Development of a more accurate calculation of HF response Capability

Note for Balancing Services Standing Group (BSSG)

Background

With the current level of costs associated with the provision of frequency response services, it is increasingly evident that NGET needs improve the representation of the generators frequency response capability curves.

The current rules for interpreting response capability curves are defined in the CUSC and consist of a set of deloads from MEL (normally six) and a set of corresponding response capabilities. This methodology was originally conceived as the most appropriate for low frequency events, such as generation losses, as LF capability tends to zero as MEL is reached. The HF curve is also defined as a deload from MEL. An example is shown in Figure 1 and Table 1 below.

Figure 1 Typical 0.5Hz Frequency Response Capability Curves at maximum MEL

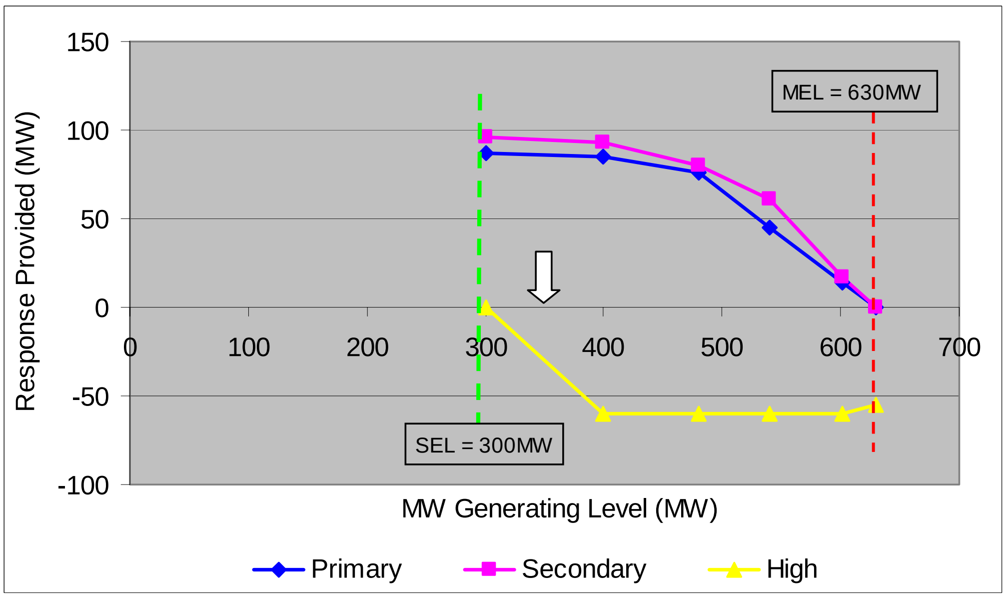


Table 1 Typical 0.5Hz Frequency Response Capability Data

	0.5Hz Response Capability (MW)			
Deload (MW)	Primary	Secondary	High	Generating Level (MW)*
330	87	96	0	300
230	85	93	-60	400
150	76	80	-60	480
90	45	61	-60	540
29	14	17	-60	601
0	0	0	-55	630

*Assume MEL = 630MW, SEL = 300MW

In Table 1, the generating level is derived from subtracting the deload from the MEL, as defined in the CUSC. For the HF curve (yellow line in Figure 1) as SEL is approached the capability reduces to zero as the capability of the unit to reduce its output to provide HF response diminishes as it approaches SEL. Note the relationship is not 1:1, i.e. 1MW of HF response, at this point on the curve, requires 100MW/60MW = 1.67MW of deload. This is broadly characteristic of generating plant across the system and is considered a reasonable average value.

Reason for Proposed Change
The CUSC currently states that the primary, secondary and high frequency capabilities should be represented at defined deloads from MEL and the capability matrices are expressed in this way. For low frequency (LF) response (Primary and Secondary) this has some logic as the provision of LF response is provided by increasing the MW output of a generator, and this decreases as deloads tend towards MEL.

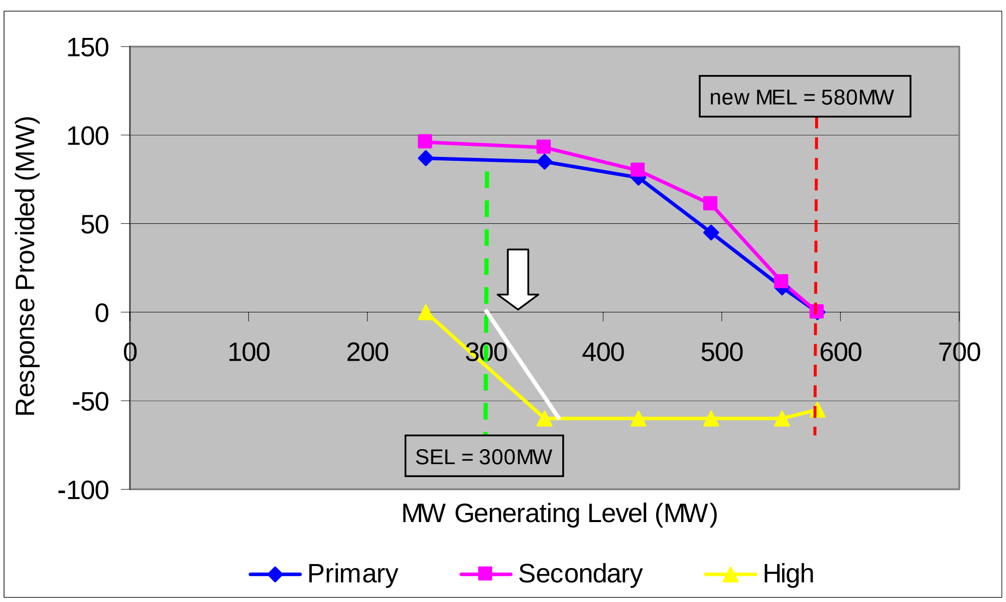
For HF response where provision is effected through decreasing the MW output of a generator, the maximum capability is typically in the range towards MEL and the lowest capability is found where SEL is approached (as shown in Figure 1).

NGET's requirement for HF response is at its highest during periods of low demand. During these periods our HF requirement can be more than double that for peak demand periods. For example, for a change in demand of 840MW and demand of 20GW our HF response requirement is 764MW, compared to 359MW for the same loss during a demand of 55GW.

The total amount of HF response capability instructed is calculated using the CUSC interpretation of each generator's capability as shown in Figure 1, then aggregated for all providers. For example, if 3 units with the characteristic and physical parameters shown in Figure 1 had been instructed to provide frequency response at an operating level of 350MW, each would "theoretically" be capable of providing 30MW of HF response, totalling 90MW.

In the above example, there are six deload points, and the plant had submitted dynamic parameters consistent with it the operating range at the time it was tested and the capability matrix produced. The MW difference between minimum and maximum deload points is 330MW, which is the difference between SEL and MEL in this case. When MEL is reduced, either for technical or commercial reasons, the whole LF and HF curves shift down the x-axis. This results in the HF capability curve moving beyond SEL as shown below in Figure 2.

Figure 2 MEL redeclared to 580MW from 630MW



Using the current CUSC arrangements to interpret the unit's HF capability, with an operating point of 350MW, the HF capability would be calculated as 60MW. However, in reality for a typical CCGT, coal or oil fired power station, the unit's HF capability would increase from zero at SEL to a stable value determined by the technology and the type of plant controller. This is shown by the white line in Figure 2 above.

One effect of this calculation approximation is that the HF unit capability is overestimated for deloads close to SEL. The overestimation can be significant depending on the operating point and capability curve. For example for an operating point 20MW above SEL (a common area of operation during periods of low demand), the true capability would be 12MW (for the unit described), with the current CUSC rules calculating this as 42MW. Thus there is the potential for a 300% - 400% overestimation.

It is important to point out that all generators' response capability curves are different and are approximations of their real capabilities. The actual response output is affected by load point, generator capability, control mechanism, etc.

It is common for units to temporarily reduce their MEL for technical or commercial reasons. In addition, an increase in SEL would have the same effect of resulting in an incorrect reading of HF and LF capability as the HF and LF curves are anchored to MEL.

Potential System Consequences

The consequence of the above overestimation can be significant. For a typical summer overnight demand, our requirement for HF response can be around 750MW. NGET control engineers will have secured the system to their best endeavours according to indications that the systems have provided them. Using the above figures, it is possible that the current method of defining response capability, we would indicate a capability of 750MW of response is being held when in reality there may be only 300 - 400MW actually provided.

The effects of this are quantifiable to a degree. For example, it can be shown that the extent of an HF frequency excursion has some correlation with number of units at SEL. Current processes involve manual work around to adjust the volume of HF response during more critical periods.

Costs

NGET settles response capability payments according to the methodology described in the CUSC. This means that capability is being procured that cannot actually be provided by the unit(s).

To mitigate this issue it is sometimes necessary to manually adjust the HF response to ensure that the correct volumes are procured. This practice has a cost associated with it of not only the additional HF response instructed, but also the Primary and Secondary response that must be instructed at the same time. It is estimated that correcting the methodology for calculating HF capabilities, could save in the region of £5million per year in response capability costs.

Options for Way forward

It is proposed that the CUSC is modified to improve the capability volume calculation to better reflect the actual capability of the unit.

It is recogniosed that one method of calculating capability volumes is not applicable to all units and there is some variation in capabilities at or near SEL and MEL. However, there are a number of benefits in providing one methodology that is coded into the CUSC.

There are three options discussed below that outline potential solutions.

Option 1 – Anchor HF capability curves to SEL rather than MEL
This proposal changes the definition of HF response only. The HF capability curve (yellow in Figues 1 & 2) would be anchored to SEL, with the LF response curves remaining anchored to MEL. This is shown in Figure 3.

This would mean that the definition of "deload" in the CUSC would be changed and separated into LF deload and HF deload.

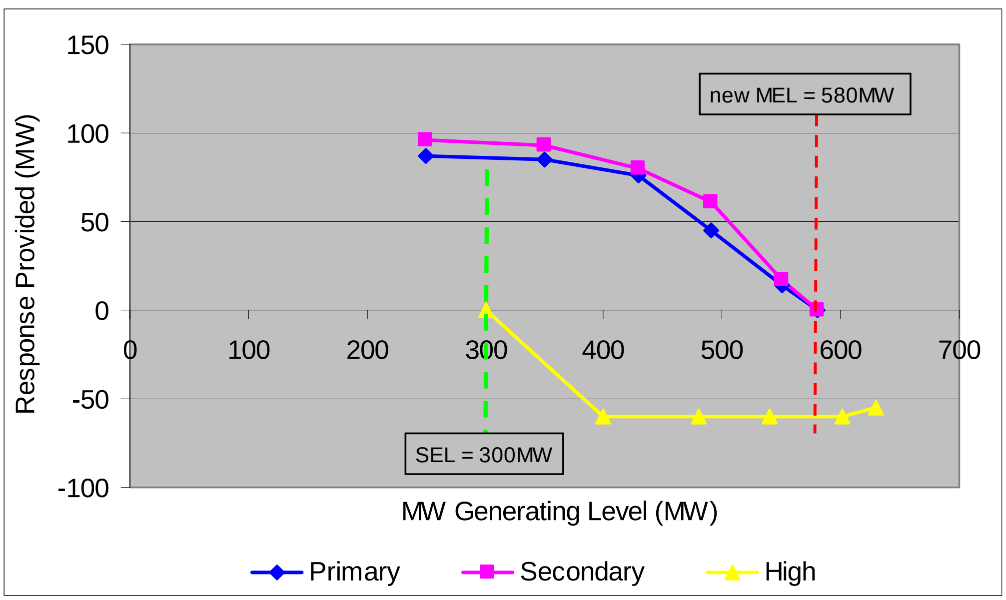
There are a number of advantages for this approach:

- The intended HF capability of the unit is seen at operating points close to SEL.
- NGET technical experts have confirmed that for the majority of units where SEL is increased HF capability remains similar to the base curve.
- At high operating points, the capability would be truncated in exactly the same way as the LF capability is truncated now at low operating points under current CUSC rules.
- Improved method of calaculating the expected volumes.

There are a number of disadvantages for this approach:

- Assumes that SEL is at its tested operating point.
- Changes in SEL level can change the capability curve. This is not accurately represented in the revised calculation.
- May not be the most accuarate method of calculating the actual capability with changes in SEL / MEL.

Figure 3 Option 1 Anchor HF capability at SEL: no change to LF capability



Option 2 – Cap the HF capability by x-SEL
This proposal changes the method of calculating the volume of response. The HF response volumes would be calculated by taking the deload point (x) and subtracting the value of SEL. An example is shown in Figure 4.

Therefore, at a particular loading point (x MW) where a unit's current capability table indicates a capability that would require the unit to deload below SEL, the capability would be capped at x-SEL.

For example:

- Unit operating at 220MW
- SEL of 200MW
- HF matrix indicates a capability of 30MW
- Proposal would limit the to x – SEL (220 – 200) = 20MW

There are a number of advantages for this approach:

- Improved method of calaculating the expected volumes.
- Changes in SEL level can change the capability curve. This is would be more accurately represented in the revised calculation than in option 1.
- At high operating points, the capability would be truncated in exactly the same way as the LF capability is truncated now at low operating points under current CUSC rules.
- CUSC changes can be relatively simply applied

There are a number of disadvantages for this approach:

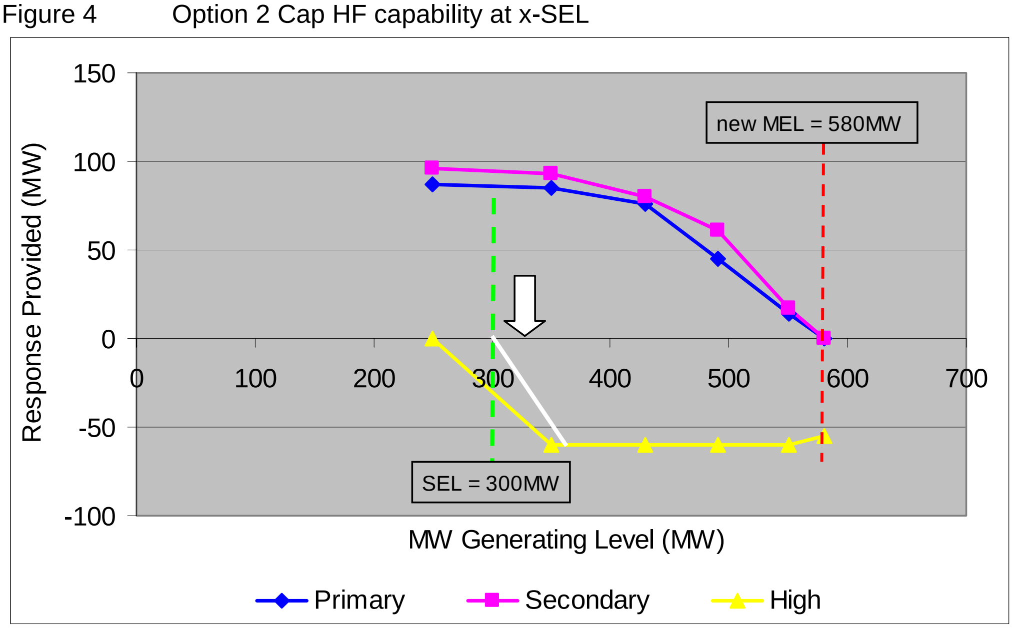
- The calculation alters the slope of the HF capability curve when approaching SEL and therefore does not represent the true intended capability of the unit
- Assumes a 1:1 relationship for delad to HF response provision

A potential solution to the 1:1 ratio disadvantage above is to apply a diviser to more accurately reflect the units true capability. As mentioned above, a diversor of 1.67 could be used to represent the current fleet of generation units.

Therefore, HF response capability would be (x-SEL)/1.67. Using the example above,

- Unit operating at 220MW
- SEL of 200MW
- HF matrix indicates a capability of 30MW
- Proposal would limit the to (x – SEL)/1.67 [(220 – 200)/1.67] = 12MW

Figure 4 Option 2 Cap HF capability at x-SEL



Option 3 – Compress the curves into the available operating range defined by SEL and MEL

In this proposal, the shape of all the response curves would be retained, but each deload point would be redefined depending on the available operating range i.e. changes in SEL and MEL.

For example, if the curves were tested using an operating range of SEL 300MW to MEL 630MW, and the MEL is redeclared to 580MW, each deload point would be reduced in magnitude by an amount proportional to the reduction in operating range, defined according to the prevailing SEL and MEL redeclarations, when compared to the "tested" SEL and MEL declarations.

This can be expressed as: newDeload = testedDeload / [testedMEL-testedSEL]

Where:
testedDeload = the tested deload over the tested operating range (i.e. current contract)
newDeload = the new deload point corresponding to the new SEL/MEL
testedMEL = the maximum (MEL) generation used for generating the current matrices
testedSEL = the minimum (SEL) generation used for generating the current matrices

This would yield the corresponding generating points (GenPoint) as follows:

newGenPoint = newMEL - newDeload

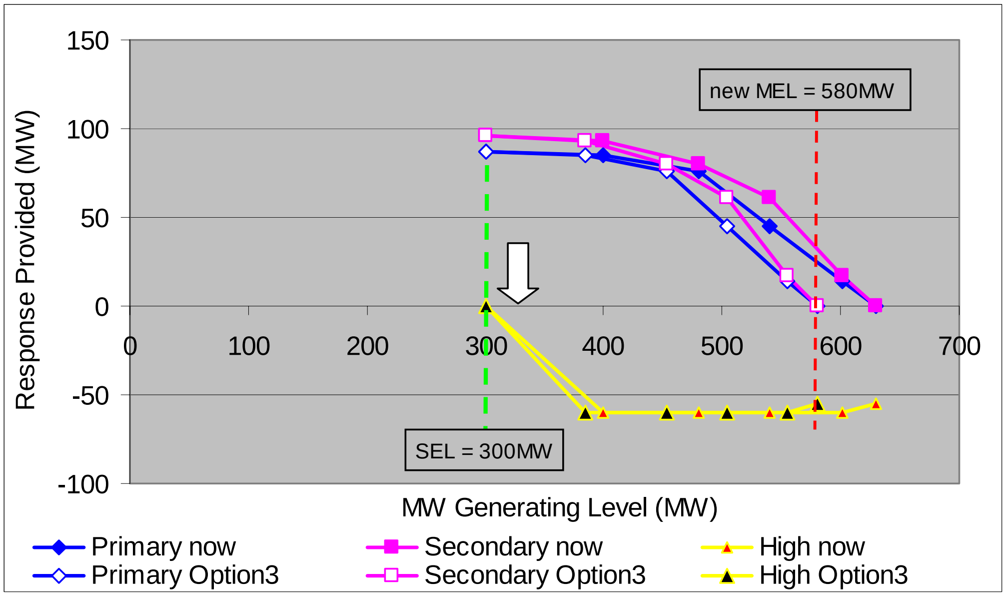
There are a number of advantages for this approach:

- Improved method of calaculating the expected volumes.
- More accurately represents both LF and HF response characteristic with the "shape" of the response characteristic is retained over the operating range of the unit. This assumes that the shape does not alter with changes to MEL or SEL.

There are a number of disadvantages for this approach:

- Much more complicated change to the CUSC
- More complicated change to the National Grid systems
- As SEL is approached the slope becomes steeper and the HF capability of the unit could be over-estimated
- The "testedMEL" and "testedSEL" will need to be defined. These would probably be the SEL and MEL at the time of production of the matrix.
- There may be a need to impose a limit to the operating range as a function of the "tested" MEL and SEL. For example, it may not be appropriate to squash the entire response characteristic within a 100MW operating range.

Figure 5 Option 3 compress the response curves between declared MEL and SEL



Option 4 – Anchor HF capability curve to the tested SEL
In this proposal, the tested capability of the generator is set at a fixed testing point, testedSEL. The variable SEL that is submitted via the BM will not change the capability of the generator.

One potential issue with this approach is that it assumes generators can supply HF response below its submitted SEL (BM SEL – where the BM SEL is above the tested SEL). This may not be the case for all generators, and may not be the case for generators at in all timescales. Therefore it is proposed to provide the ability to generators to either anchor their HF to tested SEL or to submitted BM SEL. This ‘toggle’ could be a submitted parameter that the generator would change depending on the capability of the unit at any given time.

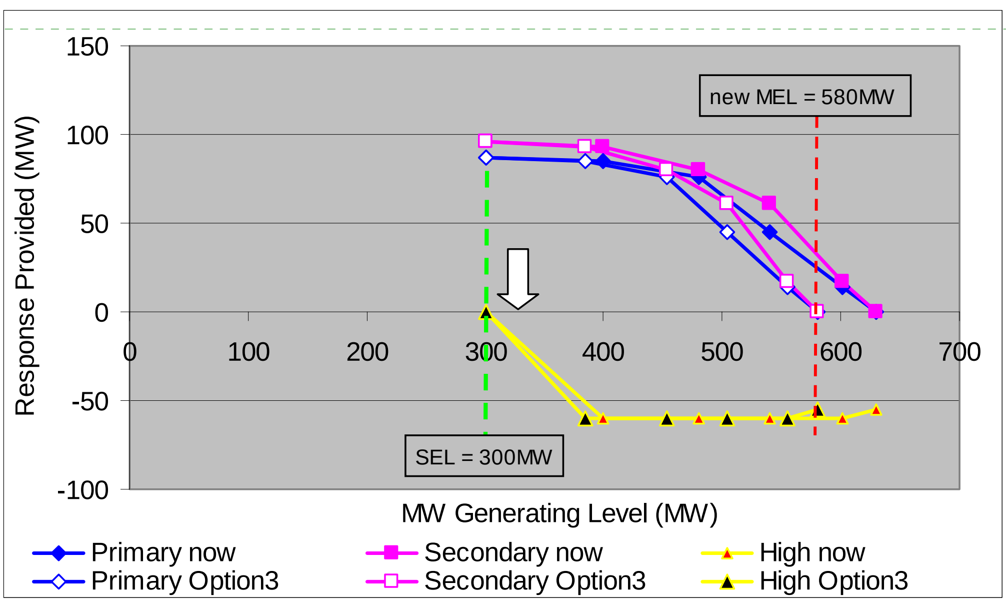
There are a number of advantages for this approach:

- Improved method of calaculating the expected volumes.
- More accurately represent actual HF response characteristic for units that can supply HF response below their submitted BM SEL.
- Allow the SO to access response capability that is not currently available via the current assessment tools and settlement process.

There are a number of disadvantages for this approach:

- More complicated change to the National Grid systems with an additional submittable paramenter (although the parameter may not change regularly)
- The “testedSEL” will need to be defined. These would probably be the SEL and MEL at the time of production of the matrix..

Figure 6 Option 4 anchor capability to fixed SEL with option to change to submitted SEL



Comment [ma1]: Need to revise diagram

Conclusion

There are a number of potential options that could be used to address the perceived problem with the current CUSC methodology for calculating response volumes. Three potential options have been briefly described in this note.

There are advantages to all the modifications, with the over riding advantage that any one of the changes are better than the current methodology. There are a number of issues that are common amounst the three options. One of the major issues is that each option only approximates the volumes for each unit and there is no one option that would accurately reflect each individual units actual response.

Also, there is a range of ease of implementation [for National Grid] ranging from option 2 – easiest to option 3 most difficult.

Overall there is no clear option that stands out as being significantly better than the others. However, for ease of use and closest approximation to actual, option 1 or 2 may be the preferred.

Way Forward

- BSSG to decide which option best meets the industries and National Grid's aims.
- National Grid to write up proposal
- BSSG to provide comments
- National Grid to submit proposal