any other core industry document is foreseen.

The revised formulae may require a change to National Grid’s incentive scheme target and consequently the Transmission Licence.

An indication of the impact of the proposed Amendment on relevant computer systems and processes used by CUSC Parties.

(This should be given where possible)

The proposed amendment will require modification to the payment calculation system (GENRES) used by National Grid to calculate the Frequency Response payments.

There will be no significant impact on processes used by CUSC Parties.

A statement to the effect that the Proposer acknowledges that on acceptance of the proposal for consideration by the Amendments Panel a Proposer shall grant a licence in accordance with 8.15.7 of the CUSC.

(A signature to this effect must be given.)

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Annex 2 – Proposed Text to Modify CUSC

DRAFT TEXT TO ACCOMPANY PROPOSED CUSC MODIFICATION**Draft 3****25 September 2001****4.1.3 Frequency Response***Introduction*

4.1.3.1 Each applicable **User** is obliged to provide (for the avoidance of doubt, as determined by any direction in force from time to time and issued by the **Authority** relieving that **User** from the obligation under its **Licence** to comply with such part or parts of the **Grid Code** or any **Distribution Code** or, in the case of **NGC**, the **Transmission Licence**, as may be specified in such direction) the **Mandatory Ancillary Service of Frequency Response** referred to in **Grid Code CC 8.1** by means of **Frequency** sensitive generation in accordance with the terms of this Paragraph 4.1.3 and a **Mandatory Services Agreement** but subject always to and in accordance with the relevant part or parts of the **Grid Code** applicable thereto.

Definitions

4.1.3.2 For the purposes of this Paragraph 4.1.3:

- (i) “**Frequency Response Service**” means the **Mandatory Ancillary Service of Frequency Response** and any **Commercial Ancillary Service of Frequency Response** as may be agreed to be provided by a **User** from time to time;
- (ii) the **Mandatory Ancillary Service of Frequency Response** shall constitute operation of a **BM Unit** in accordance with **Grid Code CC 6.3.7** and **BC 3.5** (with the exception of **BC 3.5.2**), including, without limitation, under normal operating conditions with the speed governor set so that it operates with an overall speed droop of between 3% and 5% so as to provide the applicable levels of **Response** referred to in Paragraph 4.1.3.7;
- (iii) the term "instruction" means a communication whether by telephone or automatic logging device or facsimile from **NGC** to the **User** instructing a **User** in accordance with **Grid Code BC 2.8** and this Paragraph 4.1.3 to provide any **Frequency Response Service**, and derivations of the term shall be construed accordingly;
- (iv) the amendment of an existing instruction shall be deemed to be a new instruction;
- (v) an instruction will prevail until either it is countermanded by **NGC** or until the **BM Unit** to which the instruction relates is **De-synchronised** (whichever is first to occur).

NGC's Instructions to provide Mode A Frequency Response

4.1.3.3 For the purposes of instructions and calculation of payments, the **Mandatory Ancillary Service of Frequency Response** as described in this Paragraph 4.1.3 shall be referred to as "**Mode A Frequency Response**".

4.1.3.4 **NGC** may at any time instruct a **User** to operate any one or more **BM Unit(s)** so as to provide the following components of **Mode A Frequency Response**:-

- (a) **Primary Response;**
- (b) **Secondary Response;**
- (c) **High Frequency Response,**

in any of the permissible combinations set out in the relevant table in the **Mandatory Services Agreement**.

4.1.3.5 **NGC** shall not instruct a **User** to provide **Mode A Frequency Response** and any **Commercial Ancillary Service of Frequency Response** simultaneously.

4.1.3.6 In the event that any instruction to provide **Frequency Response** does not state whether the instruction is to provide **Mode A Frequency Response** or any **Commercial Ancillary Service of Frequency Response**, such instruction shall be deemed to be an instruction to provide **Mode A Frequency Response**.

User's Obligation to Provide Response

4.1.3.7 When a **User** is instructed in accordance with Paragraphs 4.1.3.4 and/or 4.1.3.6 to operate a **BM Unit** so as to provide any component(s) of **Mode A Frequency Response**, that **User** shall operate that **BM Unit** so as to provide, for any **Frequency Deviation** and at any level of **De-Load**, at least the amount of **Primary Response** and/or **Secondary Response** and/or **High Frequency Response** set out respectively in the relevant tables in the **Mandatory Services Agreement** (as such tables are to be interpreted in accordance with Paragraph 4.1.3.11).

Calculation of Payments

4.1.3.8 **The payments to be made by NGC to a User hereunder in respect of the provision of any Mode A Frequency Response from a BM Unit shall be comprised of Holding Payments and Imbalance Compensation Payments and shall be determined in accordance with the formulae in Paragraphin, respectively, Paragraphs 4.1.3.9 and 4.1.3.9A and in accordance with Paragraphs 4.1.3.10 to 4.1.3.12 inclusive by reference to:inclusive.**

~~(i) the capabilities set out in respect of **Primary Response, Secondary Response and High Frequency Response** at given levels of **De-Load** in the summary response table in the **Mandatory Services Agreement**;~~

~~(ii) the payment rates set out in respect of **Primary Response, Secondary Response and High**~~

~~Frequency Response in the relevant payment tables in the Mandatory Services Agreement;~~

(iii) ~~the Frequency energy imbalance exposure rates IE_p and IE_H as calculated in accordance with the relevant formulae in Paragraph 4.1.3.9; and~~

(iv) ~~where a BM Unit is a CCGT Module, the plant configuration adjustment factor set out in the relevant table in the Mandatory Services Agreement;~~

~~and for such purposes references in the formula in Paragraph 4.1.3.9 to instructions shall be deemed to be references to instructions to provide Mode A Frequency Response.~~

~~Payment Formulae - Holding Payments~~

4.1.3.9 ~~The payments~~ The Holding Payments for a BM Unit to be made by NGC to a User referred to in Paragraph 4.1.3.8 shall be calculated in accordance with the following formula:-

$$HP_M = P_M + H_M + S_M$$

Where:

~~L_M is the payment per minute~~ HP_M is the Holding Payment to be made to the User calculated in £ per minute

P_M is the payment per minute to be made by **NGC** to the **User** for the **Ancillary Service of Primary Response** provided by the **User from the BM Unit concerned** pursuant to an instruction from **NGC to provide Mode A Frequency Response**, and is calculated as follows:-

$$P_M = (P_{PR} * P_{MW} (1 - SF_P)) * K_T * K_{GRC} * \left[\frac{1}{60} \right]$$

H_M is the payment per minute to be made by **NGC** to the **User** for the **Ancillary Service of High Frequency Response** provided by the **User from the BM Unit concerned** pursuant to an instruction from **NGC to provide Mode A Frequency Response**, and is calculated as follows:-

$$H_M = (H_{PR} * H_{MW} (1 - SF_H)) * K_T * K_{GRC} * \left[\frac{1}{60} \right]$$

S_M is the payment per minute to be made by **NGC** to the **User** for the **Ancillary Service of Secondary Response** provided by the **User from the BM Unit concerned** pursuant

to an instruction from **NGC to provide Mode A Frequency Response**, and is calculated as follows:-

$$S_M = (S_{PR} * S_{MW} (1 - SF_S)) * K_T * K_{GRC} * \left[\frac{1}{60} \right]$$

Where:

If $\overline{\delta f_j} < 0$ (i.e. net low frequency response delivered)

$$IE_{P_-} = 2 * [\text{adjustment factor}_{\text{low}}] * \left| \overline{\delta f_j} \right| * (\text{reference price} - SSP_j)$$

$$IE_{H_-} = 0$$

Or if $\overline{\delta f_j} > 0$ (i.e. net high frequency response delivered)

$$IE_{H_+} = 2 * [\text{adjustment factor}_{\text{high}}] * \left| \overline{\delta f_j} \right| * (SBP_j - \text{reference price})$$

$$IE_{P_+} = 0$$

Or if $\overline{\delta f_j} = 0$ (i.e. no frequency response delivered)

$$IE_{P_+} = 0$$

$$IE_{H_+} = 0$$

The reference price shall be fixed for the calendar month in question and shall be calculated as follows:-

$$\text{reference price} = \frac{(\overline{SBP_{\text{month}}} + \overline{SSP_{\text{month}}})}{2}$$

Where :

$\overline{SBP_{\text{month}}}$ and $\overline{SSP_{\text{month}}}$ are the calculated time weighted average of SBP_j and SSP_j respectively (each as defined in the **Balancing and Settlement Code**) for the preceding calendar month in which the service is provided.

$\overline{\delta f_j}$ is a factor which is calculated from the average **Frequency Deviation from Target Frequency** for each **Settlement Period**, where the **Target Frequency** shall be deemed to be the **Target Frequency** at the commencement of the **Settlement Period** concerned. For the purpose of this calculation, this **Target Frequency** will be deemed to remain constant for the whole of the **Settlement Period**.

$\overline{\delta f_j}$ shall be calculated using minute by minute frequency sampling

~~$|\delta f_j|$ is the modulus of δf_j~~

and

adjustment factor_{low} = 1.5

adjustment factor_{high} = 1.2

In this Paragraph 4.1.3.9, the following terms shall have the following meanings:-

- P_{PR} = the appropriate payment rate for **Primary Response** set out in the **Mandatory Services Agreement**;
- P_{MW} = the **Primary Response** capability (expressed in MW) for the level of **De-Load** of the **BM Unit** concerned at the end of the minute in which the service is provided;
- H_{PR} = the appropriate payment rate for **High Frequency Response** set out in the **Mandatory Services Agreement**;
- H_{MW} = the **High Frequency Response** capability (expressed in MW) for the level of **De-Load** of the **BM Unit** concerned at the end of the minute in which the service is provided;
- S_{PR} = the appropriate payment rate for **Secondary Response** set out in the **Mandatory Services Agreement**;
- S_{MW} = the **Secondary Response** capability (expressed in MW) for the level of **De-Load** of the **BM Unit** concerned at the end of the minute in which the service is provided;
- K_T = the ambient temperature adjustment factor. **NGC** and each **User** acknowledge and agree, as between **NGC** and that **User**, that K_T shall be deemed to be 1 for the purposes of calculating payments until such time as they agree upon an appropriate formula and a suitable method of measuring the ambient temperature on a minute by minute basis which shall be set out in the **Mandatory Services Agreement**. In the event that any agreed method of measuring the ambient temperature on a minute by minute basis should fail following its implementation, then **NGC** and each **User** acknowledge and agree, as between **NGC** and that **User**, that K_T shall be deemed to be 1 until the method of measuring the ambient temperature on a minute by minute basis is restored;
- K_{GRC} = where the **BM Unit** is a **CCGT Module**, the plant configuration adjustment factor set out in the relevant table in the **Mandatory Services Agreement** for the configuration of the **BM Unit** concerned at the time at which the capability to provide the service is carried, otherwise 1;
- SF_P = 0, subject to Paragraph 4.1.3.25 (e);
- SF_S = 0, subject to Paragraph 4.1.3.25 (e);
- SF_H = 0, subject to Paragraph 4.1.3.25 (e).

Payment Formulae - Imbalance Compensation Payment

4.1.3.9A (a) The Imbalance Compensation Payments [for BM Unit i in Settlement Period j] to be made by NGC to a User referred to in Paragraph 4.1.3.8 shall be comprised of an Imbalance Energy Payment and a Non-Delivery Payment, and shall be calculated in accordance with the following formulae:-

$$\underline{ICP_{ij} = IEP_{ij} + RNDC_{ij}}$$

Where:

ICP_{ij} is the Imbalance Compensation Payment to be made to the User calculated in £ per Settlement Period;

IEP_{ij} is the Imbalance Energy Payment for Settlement Period j calculated in accordance with (b) below; and

RNDC_{ij} is the Non-Delivery Payment for Settlement Period j calculated in accordance with (c) below.

(b) The Imbalance Energy Payment IEP_{ij} for Settlement Period j shall be calculated as follows:-

$$\underline{IEP_{ij} = LFIEP_{ij} + HFIEP_{ij}}$$

Where:

if $IE_{ij} > 0$

then

$$\underline{LFIEP_{ij} = |IE_{ij}| * (\text{reference price} - SSP_j)}$$

$$\underline{HFIEP_{ij} = 0}$$

Otherwise

$$\underline{LFIEP_{ij} = 0}$$

$$\underline{HFIEP_{ij} = |IE_{ij}| * (SBP_j - \text{reference price})}$$

Where IE_{ij} is the expected imbalance energy for BM Unit i in Settlement Period j calculated as follows:-

$$IE_{ij} = \sum_{m \in j} \left(\frac{FR_{mi}}{60} \right)$$

Where:

$\sum_{m \in j}$ represents the sum over all minutes in Settlement Period j for each BM Unit i.

FR_{mi} is the expected Response power for BM Unit i (expressed in MW) derived from the relevant table set out in the Mandatory Services Agreement (as such table is interpreted in accordance with Paragraph 4.1.3.11) by reference to the level of De-Load of the BM Unit concerned at the end of minute m and the mean Frequency Deviation over that minute.

For this purpose:-

- (i) for a positive Frequency Deviation in minute m, the expected change in active power output of BM Unit i shall be derived from the high frequency response capability table set out in the Mandatory Services Agreement; and
- (ii) for a negative Frequency Deviation in minute m, the expected change in active power output of BM Unit i shall be (where the User is instructed to provide Primary Response together with Secondary Response) the mean average value of the Primary Response capability and Secondary Response capability, or (where the User is instructed to provide Primary Response without Secondary Response) Primary Response capability, in each case derived from the low frequency response table set out in the Mandatory Services Agreement.

$$\text{reference price} = \frac{\overline{SBP}_{month} + \overline{SSP}_{month}}{2}$$

Where:

\overline{SBP}_{month} and \overline{SSP}_{month} are the calculated time weighted average of SBPj and SSPj respectively (each as defined in the Balancing and Settlement Code) for the preceding calendar month in which the service is provided.

- (c) The Non-Delivery Payment (RNDCj) for Settlement Period j shall be calculated as follows:-

$$RNDC_{ij} = CND_{ij} - CNDR_{ij}$$

Where:

In respect of each Settlement Period, for each BM Unit, the Period BM Unit Non-Delivered Offer Volume (Revised) will be determined as follows:

$$\underline{QNDOR_{ij} = \min(\max(QME_{ij} + IE_{ij} - QM_{ij}, 0), \sum_n QAO_{ij}^n)}$$

where \sum_n represents the sum over all Bid-Offer Pair Numbers for the Accepted Offer Volumes for the BM Unit.

In respect of each Settlement Period, for each BM Unit, the Period BM Unit Non-Delivered Bid Volume (Revised) will be determined as follows:

$$\underline{QNDBR_{ij} = \max(\min(QME_{ij} + IE_{ij} - QM_{ij}, 0), \sum_n QAB_{ij}^n)}$$

where \sum_n represents the sum over all Bid-Offer Pair Numbers for the Accepted Bid Volumes for the BM Unit.

In respect of each Settlement Period, for each BM Unit, if the Period BM Non-Delivered Offer Volume (Revised) is greater than zero then to determine values of Offer Non-Delivery Volume (Revised) ($QNDOR_{ij}^n$), the Period BM Unit Non-Delivered Offer Volume (Revised) will be apportioned across accepted Offers, in the following way.

In respect of each Settlement Period, the set of all accepted Offers will be ranked in order of decreasing price. The accepted Offer with the highest price will be allocated Non-Delivery Order Number 1, the next highest priced accepted Offer will be allocated Non-Delivery Order Number 2 and so on until all accepted Offers for the Settlement Period have been allocated a Non-Delivery Order Number. The set of accepted Offers $\{QAO_{ij}^{n1}, QAO_{ij}^{n2}, \dots, QAO_{ij}^{nu}, \dots\}$ is then a ranked set of accepted Offers.

The Offer Non-Delivery Volume (Revised) will be allocated to the first accepted Offer in the list first, then, once the first accepted Offer has been wholly accepted, to the second accepted Offer and so on until the Period BM Unit Non-Delivered Offer Volume (Revised) is fully apportioned.

Then the Offer Non-Delivery Volume (Revised) for accepted Offer n, is:

$$\underline{QNDOR_{ij}^n = \min(QAO_{ij}^{nu}, RQNDOR_{ij}^{u-1})}$$

where $RQNDOR_{ij}^{u-1}$ is the **Remaining Period BM Unit Non-Delivered Offer Volume (Revised)** determined as:

$$RQNDOR_{ij}^u = RQNDOR_{ij}^{u-1} - QNDOR_{ij}^{n_{u-1}}$$

and $RQNDOR_{ij}^0 = QNDOR_{ij}$

and $QNDOR_{ij}^{n_o} = 0$.

In respect of each **Settlement Period**, for each **BM Unit**, if the **Period BM Non-Delivered Bid Volume (Revised)** is less than zero then to determine values of **Bid Non-Delivery Volume (QNDBRⁿ_{ij})**, the **Period BM Unit Non-Delivered Bid Volume (Revised)** will be apportioned across accepted **Bids**, in the following way.

In respect of each **Settlement Period**, the set of all accepted **Bids** will be ranked in order of increasing price. The accepted **Bid** with the lowest price is allocated **Non-Delivery Order Number 1**, the next lowest priced accepted **Bid** is allocated **Non-Delivery Order Number 2** and so on until all accepted **Bids** for the **Settlement Period** have been allocated a **Non-Delivery Order Number**. The set of accepted **Bids** $\{QAB_{ij}^{n_1}, QAB_{ij}^{n_2}, \dots, QAB_{ij}^{n_u}, \dots\}$ is then a ranked set of accepted **Bids**.

The **Bid Non-Delivery Volume (Revised)** will be allocated to the first accepted **Bid** in the list first, then, once the first accepted **Bid** has been wholly accepted, to the second accepted **Bid** and so on until the **Period BM Unit Non-Delivered Bid Volume** is fully apportioned.

Then the **Bid Non-Delivery Volume (Revised)** for accepted **Bid n**, is:

$$QNDBR_{ij}^n = \min(QAB_{ij}^{n_u}, RQNDOR_{ij}^{u-1})$$

where $RQNDOR_{ij}^{u-1}$ is the **Remaining Period BM Unit Non-Delivered Bid Volume (Revised)** determined as:

$$RQNDOR_{ij}^u = RQNDOR_{ij}^{u-1} - QNDBR_{ij}^{n_{u-1}}$$

and $RQNDOR_{ij}^0 = QNDBR_{ij}$

and $QNDBR_{ij}^{n_o} = 0$.

In respect of each Settlement Period, for each BM Unit, for each accepted Offer, the Non-Delivered Offer Charge (Revised) will be determined as follows:

$$\underline{CNDOR_{ij}^n = QNDOR_{ij}^n \times \max((PO_{ij}^n - SBP_j), 0) \times TLM_{ij}}$$

In respect of each Settlement Period, for each BM Unit, for each accepted Bid, the Non-Delivered Bid Charge (Revised) will be determined as follows:

$$\underline{CNDBR_{ij}^n = QNDBR_{ij}^n \times \min((PB_{ij}^n - SSP_j), 0) \times TLM_{ij}}$$

In respect of each Settlement Period, for each BM Unit, the BM Unit Period Non-Delivery Charge will be determined as follows:

$$\underline{CNDR_{ij} = \sum_n (CDNOR_{ij}^n + CNDBR_{ij}^n)}$$

where \sum_n represents the sum over all Bid-Offer Pair Numbers for the BM Unit.

(d) In this Paragraph 4.1.3.9A, the following terms shall have the meanings ascribed to them in the Balancing and Settlement Code:-

“Accepted Offer Volumes”

“Accepted Bid Volumes”

“Bid”

“Bid-Offer Pair Numbers”

“BM Unit Period Non-Delivery Charge”

“CND_{ij}”

“Non-Delivery Order No.1”

“Non-Delivery Order No.2”

“Offer”

“QAB_{ij}ⁿ”

“QAO_{ij}ⁿ”

“QM_{ij}”

“QME_{ij}”

“SSP_j”

“SBP_j”

4.1.3.10 **NGC** and each **User** acknowledge and agree, as between **NGC** and that **User**, that no ~~payment~~ **Holding Payment or Imbalance Compensation Payment** shall be made to that **User** except in relation to periods in respect of which instructions have been issued by **NGC** pursuant to this Paragraph 4.1.3.

4.1.3.11 *Interpretation of Tables – Levels of Response*
The figures for **Response** set out in the response tables in the **Mandatory Services Agreements** shall be given in relation to specific **Frequency Deviations** and to specific levels of **De-Load** for a **BM Unit**. Such tables shall, for the purposes of Paragraph 4.1.3.7, be construed in accordance with this Paragraph 4.1.3.11. Subject to Paragraphs 4.1.3.11(d) and (e):-

- (a) for a **Frequency Deviation** at a given time differing from the figures given in the relevant response tables in the **Mandatory Services Agreement**, the level of **Response** required shall be calculated by linear interpolation from the figures specified in the relevant table(s) in respect of **Frequency Deviations**;
- (b) for a level of **De-Load** at a given time differing from the figures given in the relevant response tables in the **Mandatory Services Agreement**, the level of **Response** required shall be calculated by linear interpolation from the figures in the relevant table(s) in respect of levels of **De-Load**. For the avoidance of doubt, **Frequency Sensitive Mode** shall not be instructed for any **De-Load** greater than the maximum level of **De-Load** given in the response tables;
- (c) in respect of any time in relation to which both Paragraphs 4.1.3.11(a) and (b) apply, the level of **Response** required shall be calculated by dual linear interpolation from the figures specified in the relevant table(s) in respect of **Frequency Deviations** and in respect of levels of **De-Load**;
- and
- (d) for any **Frequency Deviation** greater than the greatest **Frequency Deviation** given in the relevant response tables in the **Mandatory Services Agreement** (whether positive or negative), the level of **Response** required shall be calculated by reference to the greatest **Frequency Deviation** (positive or negative, as the case may be) given in the relevant table(s); and
- (e) for the purposes of calculating levels of **Response** to be provided in response to **Frequency Deviations** lower than those specified in the response tables in the **Mandatory Services Agreement**, the relevant table(s) shall be deemed to specify that zero **Response** is to be provided for a **Frequency Deviation** of zero.

*Interpretation of Tables – Levels of **Holding Payment***

4.1.3.12

The summary response table in the **Mandatory Services Agreement** shall set out figures in respect of given levels of **De-Load** for the purposes of calculating payment in accordance with the formulae in Paragraph 4.1.3.9. Where the level of **De-Load** of the **BM Unit** is other than one of the levels given in such table, then, for the purposes of the payment table in the **Mandatory Services Agreement**, the figure for P_{MW} , S_{MW} or H_{MW} as the case may be, shall be calculated by linear interpolation from the figures in such table in respect of levels of **De-Load**.

[Paragraphs 4.1.3.13 to 4.1.3.27 remain unchanged.]

4.4.3 Charging Principles – Frequency Response

- 4.4.3.1 The variable cost of producing **Primary Response, Secondary Response, High Frequency Response** shall include sums in respect of the additional inefficiency costs incurred in providing these services but shall not include any sums payable in respect of any costs which are the subject of Paragraph 4.4.3.3.
- 4.4.3.2 Part-loading of a **BM Unit** at a level other than that specified in a **Physical Notification** in order to provide **Frequency Response** will normally be achieved by the issue of a **Bid-Offer Acceptance**.
- 4.4.3.3 In recognition of the costs likely to be incurred under the **Balancing and Settlement Code** when providing **Frequency Response**, an additional amount based upon an ~~assumed-expected exposure to~~ energy imbalance ~~exposure and non-delivery charges~~ when providing these services shall be payable under Paragraph 4.1.3.9A.

Related Additional Definitions for CUSC Paragraph 11.3

<u>“Holding Payment”</u>	<u>that component of the payment for Mode A Frequency Response calculated in accordance with Paragraph 4.1.3.9;</u>
<u>“Imbalance Compensation Payment”</u>	<u>that component of the payment for Mode A Frequency Response referred to in Paragraph 4.1.3.9A comprising the Imbalance Energy Payment and the Non-Delivery Payment;</u>
<u>“Imbalance Energy Payment”</u>	<u>that component of the Imbalance Compensation Payment calculated in accordance with Paragraph 4.1.3.9A(b);</u>
<u>“Non-Delivery Payment”</u>	<u>that component of the Imbalance Compensation Payment calculated in accordance with Paragraph 4.1.3.9A(c);</u>