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Duration-Limited Storage De-Rating Factor Assessment for the GB Capacity Market



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NGET EMR Modelling

Methodology Consultation, CM Workshop
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Scene Setting – Storage De-rating Methodology

- Welcome and introductions
- Scope of this workshop is around input assumptions to the modelling and the methodology involved, NOT the policy
- Any policy questions should be directed to BEIS and could be covered at their consultation workshop on 5th September
- In developing this proposal we have, in addition to our own thinking, held discussion with associations (Energy UK and ADE) and individual storage developers plus we've taken advice from academics
- We have also discussed the proposal with the independent Panel of Technical Experts (PTE) who have endorsed the approach while also identifying areas for future investigation once some results are available to finalise the approach
- Hence although this proposal has involved significant thought, our final position can still be informed by your responses and a final review from the PTE in early October

Timeline of Next Steps

- Your feedback on the EFC methodology and GB reliability modelling issues raised here today is welcome - please send comments via email by 5.30pm August 22nd 2017, to:

  Duncan.Rimmer@nationalgrid.com

- **Note that any policy related feedback should be sent to the BEIS consultation directly – NGET are consulting on the storage de-rating factor methodology only**
- A second repeat workshop will be held on 15th August at BEIS offices, Tues 15 Aug 11am-12:30pm due to participant demand
- We will publish a response to this storage de-rating consultation at the end of August 2017 on our EMR Delivery Body Website, feeding in to the final methodology
- NGET will carry out the storage de-rating factor assessment in September / October 2017, reporting the results to BEIS, Ofgem and the PTE, before finalising the approach
- That report will outline the final methodology proposal, as well as details of the numerical assessments, and the final de-rating factors proposed
- The BEIS policy consultation runs until early September, after which the new proposed methodology for storage de-rating factor may be written in to the CM rules

Overview

- Storage trends in GB
- Duration limits and security of supply – Equivalent Firm Capacity (EFC)
- International experience – a brief review
- Modelling issues for a duration-limited storage EFC assessment
  - '*Incremental EFC*' versus '*Average EFC*' for use in a CM
  - Choice of modelling Base Case
  - CM stress event overview
  - Diversity of storage visibility on the system
  - Storage state of charge level at onset of a CM stress event
  - Storage fleet coordination during a stress event
  - Choice of statistical risk metrics to evaluate an EFC – LOLE or EEU?
  - Storage 'technical breakdown' and efficiency
  - Modelling overlap with Ancillary Services

LOLE - Loss of Load Expectation
EEU – Expected Energy Unserved

Proposed Modelling Approaches/Assumptions - Summary

- *Proposing an EFC based de-rating factor for storage of different duration capabilities*
- *Incremental EFC may make more sense in a CM de-rating than average EFC*
- *Uniform storage response to a CM stress event regardless of connection level*
- *Perfect forecasting of CM stress events in the modelling environment*
- *Storage is always fully charged at the onset of a stress event*
- *Storage responds immediately at the onset of a CM stress event*
- *EEU is a more appropriate statistical risk metric to capture a storage EFC*
- *Technical availability of storage can be applied as a linear scalar to EFC*
- *Storage recharging prior to/after generation is generally an off-peak activity*
- *All storage resources have uniform CM de-rating regardless of EFR/ancillary service provision*

- Note that BEIS, Ofgem and the independent Panel of Technical Experts are in agreement with these assumptions and proposed modelling approaches
- Numerical modelling in the 2nd half of the project will be used to establish their significance and materiality before final decisions are made

EFC – Equivalent Firm Capacity

EFR – Enhanced Frequency Response

Storage Trends in the GB Power System

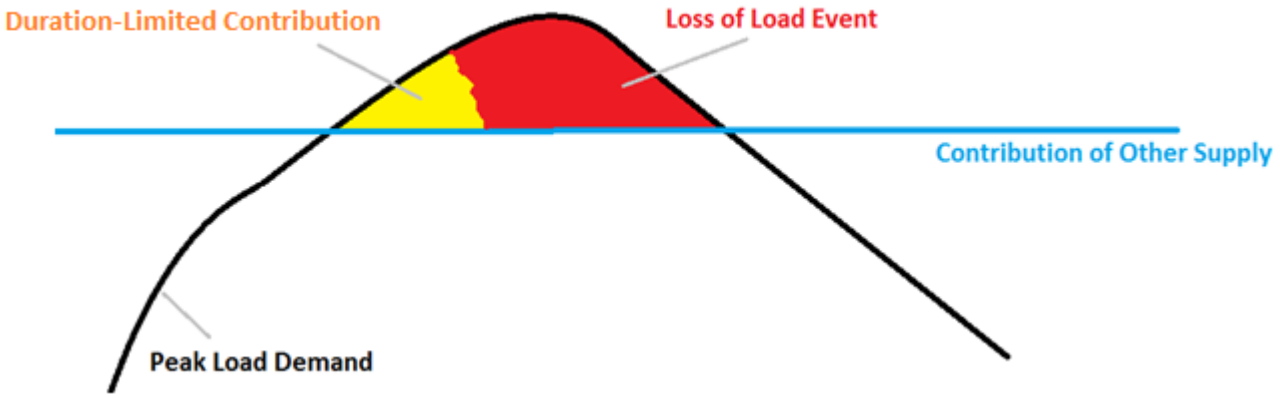
- ❖ All storage has received a de-rating factor equivalent to existing pumped hydro to date (96%) - this may be inappropriate for future storage of relatively short duration at maximum power output
- ❖ The risk is that very short-duration storage projects are presently over-compensated via the CM, and that GB system reliability is less than the CM target de-rated capacity would suggest

- Present GB pumped hydro storage duration capabilities are of the order of 5-7 hours or more, hence once the reservoir is full, they are almost like conventional units from the point of view of the CM
- Battery storage penetration levels are growing, based on increased flexibility requirements e.g. Enhanced Frequency Response (EFR), falling technology cost, and ability to "stack" revenue streams
- The 2017 EMR 5-year Base Case assumes ~ 3 GW battery capacity overall for the 2021/22 year
- Battery storage won ~ 500MW 15-year capacity contracts in the 2020/21 T-4 auction
- A subset of that 500MW capacity also won an EFR contract for next ~ 4 years
- We understand from market intelligence that some new storage may be 30-minutes duration ability, while initial analysis suggests that for the GB system CM stress events could last longer than this

Duration Limited Storage – How to Reward in a CM?

- EMR Modelling is developing a more quantitative assessment of this storage reliability contribution with an estimation of an "**Equivalent Firm Capacity" (EFC)** which will be proposed as de-ratings
- There will now need to be a separate CM de-rating factor for *30-min / 1 hour / 90-min / 2 hour /… / 4 hour* duration storage projects

- The GB policy desire at the moment is to not create a barrier to short duration storage in the CM by e.g. enforcing minimum 4 hour duration requirement, as we need more flexibility on the system
- Instead there is a preference to ensure short duration storage projects are rewarded in proportion to their security of supply contribution
- **BEIS is presently running a CM industry consultation to change the CM rules in order to use new de-rating factors for the next T-1 and T-4 CM auctions to be held in Jan/Feb 2018**



International Experience – A Brief Review

- There seems to be only short amount of experience with duration-limited storage modelling in capacity markets worldwide to date
- Some academic papers have been published on the topic though there is no widely agreed approach for defining contribution of duration limited resources to capacity adequacy
- In some of the US systems, they appear to have a pattern of mandating a minimum number of hours duration – e.g. 4 hours / 6 hours / 8 hours
  - We understand that projects of lower duration may then have their CM capacity payment linearly de-rated
  - A drawback of a linear adjustment is that it is not linked to risk reduction – though note US has different standard
  - Other US areas seem to mainly rely on a penalty regime to enforce duration of all resources
- In Ireland, there is a proposed approach for the incoming I-SEM CM that is essentially an EFC methodology which has recently been developed
  - Numerical trends indicate that the Irish system's storage EFC is non-linearly dependent on incremental duration
- We presented the GB storage EFC modelling case at a recent IEEE LOLE Working Group expert meeting, and explored international expert opinions on the modelling issues there

Storage Duration - Equivalent Firm Capacity Overview

- Equivalent Firm Capacity is a very useful construct to normalise the security of supply contribution of non-conventional adequacy resources
  - An EFC is defined essentially as *"for an additional penetration of that resource, what is the amount of perfectly reliable firm capacity it can displace while maintaining exact risk level"*
  - It exists already as a concept in the GB market via the contribution of wind to security of supply – i.e. wind power EFC reduces the amount of CM procurement

- An indication of the broad methodology to calculate an EFC for duration-limited storage would be as follows:
  - Set up a base case with a credible supply portfolio, for the given CM target horizon year, with a specific baseline reliability level - there may be some subjectivity in the choice of base case, and target reliability level
  - Add a storage resource of suitably small capacity/energy limit (e.g. 100MW power and variations of 50/100/150/200/…./800MWH duration limits, and recalculate the improved LOLE or EEU via reliability model simulation
  - Assess the level of perfectly firm capacity, that when added to the same base case, would give the same change/reduction in LOLE or EEU for each of the MW/MWH combination cases above
  - That respective firm capacity is deemed the EFC of each respective storage capacity and energy duration limit

- For storage resources of significantly long duration (e.g. 6 hours or more, present GB pumped hydro with a full store), then the EFC would be expected to tend towards 100%

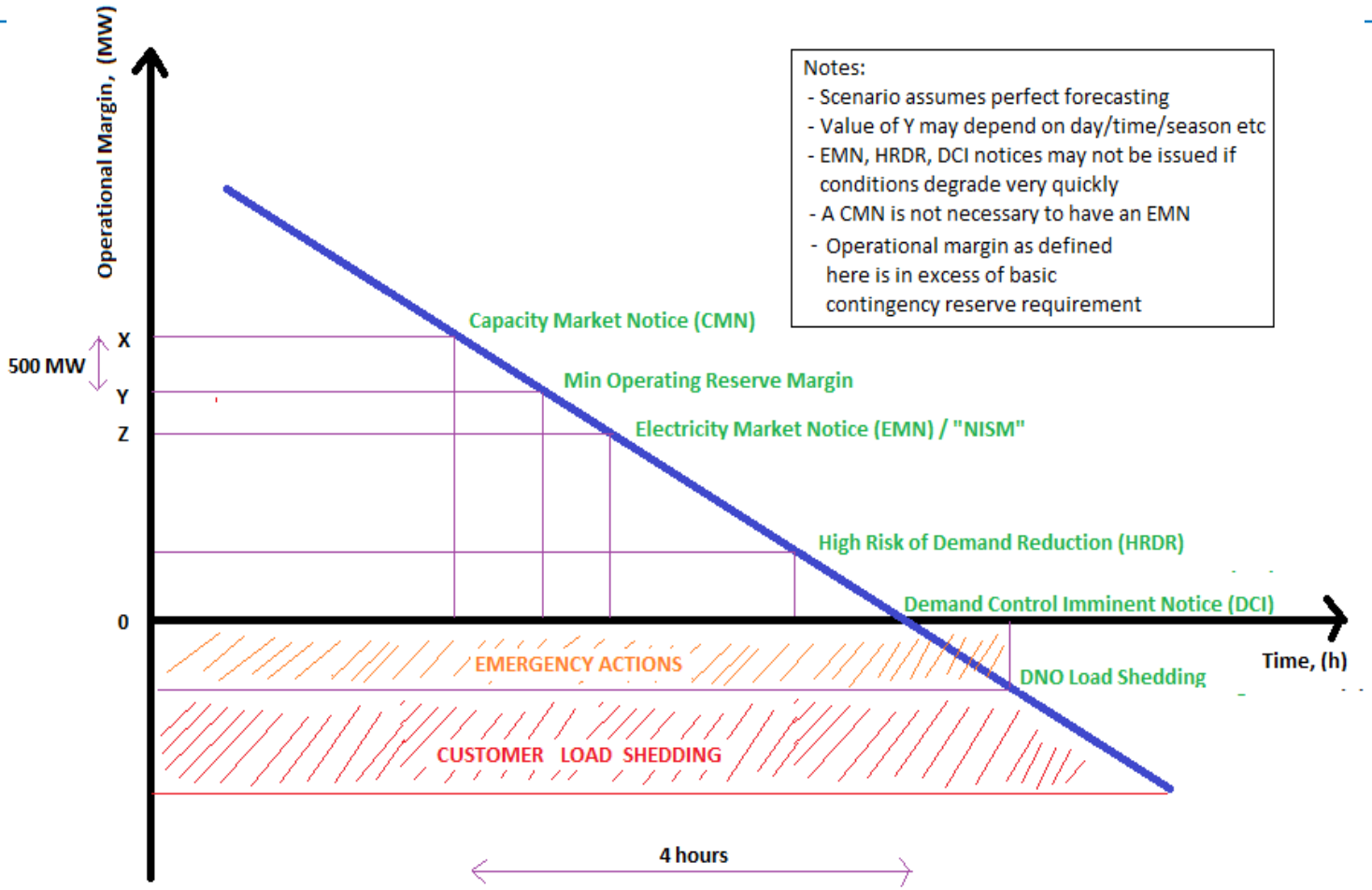
Storage Duration - Equivalent Firm Capacity Method

- **For the purposes of the calculation of the storage EFC we propose to use the FES EMR 5 year Base Case adjusted to 3 hours LOLE as the main study case**
- **We are minded to propose to use the *incremental* EFC of storage duration rather than the *average* EFC as the CM de-rating factor but numerical experimentation in 2nd half of project may be prudent before conclusion on that**

- Noted trends (based on the observations from wind power EFC to date) are that the EFC for an unconventional resource:
  - Can be sensitive to that resource's penetration level – i.e. ***incremental*** EFC of an additional unit can be different from ***average*** EFC of the entire fleet of that resource
  - Can vary from one year to the next as system adequacy margin varies

- The implications of the "*incremental vs average*" EFC issue are that storage market participants investing in different years of the CM may get a different de-ratings
  - This may create distinct financial reward values between investments in the CM in different years
  - However, the practice has some basis in how conventional plant de-ratings are updated each year and thus they too will have varied de-rating factors amongst 15-year contracts
  - An alternative approach where the average EFC might be used could have consumer cost implications

Modelling CM Stress Events – Time Sequential Evolution



- This diagram stylistically indicates the GB system margin, operational warnings and market notices in the lead up to a CM stress event
- Note that a separate presentation on the detail of Capacity Market Notices was provided earlier today by David Preston
- We plan to use the LCP sequential Unserved Energy Model (UEM) for the EFC simulation

Visibility of Storage During CM Stress Events

- The majority of future short-duration storage is expected to connect at embedded level and at the moment such resources are not expected to be BM participants
- NGET SO control centre has very little if any visibility or controllability of embedded generation (even if "BM Lite" may change this in future, it is a few years off at least)
- A CM stress event is actually defined ex-post rather than ex-ante – market participants cannot tell for sure when a CM stress event will start/end as it is determined "after the fact"
- There is thus no co-ordinated CM dispatch signal – each non-BM resource must decide for itself if it should run or not following a CM-Notice, and when it should exactly start output
- This asymmetry of visibility creates a challenge for the modelling of such resources at the onset of an adequacy event in our risk assessment software tools

- **While noting this real system modelling challenge, our EFC project must assume:**
  - **All resources regardless of BM or non-BM status respond uniformly**
  - **There is perfect forecasting of when CM stress events start/end**

Storage Charge State at the Onset of a CM Stress Event

❖ **For the purposes of the EFC calculation, we are essentially constrained to assume that storage resources are fully charged at the onset of a CM stress event**

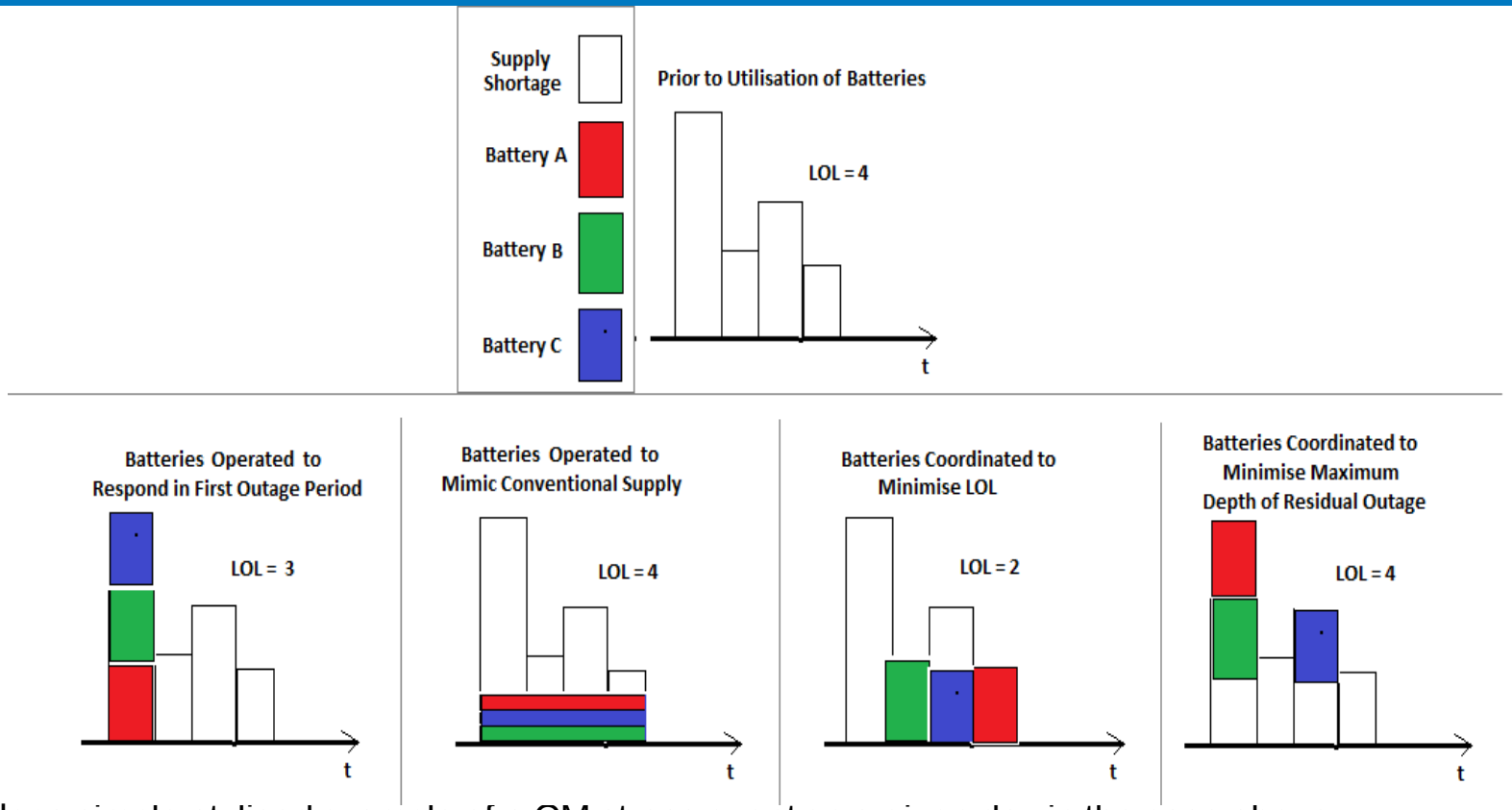
- Storage, and embedded forms in particular, may have multiple revenue streams across which they will likely be co-optimising their economic position on any given day
  - Capacity Market contract obligations
  - Ancillary services provision (though noting "relevant balancing services" exemptions in the CM)
  - Network charge / 'triad' avoidance for embedded batteries
  - Energy arbitrage between different price periods for BM participants

- Though one might expect these other revenue streams to be ~ generally correlated with CM stress periods, in reality it may be a commercial risk/reward decision for storage projects when planning their storage charge state during days with tight system margins

- Failure to provide the contracted amount during a CM stress event would lead to financial penalties based on the defined penalty regime

The Duration-Limited Storage "Coordination Problem"

- **The bottom left option in the diagram below at present best reflects the GB CM process – we are minded to propose this model for EFC simulation – i.e. all storage responds immediately at the onset of a CM stress event**



Consider a simple stylised example of a CM stress event on a given day in the case above

- There are multiple possible ways one could utilise a fleet of duration limited storage resources during an actual system outage – the number of loss of load (LOL) periods is affected, though overall unserved energy level (EU) remains similar
- A challenge is that our GB VoLL parameter is independent of duration/depth – so the damage costs are all the same in each

Which Risk Metric to Use for EFC Assessment?

- There are two risk metrics that could be used for the EFC assessment, both with pros/cons:

LOLE (hours/year with outages)

- LOLE is the national reliability standard metric
- Wind power EFC is already calculated with LOLE
- But LOLE is sensitive to operational strategy for controllable duration-limited resources
- LOLE can also be misleading on economic costs of outages

EEU (MWh per year unserved)

- More closely associated with economic costs via VoLL as used in the CM
- Less sensitive to operational strategy of controllable duration-limited resources
- But this is not the specific metric used for the national reliability standard
- Could create an apparent inconsistency of resource treatment in the CM

- For conventional / uncontrolled resources, the EFC derived would be ~ similar based on either metric as both LOLE and EEU increase/decrease ~ proportionally for such technologies
- Hence to date, the expert opinion is that it would not matter too much which metric was used
- A controllable short duration resource may create a divergence between these metrics however

- **Given that the challenge of short duration storage resources relates to energy limits at their contracted CM capacity, then an energy based risk metric such as EEU better serves this concern than LOLE**

Expert Advice on the Risk Metric to Use for Storage EFC

❖**We are minded to propose EEU as the key risk metric upon which to base the EFC assessment, though a definitive conclusion on the matter will be taken only when some numerical experimentation is carried out in the 2nd half of project**

- We have engaged Stan Zachary (Edinburgh and Heriot Watt Univ.), and Chris Dent/Amy Wilson (Edinburgh Univ.) in an academic expert advisory manner on this project to date
- Though the complexities of using a different risk metric to traditionally the case is noted, the (strong) expert opinion we have received is that for the purpose of valuation in the CM, EEU is a far more suitable metric than LOLE to use for the EFC of storage
- The academic experts have highlighted, that as per the stylised 'coordination' example above, that LOLE has a weakness in this particular storage modelling application that cannot be ignored
- EEU (in a more general sense) has weaknesses too (i.e. it imposes no limit on number of periods of outage) and hence it is proposed to be used for this EFC assessment alone
- For the purpose of assessing the total capacity to be procured to meet the reliability standard, LOLE (the national standard) should continue to be used as the metric
- BEIS' Panel of Technical Experts (PTE) is in agreement that EEU has distinct advantages as the risk metric to be used in this particular application

Storage Technical Breakdown and Efficiency Modelling

- **We are minded to scale the EFC of the incremental storage units by average technical availability to get the end-result de-rating factor**
- **Due to data limits and CM technology classification, the average availability we are constrained to assume is based on pumped hydro historical technical availability**
- **We propose to model storage re-charging as a completely off-peak activity rather than intra-day and/or immediately prior to a CM stress event**

- So far we have only considered the duration limit in the EFC assessment, but there is still the issue of "technical unavailability" due to plant breakdown and random failure
- Battery storage projects we understand are highly modular in design and thus their true availability probability is a multi-state issue, rather than the common two-state model for conventional plant
- Battery storage and pumped storage are different technology types, though the CM technology classification considers them together with same de-rating – we are also limited by data in practice
- Random outages of the existing plant in the Base Case need to be included in the sequential reliability simulation, but for the incremental storage unit of given MW/MWh under EFC assessment we can multiply it's EFC by assumed average technical availability to get a final de-rating factor
- Storage round trip efficiency is also a modelling issue, (~ 85% for Li-Ion battery and ~ 75% for pumped storage) that needs to be included in the sequential simulation

Duration-Limited Storage - CM and Ancillary Services

❖ **We are minded to propose a uniform de-rating factor for all storage resources regardless of interaction with ancillary services markets**

- Storage is expected to continue to play an increasing part in ancillary services provision as the need for flexibility and frequency control on the GB system increases
- Provision of ancillary services has an impact on the operation and charge state of a duration limited storage resource on the day of a potential CM stress event
- However most frequency response ancillary services are included in the CM "list of relevant balancing services" and thus there is an exemption from CM response
  - As provision of these resources from storage means that they are not required from conventional plant on that particular day
- Furthermore, ability to take on board a specific de-rating factor in the CM based on ancillary services provision is limited due to non-alignment of the contract timeframes – up to 15 years in the CM and maybe as short as 1-month for AS in future

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