Balancing Reserve CBA

National Grid ESO

JANUARY 2023

Contents

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Modelling Approach – Overview

Comparison of two scenarios

- ***Counterfactual*** – continuation of status quo
- ***Factual*** – adoption of Balancing Reserve for the procurement of positive reserve

***Base Case*, plus *High* and *Low* cases**

- To capture uncertainty in weather variables, which are modelled stochastically and effect both demand and generation
- Assumptions are consistent across all three cases

Sensitivity

- Change in assumptions from the Base Case, to simulate the impact of potential new licence condition on the results

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Modelling Approach

Overview of scenarios

Counterfactual scenario Positive Reserve procured through Balancing Actions (BOAs & trades)	Factual scenario Positive Reserve procured through Balancing Reserve product prior to day-ahead auctions

Modelling 2023-2025 period

Using LCP's stochastic dispatch model (running 10 simulations of each year to capture weather variations)

Reserve requirement based on NGESO assumptions (fixed profile plus dynamic element based on wind level)

Counterfactual scenario

- Plant turned down or up through balancing actions – bid-offer acceptances (BOAs) and trades
- Typically decreasing from Maximum Export Limit (MEL) to Stable Export Limit (SEL), and from off to SEL
- Often CCGT (Combined-cycle gas turbine) technology
- High costs due to premium included in the bids & offers, due to scarcity and inflexibility
- This premium has been calibrated based on recent historic data

Factual scenario

- Competitive auction to procure reserve at lowest cost, under pay-as-clear format
- Plants bid based on cost of provision including opportunity cost of lost wholesale revenues
- Expect that the plant that are on or near the margin in wholesale market will have lowest bids and clear
- This will result in similar providers to Counterfactual, but lower cost of provision due to lower premiums in bids
- Volume exiting day-ahead auction (to part load and provide reserve) will push up day-ahead price
- Higher day-ahead prices means higher wholesale costs passed on to consumers

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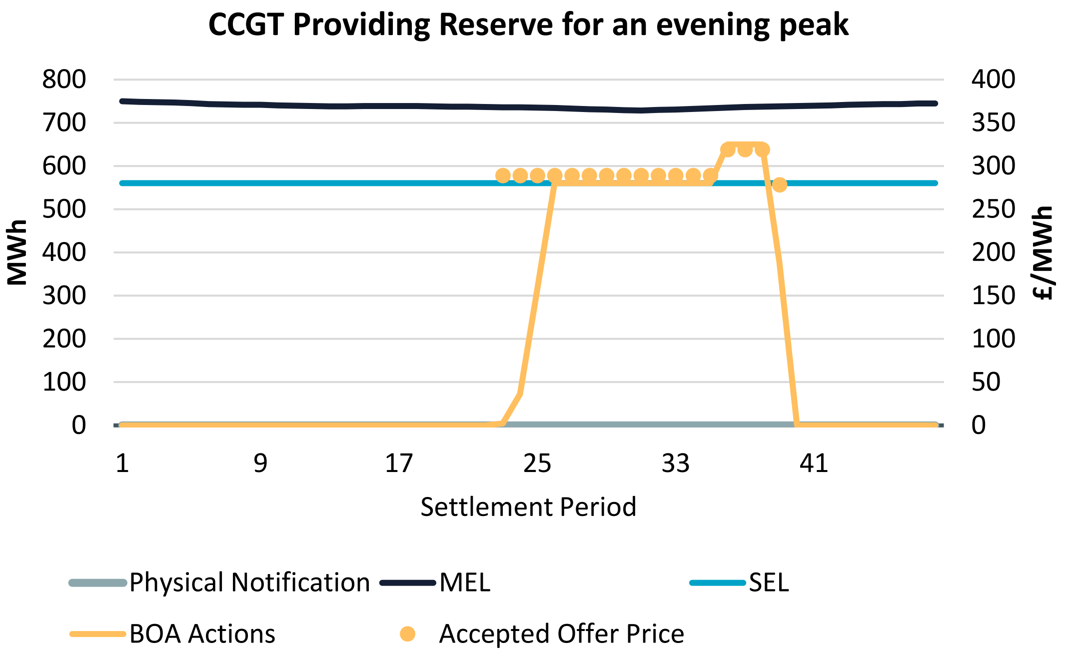
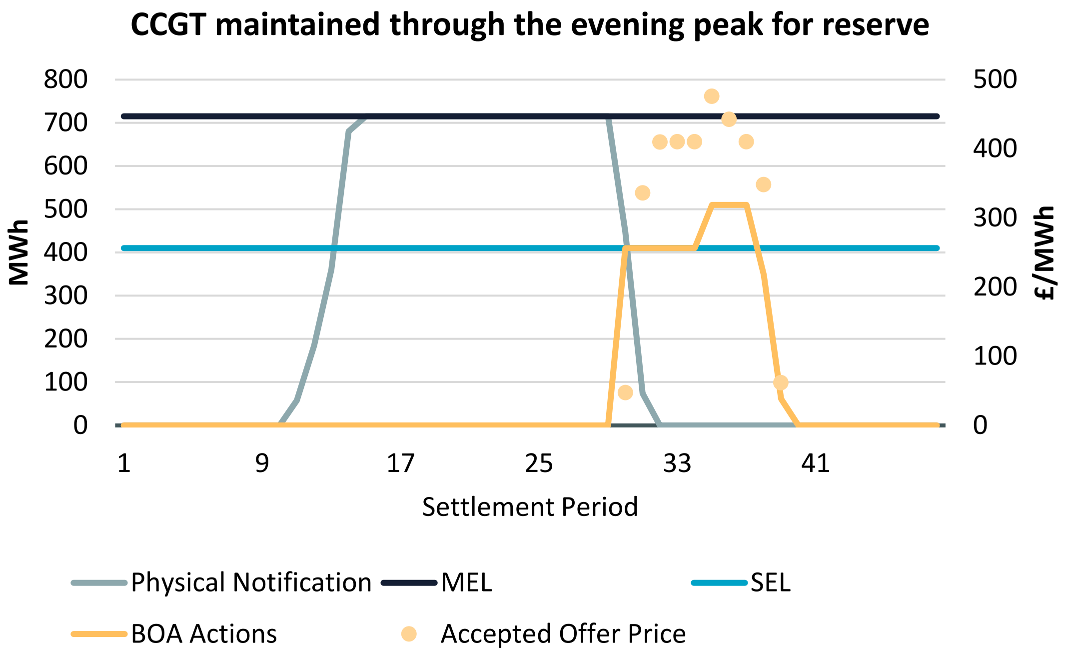
Counterfactual scenario – status quo

Currently, the ESO takes balancing actions to meet the reserve requirement





- Reserve typically provided by CCGTs being bid down from MEL to SEL, or turned-on up to SEL – most other technologies are unsuitable as they can't provide 50MW of headroom or do not participate in Mandatory Frequency Response (both requirements for Balancing Reserve eligibility)
- These turn-ons for reserve often come at a high cost due to the premium added to BM offer prices, as well as plant dynamics – such as Minimum Non-Zero Time (MNZT) and Minimum Zero Time (MZT) – which mean plant has to be run for longer than needed in order to meet the additional reserve requirement over the demand peak
- We calibrate this balancing market premium (or "scarcity adder") in our modelling, based on recent historic data

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Factual scenario – Balancing Reserve

Reserve procured through Balancing Reserve product prior to DAH auctions

Expected plant behaviour

- **Availability prices** determined by the **opportunity cost** of committing to Balancing Reserve, plus any additional costs from running inefficiently (part-loaded)
- Opportunity cost will be determined by **expected wholesale market revenue** from generating at MEL – as determined by day-ahead auction prices
- **Marginal unit** (in wholesale market) typically bids into Balancing Reserve at the lowest price – because it is making minimal returns from wholesale dispatch, so has a lower opportunity cost than more efficient units (while having lower costs to recover than less efficient units)
- Units which are accepted for Balancing Reserve are **replaced** in the wholesale market **by units with a higher SRMC** – increasing the wholesale price
- But we assume that in the status quo scenario reserve being procured through the balancing market also has some **inflationary effect on wholesale prices**, due to units factoring potential BM revenue into the price they look to dispatch at in the wholesale market
- Balancing Reserve aims to deliver a reduction in balancing costs that outweighs the impact of increased wholesale prices and represents a net saving for consumers

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Results

- **Base Case:** mean of 10 simulations
- **High Case:** most favourable sim for Balancing Reserve
- **Low Case:** least favourable sim for Balancing Reserve

- *Sensitivity:* mean of simulations, with altered assumptions to reflect the impact of potential new licence condition being in place

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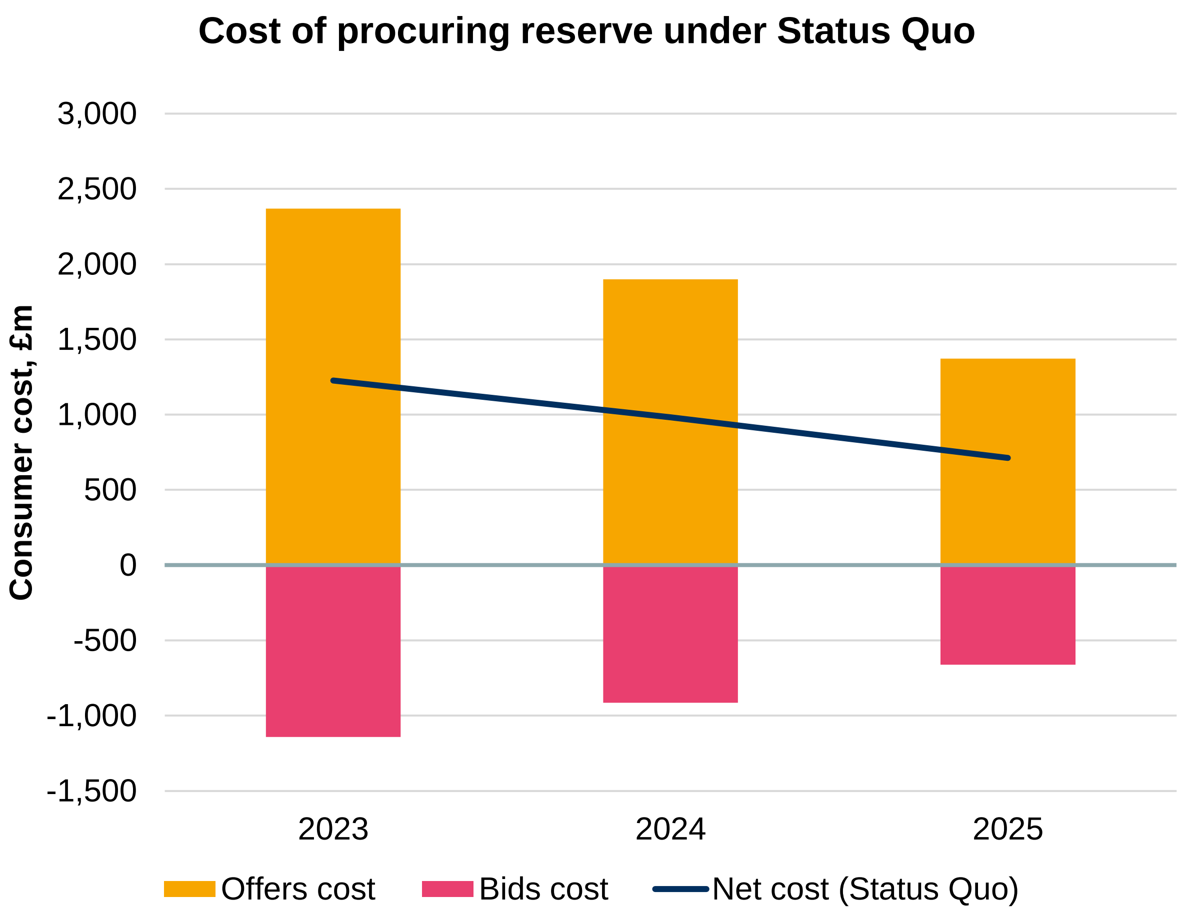
Results – Base Case

Costs of procuring reserve through BM actions under Status Quo



- Under the status quo, reserve is procured through the Balancing Mechanism
- This is through a combination of offers (paying plant to turn up) and bids (which are negative as plants typically pay to be turned down) to part load plant and so procure headroom
- Prices have been calibrated to provide similar uplift to observed in 2021/22, with very high costs when the system is tight.
- This results in costs that broadly align with NGESO's analysis, which showed around £1.3bn in 2021/22
- The offer and bid volumes are assumed to be equal (not the case in NGESO's 2021/22 analysis, where total offer volumes were > bid volumes)
- We assume the full reserve requirement is satisfied through this mechanism in this scenario.

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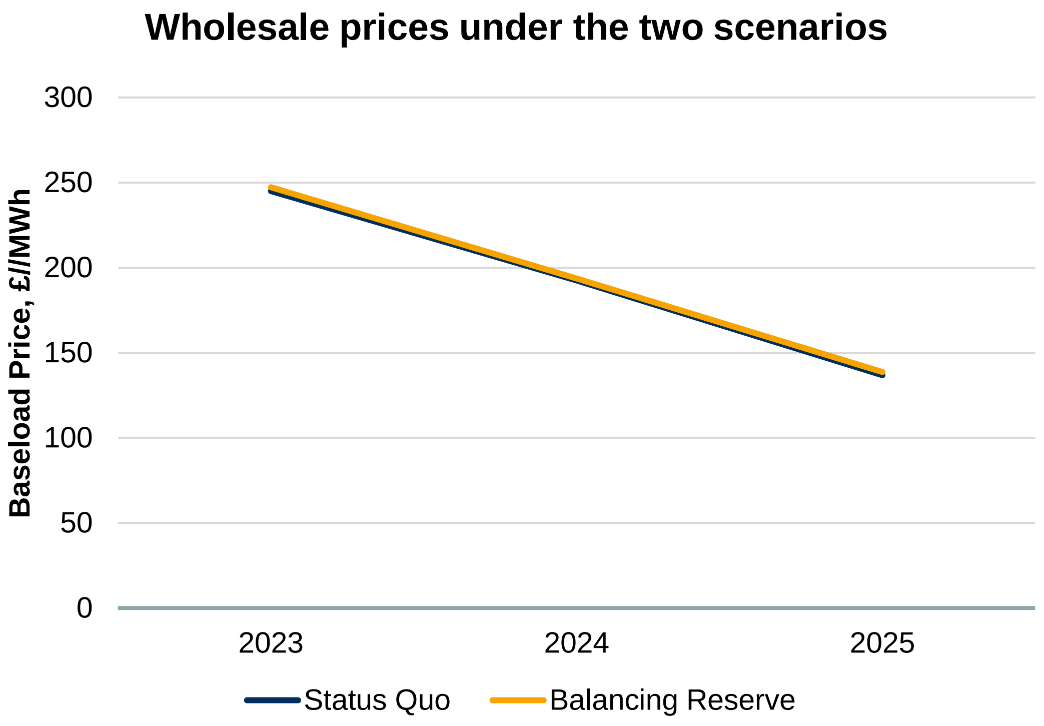
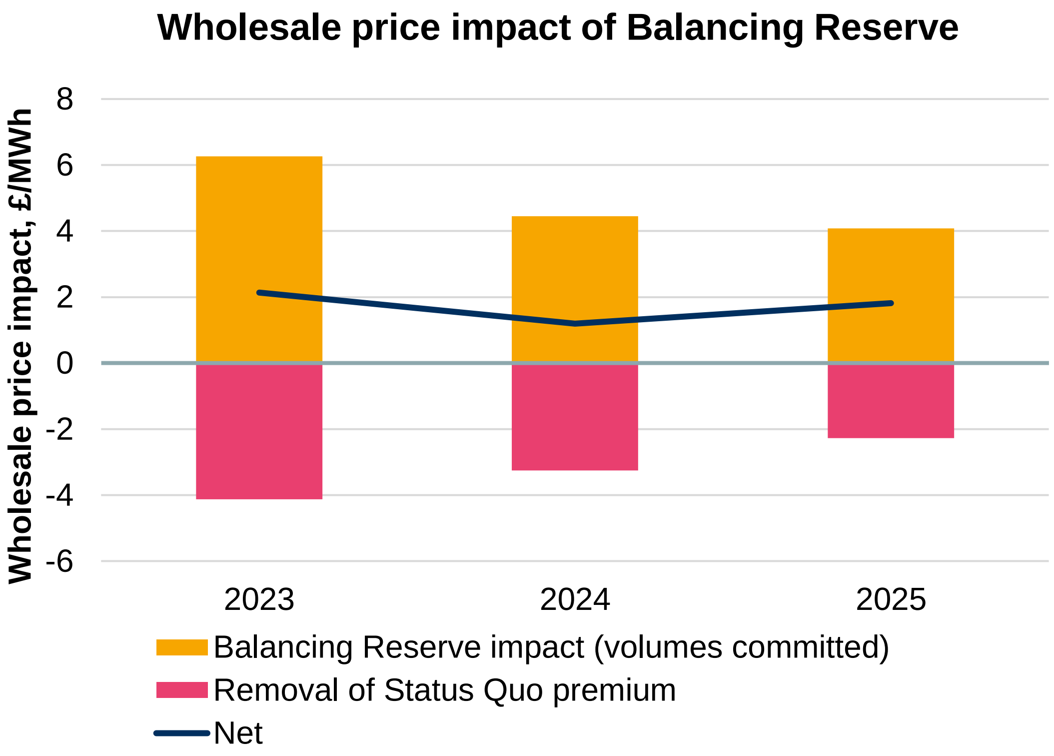
Results – Base Case

Wholesale price impact of Balancing Reserve





- With the introduction of the Balancing Reserve auction at the day-ahead stage, volumes are committed and taken out of the day ahead market. This means more expensive plant are required to run, leading to baseload wholesale prices increasing. In 2023 this results in a £6.3/MWh average increase.
- This increase is offset by a decrease due to the removal of the impact on wholesale prices of the current (status quo) arrangements for procuring reserve. This assumes that wholesale prices in the status quo scenario include a premium due to the procurement of the reserve requirement through the Balancing Mechanism. In 2023 this results in a £4.1/MWh decrease.
- The net of these two offsetting impacts results in a net average wholesale price increase of £2.1/MWh in 2023, £1.2/MWh in 2024 and £1.8/MWh in 2025.

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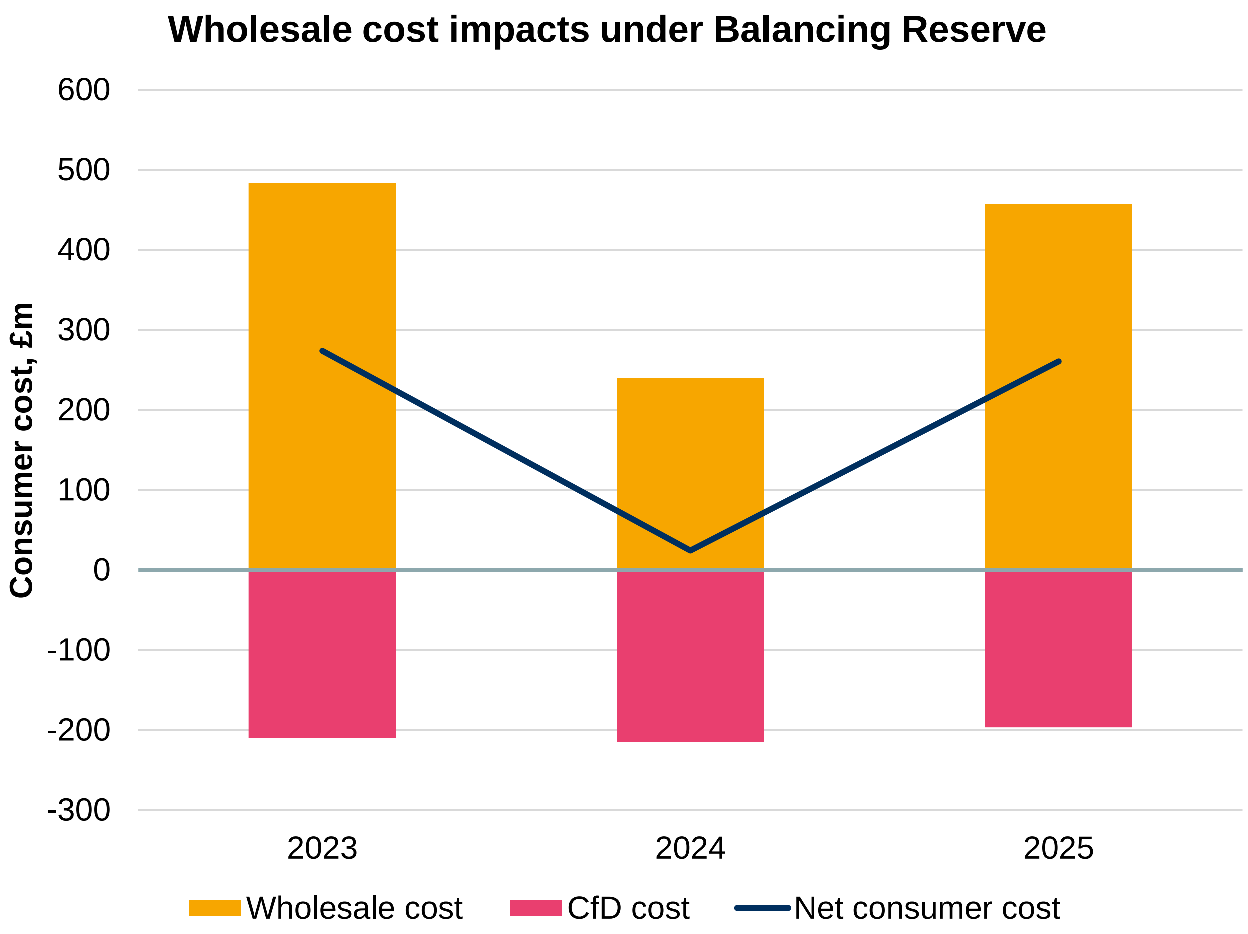
Results – Base Case

Wholesale costs passed on to consumers under Balancing Reserve scenario



- Wholesale price increases lead to an increase in consumer costs.
- These are partly offset by lower CfD payments, particularly in 2024.
- This assumes that the wholesale price increases will all be passed on to consumers. This is unlikely to be the case in the near term (as a large proportion of power is purchased ahead of time), but should be true in the long run.

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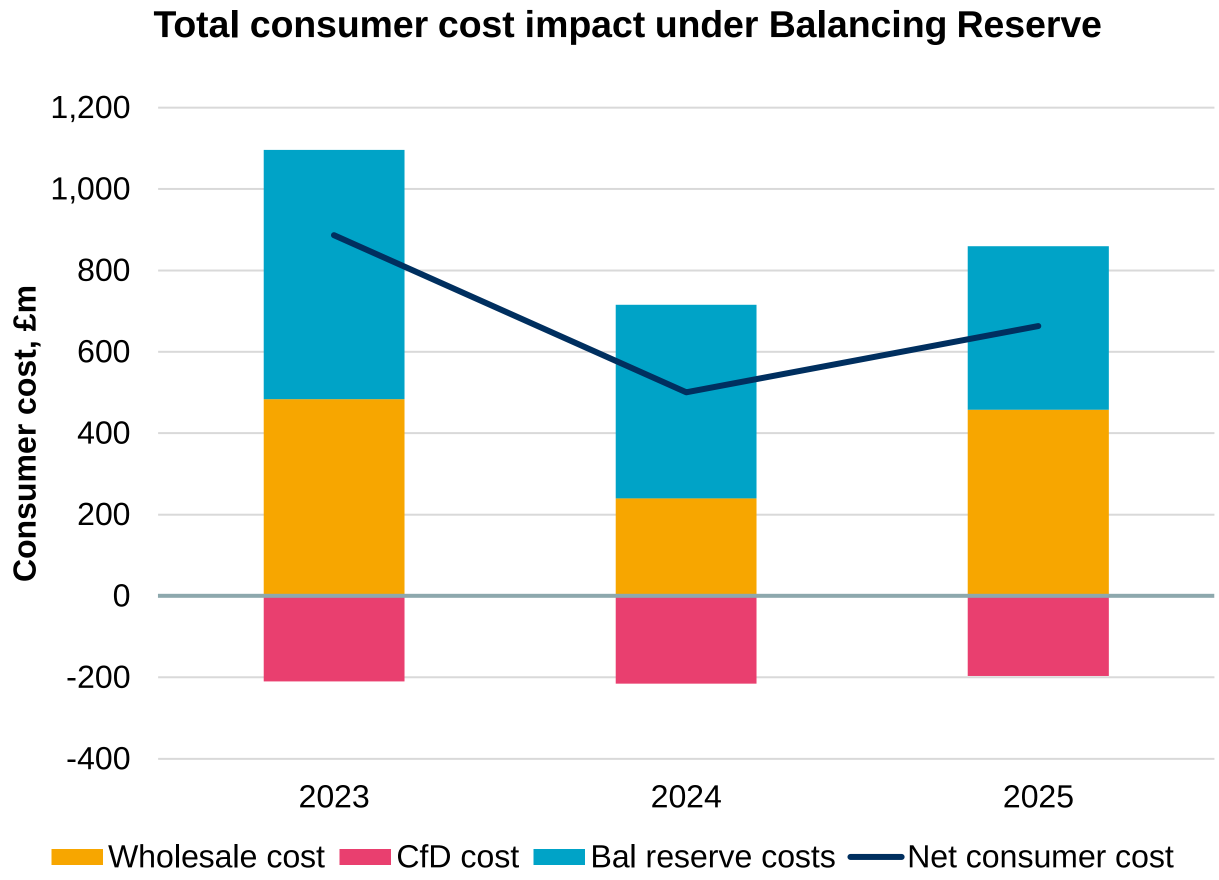
Results – Base Case

Total costs under Balancing Reserve scenario



- In addition to the wholesale cost impacts, there is also a cost to consumers from the procurement of the reserve through the Balancing Reserve auctions.
- These payments are calculated based on the amount that plant require to recover:
  - Lost wholesale profits (from plant that are turned down to provide reserve); and
  - Higher costs due to inefficient running (as plant are less efficient when part loaded)
  - Note: the majority of the costs associated with turning plant up to provide reserve are covered through selling this into the wholesale market (where the price is elevated to cover more expensive plant that would have otherwise been out of merit)
- We assume the full reserve requirement is satisfied through Balancing Reserve in this scenario.

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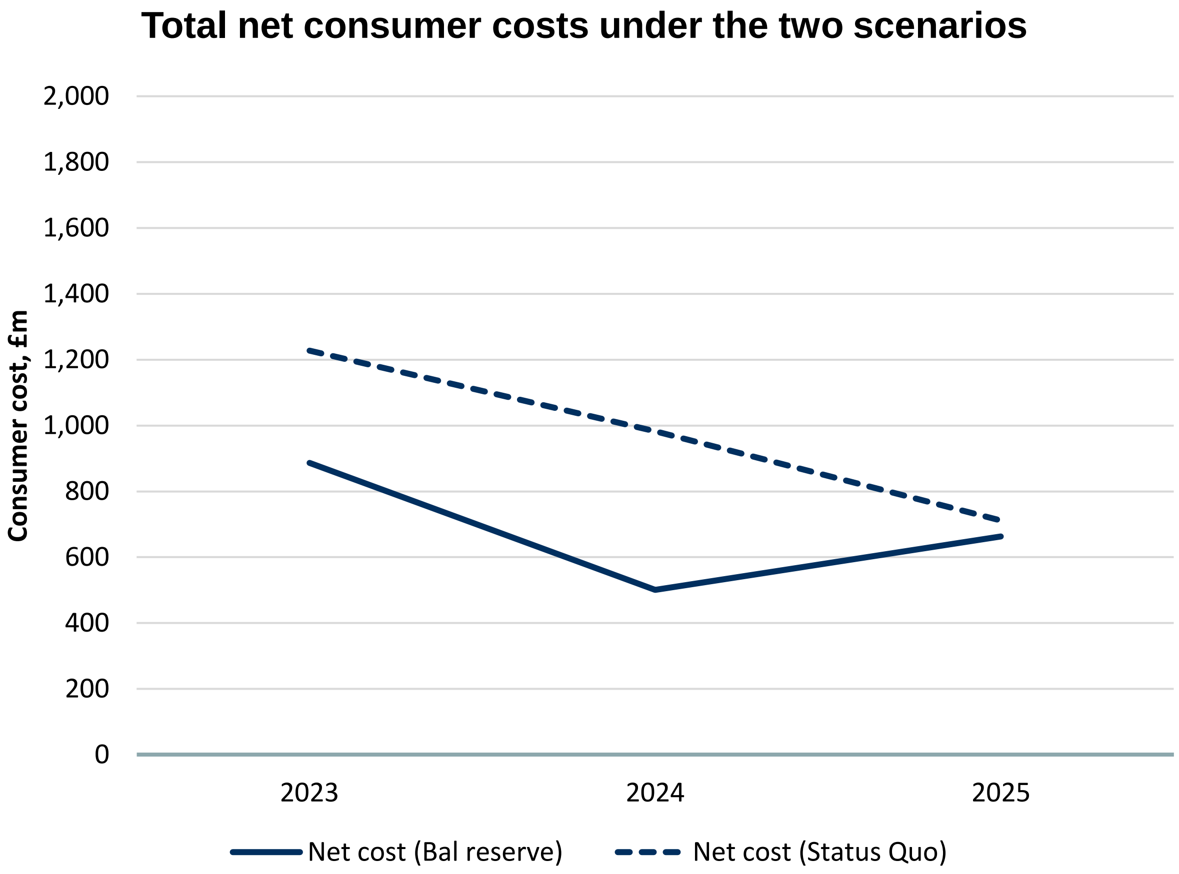
Results – Base Case

Total consumer cost impact



- Overall these initial results show that Balancing Reserve reduces the total cost to consumers, delivering a net benefit of **£873m** across the three year period from 2023-25.
- This is primarily driven by a significant reduction in the cost of procuring reserve, which outweighs the impact of higher wholesale prices for consumers.
- Key assumptions and limitations include:
  - All wholesale price impacts are passed on to consumers
  - The full volume of reserve is procured under both scenarios
  - Plant SRMC assumptions (full-load efficiency, start-up cost, no-load cost)
  - Fleet-wide assumptions (part-load SRMC uplift, SEL to MEL ratio)
  - Parameterisation of price uplifts based on historic data – relies on October 2021 to September 2022 being representative of the future
  - Assumes no disadvantage from procuring reserve at day-ahead stage relative to status quo – when in reality, less accurate wind forecasting at the day-ahead stage could reduce the benefit delivered by Balancing Reserve
  - Assumes liquid market for Balancing Reserve, with competitive price setting

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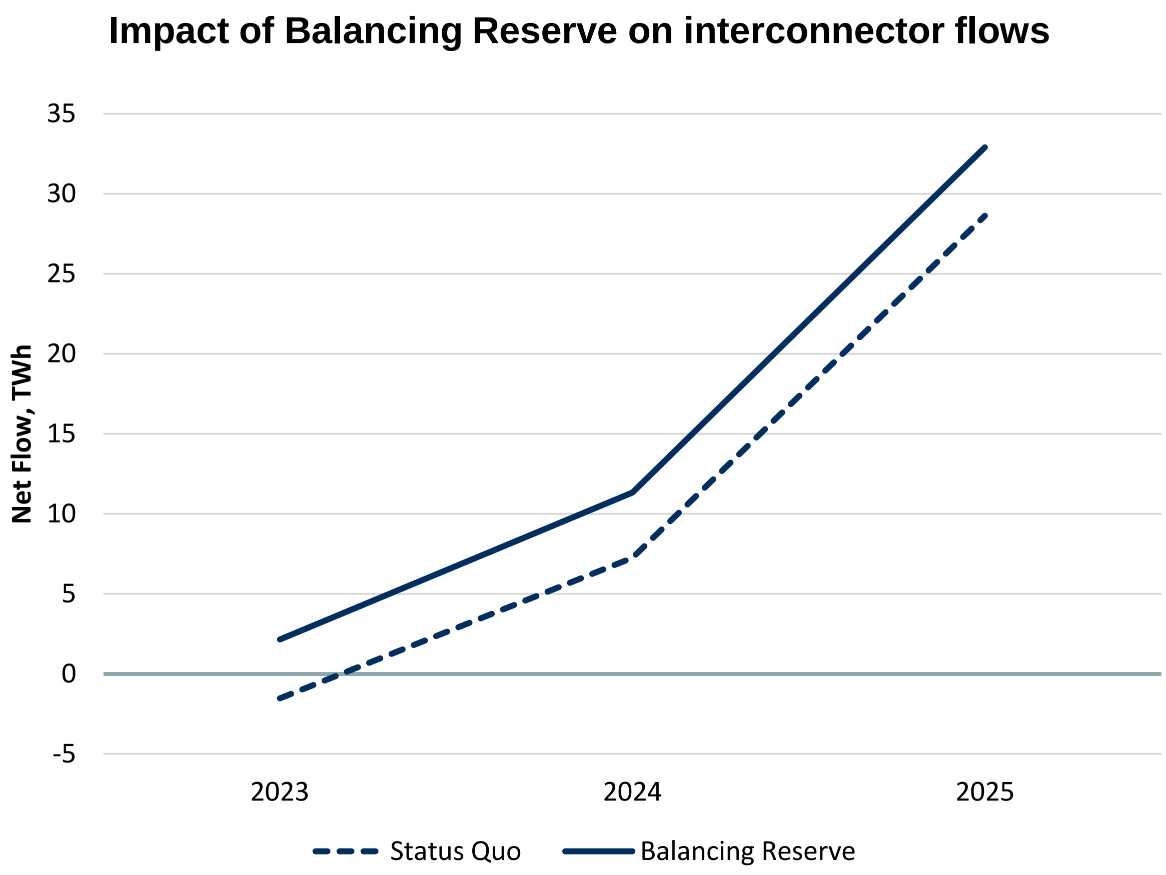
Results – Base Case

Impact on interconnector flows



- The increase to wholesale prices under Balancing Reserve sees overall net flow into GB increase in comparison to the status quo, for each of the years in the analysis

- This demonstrates how Balancing Reserve could aid security of supply – by providing a price signal at the day-ahead stage that better reflects the level of generation needed to operate the system to the reliability standard (LOLE of 3hrs per year)

- It is expected that this increase in net flows would reduce the need for NGESO to take balancing actions to adjust flows on the interconnectors

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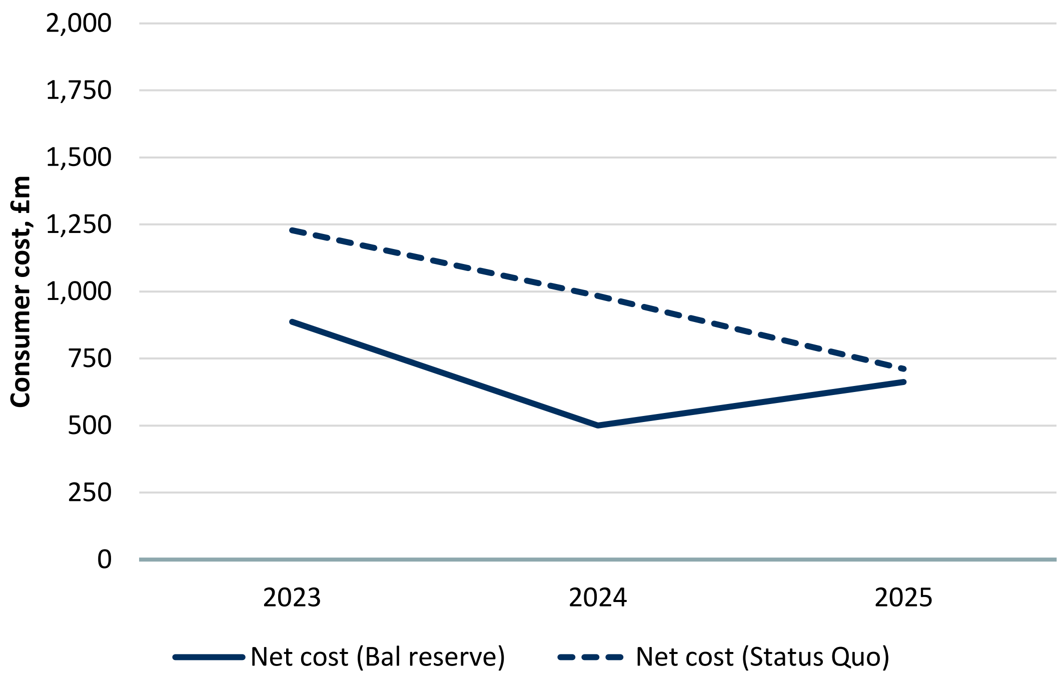
Results – Base Case

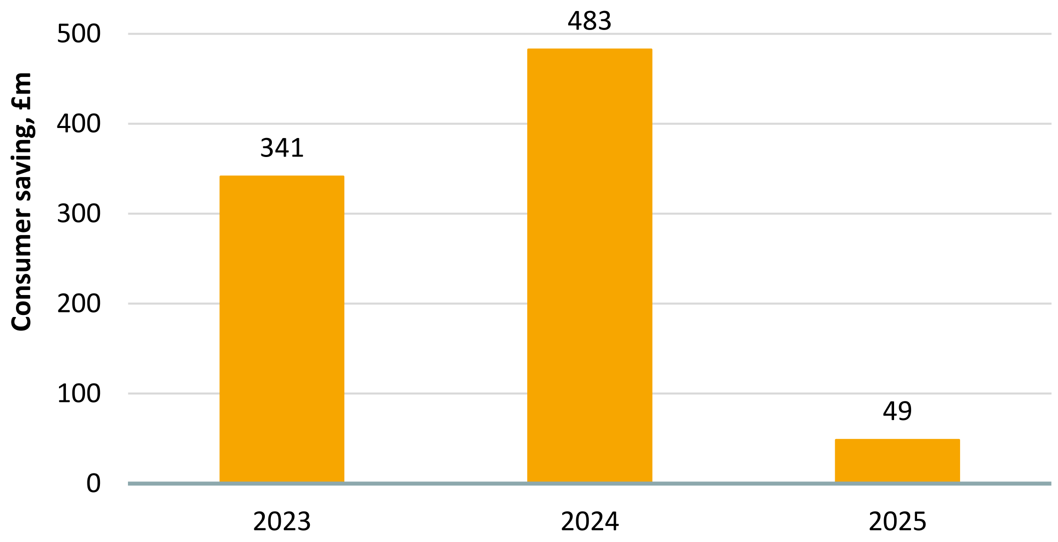
Total consumer cost impact

The introduction of **Balancing Reserve** delivers a net benefit to consumers of **£873m** across the three years

Net consumer costs under the two scenarios



Consumer saving under Balancing Reserve



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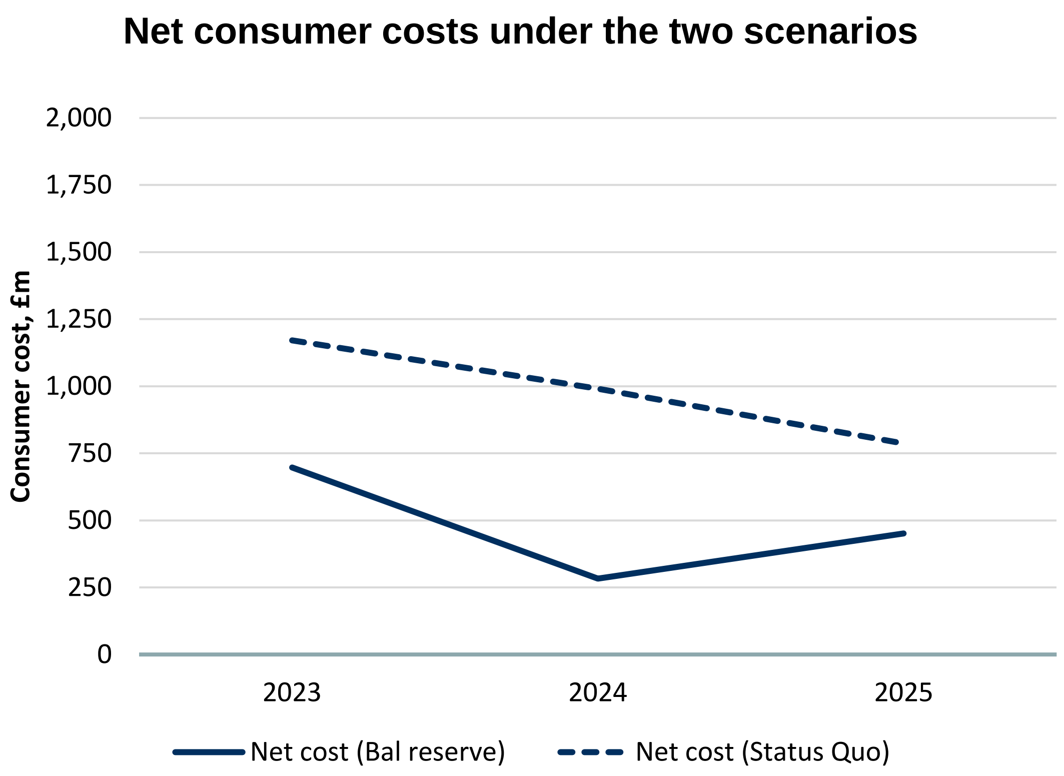
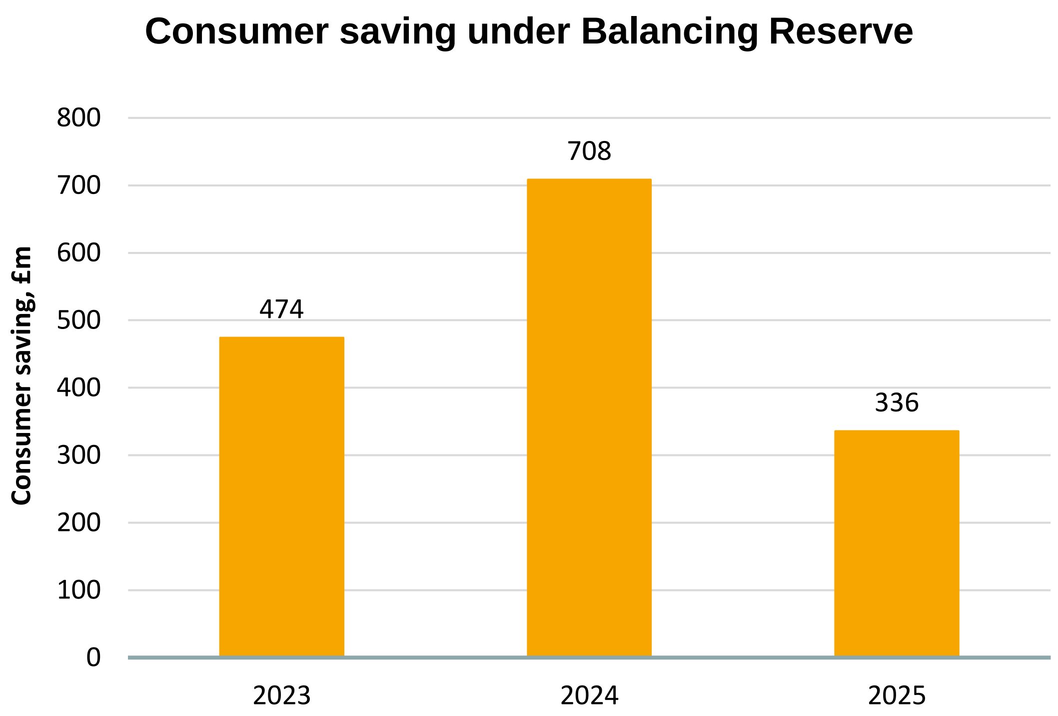
Results – High Case

Total consumer cost impact

- The consumer benefit from implementing Balancing Reserve is clear in the most favourable sim for each year, delivering a net benefit to consumers of **£1,518m** across the three years





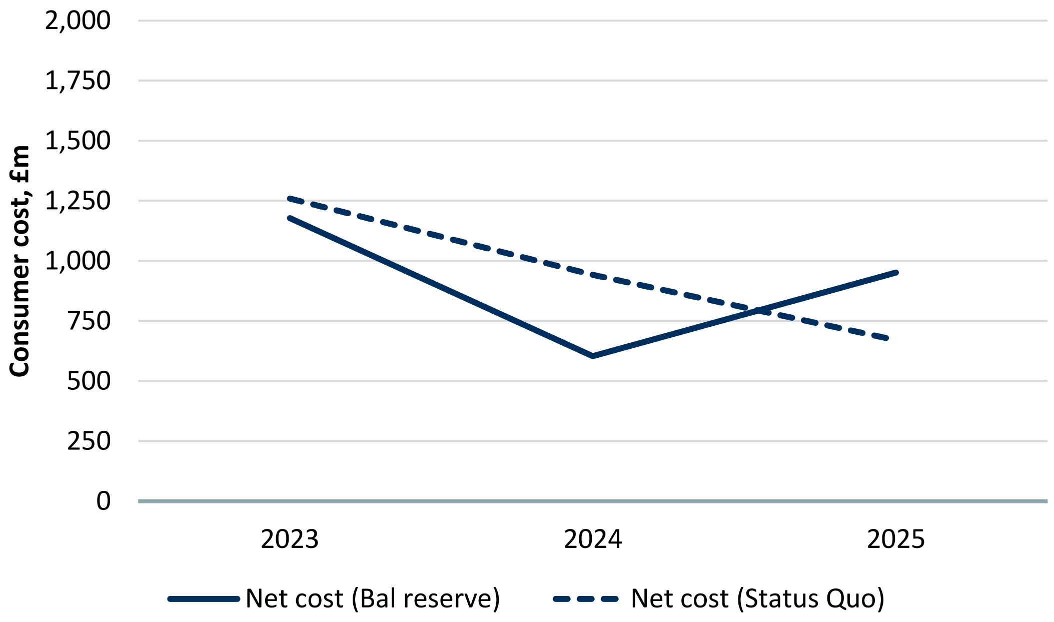
- Note that multiple simulations capture variations in stochastic weather variables only
- Assumptions are unchanged from the Base Case

Results – Low Case

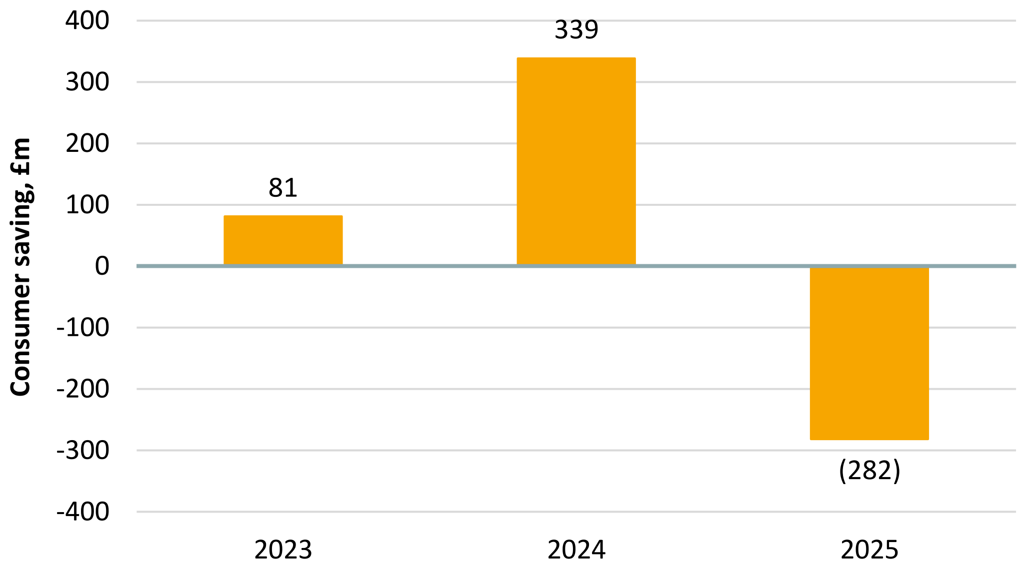
Total consumer cost impact

- The consumer benefit from implementing Balancing Reserve is more marginal in the least favourable sim in each year, however there's still a net benefit to consumers of **£138m** across the three years
- The consumer saving can go negative in periods where balancing prices are closely aligned with wholesale prices
- This alignment could typically be expected to occur during times where commodity prices are less volatile and on days where relatively small volumes of balancing actions are required to manage the system

Net consumer costs under the two scenarios



Consumer saving under Balancing Reserve



- Note that multiple simulations capture variations in stochastic weather variables only
- Assumptions are unchanged from the Base Case

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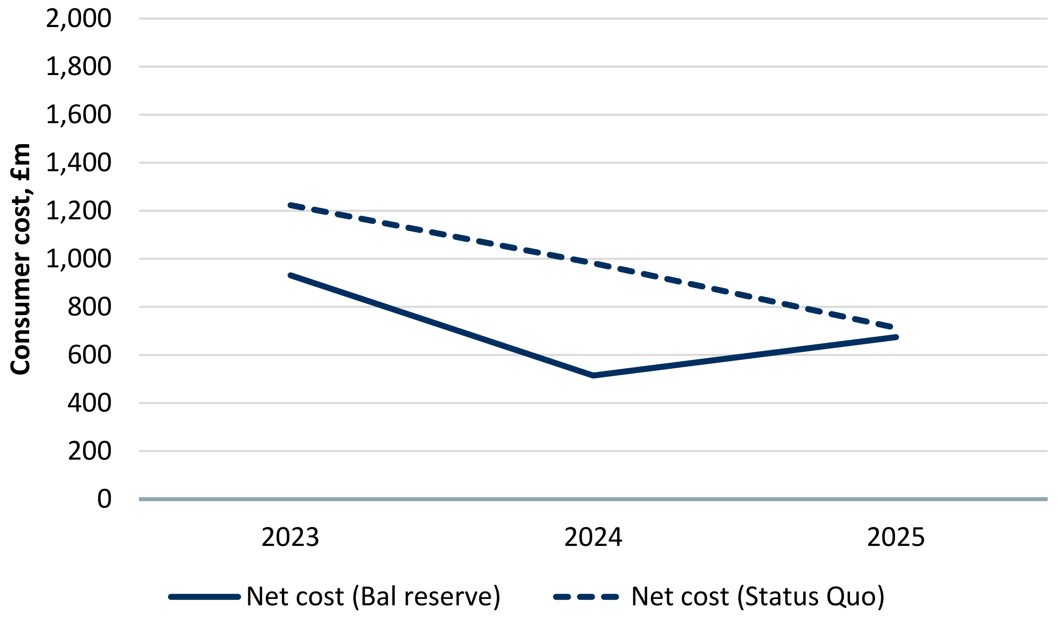
Results – Sensitivity

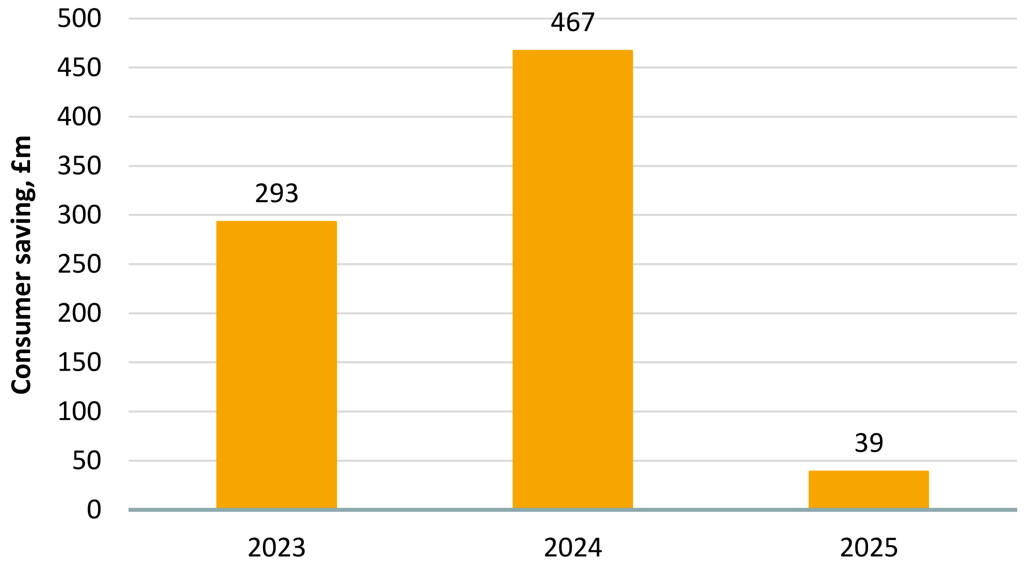
Total consumer cost impact with implementation of potential new licence condition

- The sensitivity simulates the impact of introducing a potential new licence condition to prevent units from earning excessive returns after submitting a 0MW PN
- This is achieved by applying a cap to the scarcity premium used in the modelling (£1,000/MWh to balancing prices), with the cap impacting periods where de-rated margin falls below about 1.5GW
- In a world where the potential new licence condition is already in place, the introduction of Balancing Reserve delivers a net benefit of **£799m** to consumers across the three years – a reduction of **£74m** from the Base Case
- This suggests that the two changes are complementary, as the potential licence condition does not significantly erode the benefit delivered by Balancing Reserve

Net consumer costs under the two scenarios



Consumer saving under Balancing Reserve



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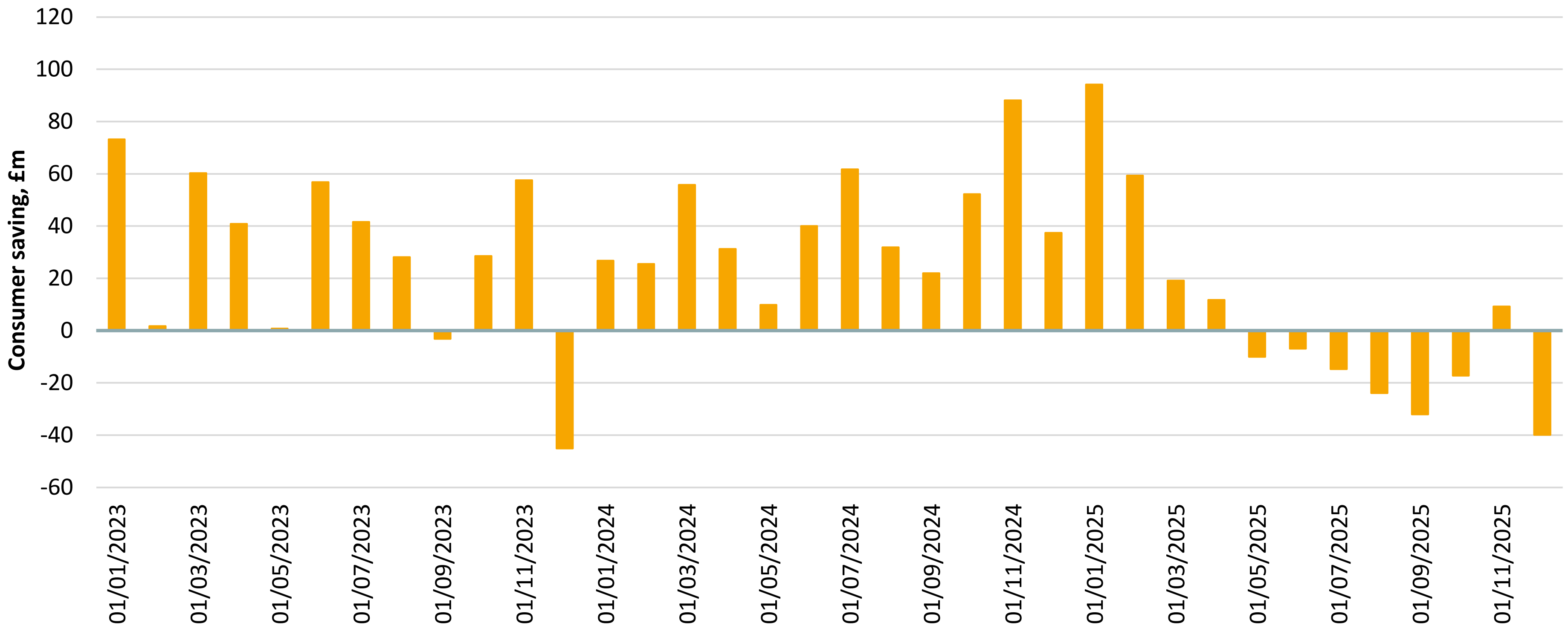
Results – Base Case

Consumer saving – monthly breakdown

- Our modelling suggests that Balancing Reserve can start delivering benefits for consumers from the outset if introduced in early 2023
- Results show a consumer saving of **£57m** in March 2023, followed by an average saving of **£28m** per month across summer 2023



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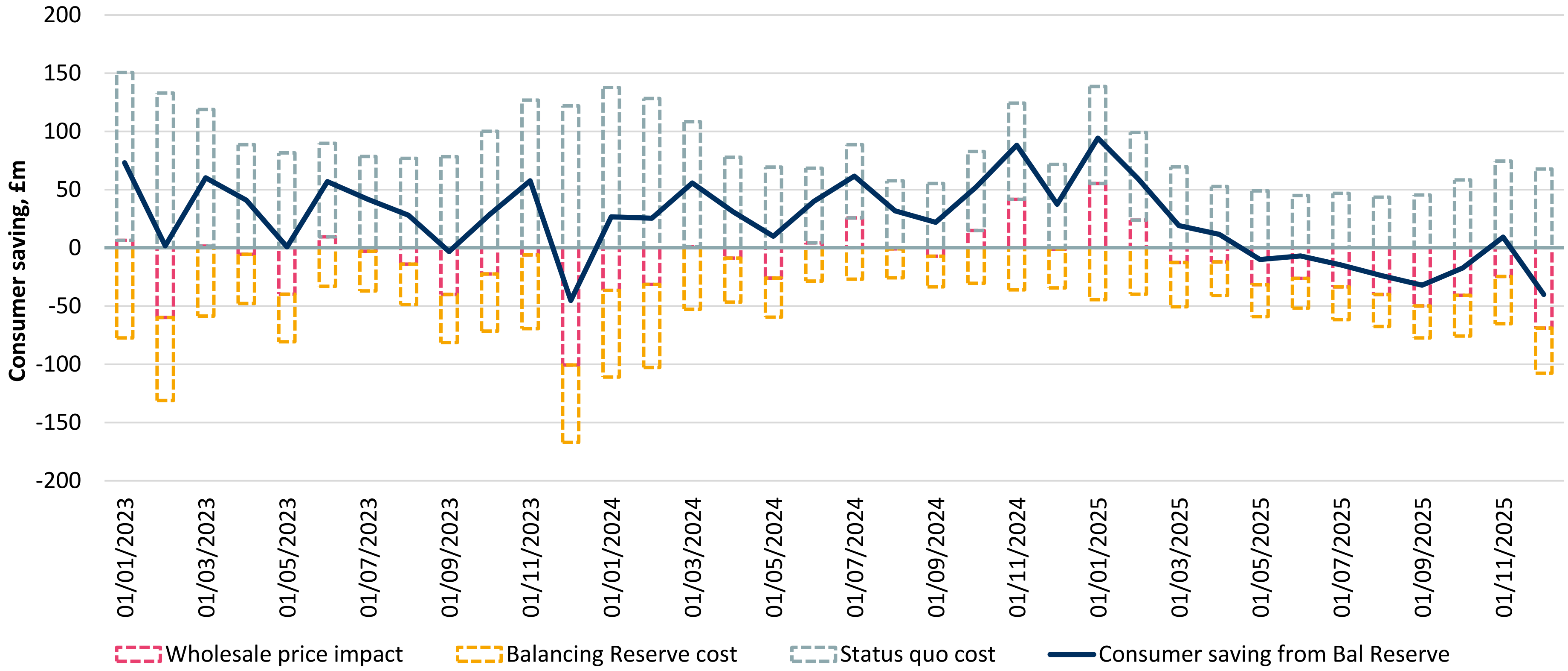
Results – Base Case

Consumer saving – monthly breakdown

- Cost to consumers in the second half of 2025 is driven by a reduction in Balancing Mechanism offer prices relative to wholesale prices
- Additional consumer benefit could be realised by accurately forecasting periods where balancing and wholesale market prices converge – and procuring some or all of the reserve requirement through the BM in these periods



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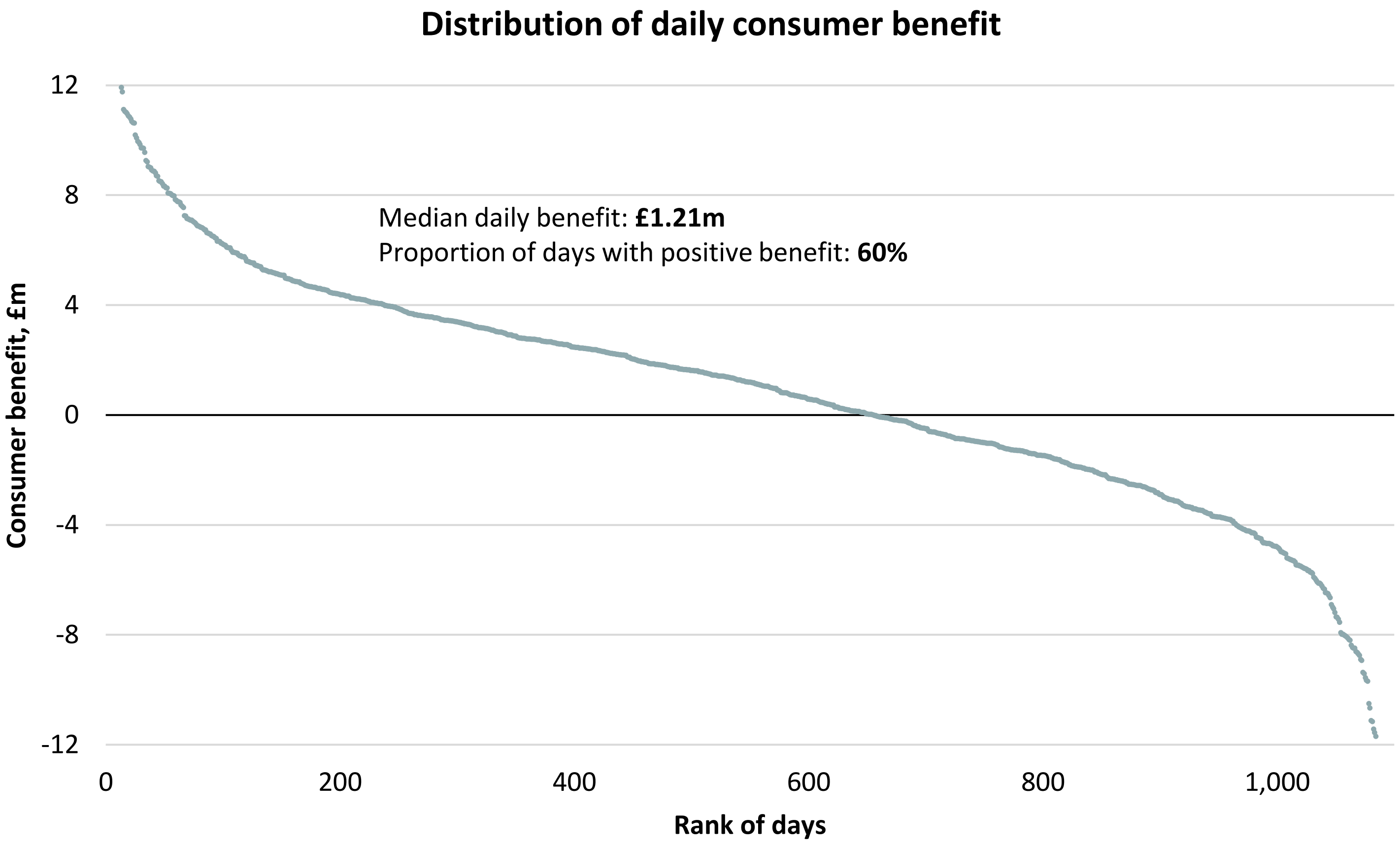
Results – Base Case

Consumer saving – daily and hourly distribution



- The benefits to consumers are spread over a majority of periods, with both the median daily and hourly benefits being positive
- Successfully identifying the worst 5% of days – on which to avoid using Balancing Reserve – could save consumers a further **£578m**
- Outliers have been excluded from the chart

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Modelling Approach – Methodology

- **EnVision modelling framework**
- **Stochastic modelling approach**
- **Reserve requirements**
- **Assumptions overview**
  - General assumptions
  - Counterfactual scenario
  - Factual scenario
  - Sensitivity

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Modelling Approach

EnVision model

Model inputs | **Model simulation engine** | **Model outputs**

Model inputs

Commodity prices
Including gas, carbon and coal price projections.

Regulatory & Policy
Support mechanisms, market arrangements, taxes and charges.

Storage
Storage parameters including round-trip efficiency, degradation and duration

Weather data
Historic half hourly wind speeds and solar irradiance at 20x20km granularity.

Demand
Hourly demand profiles and future projections (EVs, heat).

Ancillary Services
Requirements for ancillary services including inertia, frequency and reserve.

Capacity build
Build-out for some techs, like solar, wind and nuclear are input assumptions.

Interconnection & Network
Network & interconnector build, foreign market demand-supply assumptions

Plant data
Assumptions for plant, including capacity, location, efficiency and operating costs.

Model simulation engine

New investment simulated through two mechanisms:

- Capacity Market
- Contracts for Difference (CfDs)

CM bids and CfD strike prices calculated based on discounted cashflow projections.

48 x 365
Up to 30 years
20+ sims

Stochastic: each year is simulated 20+ times to capture variations in demand, wind, solar and outages.

Half-hourly dispatch

Wholesale market generation to meet demand based on generator:

- Availability
- Short-run marginal costs
- Operating parameters

Storage behaviour is optimised

Balancing market simulated by re-dispatching flexible plant based on cost to satisfy imbalance volumes.

Ancillary markets (frequency, reserve, inertia) are **also** simulated by re-dispatching flexible plant to satisfy reqt, based on opportunity cost.

Model outputs

Market outcomes

- Wholesale, BM, Ancillary, CM prices, Network charges
- Generation mix

Individual asset outputs

- Wholesale, BM, Ancillary, Capacity market revenues
- Load factor, cycles
- Captured prices

Cost benefit analysis

- System costs
- Consumer costs
- Policy costs
- Emissions, Curtailment

Portfolio & investment

- IRR, NAV
- Risk vs reward
- Diversification benefits

Outputs: Annual, Monthly, Hourly

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Modelling Approach

EnVision model

The EnVision modelling framework:

Developed inhouse at LCP over the past ten years, the EnVision modelling framework is used by:

- BEIS for long-term GB market projections to support their policy impact studies, including the modelling used to support the British Energy Security Strategy and the case for change fore REMA
- National Grid ESO for their security of supply modelling (calculation of de-rating factors for renewable and storage sites) and Net Zero market design analysis
- Ofgem for its network charging analysis (such as the Transmission Charging Review (TCR) and BSUoS impact assessment)
- LCCC (CfD counterparty) for its forecasts to project CfD costs and set supplier levies

It is used to model:

- **Wholesale Market:** agent based dispatch of existing and new build plant, taking into consideration start-up costs, part-load efficiencies and dynamic parameters such as minimum stable load and minimum up and down times
- **Balancing Market:** re-dispatch based on projected net imbalance volumes (based on wind, solar and demand uncertainty)
- **Locational Balancing:** re-dispatch for thermal constraints, maintaining supply/demand balance within regions
- **Ancillary Services:** a fundamentals based approach to determining value of services such as Frequency Response, considering the opportunity cost available in wholesale, balancing and locational balancing markets
- **Network Charges:** (locational and charge avoidance benefits) – network power flow module used to forecasts of TNUoS, TLMs
- **Capacity Market:** simulation of the capacity market (endogenous modelling of the capacity requirement and de-rating factors of intermittent and storage generators) with CM bids for new build plant based on forecast cashflows across the above markets

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Modelling Approach

Stochastic modelling approach

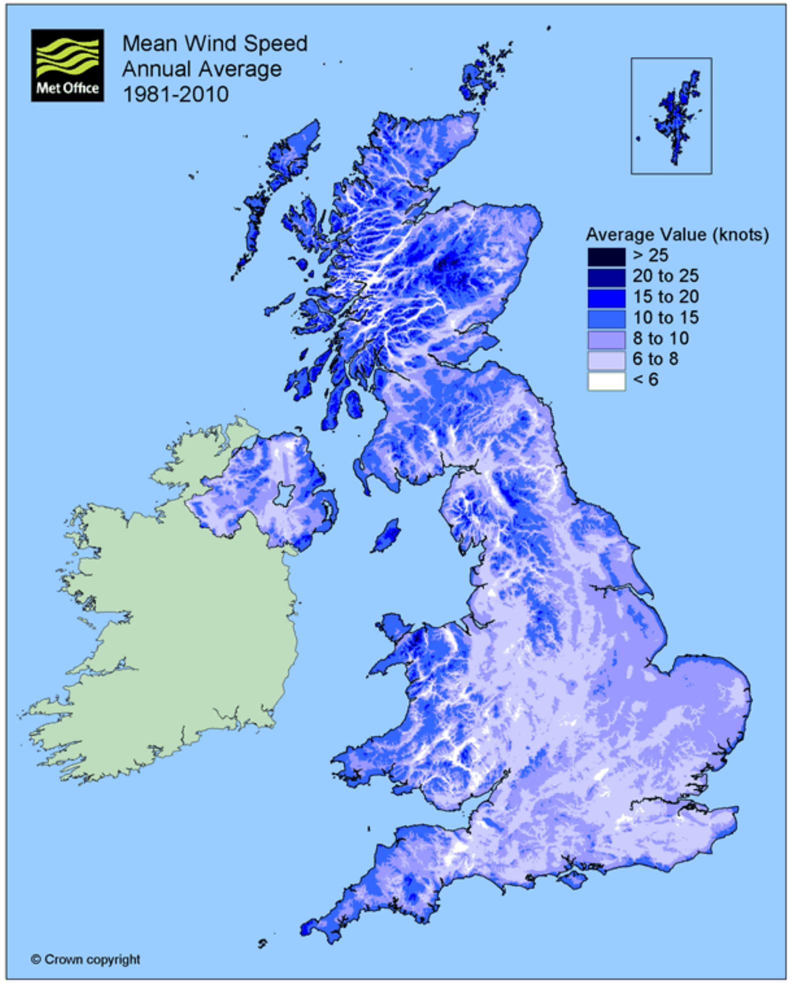
A **stochastic approach** is utilised to model the wholesale, balancing and locational balancing markets.

Many simulations of each year are run utilising differing demand and renewable generation profiles with randomised plant outages. A bootstrapping approach is utilised whereby:

- **Historical demand data** is sampled and scaled to meet projected total annual and peak demand values
- **Historical wind speeds and solar irradiation** data is sampled from the NASA MERRA-2 dataset and utilised to calculate the generation profiles of projected wind and solar assets.
- This dataset includes windspeeds for differing heights above sea level and solar irradiance **data from 1980 onwards for points on a 20km grid covering the globe.**

This allows us to capture tail events (such as high or low prices) which can provide a significant source of value, while not under- or over-estimating their likelihood.

The stochastic dispatch model also incorporates a sequential approach, modelling a full 365 days for each year in each stochastic simulation. This means we capture a **full range of intermittency profiles and the resulting running profiles from the thermal fleet**. This is particularly important for storage units, whose running profiles and revenues will vary considerably under different renewable conditions.



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Reserve Requirement

Varies between 500-2500MW, according to the following factors

Seasonal changes in demand and renewable output affect the reserve requirement.

Day of the week affects the reserve holding, for instance issues with cold plant starting up on Monday morning drives a higher requirement for reserve.

Time of day impacts the reserve requirement, with additional reserve need over the demand peaks

Wind forecast and availability increases the reserve requirement as the impact of forecasting error increases.

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Reserve Requirement

Basic Requirement

- Varies by time of day – generally increasing and decreasing in line with forecast demand
- Varies by day of the week – this affects the demand shape
- Seasonal variation – lower requirement during summer months (requirement adjusted pre and post clock-change)

Day type	Minimum Basic Requirement (MW)	Mean Basic Requirement (MW)	Maximum Basic Requirement (MW)
Monday (GMT)	400	728	1,550
Weekday (GMT)	400	700	1,300
Saturday (GMT)	400	640	1,100
Sunday (GMT)	400	715	1,250
Monday (BST)	400	578	900
Weekday (BST)	400	571	950
Saturday (BST)	400	515	700
Sunday (BST)	400	545	900

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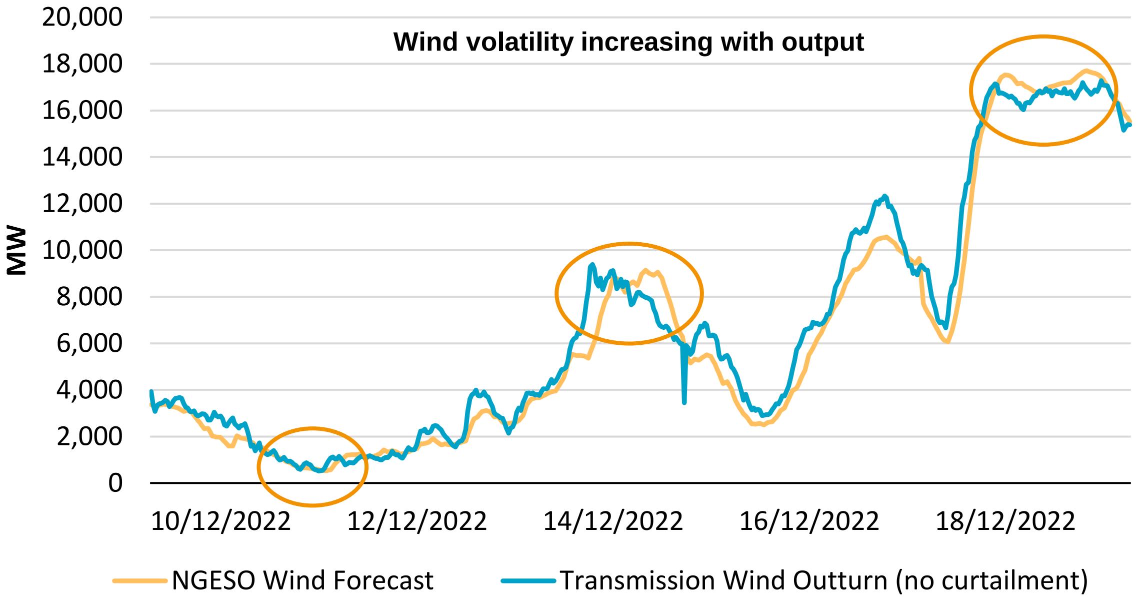
Reserve Requirement

Additional positive reserve requirement for wind

Wind forecast (MW)	Additional Positive Reserve Requirement (MW)
0	0
1 – 500	200
501 – 1,000	300
1,001 – 2,000	400
2,001 – 4,000	600
4,001 – 6,000	600
6,001 – 8,000	640
8,001 – 10,000	700
10,001 – 12,000	840
12,001 – 14,000	980
>14,001	960

- Reserve requirement increases with the level of wind output
- Higher wind output means more energy that needs to be replaced when windspeed drops unexpectedly – driving a higher requirement for positive reserve



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Modelling Approach

General Assumptions

BSUoS

- Not included as part of generator costs in order to reflect CMP308, which will be implemented in April 2023 and will see the BSUoS charge applied to final demand only
- Saving in balancing costs delivered by Balancing Reserve is assumed to be passed on in full to consumers, through a reduction in BSUoS charges

Plants self-dispatching at part-load

- Plants sometimes choose to self-dispatch at part-load where it is economical to do so, for example where overnight prices are below SRMC but the loss incurred from running at SEL is less than the unit's start-up cost
- We capture this in the analysis, under both the Factual and Counterfactual scenarios, by deducting the initial headroom provided by the market in each period from the reserve requirement for that period

Timing of Balancing Reserve auction

- BR auction expected to take place before EPEX GB Hourly auction, so to ensure a level playing field and to avoid disadvantaging smaller participants who might have more difficulty in adjusting their positions after the hourly auctions have taken place
- The alternative of running the BR auction after the Nordpool GB Hourly auction risks excluding participants who rely on the hourly auctions to determine their wholesale market dispatch
- For instance, many participants, including some optimisers of large power stations, do not have a 24hr intraday trading capability
- Meanwhile, a small number of the larger generators enjoy a portfolio benefit from trading multiple large power stations and / or consumer demand
- In the modelling, we assume that all participants make an accurate assessment of wholesale market value, given that it's a transparent market and information asymmetry is not seen to be a major issue

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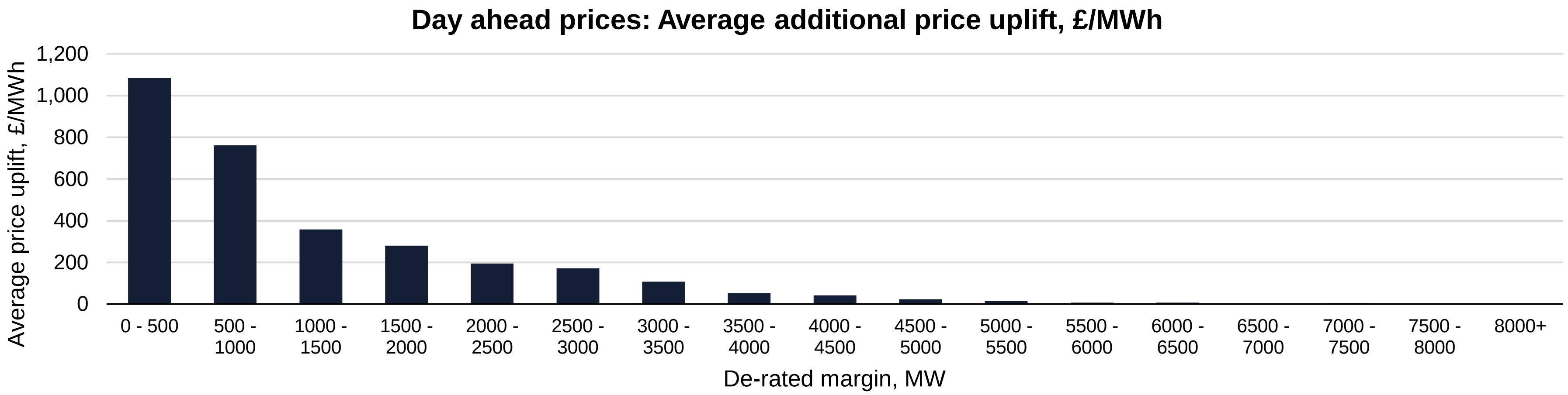
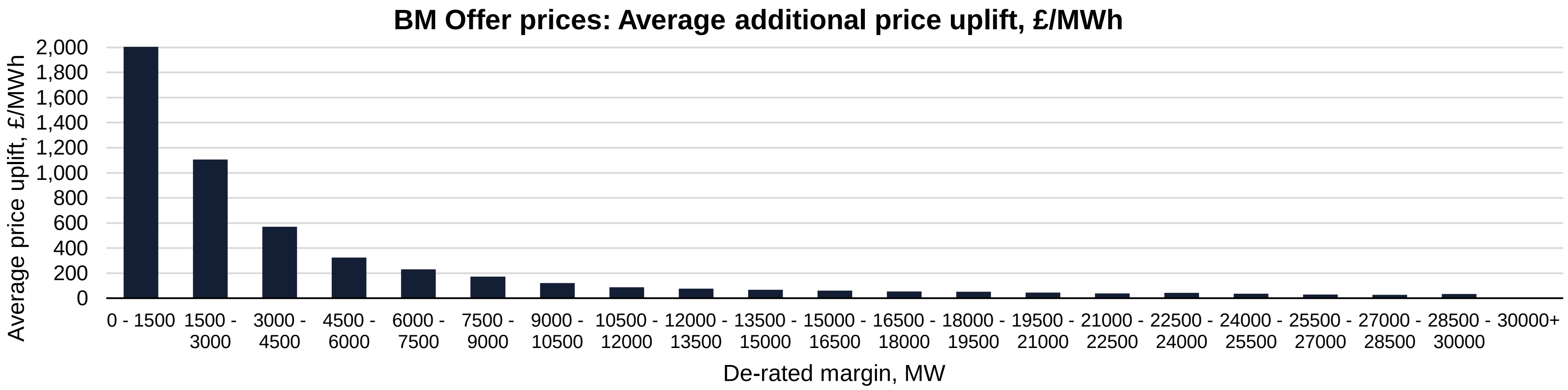
Modelling Approach

Scarcity uplift





- This graph shows the average additional add on value to SRMC figures when there is limited capacity on the system.
- This is parameterised based on 2020-22 data (DAH) and 2021-22 (BM offer prices used for reserve)
- This is used to uplift modelled prices (based on short-run marginal cost) to account for the expected level of scarcity we expect to see over modelling period.

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Modelling Approach

Counterfactual scenario – status quo

Cost of procuring reserve (from NGESO point of view)

- Calculated as cost of offers accepted for reserve, less revenue from bids accepted for reserve
- Cost of Offers accepted for reserve is calculated as follows:

$$C_o = \sum_{i=1}^{n} p_i \times R \times s$$

where $\boldsymbol{p}$ are the offer prices, which are calibrated based on the uplift seen over the October 2021 to September 2022 period

$\boldsymbol{n}$ is the number of hourly periods ($n = 26{,}304$),

$\boldsymbol{R}$ is the reserve requirement in MW

$\boldsymbol{s}$ is SEL as a proportion of MEL (set to 54% to represent the fleet average), and $s - 1$ is the headroom provided from SEL

- Bid volumes related to reserve are assumed to be equal to the Offer volumes accepted for reserve, consisting of the Bid volume taken directly to create headroom for reserve and additional Bid volume accepted in order to maintain the energy balance of the system (offsetting the energy gained by accepting Offer volume for reserve)
- Cost of Bids related to reserve procurement is calculated as follows:

$$C_b = C_o \times B$$

where $\boldsymbol{B}$ is the Bid price as a proportion of the Offer price

- The Bid price as a proportion of Offer Price assumption varies by calendar month (average 45%; minimum 36%; maximum 52%), based on analysis of historic data from October 2021 to September 2022

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Modelling Approach

Counterfactual scenario – status quo

Wholesale price impact of procuring reserve through the BM

- Procuring reserve through the Balancing Mechanism increases the opportunities for generators to earn revenue from BM acceptances
- From operational experience, we know that asset optimisers factor their assessment of potential BM revenue into the ‘strike price’ at which they are willing to sell their volume into the wholesale market
- This adjustment is added on to the marginal cost of the marginal price-setting unit and therefore represents a premium which is baked into the wholesale price to reflect the potential balancing revenue given up by units dispatching through the wholesale market
- When modelling the Factual scenario, i.e. where reserve is procured through the Balancing Reserve service, we assume that the reduced opportunity for BM acceptances will result in a generators not attaching this premium on top of their marginal cost to dispatch in the wholesale market

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Modelling Approach

Factual scenario – Balancing Reserve

Wholesale price impact

- The effect of **removing volume** from the wholesale market (by committing units to provide headroom through Balancing Reserve) **increases the wholesale price**, as this volume is replaced by units with a higher Short-Run Marginal Cost (SRMC)
- However, this wholesale price increase is mitigated to a degree due to the fact that Balancing Reserve means less opportunity for BM acceptances
- Asset optimisers should therefore use a lower probability weighting in their strike price calculation than they would under the status quo – and a lower probability weighting reduces the adjustment for expected BM revenue, which depresses the wholesale price
- We correct for this in the Factual scenario, as this premium for expected BM revenue is calibrated for the status quo
- We make this correction by deducting a proportion of the balancing price from the wholesale price
- The proportion of the balancing price to be deducted is set dynamically according to the reserve requirement – because the higher the reserve requirement then the greater the BM opportunity would have been in the status quo scenario:

Total Regulating Reserve requirement	Scaler
<= 900 MW	1.35%
901 - 1,200 MW	2.70%
> 1,200 MW	4.05%

- Note that in both the Factual and Counterfactual, there remains some premium baked into wholesale prices to reflect expected revenue from BM actions not related to the reserve requirement – we assume this premium to be constant across the two scenarios

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Modelling Approach

Wholesale price adjustment for expected Balancing Mechanism revenue

- Procuring reserve through the Balancing Mechanism increases the opportunities for generators to earn revenue from BM acceptances
- From operational experience, we know that asset optimisers factor their assessment of potential BM revenue into the ‘strike price’ at which they are willing to sell their volume into the wholesale market:

$$\text{Strike Price} = \text{SRMC@MEL} + \text{Adjustment for Expected BM Revenue}$$

$$\text{Adjustment for Expected BM Revenue} = \frac{(\text{Offer Price} - \text{SRMC@SEL}) \times \text{Acceptance Probability} \times \text{Acceptance Volume} \times \text{Acceptance Duration}}{\text{MEL} \times \text{Expected Wholesale Dispatch Duration}}$$

- **SRMC** (Short-run marginal cost) is the £/MWh cost for a given run profile
- **Acceptance Volume** would typically be assumed to be the unit’s SEL
- **Acceptance Duration** would be its MNZT, while a typical wholesale dispatch duration would be longer and at MEL
- **Acceptance Probability** will depend on expected system conditions, including the reserve requirement, but would typically not exceed 20% given the level of uncertainty inherent in predicting BM acceptances. We have assumed 5%, 10% or 15% depending on the reserve requirement.
- The Adjustment for Expected BM Revenue would therefore usually be a small fraction of the expected Offer Acceptance Price
- This adjustment is added on to the marginal cost of the marginal price-setting unit and therefore represents a premium which is baked into the wholesale price to reflect the potential balancing revenue given up by units dispatching through the wholesale market
- When modelling the Factual scenario, i.e. where reserve is procured through the Balancing Reserve service, we assume that the reduced opportunity for BM acceptances will result in a generators attaching a significantly lower premium on top of their marginal cost to dispatch in the wholesale market
- Plugging representative data into the above formula yields an adjustment of c. 1-4% of the Offer Price, hence the scalers applied to the balancing price to derive the adjustment for expected BM revenue used in the modelling

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Modelling Approach

Factual scenario – Balancing Reserve

Cost of procuring reserve

- Calculated as the cost of compensating units for lost wholesale revenue
- Lost wholesale revenue includes revenue that would have been received from selling headroom into the wholesale market, plus revenue lost due to the higher cost per MWh of generating at part-load
- SRMC at SEL assumed to be 109% of SRMC at MEL (based on typical parameters for CCGT)

Cost to consumers from increased wholesale prices

- Wholesale price changes assumed to be passed through in full onto all consumers
- This assumes forward markets are able to anticipate and accurately reflect the cost of reserve procurement – although in reality the requirement will not be known until closer to delivery, due to the difficulties in wind forecasting and the fact that the parameters for setting the reserve requirement are reviewed every six months
- The additional consumer cost from higher wholesale prices is calculated by the sum-product of the hourly price difference and the hourly demand:

$$\sum_{i=1}^{n} P_i D_i$$

where $\boldsymbol{n}$ is the number of hourly periods ($n = 26{,}304$), $\boldsymbol{P}$ is the wholesale price in the Counterfactual scenario subtracted from the wholesale price in the Factual scenario, and $\boldsymbol{D}$ is the demand

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Modelling Approach

Sensitivity to simulate the impact of potential new licence condition

- Ofgem published an open letter in July 2022 outlining **potential** interventions to address the high balancing costs seen in recent years
- A potential new licence condition, which would prevent excessive benefit after submitting a 0MW PN, was indicated as the preferred intervention from a shortlist of six options
- A call for input on the proposal for a potential new licence condition was issued in November 2022
- We have modelled the impact of this change by running a sensitivity with the scarcity premium capped at £1,000/MWh
- This cap impacts periods where the de-rated margin (DRM) falls below 1,500MW

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