Independent review of GC0154 CBA relating to IC ramping proposals

September 2023

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Agenda

Agenda

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CONTEXT

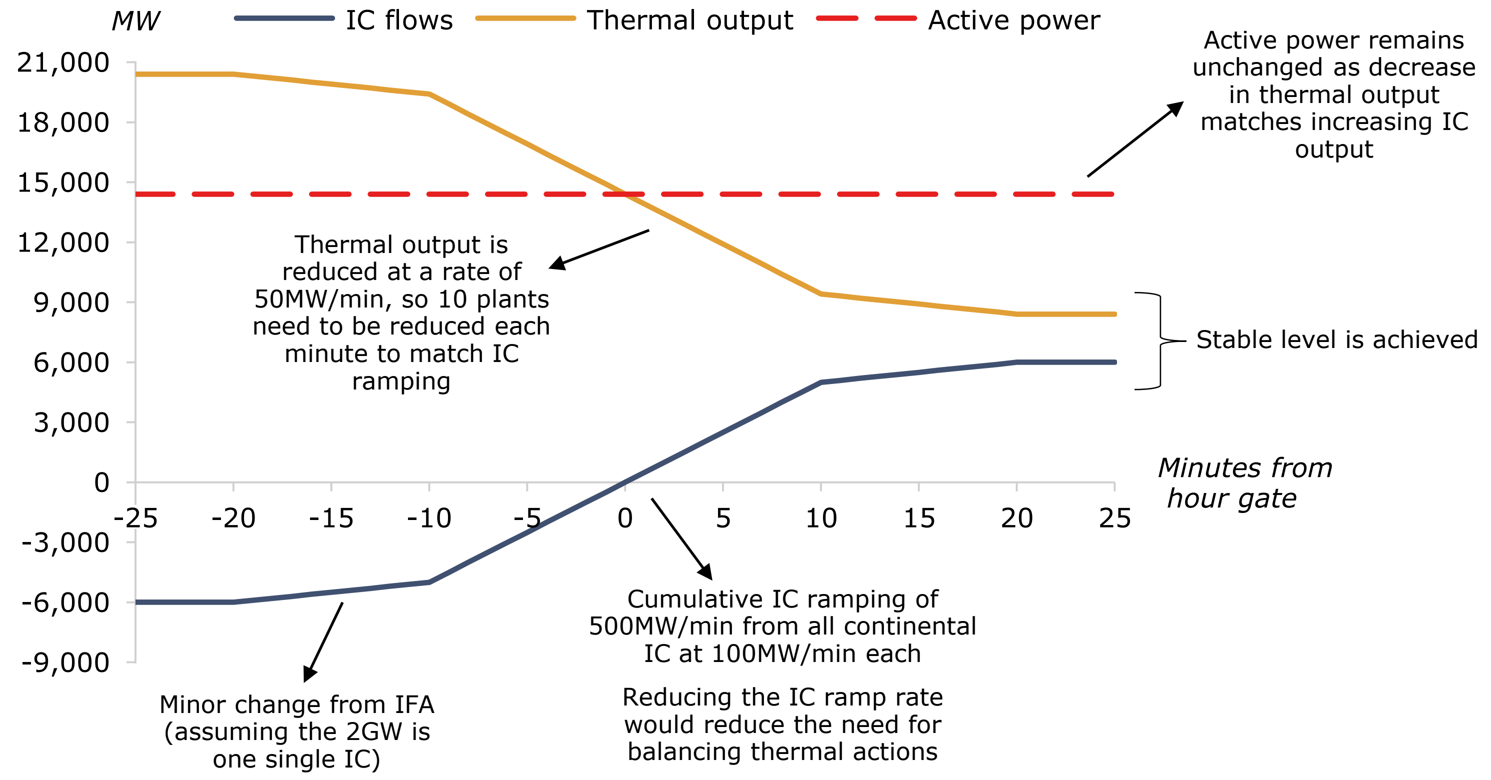
NG ESO is in the process of codifying IC ramping limits to comply with System Operation Guideline requirements

- Current ramping limits for continental ICs are specified in tri-lateral agreements (the Interconnector Operating Protocols). Such agreements are between the two connected System Operators and the relevant Interconnector Operator. To fulfil the obligations in Article 137 (3) of the SOGL, **GC0154** has been raised to incorporate interconnector ramping in the Grid Code.
- Within the GC0154 process, several options have been analysed which are intended to give NG ESO better control of frequency deviations arising from cumulative IC ramping:
  - ramp management;
  - static lower ramp rate; and
  - dynamic ramp rate periods.
- The CBA conducted as part of the GC0154 process identifies the static rate option of 50MW/min for all continental IC (instead of the 100MW/min they currently operate at) as having the **largest projected savings in balancing costs (£865m NPV)**.
- AFRY acknowledges **that lower ramping rate limits may reduce the level of reserves** that need to be held, with an associated cost saving. However, there is merit in reviewing the CBA study to help to ensure a robust evidence base for decision making.
- Given the potential impact of adopting lower ramping rates, a group of IC owners has asked AFRY to provide an independent review of and commentary on the CBA assessment that has been undertaken as part of the GC0154 process.

CONTEXT

IC ramping requires repositioning of other technologies as the balance of active energy needs to be maintained

EXAMPLE OF IC ENERGY FLOW AND THERMAL PLANT OUTPUT AROUND HOUR CHANGEOVER TO KEEP THE SYSTEM BALANCED (MW)



COMMENTARY

- The chart shows the balancing actions that NG ESO needs to undertake to balance the overall active energy output (MW).
  - This is a simplified example where demand, RES and other sources of generation are assumed to be **unchanged** in the period shown.
- Continental ICs are ramping to move from full export (-6000MW) into full import (+6000MW) over 40 minutes in all. This means an **increase in active energy** coming into GB, which can drive an **increase in frequency**.
- Thermal assets need to be **ramped down** so that the energy balance is maintained. The decreasing output from thermal plants has a **downward effect on frequency**, which ideally should balance the upward effect from increasing IC imports.
- Modifying thermal positions, as shown in the chart, is the **current method** for NG ESO to balance the energy from IC ramping. It is unclear the magnitude, but a significant amount of these balancing actions come from Bid-Offer Acceptances (BOAs).

Our focus is to provide a third-party, independent view on elements of the CBA

SCOPE AND PURPOSE

- A group of IC owners has asked AFRY to provide an independent review of and commentary on the CBA assessment that has been undertaken as part of the GC0154 process.
- Our focus is to provide a third-party review of the CBA
- Our assessment is from an independent perspective
- What we have tried to do:
  - See if we can replicate some of the trends used to inform assumptions that feed into the CBA
  - Consider the effects of different assumptions on outcomes
  - Consider how anticipated evolution of the resource mix in the coming years may affect results
- What we have not done:
  - Conducted an alternative CBA or similar

INFORMATION USED

- Our review has centred on information provided in the GC0154 CBA documentation, main sources:
  - GC0154 Interconnector Ramping Workgroup session 11 (9 May 2023)
  - Appendix A & B of detailed Options and Methodology
- We have also used publicly available information within the analysis as follows:
  - ESO's Dispatch transparency platform[1] for BOAs in 2022
  - ESO's Historic demand data[2] for demand and IC flows
- Finally, we have made reference to our own analysis in some cases for forward looking quantitative analysis
  - 2023 Q2 Central scenario price projections for wholesale electricity in GB
  - 2023 Q2 Central scenario price projections for Dynamic Moderation (DM) and Quick reserves

1. https://data.nationalgrideso.com/balancing/dispatch-transparency
2. https://data.nationalgrideso.com/demand/historic-demand-data

Agenda

There are aspects of the CBA assessment where further detail / consideration may support the evidence base for decision making on GC0154

High correlation of IC cumulative ramping and increased balancing volumes has not been replicated

The high correlation between IC cumulative ramping and balancing volumes presented in the CBA assessment could not be replicated based on our understanding of the methodology from available information. Our historic review of year 2022 does not reveal particular correlation between these two conditions. Given the role of this correlation in the CBA, further transparency on its derivation will be helpful for upcoming considerations of GC0154.

Expected changes in method for procurement of reserve and response products do not appear to be reflected

Projected reserve and response volumes are monetised at day-ahead prices, reflecting today's means for managing ramping. However, the expected future deployment of longer duration batteries (2+ hours) and the implementation of new reserve and response products on procurement have the potential to change the price at which services may be secured in future.

Scale of balancing cost savings may be lower with different a monetisation factor for balancing volumes

Alternative monetisation factors, consistent with procurement of balancing volumes through market-based products, could potentially significantly reduce the balancing costs savings.

Not clear how potentially negative impacts on limiting IC ramping have been considered

Consideration of potentially negative impacts of limiting IC ramping on system adequacy or flexibility is not clear. Based on the expectation that future needs for flexibility will increase, potential negative impacts of limiting IC ramping in these regards may be more significant in time.

The value of implementing a static IC ramp rate of 50MW/min is likely to reduce in the second half of the 2020s

The scale of potential cost savings identified in the CBA is expected to reduce in the second half of the 2020s (and potentially beyond the period considered). Combined with the possible balancing costs savings reductions referred to above, potential benefits and the differences between options assessed may both be expected to become less significant.

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The CBA assessment focuses on the balancing volumes required to guarantee the safe operation of the network due to IC ramping

- The CBA identifies the static rate option of 50MW/min as having the largest projected savings in balancing costs (£865m NPV).
- Balancing costs are driven by two factors:
  1. The **volume** of repositioning, frequency response and reserves required to manage cumulative IC ramping.
  2. A **monetisation** factor (on a per MWh basis) linked to the volumes mentioned above. In the case of the CBA assessment, this monetisation factor is assumed to be the Day-ahead wholesale price.
- The main focus for the quantitative analysis of the review of the existing CBA assessment is on the **monetisation factor** used and it considers the impact of alternatives on outcomes. These alternatives are considered in light of ongoing changes in the reserve and response markets (currently being developed by NG ESO), as they can provide an alternative route for procuring such services.
  - Qualitative commentary is also provided for the potential evolution of the volumes required as new providers of reserve and response comes online, namely batteries.
  - Batteries can potentially reduce the extent to which balancing actions involve repositioning thermal generators, as they would be able to match ramping by ICs. This would be enabled by the expected increase in capacity from batteries, which means the cumulative flexibility they offer could potentially balance IC ramping.
    - Expected deployment of batteries in GB could potentially provide enough flexibility to allow for IC to ramp at 100MW/min or potentially at higher rates.

The CBA assessment assumes three different sources of balancing volumes: 1) repositioning BOAs, 2) frequency response and 3) additional reserves

Repositioning BOAs

- As active energy changes due to IC ramping, NG ESO needs to take actions (via bids and offers from the balancing mechanism) to keep the system balanced in terms of energy
- At least the same amount of active energy driven by IC ramping needs to be secured in the opposite direction from units acting in the BM (which ESO can access via BOAs)
- The change in volumes driven by these energy actions will require a payment (coming from BOAs). The CBA assessment uses the day-ahead wholesale price as the basis for payment, which is likely a reasonable compromise. For all energy actions analysed in this report, AFRY will use the DA wholesale price as a proxy for the value of BOAs coming from the BM

Frequency response

50Hz

- As ICs ramp, causing a change in active energy, system frequency changes (assuming all other variables are left unchanged)
- Enough frequency response needs to be available while ICs ramp in order to contain any frequency deviation
- Based on current methods, procurement of frequency response is likely related to an energy action. This is because, in order to have more response, a thermal plant potentially needs to be synchronised and part-loaded to provide MFR.
- The energy component of this action would likely be accessed by NG ESO via BOAs (as this is the current procurement mechanism)

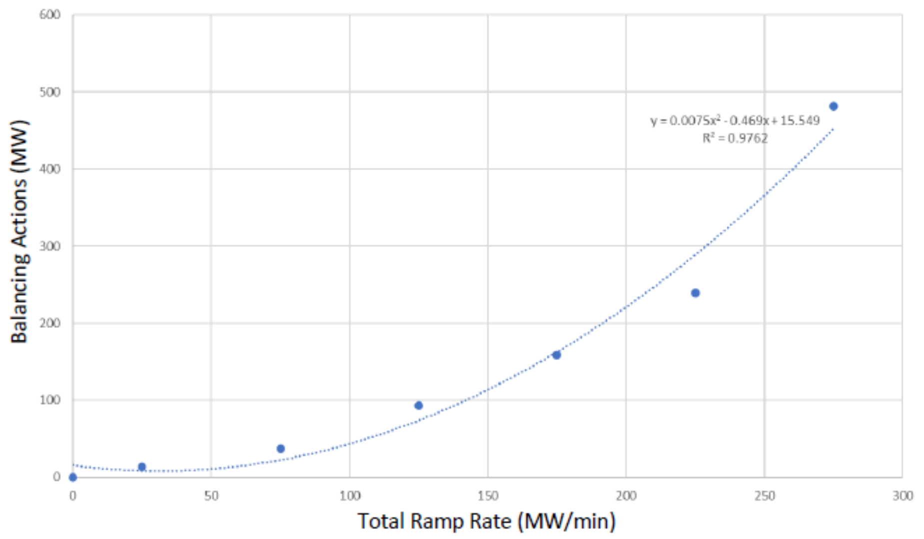
Operating reserves

- ESO needs to have enough reserves available that can respond quickly to any imbalances that may arise when ICs ramp
  - For example, some plants need headroom in case some of the balancing actions taken while IC ramps fail. The reserves on the system will increase their active power output, thus dampening the drop in frequency due to the thermal outage
- As it currently stands, thermal plants need to be synchronised and part-loaded to provide reserves. This means there is an energy action involved in the provision of reserves, as increasing reserves might only be possible if an additional thermal plant is synchronised

Given that most providers of these services are currently thermal plants, the procurement of these products is predominately done by BOAs of BM units and MFR (Mandatory Frequency Response). This means the majority of these services incur a cost through the change in the energy component of plants (changing their output in the BM). **The current CBA assessment appears to assume that the procurement of these balancing volumes will not deviate from the current methodology**, meaning balancing IC ramping will always result in significant changes in thermal output.

The volumes for repositioning (BOAs) and frequency response represent one of the components for estimating total balancing actions due to IC ramping

BALANCING ACTIONS FOR REPOSITIONING OF BOAS AND FREQUENCY RESPONSE (MW) AS PRESENTED IN THE EXISTING CBA



AFRY attempted to replicate this correlation, but was unable to based on available information, as discussed in the next section

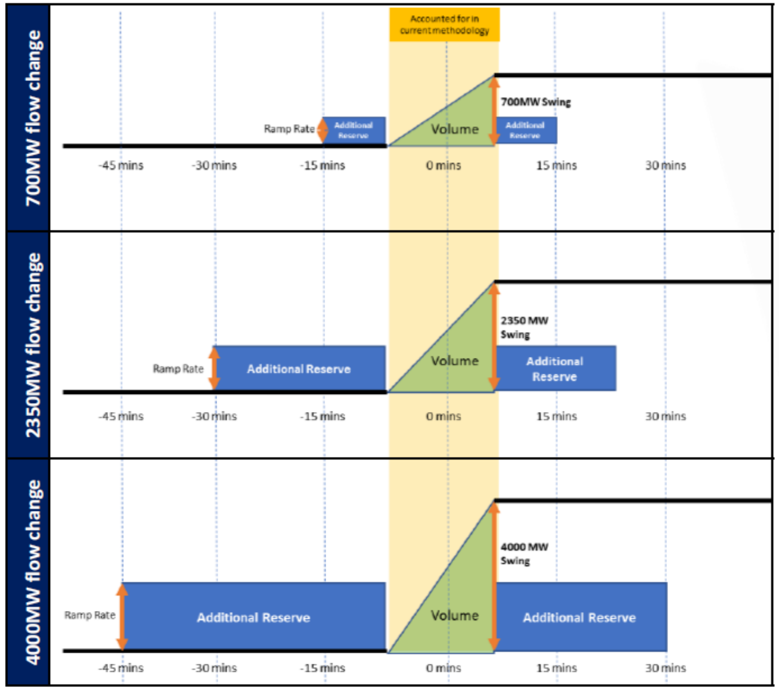
Source: The chart and formula used comes from the Appendix B of the CBA

COMMENTARY

- The historic analysis of 2022 presented in the existing CBA assessment shows a strong correlation between increased balancing volumes and cumulative ramping.
  - Given the unprecedented conditions of 2022, it is an **open question whether this is an appropriate year** to use for this correlation analysis.
  - This correlation suggests higher cumulative IC ramping results in increased balancing actions taken by ESO.
- The chart taken from the CBA shows that after 200MW/min of cumulative ramping, the balancing volumes exceed the active energy change. This implies that more energy actions are needed to procure more frequency at ramp rates >200MW/min.
  - This likely means having to synchronise an additional plant to provide more frequency.
- For the analysis in the next section, the same formula is used to define the total balancing actions (MW) required based on IC cumulative ramping. This is to allow for comparability of outcomes rather than being a validation.
- This formula represents one of the two components used in calculating the total volumes required due to IC ramping.

The second component of total balancing volumes due to IC ramping is the provision of additional reserves

RESERVE NEEDS BASED ON MAGNITUDE OF FLOW CHANGE AS PRESENTED IN THE EXISTING CBA

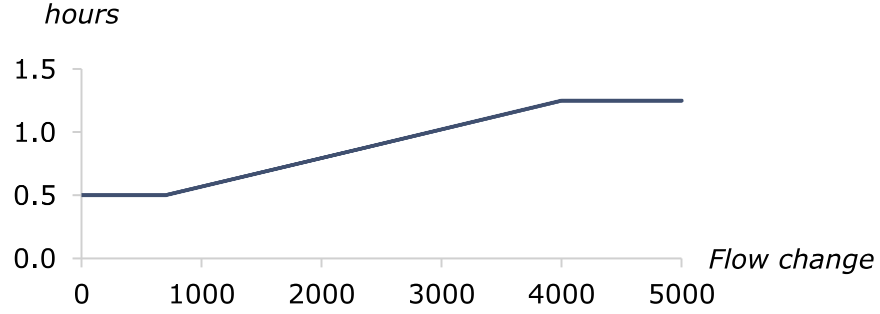


Based on the 3 points given in the CBA assessment we have constructed this relation

Source: The chart and formula used comes from the Appendix B of the CBA

COMMENTARY

– The CBA assessment presents an analysis that relates the duration of holding reserves to the cumulative flow change across continental ICs. The relation is:



– The volume of reserves needed is the result of multiplying the hourly ramp rate by the time (in hours) that reserves need to be hold

– The additional reserve that needs to be procured is likely linked to energy actions in the form of synchronising thermals plants (hours ahead of the ramp) to provide increased operating reserves

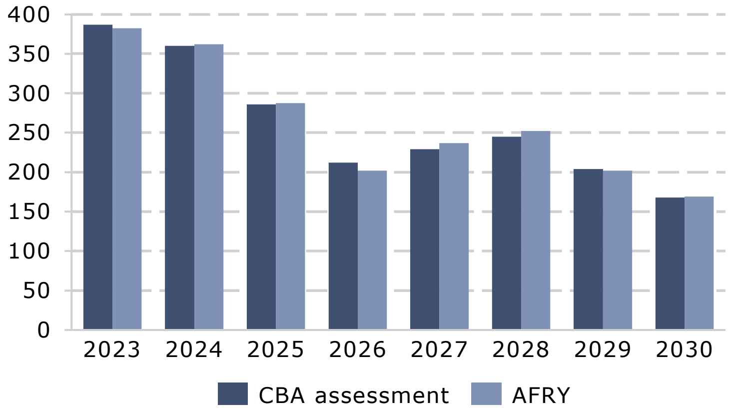
– It is not clear to AFRY how these volumes have been defined (left chart). However, for the purpose of the analysis, we use the same formula used in the CBA assessment (chart above)

We benchmarked the calculations from the CBA assessment, to validate the methodology and allow us to evaluate the impact as we change assumptions

BASELINE RESULTS FROM CBA ASSESSMENT

MW/min	2023	2024	2025	2026	2027	2028	2029	2030
0	1806	1910	2187	1967	1981	2045	2393	2585
0 – 100	4020	3699	3372	3664	3484	3169	3111	3124
100 - 200	1800	1740	1720	1645	1602	1659	1464	1388
200 - 300	699	839	874	835	940	940	899	841
300 - 400	297	362	376	385	450	522	468	449
400 - 500	138	146	156	180	188	240	263	222
500 - 600	0	64	75	84	115	125	100	85
600 - 700	0	0	0	0	0	60	62	66
700 - 800	0	0	0	0	0	0	0	0
Avg Ramp Rate	89	97	99	100	106	117	109	104
Wholesale Price (£/MW)	£221	£175	£134	£92	£87	£79	£67	£60
Overall Cost (£)	£387m	£360m	£286m	£212m	£229m	£245m	£204m	£168m

TOTAL BALANCING COSTS (M£, REAL 2022)*



*We are assuming the values in the CBA assessment are in real 2022 money

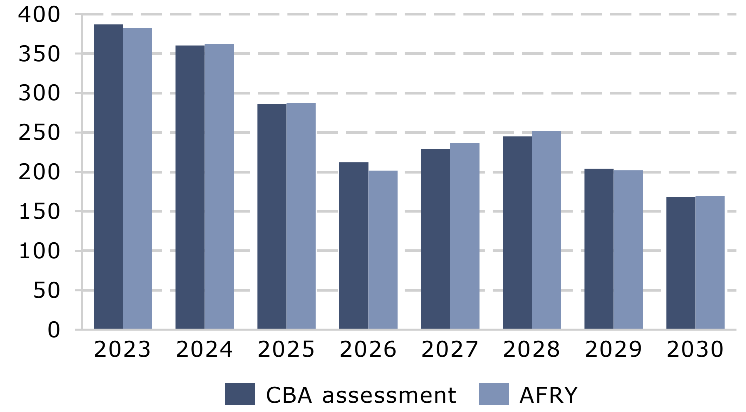
COMMENTARY

- Using the information presented in the report (upper chart), we replicated the baseline results of overall balancing costs
- The assumption of hourly ramp rate for each range provided was taken between 60 to 75%, this means that for the ramping range between 300 to 400 we assumed ALL ramping would be between 360 to 375 MW/min
  - We used the formula developed in the CBA assessment to calculate the total required volumes due to IC ramp
- For estimating the reserve volumes, we needed to calculate the hourly flow change of each ramping. We assumed the ramping for each interconnector would be 10 minutes (reflecting that IC would have a maximum flow change of 1,000MW)
  - We used the formula linking flow change with time required for reserves
- After having calculated the total volumes, we multiplied by the DA price assumed in the CBA. The comparison is shown in the bottom left chart. The results are closely aligned with the original CBA, indicating we have a reasonable approximation of the CBA methodology
- Finally, we calculated a NPV of the balancing costs for the baseline at £1,570m (assuming an 8% discount rate)
  - Based on the NPV of cost savings in the CBA assessment for the 3 different options evaluated, we estimated the NPV of the balancing costs for each option as follows:

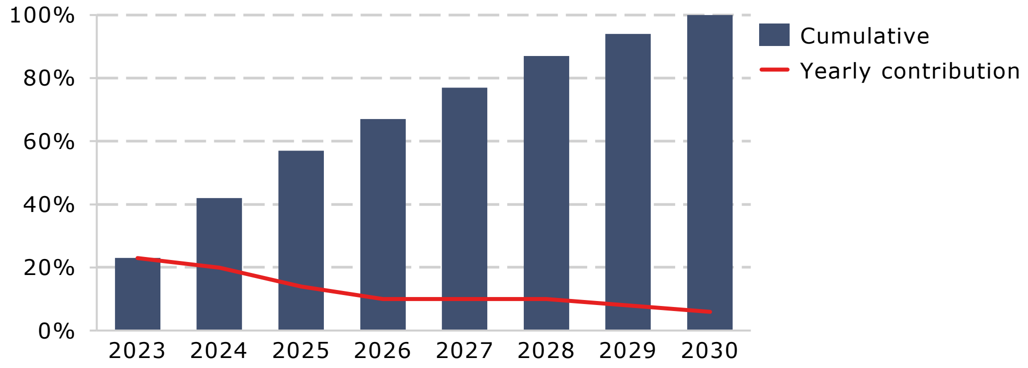
1A: Ramp management	2B: Static low ramp	3.1: Dynamic ramp
£1,142m	£705m	£773m

High commodity prices in the short-term are an important driver of the balancing costs savings in the CBA assessment

TOTAL BALANCING COSTS (M£, REAL 2022)*



SHARE OF YEARLY BALANCING SAVINGS AGAINST THE TOTAL (%)



*We are assuming the values in the CBA assessment are in real 2022 money

COMMENTARY

- The **high-commodity prices** experienced (and expected in the short-term) when the CBA assessment was done contribute to more than half of the NPV of the overall balancing costs savings coming in the initial years
  - Projected savings in the initial 3 years represent around 57% of the total savings over the years assessed
- **The decreasing trend of total balancing costs** show that the **benefits** of implementing a static ramp rate of 50MW/min **almost halves in the second half of the 2020s**
  - **Additional market-based procurement** of balancing volumes could also **potentially reduce** the balancing costs in the second half of the 2020s. This is explored in the next section

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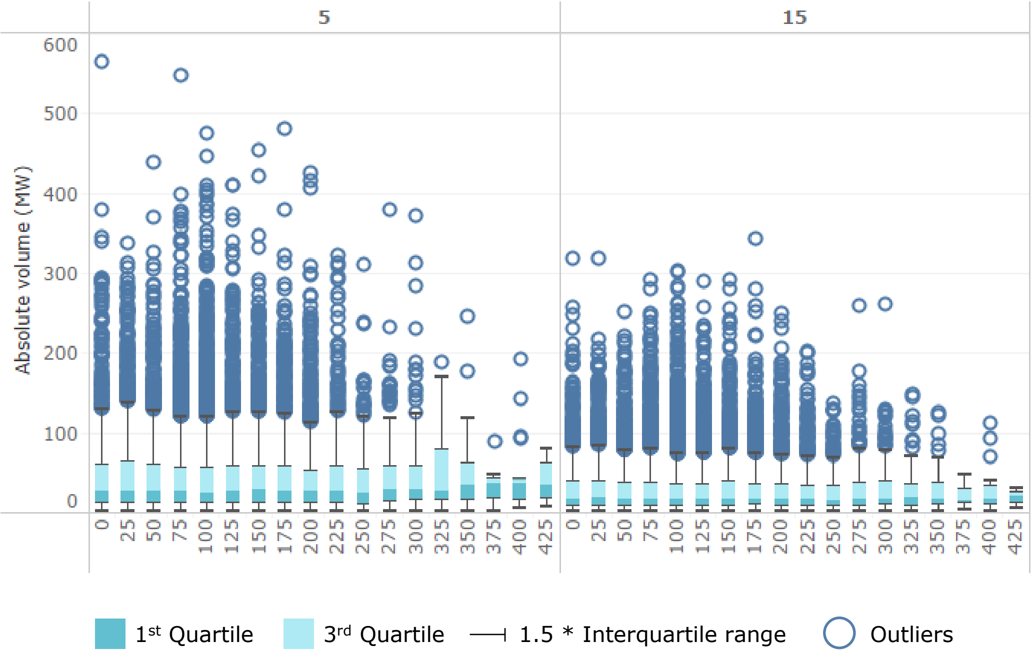
AFRY has not been able to replicate CBA's correlation between IC cumulative ramping and increasing balancing volumes, with more transparency needed

BALANCING VOLUMES (MWH) AT DIFFERENT IC CUMULATIVE RAMP RATES (MW/MIN)

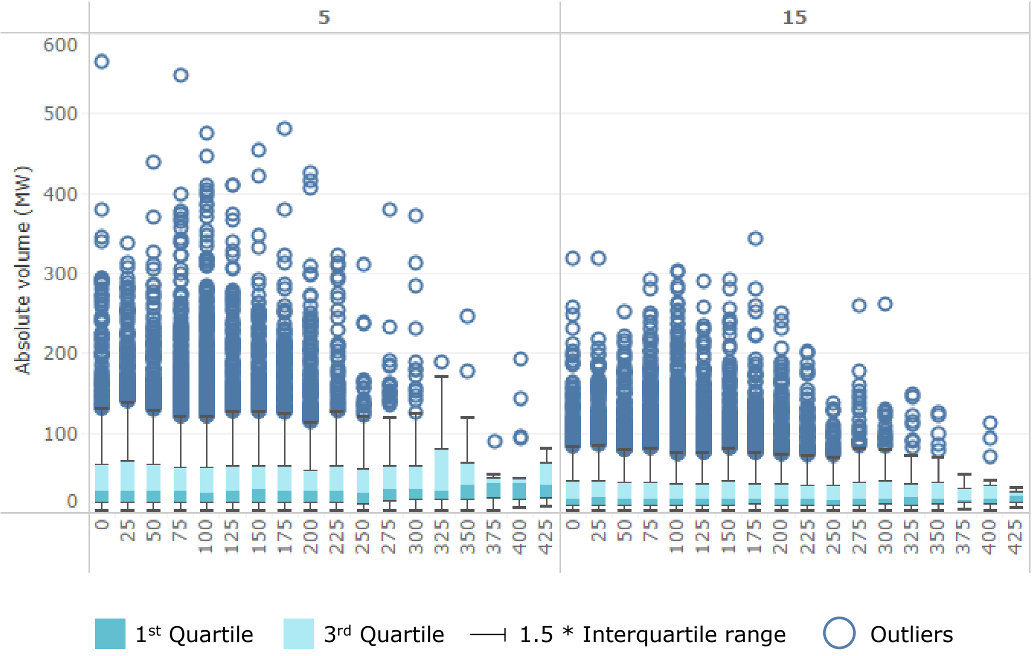


COMMENTARY

- **AFRY acknowledges** the concept that fast IC ramping could impact negatively the system's frequency and, as such, ESO needs procure more reserve and response volumes to limit the operability impacts of IC ramping
- That being said, **the historic review performed by AFRY** on balancing volumes so far (through BOAs), **cannot confirm this**
- The chart shows the **median balancing volume** at internals of **25MW/min cumulative IC ramping** for the year 2022 (to be consistent with the CBA). One chart looks at the balancing volumes taken 5 minutes before and after the hour, while the other one looks at the volumes in a 15min window before and after the hour. Limiting balancing volumes at these time ranges intends to leave out other BOA volumes not procured while ICs ramp
  - Both time frames show **consistent median** balancing volumes, **irrespective** of IC cumulative ramping
  - Both time frames also **fail to** show a significant increase in balancing volumes at high IC cumulative ramp rates, although a slight upward effect is seen (i.e., >250MW/min)

AFRY has not been able to replicate CBA's correlation between IC cumulative ramping and increasing balancing volumes, with more transparency needed

BALANCING VOLUMES (MWH) AT DIFFERENT IC CUMULATIVE RAMP RATES (MW/MIN)



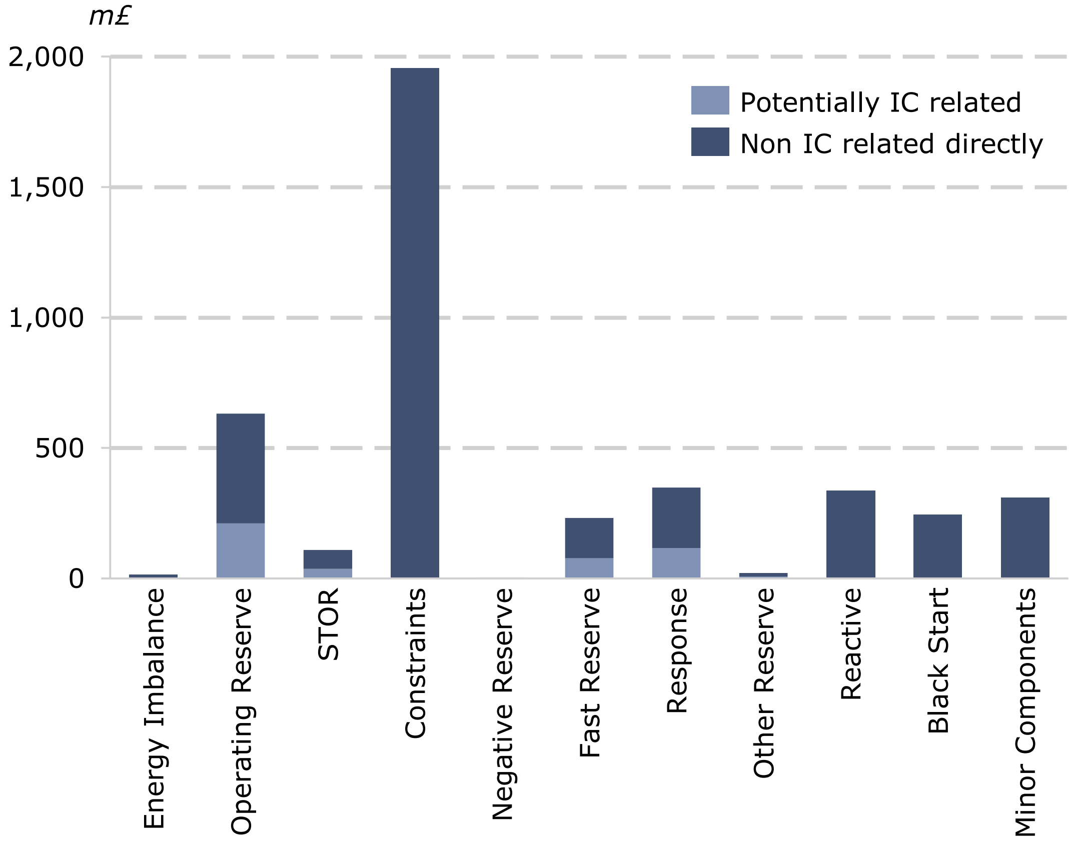
COMMENTARY

- The methodology to relate IC cumulative ramping with balancing volumes is explained in appendix B of the CBA assessment. It mentions that data has been filtered based on some reasons and timeframes.
  - AFRY assumes this data refers to the **Dispatch Transparency** on **ESO's data portal[1]**
  - It is unclear as to how the filtered data resulted in the distribution showed in page 12 of the Appendix B (also seen in slide 11 of this report), as AFRY has performed several combinations and it **cannot replicate** similar results
- This analysis would likely need **some additional inputs from ESO** to truly understand the reasons for each balancing action, as at the moment in remains unclear
- The analysis we have conducted suggests that there is little impact on IC ramping rate on overall balancing actions performed by ESO.
- However, **greater transparency** on the methodology used in the CBA to derive the correlation may allow for a different outcome to be reached in this regard.

https://data.nationalgrideso.com/balancing/dispatch-transparency

The distribution of total balancing services costs might highlight that balancing actions are mostly done for non-IC related changes on the system

TOTAL BALANCING SERVICES COSTS IN 2022 (M£)

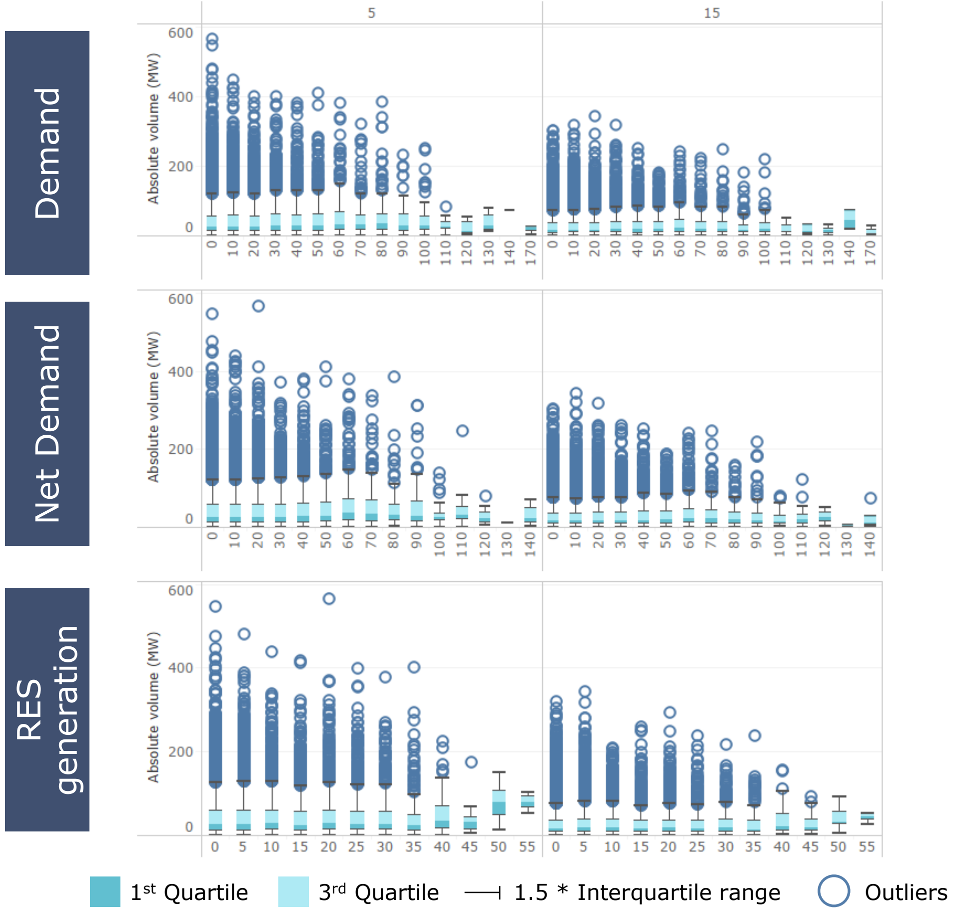


COMMENTARY

- On the basis that the volume of balancing actions does not seem to grow with increasing IC cumulative ramping, we have looked at the overall **distribution of costs** to gain additional insights on the **impact of IC ramping in balancing actions** taken
  - We have classified these services by whether they can be **partially impacted by IC ramping or not**. For example, "Constraints" are mostly dominated by transmission constraints and RoCoF, which IC ramping has no direct impact on. As such, no costs from this service is associated to IC ramping
  - On the contrary, the "Response" service can **be likely impacted by IC ramping**, so we assign a part of these costs to it. We have assumed up to 33% of the entire costs could be linked to IC ramping on the services impacted by it. This comes from the assumption that such balancing actions will be faced in 20/60 minutes of an hour, when ICs ramp
- This simple analysis shows that ~10% of the costs might be linked to IC ramping. Taking costs as a proxy for volumes of balancing actions taken, this may suggest that the **majority of actions come from non-IC related issues**, such as thermal network constraints

We have found low correlation between rate of change of demand, net demand and RES generation against balancing volumes

BALANCING VOLUMES (MWH) AT DIFFERENT RATES OF CHANGE OF SEVERAL SYSTEM CONDITIONS



COMMENTARY

- In addition to comparing IC cumulative ramp rate against balancing volumes, we have evaluated the impact of fast changing system conditions, such as **total** and **residual (net) demand** and **RES generation**
  - Similarly to **IC cumulative ramp rate**, the historic data suggests a **minor relation** between faster changing conditions and balancing volumes
  - What the analysis shows is that the periods of fastest change in respect of these 3 system conditions tend to see much **lower variability on balancing volumes**. This differs compared to IC cumulative ramping, as a minor upward effect is seen.
- The intention of this analysis was to identify other fast changing system conditions that may have some correlation to overall balancing volumes to make the argument that the correlation found in the CBA assessment did not necessarily need to be causation.
  - The low correlation seen across these system conditions fail to provide individual reasons for balancing volumes, highlighting the fact that actions taken by ESO through BOAs are for multiple causes, making it difficult to single out individual contributors, including IC ramping

The historic data review considered publicly available data from ESO's data portal, which AFRY believes should be the same data as used in the CBA

METHODOLOGY STEPS

- The data for continental IC cumulative ramping was taken from the **ESO's Historic Demand Data**, which has flows for every settlement period[1] for every IC.
  - We assumed all ICs ramp symmetrically before and after hour changeovers and that they ramp at their maximum level, 100MW/min (even if this assumption is wrong, assuming that they ramp at the maximum means we do not underestimate any ramping)
  - Based on the change of flow of each IC and their maximum ramp rate, we calculate the time it takes for each IC to ramp
  - Lastly, we take the net flow change across continental IC and divide that by the longest time it takes any IC to change its position. This approach means that we are slightly overestimating the duration of the overall maximum cumulative ramping, as we assume all IC ramp for the same duration as the one that takes longest. We have done this to be conservative.
- The data for the BOAs comes from the **Dispatch Transparency of ESO's data portal**[2].
  - We identified the time for 1st action of all BOAs in 2022 and made sure to consider only the actions that start within a window timeframe (of 5 and 15mins) that relates to IC ramping. This allowed identification of the balancing volumes taken 5 and 15 minutes before and after an hour change, when IC ramps
  - The data from the Dispatch Transparency information has a column labelled "Exclude BOA reasons". We aggregated all actions, regardless of what reason had been given
- The last step was to link the balancing volumes that happen at each individual hour change of 2022 with the IC cumulative ramping for 2022 (this year was used to have the CBA assessment results as a benchmark for our findings).
- We made several combinations between IC cumulative ramping and BOAs from different reasons (Exclude BOA reasons) and neither combination gave anything similar to the results shown in the CBA assessment.

1. https://data.nationalgrideso.com/demand/historic-demand-data 2. https://data.nationalgrideso.com/balancing/dispatch-transparency/r/all_boas

Agenda

ALTERNATIVES FOR MONETISATION

Alternative reasonable monetisation factors lead to lower balancing cost savings relative to the CBA assessment

- The CBA assessment values all the balancing volumes required due to IC ramping at the **day-ahead wholesale price**. This is, in AFRY’s understanding, a proxy for the value of the energy actions that need to be taken to accommodate additional reserve and response.
  - After having made some analyses on potential costs for balancing actions on a CCGT, this appears as a reasonable assumption (see Annex). However, the assumption implies that the procurement of reserve and response products in the future **will remain unchanged**.
  - NG ESO is currently developing a new suite of reserve and response products with the intention of increasing the flexibility of the system. One of the aims is to procure these services closer to the time when they are required. The suite of new products are likely to predominantly be **fulfilled by batteries** due to their (almost) immediate response time.
  - Given this, it appears reasonable that some of the balancing volumes required due to IC ramping could be covered by these new products. In this case, **the balancing cost of IC ramping would decrease**, as the new products are projected to have significantly lower cost than the balancing actions using a thermal asset.
- The following section looks at the potential reduction in balancing costs on the baseline and the consequent potential reduction in savings offered by implementation of the three alternatives considered for GC0154.
  - This is achieved by **reducing the volumes** that are related to active energy actions (actually changing the output of thermal assets), valued at the day-ahead price and instead being valued at AFRY’s projected price for new reserve and response products.
  - Given that only the ramping data for the Baseline is provided in the CBA assessment documents, we have estimated the **NPV of the balancing costs** for the different options based on the **Baseline reduction**. This means that if, for a given set of assumptions, the balancing costs decrease 20%, we assume the same reduction (in percentage) will occur in the alternative options. We acknowledge this is not ideal, but it is the best we can do with the available data.
  - The results shown here could be realised by enabling market based products to contribute to additional reserve and response needs due to IC ramping. Market-based solutions likely differ to a limitation via the grid code, however this is a potentially viable alternative in terms of economics and enhancing system’s flexibility

A range of iterations are considered by gradually increasing the balancing volumes that can be procured without incurring in energy actions

- The following table covers the combination of inputs changed in the analysis of alternative monetisation factors
- The non-energy actions for frequency response are priced at AFRY's Central Q2 2023 projections for Dynamic Moderation
- The non-energy actions for reserves are priced at AFRY's Central Q2 2023 projections for Quick reserves

Iteration number	Wholesale price	Frequency response	Reserves
1	AFRY's Central 2023 Q2	Same as CBA assessment	Same as CBA assessment
2		Twice the volume of ramping demands energy actions	Gradually increase until 50% of these volumes do not demand energy actions
3		One and a half times the volume of ramping demands energy actions	Gradually increase until 50% of these volumes do not demand energy actions
4		One time the volume of ramping demands energy actions	Gradually increase until 50% of these volumes do not demand energy actions
5		Twice the volume of ramping demands energy actions	Gradually increase until 65% of these volumes do not demand energy actions
6		One and a half times the volume of ramping demands energy actions	Gradually increase until 65% of these volumes do not demand energy actions
7		One time the volume of ramping demands energy actions	Gradually increase until 65% of these volumes do not demand energy actions
8		Half the volume of ramping demands energy actions	Gradually increase until 100% of these volumes do not demand energy actions

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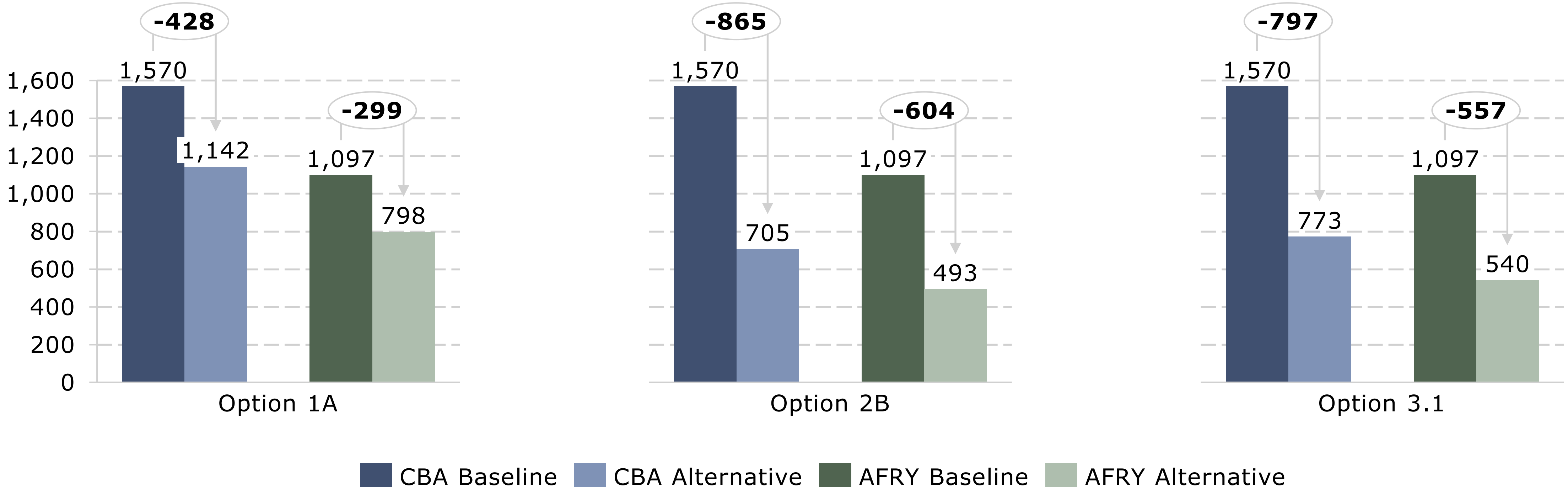
NPV comparison of iteration 1: only updating the DA wholesale price to AFRY's Central Q2 2023

Iteration 1

Only the **day-ahead price** used is updated.

AFRY's Central Q2 2023 prices are lower than those considered in the CBA assessment. As such, updating the day-ahead prices results in decreased savings, with the reduction in cost savings ranging between £131m (Option 1A) to £265m (Option 2B)

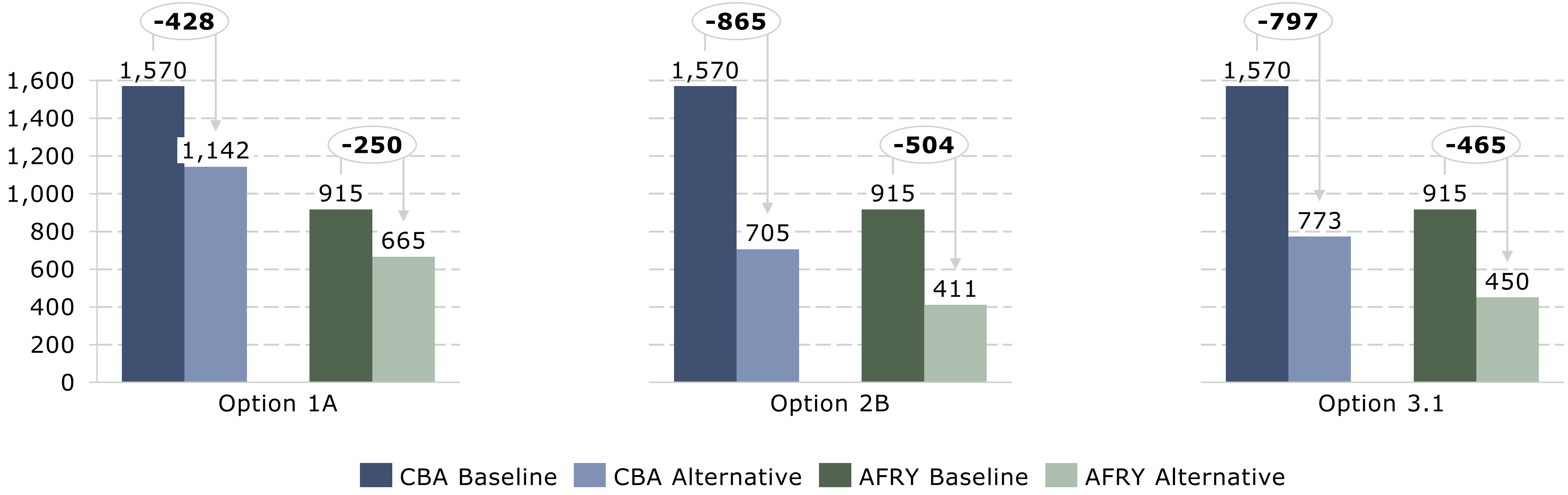


NPV comparison of iteration 2: twice the ramping volume requires frequency control energy actions and 50% of reserves covered by new products

Iteration 2

Up to **50% of the reserves** are procured from a new reserve product (by 2030) and **two times the ramping volume** of IC will result in a change in active energy output from generators (i.e., repositioning of BOAs)

There is a reduction in balancing costs as the value for new reserve and response products is projected to be significantly lower than the repositioning costs of BOAs.

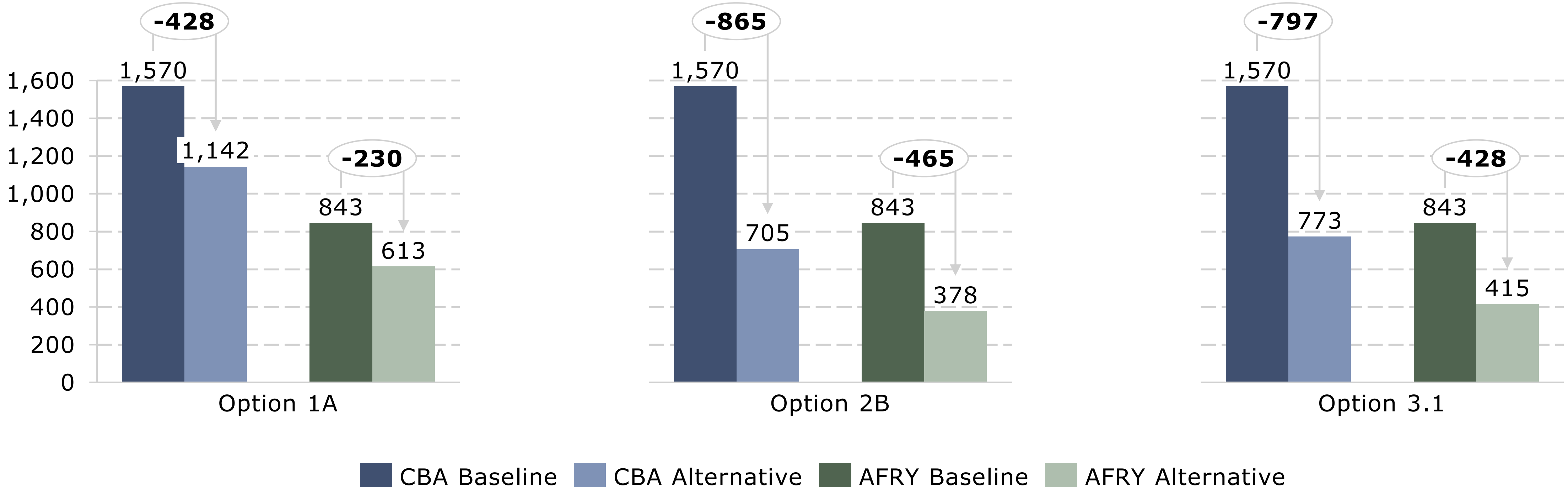


NPV comparison of iteration 3: 1.5X the ramping volume requires frequency control energy actions and 50% of reserves covered by new products

Iteration 3

Up to **50% of the reserves** are procured from a new reserve product (by 2030) and **one and a half times the ramping volume** of IC will result in a change in active energy output from generators (i.e., repositioning of BOAs)

There is a reduction in balancing costs as the value for new reserve and response products is projected to be significantly lower than the repositioning costs of BOAs.

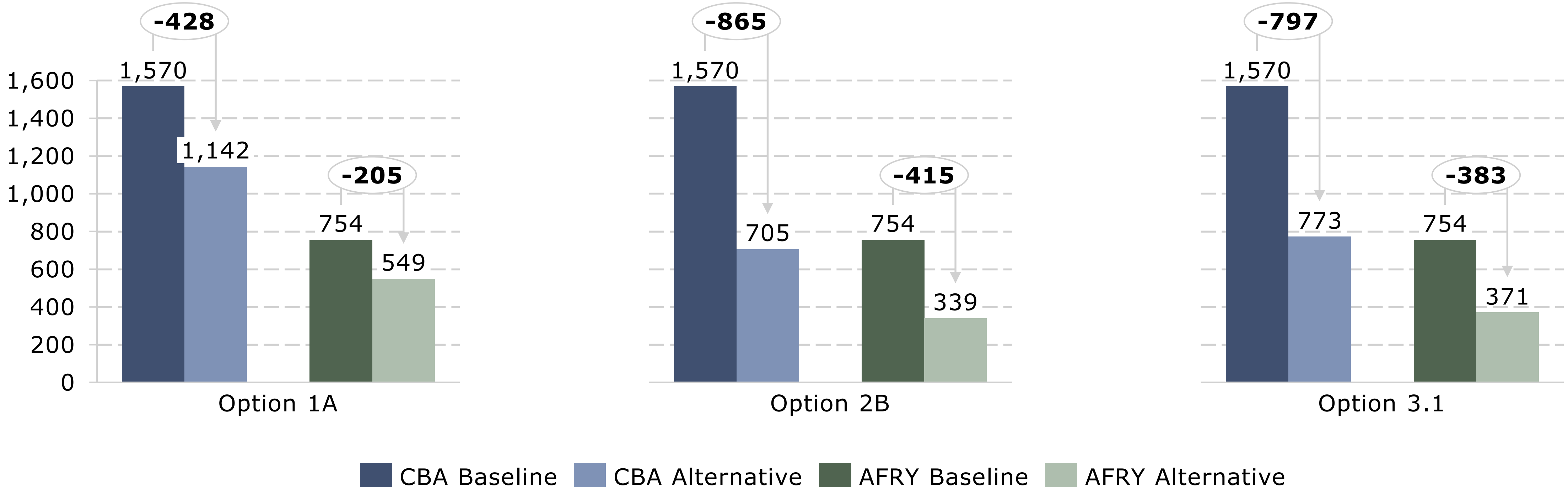


NPV comparison of iteration 4: 1.0X the ramping volume requires frequency control energy actions and 50% of reserves covered by new products

Iteration 4

Up to **50% of the reserves** are procured from a new reserve product (by 2030) and **one time the ramping volume** of IC will result in a change in active energy output from generators (i.e., repositioning of BOAs)

There is a reduction in balancing costs as the value for new reserve and response products is projected to be significantly lower than the repositioning costs of BOAs.

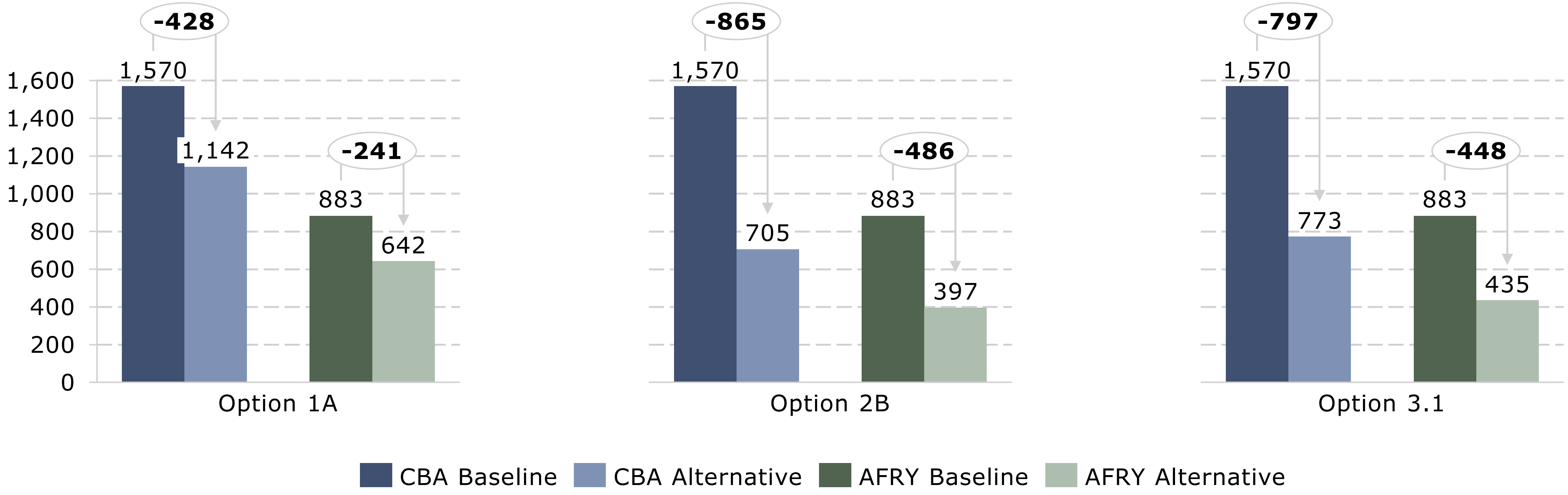


NPV comparison of iteration 5: 2.0X the ramping volume requires frequency control energy actions and 65% of reserves covered by new products

Iteration 5

Up to **65% of the reserves** are procured from a new reserve product (by 2030) and **two times the ramping volume** of IC will result in a change in active energy output from generators (i.e., repositioning of BOAs)

There is a reduction in balancing costs as the value for new reserve and response products is projected to be significantly lower than the repositioning costs of BOAs.

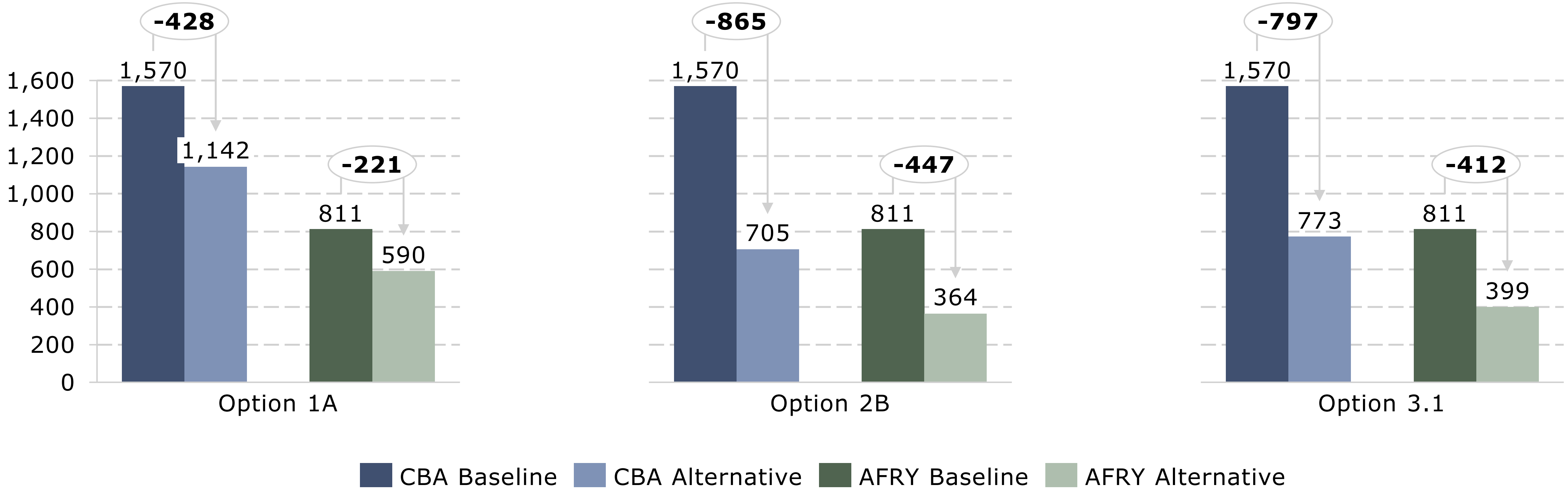


NPV comparison of iteration 6: 1.5X the ramping volume requires frequency control energy actions and 65% of reserves covered by new products

Iteration 6

Up to **65% of the reserves** are procured from a new reserve product (by 2030) and **one and a half times the ramping volume** of IC will result in a change in active energy output from generators (i.e., repositioning of BOAs)

There is a reduction in balancing costs as the value for new reserve and response products is projected to be significantly lower than the repositioning costs of BOAs.

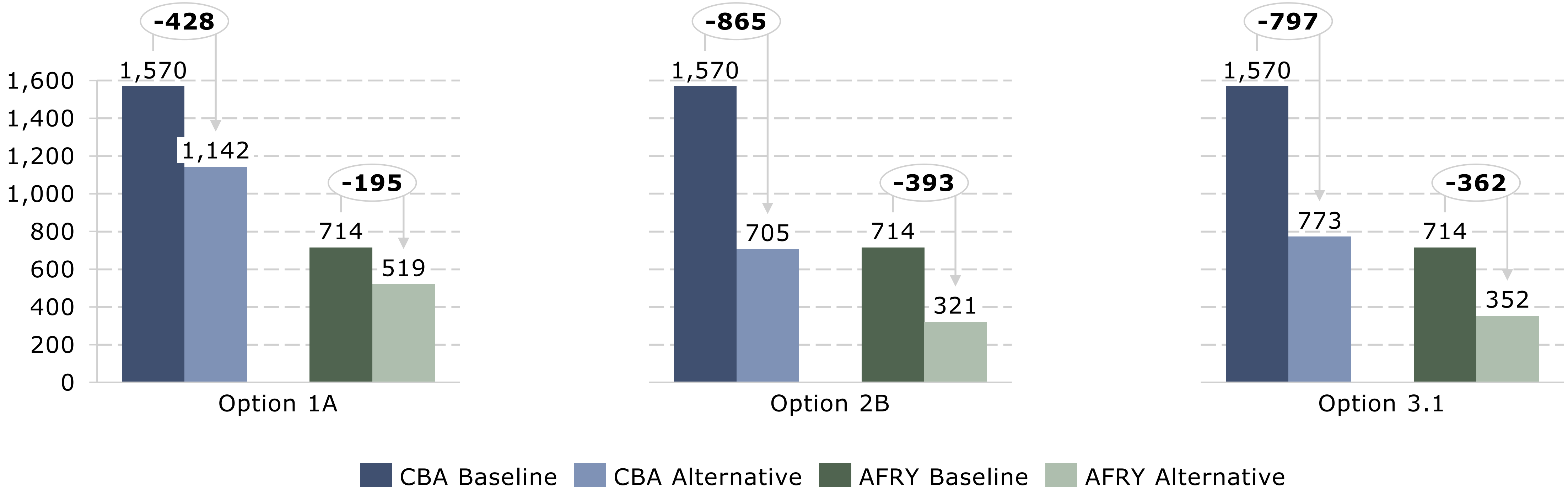


NPV comparison of iteration 7: 1.0X the ramping volume requires frequency control energy actions and 65% of reserves covered by new products

Iteration 7

Up to **65% of the reserves** are procured from a new reserve product (by 2030) and **one time the ramping volume** of IC will result in a change in active energy output from generators (i.e., repositioning of BOAs)

There is a reduction in balancing costs as the value for new reserve and response products is projected to be significantly lower than the repositioning costs of BOAs.

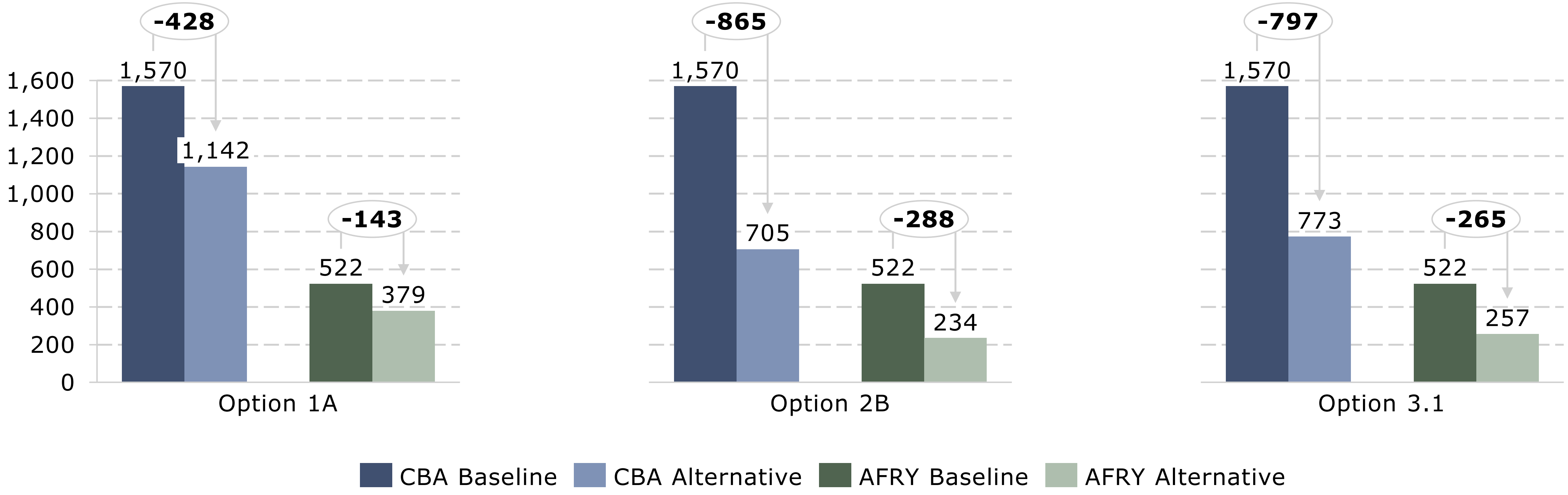


NPV comparison of iteration 8: 0.5X the ramping volume requires frequency control energy actions and 100% of reserves covered by new products

Iteration 8

Up to **100% of the reserves** are procured from a new reserve product (by 2030) and **half the ramping volume** of IC will result in a change in active energy output from generators (i.e., repositioning of BOAs)

This iteration represents the most aggressive assumptions analysed. This does not necessarily mean that this could be implemented in the future, however it is useful to consider it as an upper range for saving reductions compared to the existing CBA assessment



Our different iterations show a potential reduction in NPV of balancing cost savings of between ~30% to ~55%, compared to the CBA assessment

	CBA Assessment	Iteration 1	Iteration 2	Iteration 3	Iteration 4	Iteration 5	Iteration 6	Iteration 7	Iteration 8
		All balancing volumes procured mostly by BOAs, without any future improvement (i.e., Status Quo)	2X ramping volume requires BOAs	1.5X ramping volume requires BOAs	1X ramping volume requires BOAs	2X ramping volume requires BOAs	1.5X ramping volume requires BOAs	1X ramping volume requires BOAs	0.5X ramping volume requires BOAs
			50% (2030) of reserves procured by new products			65% (2030) of reserves procured by new products			100% (2030) of reserves procured by new products
Baseline	£1,570m	£1,097m	£915m	£843m	£754m	£883m	£811m	£714m	£522m
Option 1A	£1,142m (£428m)	£798m (£299m)	£665m (£250m)	£613m (£230m)	£549m (£205m)	£642m (£241m)	£590m (£221m)	£519m (£195m)	£379m (£143m)
Option 2B	£705m (£865m)	£493m (£604m)	£411m (£504m)	£378m (£465m)	£339m (£415m)	£397m (£486m)	£364m (£447m)	£321m (£393m)	£234m (£288m)
Option 3.1	£773m (£797m)	£540m (£557m)	£450m (£465m)	£415m (£428m)	£371m (£383m)	£435m (£448m)	£399m (£412m)	£352m (£362m)	£257m (£265m)

Numbers in brackets represent the NPV of balancing costs savings against the Baseline

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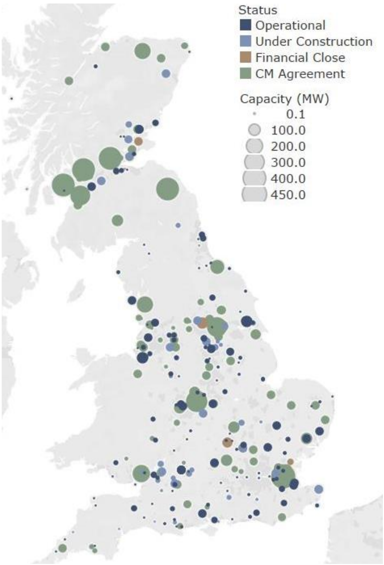
Agenda

The new reserve and response products and the expected growth of batteries drive alternative monetisation factors

- NG ESO is currently developing a new suite of reserve and response products with the intention of increasing the flexibility of the system. One of the aims is to procure these services closer to the time when they are required. The suite of new products are likely to predominantly be **fulfilled by batteries** due to their (almost) immediate response time
  - The replacement of thermal actions for balancing the system with batteries (with significantly quicker response times) are likely to reduce the cost of providing the required flexibility on the system. In other words, incoming batteries are expected to allow for a faster-changing system (based more on RES) while making sure the system operates safely.
  - The image below gives a snapshot of the outlook for battery deployment in GB

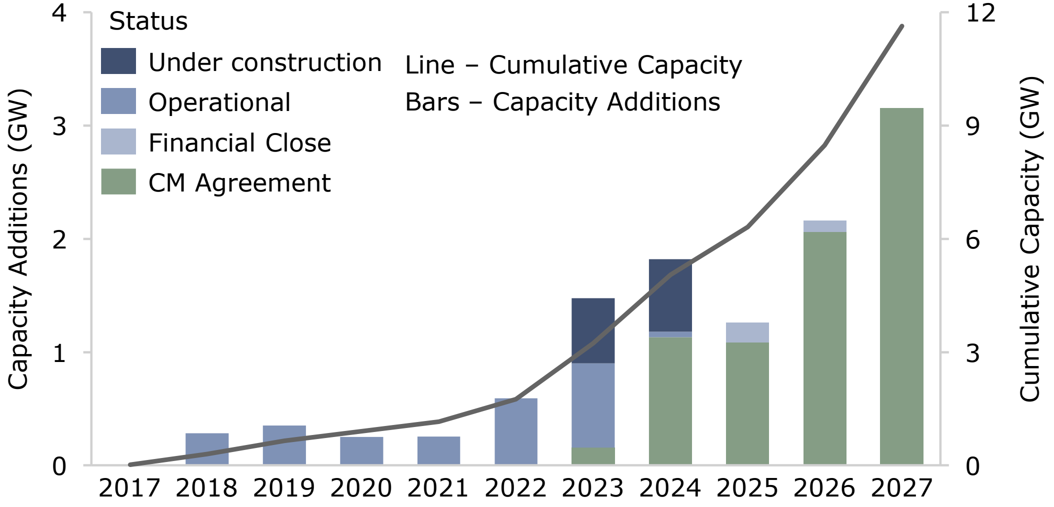
	Past	Future
	Less than 50MW	Larger, often 100s of MW
	Mostly 1 hour or less	Increasingly 2 hour and a few 4 hour projects
	Typically Southern England	Stronger focus on projects in Scotland and Northern England
	Distribution connected	Transmission or Distribution, plus co-location

Existing and future BESS assets



More than 6GWs of additional batteries will be commissioned in the next few years based on long-term contracts secured in the Capacity Market auctions

CAPACITY DEVELOPMENT OF LI-ON BATTERIES



Source: AFRY, DESNZ, NG ESO

COMMENTARY

- The results from the T-4 Capacity Market auction held in 2023 show that battery developers are aiming more towards revenues coming from energy arbitrage, as response markets seem to be saturated (the stability pathfinders also added sources for flexible and stable operation of the system)
  - In this context, **increasing the response requirements** of new products (DC, DM and DR) to balance IC ramping could be done at **low additional costs**
- The trend is also growing towards longer duration storage, which means batteries could provide flexibility services for longer, **vastly covering the IC ramping periods**
- The battery capacity is expected to double by 2025, and almost double again by 2027. This additional capacity will have to play a **key role** for the flexible operation of the network under a **net-zero** context
- The rapid response of batteries, and the availability of take power in as well as out, make them well suited to provide additional balancing volumes when IC ramp

Agenda




Limiting IC ramping could potentially increase balancing costs in certain periods when conditions change rapidly

- When the system is in relatively stable operation and IC ramping happens, it could cause frequency deviations. However, if other system conditions change quickly, having higher ramp rates on IC could potentially reduce balancing actions as ICs could match the rate of change of such conditions. This could potentially result in decreased balancing costs and increased system **adequacy** and **flexibility**, compared to a situation with lower static ramp limits. This is an aspect which does not appear to be reflected in the current CBA assessment, as it appears that IC ramping is always assumed to cause more system imbalance.

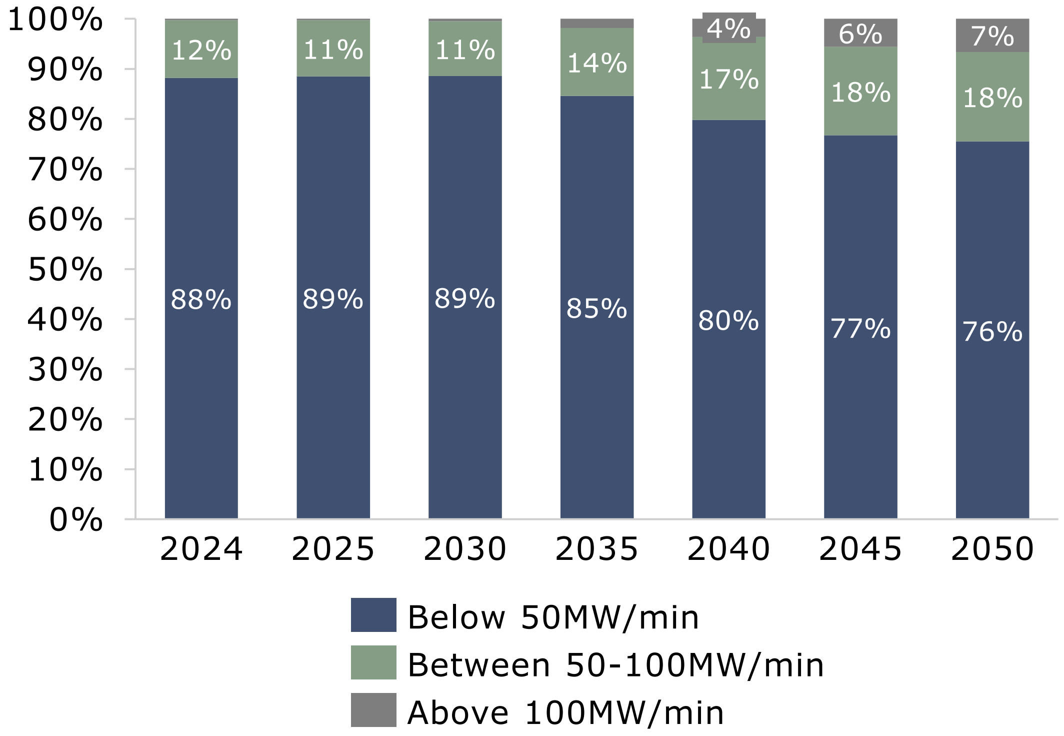
- We can define **adequacy** as the ability to match power demand with available generation (including IC flows) at any given point. In cases when the demand net of RES generation (i.e., the power demand that needs to be meet by dispatchable sources) changes fast, having higher ramp rates on IC could offer benefits to the system.
  - For example, if RES generation slows down as demand increases in the evening, the frequency will tend to decrease. Allowing ICs to quickly reduce exports (matching the rate of change of net demand) would have an upward effect on frequency, thus helping to balance the system.

- The term **flexibility** is broader than adequacy as it also matches demand with available generation (firm or intermittent). However, flexibility implies that this balance is maintained every moment in a continuous way, while adequacy focuses more on specific periods of system stress.

- The following slides look at the share of time that some system conditions change in the future and the rate at which that they do so. We look at the rate of change (in MW/min) of **net demand to evaluate the adequacy** impact of limiting IC ramping. For evaluating the **impact on flexibility**, we focus on the rate of change of **RES generation or system demand**. We have aggregated future periods in 3 groups:
  - When the rate of change is **below** 50MW/min. In this case, ICs could technically help to balance the system (if this ramp limit was implemented) as it could operate at the same rate as other system conditions change
  - When the rate of change is **between** 50 and 100MW/min. In these periods, limiting the IC ramp capabilities would prevent them from potentially balancing those actions, as they could not cover the whole rate of change
  - When the rate of change is **above** 100MW/min. These are periods when system conditions change at such quick rates that having higher than 100MW/min IC ramping could allow for better balancing options for ESO

Limiting IC ramping could potentially result in higher balancing costs and lower system's security on more than 10% of the time

EVOLUTION OF SHARE OF RAMPING RATE OF NET DEMAND (%)



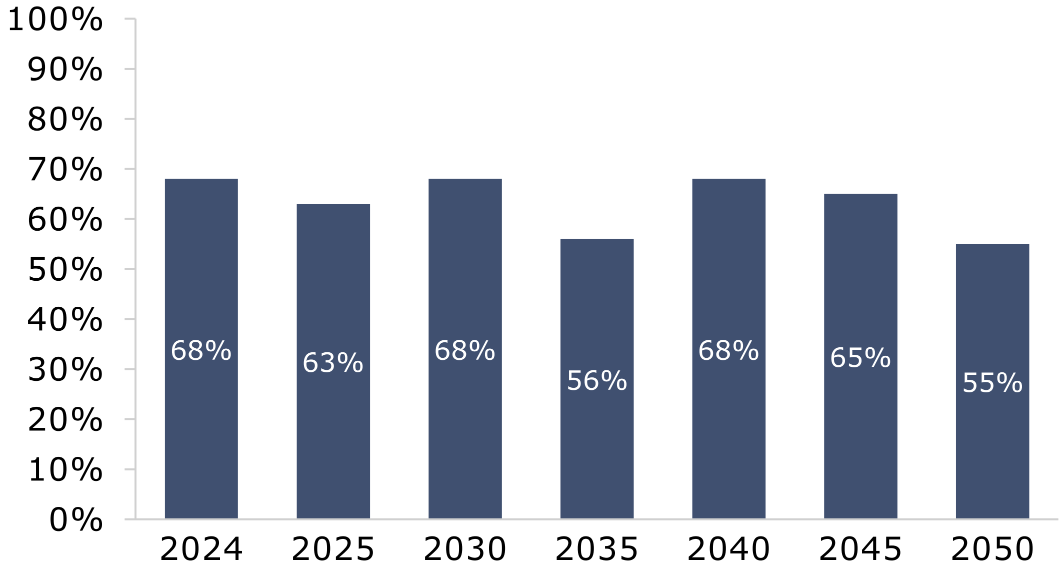
Analysis based on AFRY's 2023 Q2 Central scenario

COMMENTARY

- Net demand usually has an impact on flows, as **periods of high net demand** (combination of high demand and low RES output) tend to experience high prices, thus **resulting in imports**
  - **Limiting the ramp rate** of IC could potentially result in **higher costs** for ESO when the net demand changes quickly
  - If demand is growing at a fast pace and IC can import at a similarly fast pace, there could **be potential savings by avoiding starting** flexible thermal plants (e.g., engines). These savings could potentially be significant as turning on and synchronising a thermal plant is among the more expensive actions taken in the BM
- Beyond potential cost savings, there could be an **impact on system security** (adequacy) if IC ramping capabilities are limited
  - In periods of fast-growing net demand (when prices are likely resulting in imports into GB), **faster ramping IC could potentially balance the system quicker**, avoiding a potential drop in frequency and making sure the demand is met safely
- AFRY's 2023 Q2 projections show that limiting IC ramping at 50MW/min could mean **reduced system capability** of matching demand in more than **10% of the time**. By implementing this ramping limit, IC could only match this pace cumulatively, not individually
  - Long-term projections show that these periods (when net demand grows faster than the new IC ramp limit) will increase in the future, particularly beyond the years considered in the existing CBA assessment. This **could exacerbate the adequacy limitations** of the system even more if IC are not allowed to ramp faster to counterbalance the fast change of net demand

IC ramp in the correct direction on more than half of the tightest hours in the future, highlighting potential benefits for GB's adequacy

SHARE OF HOURS WITH LOWEST OPERATING MARGINS WHERE IC RAMP IN THE CORRECT DIRECTION TO THE NEED OF THE SYSTEM (%)



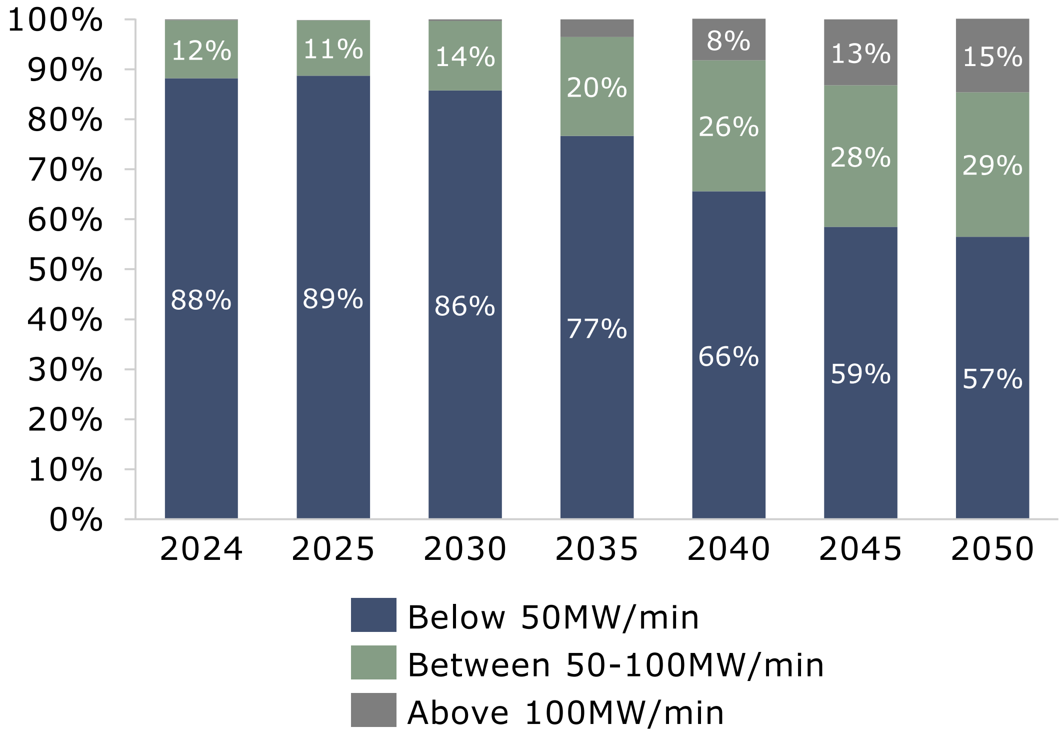
COMMENTARY

- We have evaluated the IC behaviour during the tightest hours in GB in future years and have identified that they **operate in the correct direction** for system needs in more than **60%** of the time during the 2020s
  - We have **defined tightest hours** as +10% of the lowest annual operating margin for every year
- The results highlight that during potential periods of system adequacy stress, the IC are usually contributing to reducing system tightness.
  - Having the possibility to ramp quicker could potentially result in benefits in terms of **increasing the adequacy of the system**, as well as **avoiding some thermal actions** in order to meet the demand during these periods
  - This is a particular topic that **does not appear to be covered** in the modelling methodology provided in the existing CBA assessment, potentially meaning that adverse consequences of imposing a lower static ramp rate compared to the current one may not be captured
- The data shown here looks **exclusively at IC ramping** that occurs during **tight hours**. It excludes periods with low operating margins when there is no change in IC flows, i.e., no ramping

Analysis based on AFRY's 2023 Q2 Central scenario

Limiting IC ramping could significantly decrease the flexibility of the system, especially beyond 2030, as the system targets for net-zero

EVOLUTION OF SHARE OF RAMPING RATE OF RES GENERATION OR DEMAND (%)



COMMENTARY

- **ICs** are (technically speaking) **highly flexible**, as they can adapt their output almost immediately. If the overall conditions of the system change slowly, then the value of flexibility of fast changing IC is low, as the whole system is relatively inflexible
  - However, as more RES and demand-side response is implemented in GB, **fast ramping IC** could be used to **balance fast-changing conditions** on the system
  - Limiting IC ramping **limits the flexibility of the system**, as it restricts one of its fast responding assets
- Based on the first years on the chart on the left, we see that the current value of fast ramping IC is for balancing fast changes of net demand (values are almost the same between this and the previous chart).
- As the power system transitions to net-zero (2030 onwards) and more intermittent generation is deployed, the potential impact of **reduced flexibility from limiting IC ramping grows significantly**

Analysis based on AFRY's 2023 Q2 Central scenario

Agenda

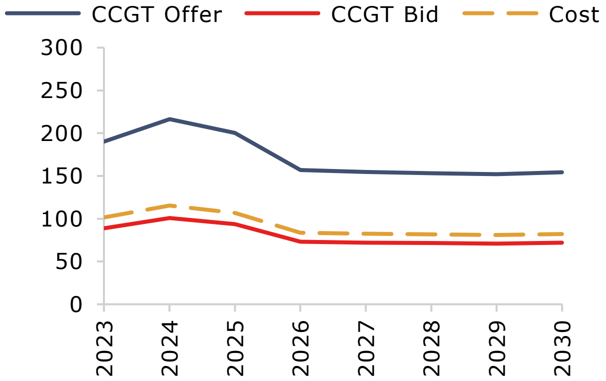
AFRY understands that the CBA assessment considers the DA price as a proxy for the balancing cost paid to generators through BOAs

– The CBA assessment appears to assume that all balancing volumes due to IC ramping will be procured in the same method as it has done in the past, namely through BOAs to reposition generators. As such, the assessment considers the DA price as a proxy for the actual BOA cost

– AFRY has reviewed this assumption by comparing the average DA price against potential costs of repositioning a thermal generator (CCGT). **Three** different scenarios are considered for repositioning a CCGT.

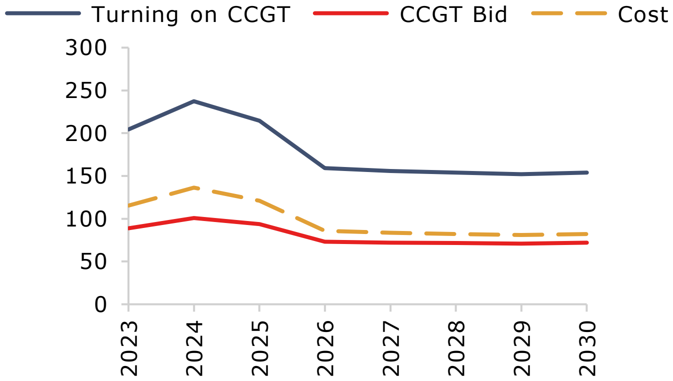
Ramp down a CCGT and ramp up an already synchronised CCGT

- CCGT offer +50% of variable cost
- CCGT bid -30% of variable cost



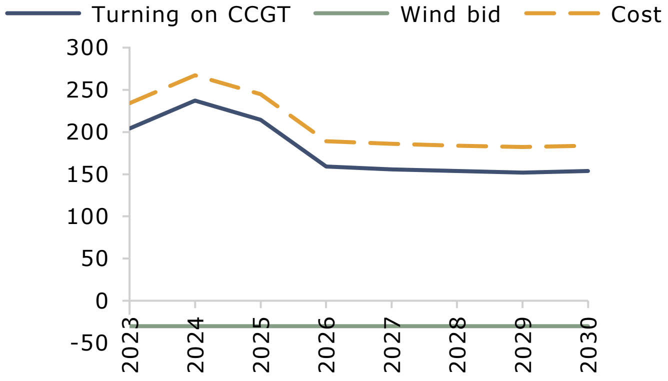
Ramp down a CCGT and synchronise another CCGT

- CCGT turns on at 75% (reserve both directions)
- CCGT bid -30% of variable cost



Bid down a wind farm and synchronise a CCGT

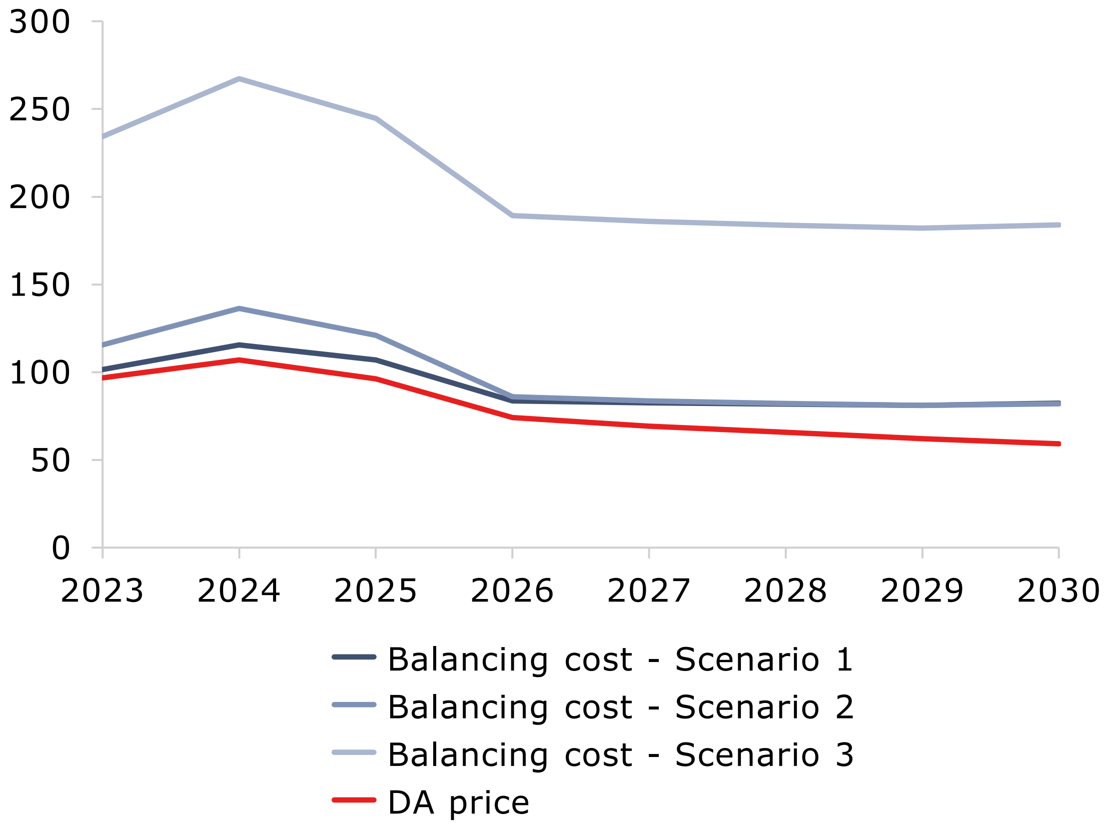
- Wind bids negative (cost to ESO)
- CCGT turns on at 75% (reserve both directions)



All calculations based on AFRY's Central Q2 2023 projections for gas and thermal costs

The DA price is lower than any of the three scenarios analysed, however the values do not deviate greatly from scenarios 1 and 2

DA PRICE AND BALANCING COST (£/MWH)



COMMENTARY

- The average DA price is lower than the balancing actions needed. However, the values from the 2 scenarios where no wind needs to be curtailed (1 & 2) are not significantly different than the DA price
  - This shows that the approached followed in the CBA assessment for valuing the additional balancing volumes due to IC ramping is reasonable as a simplification
  - The main difference lies in assuming that all future volumes will still be procured in the same way as they have been procured recently
- The scenario 3 represents, by far, the most expensive action needed to be taken to increase reserve and response products; however, it is unlikely that this process will be done for IC ramping. This would usually occur due to boundary limits, limiting the amount of wind generation in Scotland