Consultation Response: Long Duration Electricity Storage Consultation

This is Aurora Energy Research's formal response to the ongoing consultation "Long duration electricity storage consultation, Designing a policy framework to enable investment in long duration electricity storage."

As a company, we have done extensive research on the benefits of Long-Duration Energy Storage. This includes our public report, "Long Duration Energy Storage in GB" and an address to the House of Lords on the appropriate next steps for the sector.

We have gone through the questions in the consultation and selected those where we feel that our analysis has equipped us to answer in a meaningful way. Some of these responses include specific pages of analysis that we had prepared separately, which we have provided as a separate PDF.

We hope that this material is useful to you. If any of this is unclear, or you are interested in discussing our analysis further, please reach out to cara.valentine@auroraer.com and we can organise a call.

1. Do you agree with the policy objectives that have been identified? Please explain your reasoning.

2. Are there other factors we should consider in our policy objectives?

Q1 and 2 answered together: For reviewing these two questions. Policy objectives: Policy alignment, Reduce System costs, Enable investment, System Benefits and Delivery.

Overall, Aurora agrees with the five policy objectives identified but that additional angles must be clarified in some objectives to ensure the framework policy developed maximises the impact of LDES. Furthermore, Aurora also has 1 additional suggested objective: Technology Neutrality.

- **Policy alignment:**
    - Aurora agrees with Policy alignment phrasing as a core objective: any framework developed must be consistent with existing energy policy by ensuring energy security is not compromised, costs to the consumer are minimised and the overall system is decarbonised.
    - The increasing amount of variable renewable generation coupled with the reduction in synchronous dispatchable generation needed to decarbonise and the decentralisation of power production with supply located further from demand centres will challenge the overall system's security and stability. LDES is well position to address some of these challenges, thereby accelerating the decarbonisation of the system to an earlier timeline than alternative low-carbon solutions.
    - Aurora notes that overarching energy policy is developed to ensure that GB's power system needs are being sufficiently met through the structure of several markets (WM, BM, CM and ancillary services) – Aurora would like to highlight that the LDES framework should not inhibit LDES in addressing system needs by curbing the participation of LDES in these markets. The system needs that LDES is particularly well-positioned to address are: provision of firm capacity, provision of flexible capacity, network constraint management and grid stability.
    - **Firm capacity** (dispatchable capacity that is available to ensure supply meats demand) is met via the load-shifting nature of storage, absorbing excess generation during periods of low demand and dispatching it later at periods of high demand.

        - This shifting can happen on a daily basis, due to the variation of a typical daily demand profile, and can also be met by shorter-duration technologies. As decarbonisation through electrification increases, we expect peak demand in cold periods to be amplified.
        - Energy shifting on a weekly basis is largely caused by weather variation. A period of reduced wind can last up to several days, as can storms with higher winds. LDES is able to shift this excess over a period of several days, providing energy security over a longer time frame. This is especially important in GB, where the grid will rely so heavily on wind power, and a see a rapid fall in thermal generation.
        - Energy shifting on a seasonal basis should not be considered within the scope of this framework, as it relates more to seasonal storage, which should be considered separately from LDES.
    - **Flexible capacity** refers to the grid's growing need for capacities that are able to ramp up and down quickly in order to balance supply and demand and provide security to the grid.
        - Greater build-out of renewables and variability in weather results in peakier periods of excess and generation, requiring a higher capacity of technologies that can rapidly ramp
        - In order to balance the grid on a second-by-second basis, Aurora estimates that the need for ramping will double between 2030 and 2050, reaching as much as 26 GW/hour
    - **Network constraint management** refers to the role LDES can play in supporting the utilisation of the transmission network. Renewable capacity is most often located far from demand centres and this will lead to increasingly binding thermal constraints.
        - This constraint management is not only costly, totalling £1.6 billion in 2022, but can also result in excess emissions and demand centres rely on unabated thermal generation, such as from gas peaking plants, during these periods.
        - LDES can be key in helping alleviate these constraints by absorbing excess generation when transmission lines are at capacity and dispatching during less constrained periods.
        - It is important to note that LDES should not be considered a total replacement for transmission capacity build out – a scenario which would lead to LDES technologies in the north perpetually charged/at capacity and unable to dispatch due to constrained transmission lines. Grid build-out is still required for the effective distribution of energy across GB. Instead, LDES will be key in redistributing renewable generation over time by preventing curtailment and keeping transmission capacity utilisation high.
- **<u>Reduce System costs:</u>**
    - Aurora agrees that a key objective should be to minimise the overall costs to the system, and thus consumers, of decarbonising the power system securely. However, specific reference must be made to high upfront costs, not just operational costs, as this is a key barrier to be overcome for investors in most LDES technologies.
    - Additionally, although the system will bear the additional costs needed to deploy LDES as a result of any policy framework, Aurora would like to flag that our analysis has indicated that a system that utilises LDES as part of the path to Net Zero can have lower ***net*** system costs, despite the cost of bringing LDES online. This is due to the costs savings associated with the benefits LDES provides to the system: reduced renewables curtailment, increased network utilisation and particularly the reduction

in flexible dispatchable generation build out required due to the firm/flexible capacity provided.
    - These net savings should be taken into consideration when considering the extent to which the policy framework should support LDES.
- **Enable investment:**
    - Aurora agrees with the policy objective of enabling investment through reducing uncertainties in revenues projections. Currently, the uncertainty around potential CM reform, TNUoS changes, locational pricing through REMA and ancillary service pathfinders means that over 40% of the LDES gross margin stack is subject to medium-term uncertainty, making it challenging for LDES projects to access debt financing. Although the framework cannot provide clarity on the trajectory of other energy policies, it can eliminate the uncertainty of the impact of those policy changes by limiting any downside risk that could materialise (revenue floor).
    - Aurora wants to highlight that in addition to reducing uncertainties in current and future markets, the policy should also outline the main drivers for the revenue floor. For example: to ensure a part or full recovery of upfront costs, rather than just to mitigate against downside risk of revenue from different markets changing going forward. Nonetheless, the framework should not be explicitly designed to ensure CAPEX recovery for all LDES, as this risks the funding of inefficient and expensive technologies.
    - Finally, another objective of enabling investment that the framework should meet is allowing/incentivising upsides so to attract equity investment by boosting forecast project returns. For example, a hard cap might limit equity investment as a ceiling to returns is known. Furthermore, at a system level, it could disincentivise LDES from fulfilling key functions in multiple markets as no extra return can be won. Any framework should acknowledge that incentivising upside – through scarcity event participation or through participating in additional markets, such as ancillary services – is beneficial for the system and will accelerate LDES deployment. Aurora proposes a soft cap with a gain share to address this.
- **System benefits:**
    - Aurora fully agrees that the framework should be structured to work with existing market signals.
    - As mentioned in the objective “Enabling investment” above, a “soft” ceiling would allow the LDES asset to chase the market signals to ensure the benefit of energy balancing is felt by the whole system.
    - Furthermore, the framework should make consideration for ensuring storage projects are incentivised to reserve dispatch ahead of scarcity periods (periods of low wind for example) regardless of shorter-term WM and BM market signals. It is true that the CM has penalties for capacity not being available when called upon; even so, the policy framework must consider the interactions it has with other policies’ stop gaps to insure proper functioning of the market.
    - LDES participation in the wholesale market and in balancing mechanism energy actions should be maximised by the proposed policy framework to ensure LDES is best utilised for balancing supply and demand over time.
    - Equally, the framework should complement LDES participation in balancing mechanism system actions to ensure capacity is best utilised for locational energy rebalancing. This should not be at the expense of transmission capacity build-out, which will still be required for effective distribution of energy across GB. Instead,

LDES will be key in redistributing renewable generation over time by preventing curtailment and keeping transmission capacity utilisation high.
    - The framework should allow LDES participation in the Capacity Market, ensuring that the technology is sufficiently incentivised by, and remunerated for, firm capacity provision. However, consideration should be given to the impact additional LDES capacity might have on installed firm (de-rated) capacity and how this might impact the functioning of the CM and important technologies procured via the CM.
    - Finally, the framework should allow LDES participation in ancillary services in addition to active energy trading in the WM and BM, as well as firm capacity provision via the CM. Revenues from ancillary services provide potential upsides for LDES projects and should be stackable with other market participation. This stackability should not be limited by the policy framework. The decommissioning of firm, dispatchable and synchronous generation combined with the increase in variable RES generation will risk system stability (inertia, voltage control and frequency provision). It is key that LDES is incentivised to participate in these ancillary markets to provide system stability.
- **Delivery (pace)**
    - Aurora agrees that the framework should deliver storage projects as soon as feasible. "Feasibility" should be defined by minimising cost to consumer without risking energy security and, most critically, enabling system decarbonisation. The framework should take into account at what point LDES is needed to be brought on to enable the system to transition to Net Zero as soon as possible.
- **Additional Objective: Technology Neutrality**
    - Aurora notes that LDES is well positioned to address a range of system operability challenges. Different LDES technologies have a range of benefits, some with faster ramping, others with locational flexibility for example.
    - The framework should be structured to ensure that LDES is able to participate in several markets, enabling it to address a range of system challenges. However, Aurora recommends technology neutrality in the design of the framework, allowing the markets to fund the lowest cost/most effective technology needed for each and all system needs.

3. Will these policy objectives help to bring forward LDES projects to help the electricity system reach net zero in the most effective way? If so, why?

Yes, Aurora feels that if the framework is developed to ensure these policy objectives are met, then:

- The deployment of LDES will be accelerated as the cost barriers will be addressed, with de-risking mechanisms unlocking debt financing. Allowing projects to participate in multiple markets to maximise revenues will likely attract equity investment too.
- The addition of LDES to the system will enable a more rapid adoption of renewables and will help replace the operability and security requirements that are presently met by thermal generation.

It is worth noting that there are several paths/routes to net zero that could be followed, with varying levels of LDES and other low-carbon technologies and associated benefits.

However, LDES has a valuable contribution to make in any plausible scenario because of its ability to balance energy over longer timeframes, alleviate grid constraints and provide flexibility to accelerate

res deployment. Additionally, the cost and level of maturity of some LDES technologies means it can compete with other flexible abated alternatives such as CCS or hydrogen peakers.

Given this, LDES brought online by this framework would be part of an effective path to next zero: Aurora's Net Zero view has 20-25 GW of storage on the system by 2035.

Without incentivising a more rapid deployment of LDES, alternative paths to NZ would be costlier.

4. Do you agree with our assessment that a cap and floor is the most appropriate policy option to enable investment and bring forward the required LDES? Please explain your reasoning.

Aurora does agree with this. Ideally, LDES would be brought onto the system through existing market structures. The challenge is that existing market mechanisms for the delivery of new capacity are not well-suited to most LDES technologies. Additionally, price signals are unlikely to support an LDES business case, as unabated gas assets remain competitive in the system. LDES has not built out as it cannot properly access its full value in the WM, BM, CM and ancillary services.

A radical policy option would be to force gas assets off the system via high carbon prices or forced closures. This would make LDES more competitive in power markets, including the WM and BM directly, and the CM and ancillary services indirectly. The key limits of this approach are timeliness and cost-effectiveness. An approach like this would entail huge and immediate costs to consumers (it would cause a significant spike in power prices). Much of that value would not be captured by LDES assets but by existing assets, renewables and interconnectors, essentially imposing large costs on the system for the goal of enabling LDES, relative to a more targeted support scheme.

Specific policy structures like Regulated Asset Base or Cap-and-Floor have the benefit of spreading out that cost impact over time and protecting consumers and the economy from the impact of a spike in power prices. Furthermore, forcing thermal generation off the system will not necessarily bring LDES to market so long as routes-to-market do not support LDES technologies. Given that LDES is needed imminently to ensure Net Zero targets can be reached, this approach may struggle to deliver capacity in time. Finally, the potential risks of forced thermal retirement to energy security are significant and would make this policy approach unfavourable.

A cap and floor mechanism, as has been used with interconnectors, is the most appropriate policy option as it is the most likely option to maximise LDES deployment quickly and reliably, without distorting energy markets or causing unfavourable system shocks.

Alternative policy solutions, such as a Regulated Asset Base (RAB), a Contract for Difference (CfD) or a Dispatchable Power Agreement (DPA) provide a fixed revenue stream, thus maximising investor confidence. However, these schemes are less suited to storage technologies, as these assets must operate under market signals. The system benefits of storage technologies are contingent on following market signals, purchasing cheap or excess generation, and selling energy at times of high prices and scarcity. Replicating these signals under a DPA, CfD or RAB without distorting the market and causing suboptimal dispatch is likely impossible.

A reform to the CM by allowing longer lead times (rather than the ~3.5 years of T-4 auctions) to overcome the mismatch of LDES and CM lead times would allow LDES to meaningfully participate. A CM contract would also minimise any distortions to energy markets as it purely acts as an availability payment. However, bringing CM auctions earlier increases the forecasting inaccuracy of auction targets and the timelines for LDES deployment are long enough that ideally the CM should not take place this early. Additionally, a Cap-and-floor mechanism is perfectly compatible with operation in the CM, as shown by the Interconnector scheme.

A suite of options to provide direct support to LDES are available to policymakers

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	Policy option	Description	Assessment criteria: Accelerate LDES deployment	Incentivise effective dispatch of LDES[5]	Prevent market distortions	Provide investor confidence
	Merchant (no support or reform)	▪ Relies on existing market arrangements and would rely on investors gaining confidence over different elements of a forecasted merchant revenue stack.	○	○	●	○
	Reformed CM[1]	▪ Entails a reform of the existing capacity market to directly incentivise low-carbon generators and plants able to contribute towards system security.	◔	◑	●	◕
	CfD[2] for storage	▪ This model has been successful in providing long-term revenue stability for renewable generators, where a generator is guaranteed a pre-agreed price level (the Strike price) in £/MWh for the duration of the contract. Wholesale revenues for generation above the strike price are returned by the generator.	◔	◔	◔	◕
	DPA[3]	▪ Similar to the CfD, with the key difference being that payment terms comprise of a capacity based availability payment and an variable payment designed to incentivise dispatch. This is being proposed to support power CCUS.	◕	◑	◑	●
	RAB[4]	▪ Companies receive a licence from an economic regulator to charge a regulated price to consumers in exchange for providing the proposed infrastructure with customers face risks of overruns. This is proposed for future nuclear projects	●	◑	◑	●
Deep-dive	Cap & Floor	▪ This model provides a guarantee underwritten by energy consumers of a revenue floor so that investors would be guaranteed a minimum revenue for an efficient project construction cost and cost of debt. Equity investors would have all their profits at risk which would also be capped at a reasonable rate of return. This model was able to attract investment for the development of interconnectors[6]	●	◑	◕	◕

● More applicable ○ Less applicable

Individual policies may be insufficient to incentivise LDES capacity and effective dispatch in isolation. Policy support could be combined with other market reforms to incentivise dispatch behaviour to maximise the benefit to the system

1) Capacity Market; 2) Contracts for Difference; 3) Dispatchable Power Agreement; 4) Regulated Asset Base. 5) With respect to the system. 6)Note that LDES can provide a range of grid services, like interconnectors, but without the firm OPEX costs.

A Cap & Floor mechanism is best positioned to support the deployment of LDES, however additional signals may be needed

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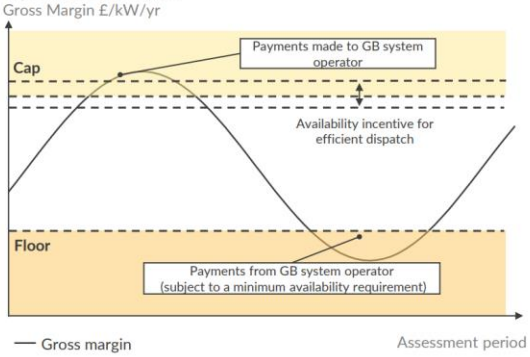
The Cap and Floor mechanism is currently the best positioned to support investment in LDES, however there are several limitations and potential modifications that should be considered.

Cap and Floor mechanism

Gross Margin £/kW/yr



1 Cap and Floor policy limitations

- **Does not fully incentivise optimal dispatch to benefit the grid**
- **May not support equity investment into LDES projects**

2 Potential considerations and modifications

- **Forecasted returns from energy and system actions** – LDES provides services that are not currently contracted in separated markets; a cap & floor scheme should consider recognising value from all services contributing to grid operation (such as inertia, SCL, constraint relief)
- **Length of contracts and timing of revenues assessment** – contract length should be considered to reflect LDES lifespans and could be combined with revenue assessments to ensure fairness for developers and consumers
- **Contract awarding** – contracts will likely need to be decided on a case by case basis initially but a move towards a competitive auction should be considered
- **Cap and floor prices** - Policymakers should consider whether the cap & floor is set: a) to be technology agnostic, such as only based on market signals and revenues (assuming reforms can provide these), or; b) set for individual assets based more granularly on their locational benefit and grid services provided
- **Hard floor and flexible cap** – projects should have to maintain a minimum level of performance to receive the floor price. A flexible cap would incentivise further output when needed by the grid if the cap is reached, this should be set to ensure services continue to be provided
- **Support to debt & equity** – price floors will need to be high enough to reduce merchant risk, to secure debt and operational costs. Better market signals may be needed to avoid revenues staying at the floor, to attract equity investors
- **Other reforms** – A cap & floor mechanism could be implemented in conjunction with further market reforms to improve market signals

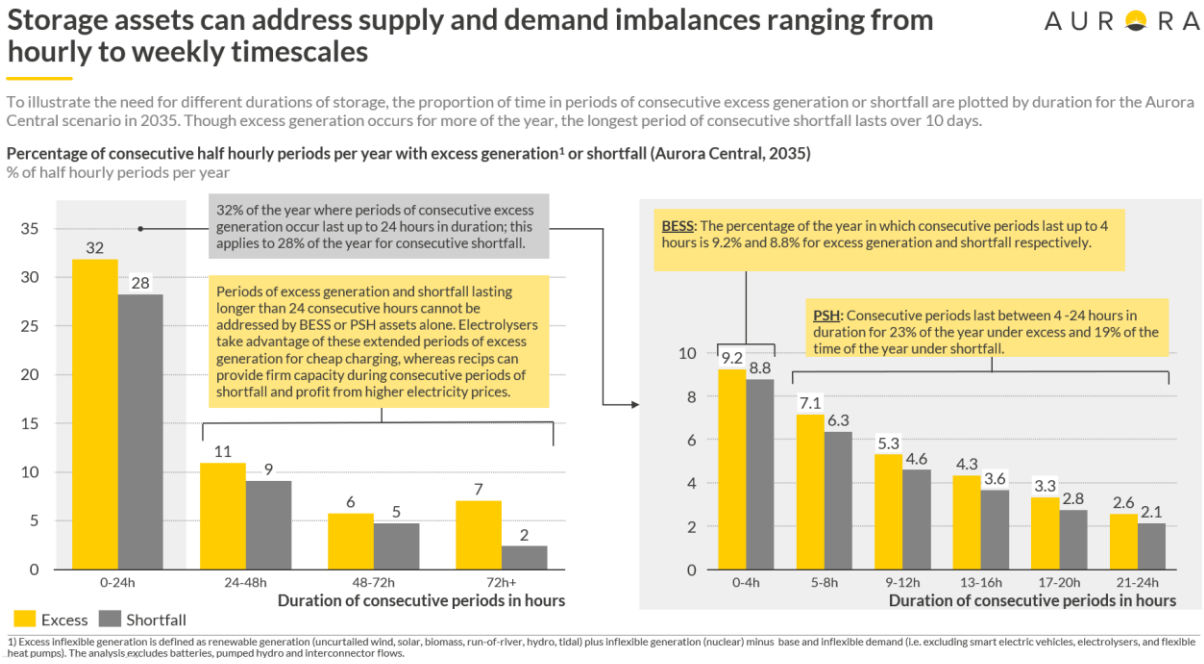
9. Do you agree with our proposal for a minimum duration of 6 hours? If not please provide a rationale.

Our view is that the 6-hour benchmark is more inclusive than necessary a duration to reflect a definition of LDES required on the system, and that a definition of at least 8 or 10 hours would be more appropriate. The definition of 6 hours does not seem to match up with our analysis on the characteristics of the expected residual demand level or shape for the GB System. Ideally, the duration of LDES projects should be defined in a way that reflects durations at which LDES projects can provide benefits to the system. This means that assets should be sized to a duration that meaningfully contributes to security of supply, and is able to address a significant portion of the periods of excess supply/demand.

We note that the duration of 6h is such that it allows participation from all technologies identified in Table 1 of the consultation. Our view is that in the spirit of technology-neutrality, the scheme

parameters should be set by the needs of the system, and not to enable the participation of certain technologies.

Our analysis of residual demand suggests that the shape of demand and supply would justify durations longer than 6h, with only ~31% of the year being periods of excess demand or supply supported by assets of 8h or less.



Generally, we consider that residual demand periods of more than 24 hours are not appropriate to address via LDES, and better addressed by thermal assets, or through end-uses for electricity, such as hydrogen production via electrolysis. Some level of curtailment is also inevitable for any high-renewables system, and the goal of system design should not be to eliminate all renewable curtailment. However, a 6h asset will not capture the majority of the periods that fall within the 24-hour bracket that we consider appropriate to seek to address via LDES technologies.

Additionally, Aurora notes that in the latest NGESO parameters for the capacity market, a 6-hour asset would be considered to be "duration-limited" in type and receive a de-rating factor of less than 50%, or more telling, less than half the de-rating factor available for 9.5+ hour assets (94.37%).

A duration of 10 hours or longer for LDES would be fully consistent with the latest auction in the Capacity Market. Even a duration of 8 hours would allow assets to shift the majority of residual demand within the 24-hour window we believe appropriate for consideration for LDES projects. Both of these are at the low end of what Aurora considers “long-duration” storage but it would be appropriate for the minimum of the scheme to be defined at the lower end of that range.

As we will discuss in response to other questions, this seems to have implications for other aspects of the scheme's design, particularly around the participation of technologies at a different level of readiness.

11. Do you agree with the proposed approach to splitting the streams by TRL level? Please provide your reasoning. If not, please suggest an alternative approach.

The decision to split the LDES consultation seems to be justified on the basis that TRL 9 technologies (chiefly pumped storage) have limited potential for cost declines, but can still bring system benefits,

while TRL 8 technologies have the potential for cost declines, so the funding decisions for the two should be made separately.

Our view is that if the justification of the TRL 9 workstream seems inconsistent and violates the principle of technology neutrality that we have outlined above. If the reasoning for securing these assets is to attain system benefits, then costs should be minimised and this scheme should be open to participation from all technologies, including less mature technologies and those which are able to be brought to market via other routes. The stated objectives of this procurement are at odds with the proposed design of the scheme. In our view, if the duration of the scheme was defined appropriately (by a longer duration) then there would be no need to explicitly exclude BESS from participation and participation could be opened up as much as possible.

The decision to split out TRL 8 from TRL 9 makes sense on its stated basis, although in practice we believe a better design would be a separate scheme for TRL 8 projects and a general scheme which is totally technology-neutral.

12. Do you agree with the different capacity minima set out for the streams? Please provide your reasoning.

In practice, we suspect that a 100MW minimum for TRL 9 technologies will have a small impact, as the technology we expect to dominate this scheme (pumped hydro storage) will generally have capacities larger than 100MW for a single site.

For TRL 8 technologies, a capacity minimum of 50 MW is likely to result in "herding" of projects, such that projects enter with a capacity at or around 50 MW. The extent to which a number of 50 MW projects will lead to future cost declines is questionable. Cost declines for BESS were achieved with a large number of projects just under 50MW, but this is largely attributable to the broader industrial advances in Lithium-ion batteries driven by the market for electric vehicles and consumer electronics.

Additionally, 50MW is, in our view, a fairly large project for a TRL-8 technology to achieve. Given that we are sceptical of the potential for cost declines from 50MW projects, we feel that a smaller minimum project size should be considered and that there is a reasonable argument for no minimum project size. Larger projects will likely enjoy benefits accruing from their size, principally in terms of cost savings, so they are likely to succeed anyway.

13. Do you agree that the identified wider system benefits should be considered when assessing a project?

It is sensible that wider system benefits should factor into the usage of the cap-and-floor scheme, as this scheme threatens to distort market forces that might otherwise account for those benefits.

As such, the goal of the assessment should target those benefits that are not necessarily captured by current market design. Ancillary service outcomes and energy security outcomes are already covered by robust markets, so these should not be considered as part of cap-and-floor eligibility.

There are signals for locational network benefits, but these are often not fully reflective, and are subject to significant reform, so some additional analysis here would be appropriate.

Benefits to the local economy are notoriously hard to quantify. Our view is that the benefits to the national economy should be the primary consideration in the administration of the LDES support scheme, and these can be adequately supported via a proper assessment of the scheme and other associated benefits.

Benefits to consumers and to system costs are likely to be primarily driven by technical characteristics and by project costs. We expect these to be the primary criteria on which decisions are made within the proposed LDES scheme.

21. What performance incentive could be used to encourage full operation of assets to prevent dispatch distortions around the cap?

The consultation offers three mitigation measures that effectively rely on price signals to feed into the dispatch decisions of the asset, therefore ensuring that the subsidy scheme does not distort the dispatch, in particular around the cap:

1. Introducing a longer period (multi-year) to review gross margin revenues, allowing the asset to transfer revenues between years to smooth out periods above/below cap. As noted above, the interconnector cap and floor uses 5-year review periods. In the context of a flexible storage asset, this is particularly important as returns are volatile and will vary significantly year on year.

2. Setting soft-caps to return gross margin to asset on sliding scale, where returns are gradually increased to the consumer rather than a cliff-edge point where all returns are removed from the asset operator.

3. Setting availability or performance requirements that could penalise the operator if agreed performance expectations are not met.

The first two are not so much mitigating cap distortion but more ensuring that assets have full access to price signals, which should result in dispatch synchronized to market needs. The third is akin to a provision made around system stress events, so that the assets are required in a CM-like way to generate over these periods.

On a broader point, providing subsidy support to LDES will lead to changes to the overall system, and a distortion of the market. Some of those distortions are intentional, for instance favouring LDES and displacing peaking gas in capacity and wholesale markets.

However, supporting deployment of LDES with a subsidy scheme such as a Cap-and-Floor regime will cannibalise the business model of existing short-duration storage assets such as Lithium-Ion batteries on the bulk of their revenue streams: energy trading revenues. This may lead to some stranded assets, and entail artificial depression of prices in particular in ancillary service markets. In the long term, as stranded assets exit the system, either for economic or technical reasons, we would expect to see ancillary prices recover but the medium-term impact on short-duration storage economics could be substantial.

We mentioned above in our answer to Question 4 that other ways exist to bring LDES projects to market outside of direct subsidy support. However, our view is that these interventions would bring potentially undesirable consequences.

28. Do you agree that cap and floor recipients should also be able to participate in other electricity markets, such as the CM? Please provide reasoning.

The precedent from the interconnector scheme is that assets should be allowed to participate in the CM, although not to secure multi-year contracts, as they do not need these contracts to be brought to market.

Our view is that a similar approach should be instituted in the case of an LDES scheme. As such, it is appropriate for LDES to participate in the CM in the manner described above. Similarly, assets should be permitted to participate in balancing markets, wholesale markets, and ancillary service markets, and efforts should be made to ensure that these markets are designed in a way that will incentivise optimal dispatch of LDES assets.