Real-time Dynamic Response

Detailed Service Design

Public

Purpose

This document describes the intended structure of the real-time element of the Dynamic Response services (Dynamic Regulation, Dynamic Moderation, Dynamic Containment). It will be implemented as a supplement to the existing service terms and does not supersede them.

Every effort has been made to keep the wording of this document plain and unambiguous to facilitate discussion and feedback on the proposed terms, however it is not a legal instrument and should not be construed as such.

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Document History

Version	Author	Changes
Original	Ed Silverstone	-
v1	Mike Coldwell	Data publication timescales changed from end of half-hour to in line with BM timescales (near real-time)

v1

Related Documents

Documents related to Dynamic Response can be found online here. Of most relevance to this document are the Service Terms and Provider Guidance.

Service Overview

The six Dynamic Response services (Dynamic Regulation High, Dynamic Regulation Low, Dynamic Moderation High, Dynamic Moderation Low, Dynamic Containment High, and Dynamic Containment Low) are currently procured in daily increments in a day-ahead auction. In practice, the exact requirement is not always known until after this auction.

It is therefore proposed to introduce an ad-hoc real-time procurement mechanism to supplement the day-ahead auction. NESO will still seek to procure frequency response through the day-ahead auction whenever possible.

The proposed changes to the existing Dynamic Response service terms are:

- New pre-qualification data items:
    - Unit service capability
    - Static MEL/SEL/MIL/SIL (non-BM units only)
- New submitted data items:
    - Per-service limits and prices, submitted at half-hourly granularity in time for gate closure.
- A process for sending, receiving, accepting and rejecting instructions.
- Logic specifying the expected behaviour of a unit under instruction.
- Provisions for stacking with Dynamic Response procured in the day-ahead auction, and other Ancillary Services.
- Provisions for State of Energy management, and interactions with GC0166.
- Logic specifying how the service will be settled.

- Logic specifying how unit performance will be monitored, and how under-performance will be penalised.
- Provisions for publication of transparency data.

Prequalification

1. All units which are prequalified for any Dynamic Response service must prequalify for both the day-ahead and real-time components of the service.
    1.1. This does not oblige the unit to participate in either component – it may simply decline to submit prices into one market or the other (or, indeed, both).
    1.2. Units already prequalified for the day-ahead service will not be required to undergo any additional testing.
    1.3. A unit suspended or de-registered from the day-ahead service would also be suspended or de-registered from the real-time service, and vice versa.
2. For each Dynamic Response service, all units must (as part of prequalification) submit their response delivery capability, composed of 2-5 capability points.
    2.1. For each of the Low Frequency services, a capability point is composed of one Headroom value (in MW) and one Response Capability value (also in MW)
    2.2. For each of the High Frequency services, a capability point is composed of one Footroom value (in MW) and one Response Capability value (also in MW)
    2.3. In both cases, the first capability point must have a Headroom/Footroom value of 0.
    2.4. Note that for many units (such as batteries) it will only be necessary to submit two capability points per service, as the Response Capability is always equal to the unit's Headroom/Footroom. Other technology types will have a non-linear relationship between Headroom/Footroom and Response Capability and will be best advised to submit a full set of five capability points per service.
        2.4.1. NESO reserves the right to request more information to justify the choice of capability points as part of the prequalification process.
    2.5. These capability points may be updated from time to time by the unit.
3. All non-BM units must additionally submit technical parameters, which are used to determine the unit's capability in real-time.
    3.1. The technical parameters are non-time-varying versions of the following BM parameters:
        3.1.1. Maximum Export Limit (MEL)
        3.1.2. Minimum Import Limit (MIL)
        3.1.3. Stable Export Limit (SEL)
        3.1.4. Stable Import Limit (SIL)
    3.2. These technical parameters will be known as "Static MEL", "Static MIL", "Static SEL", and "Static SIL"
    3.3. These technical parameters may be updated from time to time by the unit.

Data Submission

4. Each unit may submit one limit (in MW) per service per half-hour.
    4.1. The limit denotes the maximum quantity of that service that the unit is willing to provide during that half-hour.
    4.2. For the avoidance of doubt, the limit does not constitute a guarantee that the service will be available, or that the unit will have enough Headroom/Footroom to deliver up to its limit.
    4.3. The limit may be submitted up to seven days in advance of the Operational Day when the half-hour falls.
    4.4. The limit may be revised freely until one hour before the start of the half-hour ("gate closure").
        4.4.1. If no limit is submitted by this deadline for a particular service, the unit is treated as having submitted a limit of zero for that service for the half-hour.
5. Each unit may submit one price (in £/MW/hr) per service per half-hour.
    5.1. The price is the rate at which the unit will be paid for any instructions issued under that service.
    5.2. The price may be submitted up to seven days in advance of the Operational Day when the half-hour falls.
    5.3. The price may be revised freely until one hour before the start of the half-hour ("gate closure").
        5.3.1. If no price is submitted by this deadline for a particular service, the unit is treated as having submitted a limit of zero for that service for the half-hour.

Instructions

6. NESO will, from time to time, send an instruction to a unit requesting that it commence delivery of one of the Dynamic Response services (a "start instruction").
    6.1. A start instruction may not be sent if:
        6.1.1. The unit has a limit of zero for that service (either submitted or deemed as a result of no limit/price submission having been made).
        6.1.2. The unit is not Available for the service.
        6.1.3. The unit is already following a real-time instruction for another Dynamic Response service in the same direction.
        6.1.4. The unit is currently Disarmed following a Disarming Instruction issued by NESO in respect of the service (and has not yet been Re-Armed).

6.2. For the avoidance of doubt, a start instruction may be sent at a time when a unit has zero Headroom (in the case of a Low Frequency service) or zero Footroom (in the case of a High Frequency service).

6.3. The instruction will include a "start time", the time at which the unit is required to start delivering the service. This start time will be expressed to the nearest second and will always be at least 2 minutes after the time of issue.

6.4. Once the provider has received a start instruction, an acceptance or rejection should be sent back to NESO as soon as practicable, and in any case within two minutes of the issue time, indicating whether the unit will follow the instruction.

6.4.1. If no response is received within two minutes, the instruction will be treated as having been rejected.

6.5. An instruction may only be rejected on technical and safety grounds.

6.5.1. In either case, the provider should immediately furnish NESO with an explanation for the rejection.

6.5.2. Failure to do so, or provision of an explanation which does not adequately justify the rejection on technical and/or safety grounds may, at NESO's sole discretion, result in the unit being suspended both from the real-time and day-ahead Dynamic Response markets.

7. Some time after a start instruction has been issued and accepted, NESO will issue a second instruction requesting that the unit cease its provision of Dynamic Response (a "cease instruction")

7.1. The instruction will include a "cease time", the time at which the unit is required to cease delivering the service. This cease time will be expressed to the nearest second and will always be at least 2 minutes after the time of issue.

7.2. Once the provider has received a cease instruction, an acceptance or rejection should be sent back to NESO as soon as practicable, and in any case within two minutes of the issue time, indicating whether the unit will follow the instruction.

7.2.1. If no response is received within two minutes, the instruction will be treated as having been rejected.

7.3. An instruction may only be rejected on technical and safety grounds.

7.3.1. In either case, the provider should immediately furnish NESO with an explanation for the rejection.

7.3.2. Failure to do so, or provision of an explanation which does not adequately justify the rejection on technical and/or safety grounds may, at NESO's sole discretion, result in financial penalties or, ultimately, the unit being suspended both from the real-time and day-ahead Dynamic Response markets.

8. If any of the following happen while a unit is providing real-time Dynamic Response, NESO will send a cease instruction as soon as practicable (and in any case the Contracted Quantity for the service is set to zero)

   8.1. The unit indicates that it is unavailable for the service in question.

   8.2. The unit's limit becomes zero.

   8.3. (If the unit has a non-zero SEL or SIL) the unit's Operating Level moves between its SEL and SIL.

   8.4. A Disarming Instruction is issued to the unit by NESO in respect of the service in question.

Delivery

9. The issuing and acceptance of a start instruction constitutes the formation of a Response Contract between NESO and the Service Provider. The period between a start and cease instruction is the Contracted Service Period, and each start instruction forms a new Response Contract, but with a time-varying Contracted Quantity.
   During this Contracted Service Period, the Contracted Quantity at a given time t is:

$$Q_{ai}(t) = \min(C_{ai}(t), L_{ai}(t))$$

   9.1. Where:
   $Q_{ai}(t)$ is the Contracted Quantity from unit i for service a at time t
   $L_{ai}(t)$ is the limit submitted by unit i for service a at time t
   $C_{ai}(t)$ is the Response Capability of unit i for service a at time t

   9.2. The Response Capability $C_{aij}(t)$ is determined by linear interpolation of the unit's Headroom (in the case of Low Frequency services) or Footroom (in the case of High Frequency services) against the unit's capability points.

      9.2.1. Where the unit's Headroom or Footroom (as the case may be) is greater than any of the values specified in capability points, the Response Capability is determined by linear interpolation from the highest two capability points.

      9.2.2. Headroom and Footroom are defined in the Glossary, and examples of their calculation are given in Appendix 1. Examples of Response Capability calculations are given in Appendix 2.

10. Where the Headroom or Footroom (as the case may be) varies with time, the Contracted Quantity of response varies accordingly.

   10.1. This includes variation in the Headroom or Footroom as a consequence of other instructions (such as Bid-Offer Acceptances) issued by NESO to the same unit.

Stacking

11. When a unit is providing one or more response services procured in the day-ahead auction, real-time response should not be offered to NESO unless it can be split with day-ahead response obligations.
    11.1. To be clear: this point is only talking about re-using the same flexibility. Interactions in terms of State of Charge will be addressed later.
    11.2. In the case of a BM unit, the day-ahead volumes are already protected via MEL and MIL submissions, so no further action is needed.
    11.3. In the case of a non-BM unit, the limits submitted during a response service window must be set so as to protect its day-ahead provision.
    11.4. Within this restriction, it is permitted for a unit to offer real-time response while delivering day-ahead response, even in the same direction, and even of a service which is already being delivered as a result of the day-ahead auction.
    11.5. In any of those scenarios, the existing provisions for providing multiple Dynamic Response services concurrently will apply (as detailed in Schedule 2 of the Service Terms).
12. When a unit is providing one or more reserve services procured in the day-ahead auction, real-time response may be offered to NESO co-delivered with the reserve services procured.
    12.1. Again, this point is only talking about re-using the same flexibility. Interactions in terms of State of Charge are addressed later.
    12.2. To be clear, the reserve services currently procured by day-ahead auctions are Quick, Slow and Balancing reserve. If NESO introduces other reserve products with day-ahead procurement, an explicit ruling will be made on the suitability of those products for co-delivery.
    12.3. If a unit is instructed to provide reserve while delivering response, the unit's Headroom and Footroom will change during the provision of the reserve, and hence the Contracted Quantity of response will also change.
        12.3.1. In the case of a BM unit, this matches the procedure for delivering response during a BOA.
        12.3.2. In the case of a NBM unit, the desired reserve delivery becomes the unit's Operating Level for the duration of the reserve instruction.
    12.4. Implementing this co-delivery will require parallel changes to reserve service terms, so it may not be available immediately on service launch.

State of Energy Management

13. These terms are expected to go live after the implementation of GC0166. Under the new rules, BM units will indicate their State of Energy to NESO through two time-varying profiles, MDO (Maximum Delivery: Offer) and MDB (Maximum Delivery: Bid).

    13.1. MDO and MDB values do not include energy reserved for the delivery of day-ahead frequency response obligations. If, for example, a unit had 30 MWh of charge, but was delivering a day-ahead response contract which had a Minimum State of Energy Requirement of 12 MWh, the unit's MDO would be (no greater than) 18 MWh.

    13.2. The main consequence of this is that no amount of delivery of the real-time service would be expected to impact on the unit's ability to meet its Minimum State of Energy requirements as per the day-ahead service.

14. A unit with zero MDO may not be instructed to provide a real-time Low Frequency service, and a unit with zero MDB may not be instructed to provide a real-time High Frequency service.

    14.1. Similarly, a unit providing a real-time Low Frequency service which reaches zero MDO, or a unit providing a real-time High Frequency service which reaches zero MDB, will have its Contracted Quantity set to zero from that point, and NESO will send a cease instruction as soon as practicable.

15. If MDO or MDB is low enough that an instruction issued by NESO could credibly exhaust the unit's State of Energy within the first fifteen minutes, then NESO may without fault or explanation exclude the unit from economic dispatch.

    15.1. This is an attempt to balance economic dispatch of ancillary services with the need to minimize risk of units becoming unavailable at short notice.

    15.2. This will not form part of the contract terms.

16. For performance monitoring purposes, a unit's MSoE (Minimum State of Energy) requirement will be set based only on its day-ahead contracted volume and the volumes of energy which would have been delivered against that day-ahead contract.

Service Settlement

17. In each Settlement Period, the payment to service providers for the delivery of real-time dynamic response will be:

$$S_{aij} = Round\left(\left(\left(P_{aij} - \left(\left(1 - K_{aij} \times F_{aij}\right) \times PF_{aj}\right)\right) \times \int_{t_{start}}^{t_{cease}} Q_{ai}(t)dt\right), 2\right)$$

Where:

S_{aij}, F_{aij} and K_{aij} have the same meanings as in the Service Terms;

P_{aij} is the price submitted for that unit to provide that service in that period (per paragraph 5);

PF_{aij} is the lower of P_{aij} and the Minimum Adjustment Price;

$Q_{ai}(t)$ is the Contracted Quantity at time t (per paragraph 9); and

t_{start} and t_{cease} are the start and cease time from the issued start and cease instructions, respectively.

Performance Monitoring

18. As per the performance monitoring regime for day-ahead contracts, a K-factor will be calculated for each Settlement Period where real-time response is being delivered.

    18.1. If both day-ahead and real-time response are contracted coincidentally, the K-factor is calculated based on the unit's performance against the aggregated response delivery curve.

    18.2. When a unit starts or ceases delivering the real-time service and no other response service is being delivered, Grace Period 1 and its arrangements will apply. When a unit starts or ceases delivering the real-time service and some other response service is being delivered (a day-ahead service or a real-time service in the opposite direction), Grace Period 2 and its arrangements will apply.

19. For the settlement of the real-time service, each settlement period will have its K-factor calculated and applied independently.

20. For the settlement of the day-ahead service, the K-factor will be determined according to the current methodology, with no prejudice to the delivery of real-time response at any point during the service window.

Transparency

21. Data provided as part of pre-qualification (capability curves, Static MEL/MIL/SEL/SIL) will be published by NESO once a month.

22. Data submitted for individual half-hours will be published once the submission deadline has passed for that half-hour.

23. Instructions issued by NESO will be published in line with BM data publication timescales (near real-time).

24. Changes to the availability of units will be published in line with BM data publication timescales (near real-time)

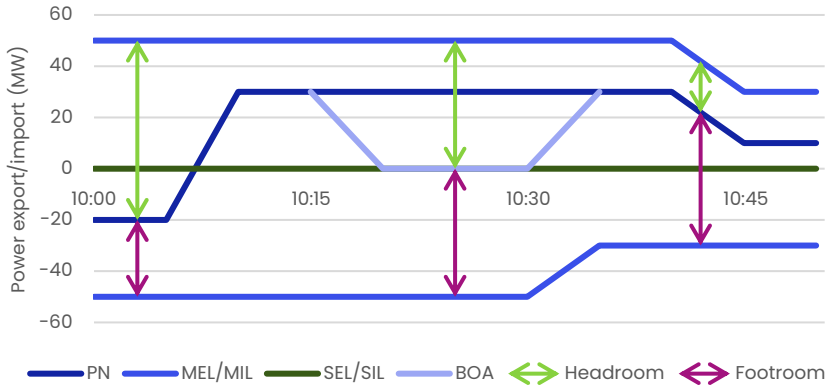
Glossary

Balancing Mechanism Unit (BMU or BM unit)	A unit participating in the Balancing Mechanism (the GB real-time balancing market utilised by NESO to perform residual balancing).
Bid-Offer Acceptance (BOA)	An energy activation instruction to a Balancing Mechanism unit. Details of BOA structure and management can be found in the Grid Code, mostly section BC2.
Dynamic Containment (DC)	A frequency response service delivered between 49.5-50.5 Hz, with a 1-second delivery time. Split into high- and low-frequency services (DCH and DCL). Mostly delivered outside of the 49.8-50.2 Hz range to contain frequency following a large fault.
Dynamic Moderation (DM)	A frequency response service delivered between 49.8-50.2 Hz, with a 1-second delivery time. Split into high- and low-frequency services (DMH and DML). Mostly delivered in the final 0.05 Hz in each direction, to provide a buffer against rapidly emerging imbalance.
Dynamic Regulation (DR)	A frequency response service delivered between 49.8-50.2 Hz, with a 10-second delivery time. Split into high- and low-frequency services (DRH and DRL). Delivered linearly across the range, to mitigate slowly emerging imbalance.
Dynamic Response (Dx)	The collective name for DC, DM and DR. The three services share a large portion of their service terms and are designed to work in concert.
Footroom	In this document, Footroom means the absolute difference, in MW, at a given point in time between the unit's operating level and: • If the unit's OL is greater than or equal to SEL, and has a non-zero SEL or SIL, its SEL, or • If the unit's OL is less than or equal to SIL, or has a zero SEL and SIL, its MIL. If the unit has a non-zero SEL and/or SIL, and its OL is between its SEL and SIL, its Footroom is zero. (See Appendix 1 for examples.)
Frequency	The frequency of oscillation of alternating current in the GB power system. In the event of an imbalance between energy imports and exports from the power system, frequency will rise (when there are more imports) or fall (when there are more exports). Frequency is thus the first and most useful indicator of imbalance on the power system. For the GB power system, nominal frequency is 50Hz ±1%
Headroom	In this document, Headroom means the absolute difference, in MW, at a given point in time between the unit's operating level and: • If the unit's OL is greater than or equal to SEL, or it has a zero SEL and SIL, its MEL, or

	• Alternatively, if the unit so chooses, if the unit's OL is greater than or equal to SEL, and it provides a Power Available signal, its current Power Available value, or • If the unit's OL is less than or equal to SIL, and it has a non-zero SEL or SIL, its SIL. If the unit has a non-zero SEL and/or SIL, and its OL is between its SEL and SIL, its Headroom is zero. (See Appendix 1 for examples.)
Mandatory Frequency Response (MFR)	A frequency response service delivered between 49.5-50.5 Hz, with a 10-second delivery time. Delivered roughly linearly across the range. Provision of this service is mandatory for most BM participants.
Maximum Delivery Bid	The maximum volume of bids a unit is willing to accept. A BM data item expected to be introduced by the GC0166 Grid Code modification.
Maximum Delivery Offer	The maximum volume of offers a unit is willing to accept. A BM data item expected to be introduced by the GC0166 Grid Code modification.
Maximum Export Limit (MEL)	A time-varying parameter submitted by BM units to indicate their maximum achievable export level. See Grid Code BC1.A.1.3.1 In the case of NBM units, this would be assumed equal to the corresponding pre-qualification parameter.
Maximum Import Limit (MIL)	A time-varying parameter submitted by BM units to indicate their maximum achievable import level. See Grid Code BC1.A.1.3.2 In the case of NBM units, this would be assumed equal to the corresponding pre-qualification parameter.
Non-BM Unit (NBMU or NBM unit)	A unit participating in Dynamic Response (or another ancillary service) which does not participate in the BM.
Operating Level (OL)	The level at which a unit is expected to be operating outwith any frequency response delivery. For a BM unit, this is the unit's PN, plus or minus any accepted BOA's, capped by MEL and collared by MIL. For a non-BM unit, this is simply the unit's operational baseline.
Response Capability	Response Capability means the quantity of a specified service that a unit can consistently provide at a specified Headroom (for Low Frequency services) or Footroom (for High Frequency service), assuming adequate State of Energy.
Stable Export Limit (SEL)	A parameter submitted by BM units to indicate the minimum export level achievable in a stable manner. See Grid Code BC1.A.1.5
Stable Import Limit (SIL)	A parameter submitted by BM units to indicate the minimum import level achievable in a stable manner. See Grid Code BC1.A.1.5

Appendix 1: Response Capability

This appendix provides a number of examples of Headroom and Footroom calculations.

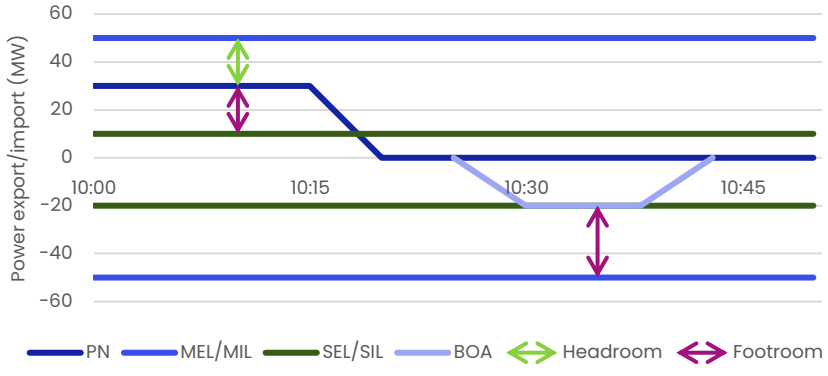


Time 1: The unit is operating below SIL, and both SEL and SIL are zero. Its OL is equal to its PN. Its Headroom is the absolute difference between its MEL and OL, which is 70MW. Its Footroom is the absolute difference between its MIL and OL, which is 30MW.

Time 2: The unit is operating at SEL, and both SEL and SIL are zero. Its OL is its PN plus the BOA it has received. Its Headroom is the absolute difference between its MEL and OL, which is 50MW. Its Footroom is the absolute difference between its MIL and OL, which is also 50MW.

Time 3: The unit is operating above SEL, and both SEL and SIL are zero. Its OL is equal to its PN. Its Headroom is the absolute difference between its MEL and OL, which is 20MW. Its Footroom is the absolute difference between its MIL and OL, which is around 50MW.

Further examples (with non-zero SEL and SIL):



Time 1: The unit is operating above SEL, and SEL and SIL are not both zero. Its OL is determined by its PN. Its headroom is the absolute difference between its MEL and OL, which is 20MW. Its footroom is the absolute difference between its SEL and OL, which is also 20MW.

Time 2: The unit is operating at SIL, and SEL and SIL are not both zero. Its OL is determined by its PN plus the BOA it has received. Its headroom is the absolute difference between its SIL and OL, which is 0MW. Its footroom is the absolute difference between its MIL and OL, which is 30MW.

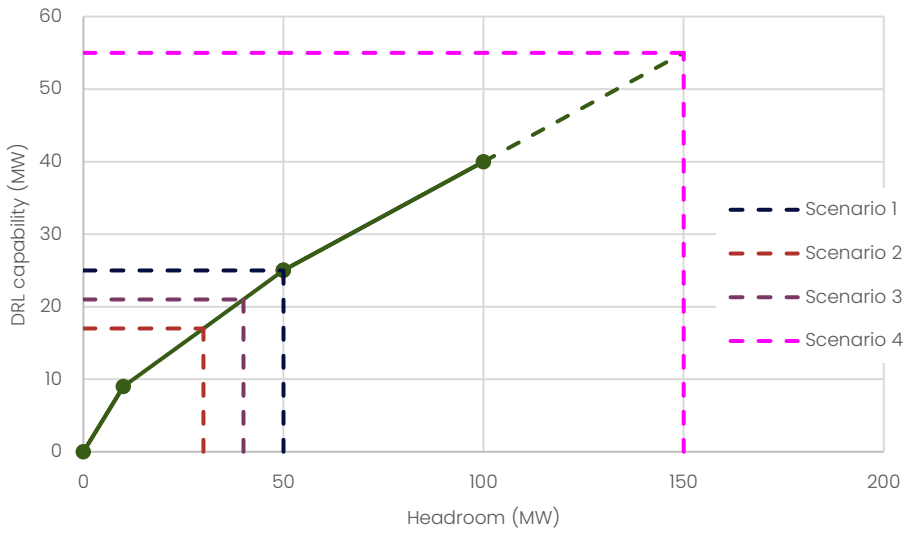
Appendix 2: Capability Interpolation

Low Frequency Services:

Consider the following row of data from a unit submission, in the following scenarios.

Capability point	#1	#2	#3	#4	#5
Headroom MW:	0	10	50	100	-
DRL MW:	0	9	25	40	-

1. *The unit is operating at 50 MW, with a MEL of 100 and a SEL of 0. The unit's headroom is 50 MW (determined relative to MEL, as the unit is above SEL), so it has a DRL capability of 25 MW, as per capability point #3.*
2. *The unit is operating at 70 MW, with a MEL of 100 and a SEL of 0. The unit's headroom is 30 MW (determined relative to MEL, as the unit is above SEL), so it has a DRL capability of 17 MW, determined by linear interpolation between capability points #2 and #3.*
3. *The unit is operating at -50 MW, with a MEL of 100, MIL of –100, SEL of 10 and SIL of -10. The unit's headroom is 40 MW (determined relative to SIL, as the unit is below SIL and at least one of SEL and SIL is non-zero), so it has a DRL capability of 21 MW, determined by linear interpolation between capability points #2 and #3.*
4. *The unit is operating at -50 MW, with a MEL of 100, MIL of –100, and a SEL and SIL of 0. The unit's headroom is 150 MW (determined relative to MEL, as both SEL and SIL are zero), so it has a DRL capability of 55 MW, determined by linear interpolation from capability points #3 and #4.*



High Frequency Services:

Consider the following row of data from a unit submission, in the following scenarios.

Capability point:	#1	#2	#3	#4	#5
Footroom MW:	0	30	100	-	-
DRH MW:	0	20	60	-	-

1. *The unit is operating at 40 MW, with a MEL of 100 and a SEL of 10. The unit's footroom is 30 MW (determined relative to SEL, as the unit is above SEL and the SEL is non-zero), so it has a DRH capability of 20 MW, as per capability point #2.*
2. *The unit is operating at 15 MW, with a MEL of 50, MIL of –50, and a SEL and SIL of 0. The unit's footroom is 65 MW (determined relative to MIL in this case, as both SEL and SIL are zero), so it has a DRH capability of 40 MW, determined by linear interpolation between capability points #2 and #3.*
3. *The unit is operating at -26 MW, with a MEL of 50, MIL of –50, SEL of 10 and SIL of -10. The unit's footroom is 24 MW (determined relative to MIL in this case, as the unit is below SIL), so it has a DRH capability of 16 MW, determined by linear interpolation between capability points #1 and #2.*
4. *The unit is operating at 70 MW, with a MEL of 100, MIL of -100, and a SEL and SIL of 0. The unit's footroom is 170 MW (determined relative to MIL in this case, as both SEL and SIL are zero), so it has a DRH capability of 80 MW, determined by linear interpolation from capability points #2 and #3.*