Balancing Reserve CBA

National Grid ESO

AUGUST 2023

Contents

Executive Summary

Balancing Reserve CBA

Background

LCP Delta conducted a Cost Benefit Analysis (CBA) on the initial proposals for Balancing Reserve, which was published earlier in 2023.

National Grid ESO has proposed changes to the design of the Balancing Reserve service, to address concerns raised during the consultation on the initial proposals.

These changes will widen the pool of providers which are eligible to participate in Balancing Reserve.

What's changed from the previous analysis?

Balancing Reserve service design changes

- The minimum unit size has been reduced from 50MW down to 1MW
- The requirement for all units to be capable of providing Mandatory Frequency Response (MFR) has been dropped
- A webinar on Balancing Reserve hosted by NGESO in June 2023 includes a discussion of the full list of changes proposed as part of the updated service design

Refresh of modelling inputs

- We have used the latest commodity input prices, which have fallen markedly since the initial CBA
- Our scarcity pricing assumptions have been calibrated to recent market conditions – with less price volatility meaning that we assume a lower scarcity premium added on to power prices during tight periods
- We have widened the pool of generation technologies that can participate in Balancing Reserve, to reflect the changes made to the design of the service

Key messages

- **We continue to see Balancing Reserve delivering value for consumers over 2024 – 2027**

  Our modelling indicates that using the Balancing Reserve service to procure the full positive reserve requirement in every period would save consumers a total of £639m across the four years.

- **Additional benefit could be unlocked if Balancing Reserve can be deployed in a more targeted way**

  Additional consumer benefit could be realised by accurately forecasting periods where the wholesale price impact of Balancing Reserve outweighs the balancing cost saving.

- **Balancing Reserve is shown to be particularly cost effective for consumers during the winter months**

  This is one example of how the probability that Balancing Reserve would benefit consumers on any given day could be reliably assessed by looking at certain key variables.

Modelling Approach

Modelling Approach

Overview of scenarios

Status Quo scenario
Positive Reserve procured through Balancing Actions (BOAs and forward trading)

Balancing Reserve scenario
Positive Reserve procured through Balancing Reserve product, prior to day-ahead auctions

Modelling horizon: **2024-2027**

LCP’s **stochastic dispatch model** is used to simulate the wholesale and balancing markets (5 simulations of each year to capture weather variations)

Reserve requirement varies according to factors such as time of day and forecast wind output

Reserve secured through balancing actions

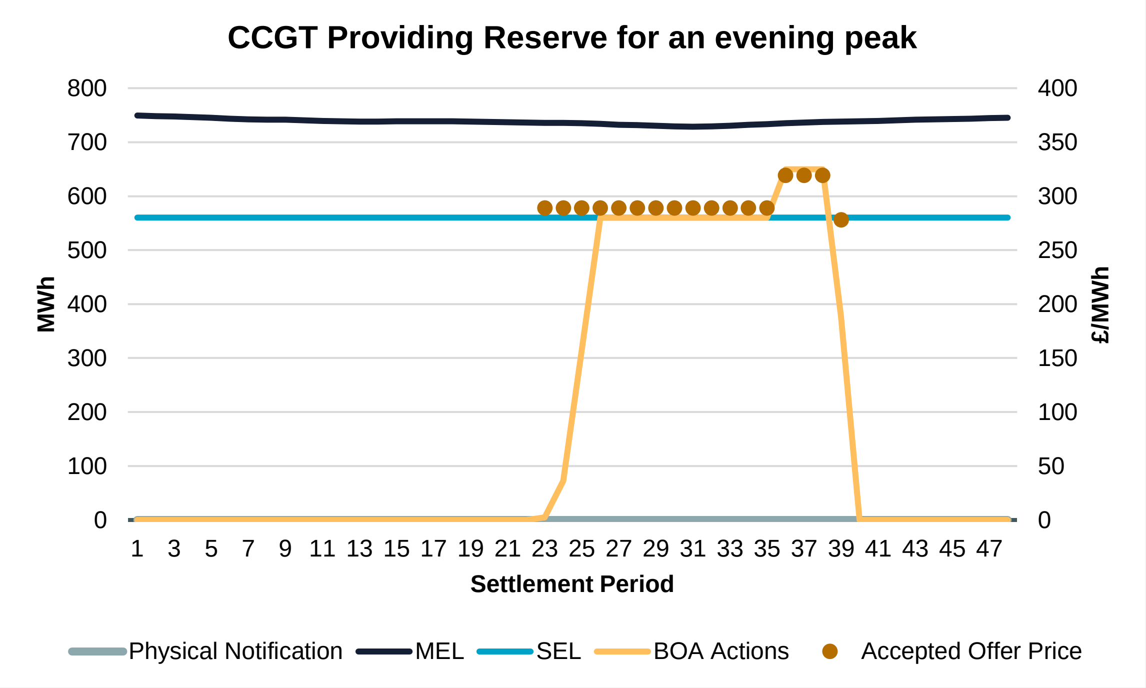
- Plant are turned down or up through balancing actions – bid-offer acceptances (BOAs) and trades
- Typically decreasing from Maximum Export Limit (MEL) to Stable Export Limit (SEL), and from off to SEL
- CCGT (Combined-cycle gas turbine) plant tend to provide the bulk of positive reserve, as they offer good on-load flexibility and are often the marginal units on the system, so it’s rational for them to the first to be turned up or down
- These balancing actions can incur high costs, due to the premium included in BM prices (which are pay-as-bid)
- This premium has been calibrated based on recent historic data

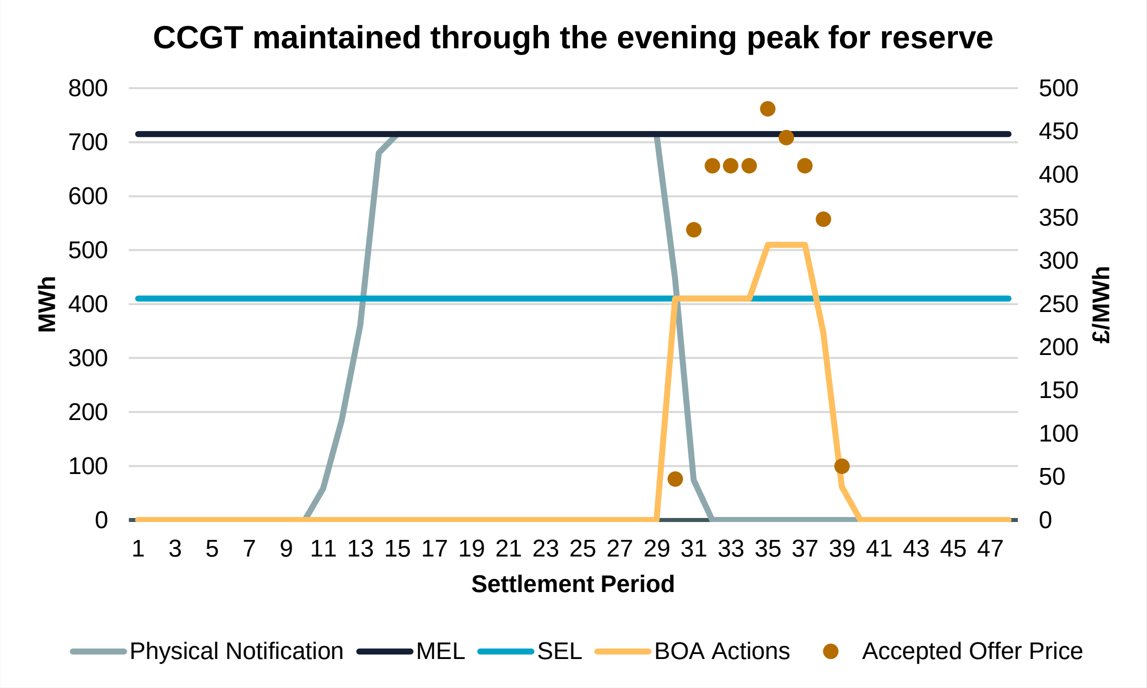
Balancing Reserve

- 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
- It follows that the plant that are on or near the margin in wholesale market will have lowest bids
- This will result in similar providers to Status Quo, but lower cost of provision due to lower premiums in bids
- Volume exiting day-ahead auctions (to part-load and provide reserve) will push up the auction clearing price
- Higher day-ahead wholesale prices means higher wholesale costs passed on to consumers

Status Quo scenario

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





- Reserve is typically provided by CCGTs being bid down from MEL to SEL, or turned-on up to SEL
- 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 in our modelling, based on recent historic data

Balancing Reserve scenario

Reserve procured through Balancing Reserve service

How will units bid into Balancing Reserve?

Availability prices would be determined by the **opportunity cost** of committing to Balancing Reserve, plus any additional costs from running less efficiently at part-load

The opportunity cost of participating in Balancing Reserve is the **expected wholesale market revenue** from generating at full-load, which is determined by day-ahead auction prices

The **marginal unit** (in the wholesale market) would typically bid into Balancing Reserve at the most competitive price – because it makes minimal margin from wholesale dispatch, so has a lower opportunity cost than more efficient units (while having lower costs to recover than less efficient units)

How would this impact the wholesale market?

Units which are accepted for Balancing Reserve are **replaced** in the wholesale market by **units with a higher SRMC** – which increases the wholesale price

But we assume that in the **Status Quo** scenario, the additional balancing actions taken to create reserve have some inflationary impact 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 an overall **saving for consumers**

Results

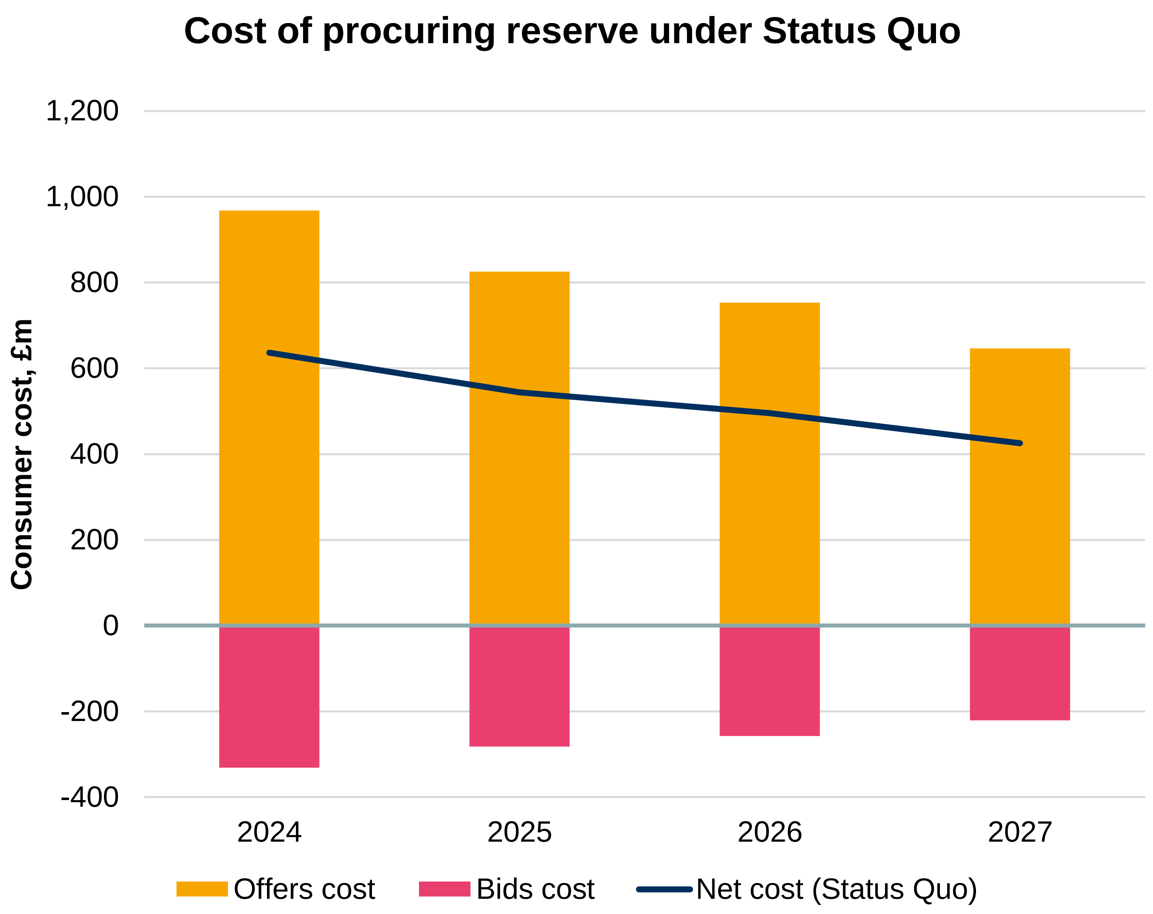
Base Case: mean of 5 simulations

High Case: most favourable simulation in each year

Low Case: least favourable simulation in each year

Results – Base Case

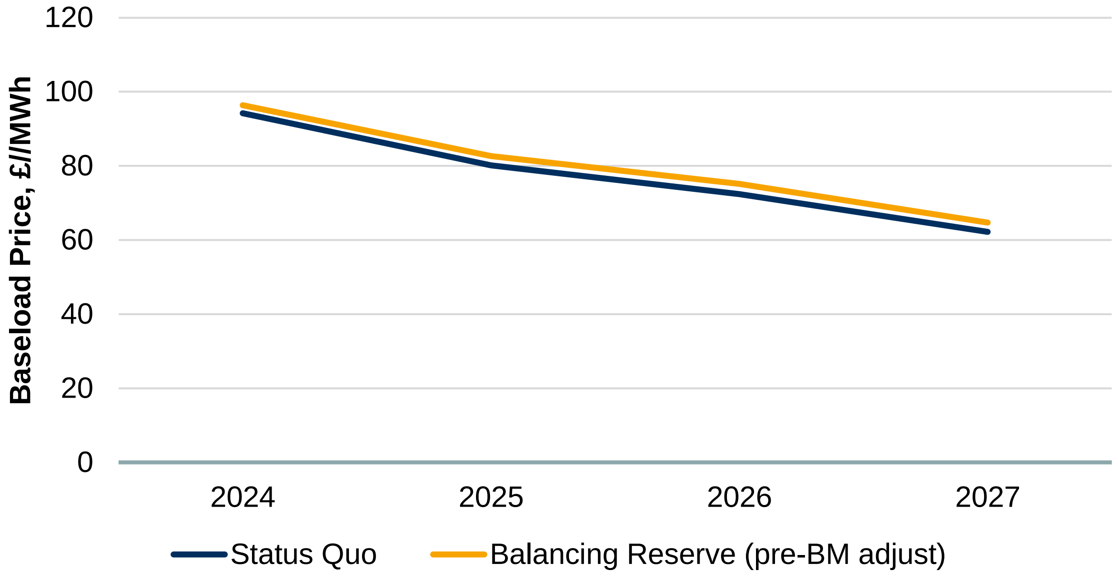
Costs of securing reserve through Balancing Mechanism actions

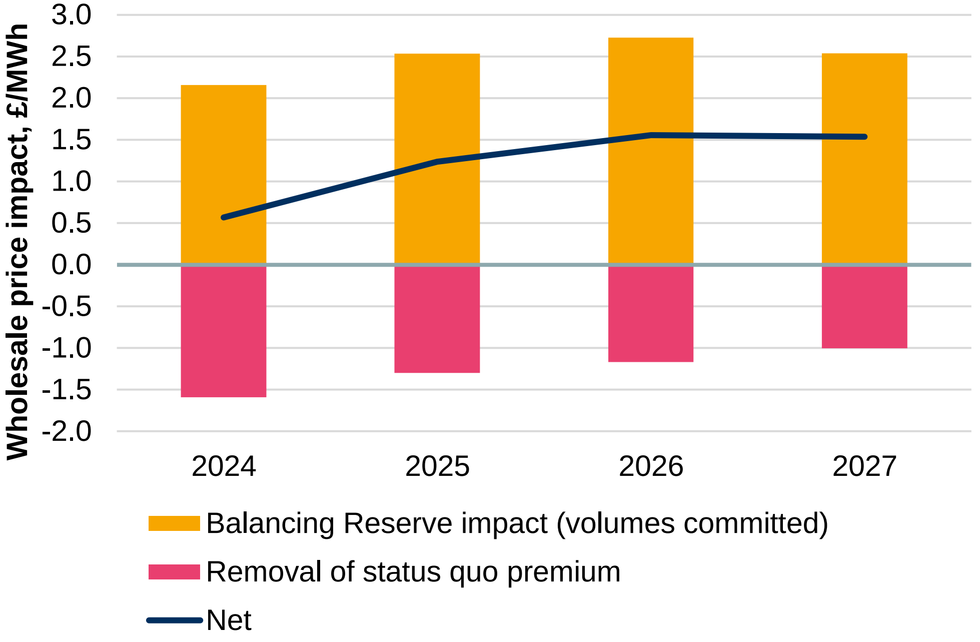


- In the **Status Quo scenario**, the reserve requirement is secured by repositioning units in the Balancing Mechanism (BM), with certain plants instructed to run at part-load, to ensure that the requirement for positive reserve is met in each period
- This is done through a combination of offer acceptances (where plant are paid to increase generation) and bid acceptances (which are a negative cost overall, as plant typically pay to be turned down at a price that is lower than their SRMC)
- Offer prices have been calibrated to reflect the uplift between wholesale and BM offer prices over the 12 months up to and including June 2023
- Bid prices have been calibrated to reflect the average difference between BM bid and offer prices over that same period
- The offer and bid volumes accepted for reserve purposes are assumed to be equal
- We assume the **full reserve requirement is satisfied** through the BM in this scenario.
- Costs fall over time, reflecting the projected **fall in wholesale gas prices** over this horizon – which leads to lower SRMCs for gas-fired generators and therefore lower offer prices in the BM

Results – Base Case

Wholesale price impact of Balancing Reserve

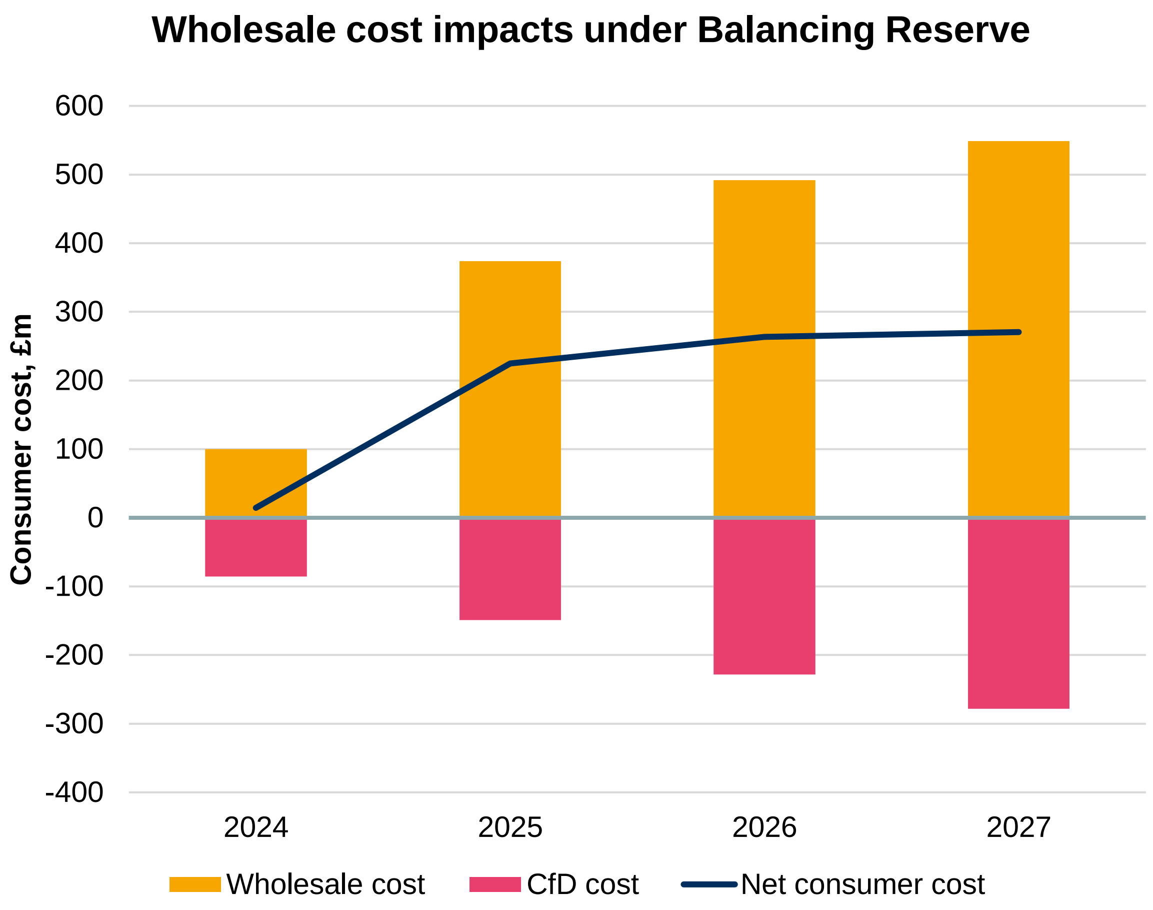




- With the introduction of the Balancing Reserve auction at the day-ahead stage, volumes are committed and taken out of the day ahead market. This means more expensive plant are required to dispatch in the wholesale market, leading to baseload wholesale prices increasing. In 2024 this results in a £2.5/MWh 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 2024 this results in a £1.6/MWh decrease.
- These two offsetting impacts result in a net average wholesale price increase of £0.6/MWh in 2024, £1.2/MWh in 2025, £1.6/MWh in 2026 and £1.5/MWh in 2027.

Results – Base Case

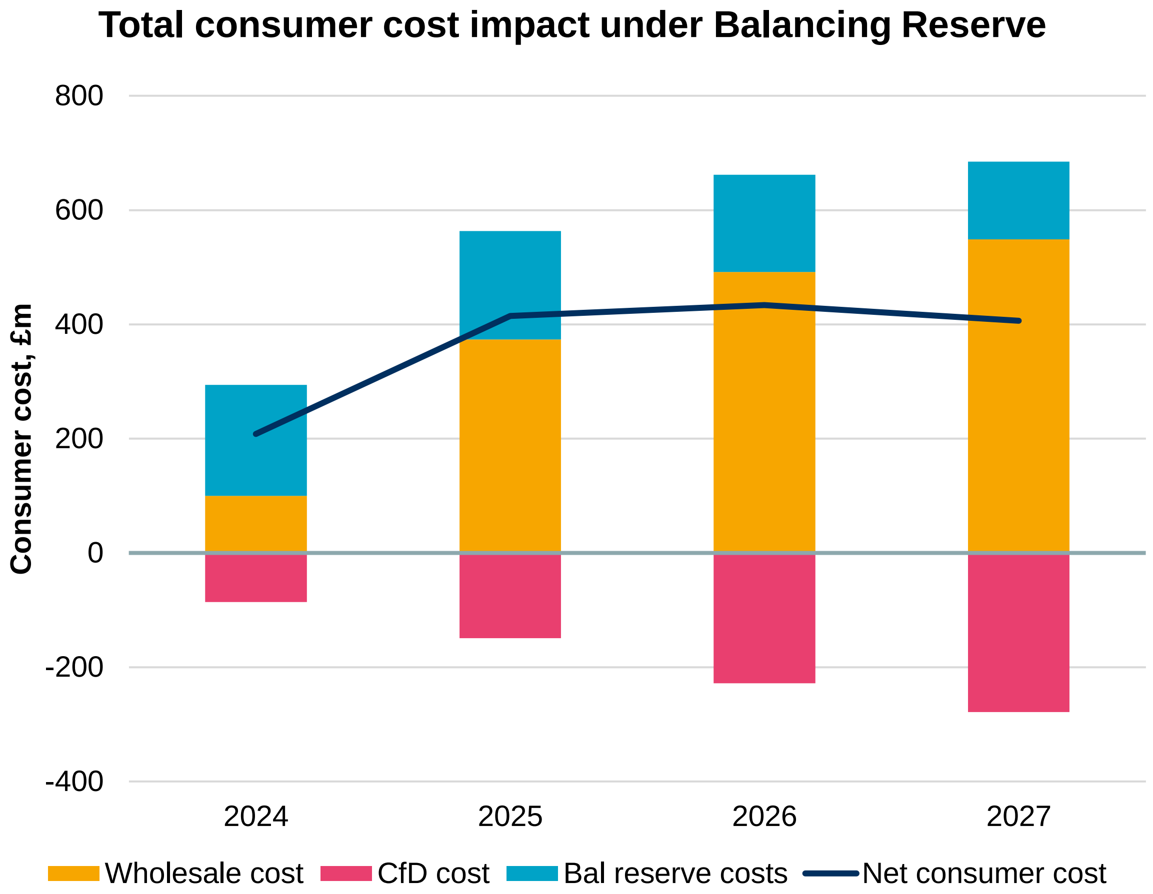
Wholesale costs passed on to consumers under Balancing Reserve scenario



- Wholesale price increases lead to an increase in consumer costs.
- These are partly offset by lower CfD payments, particularly in later years.
- 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.

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.

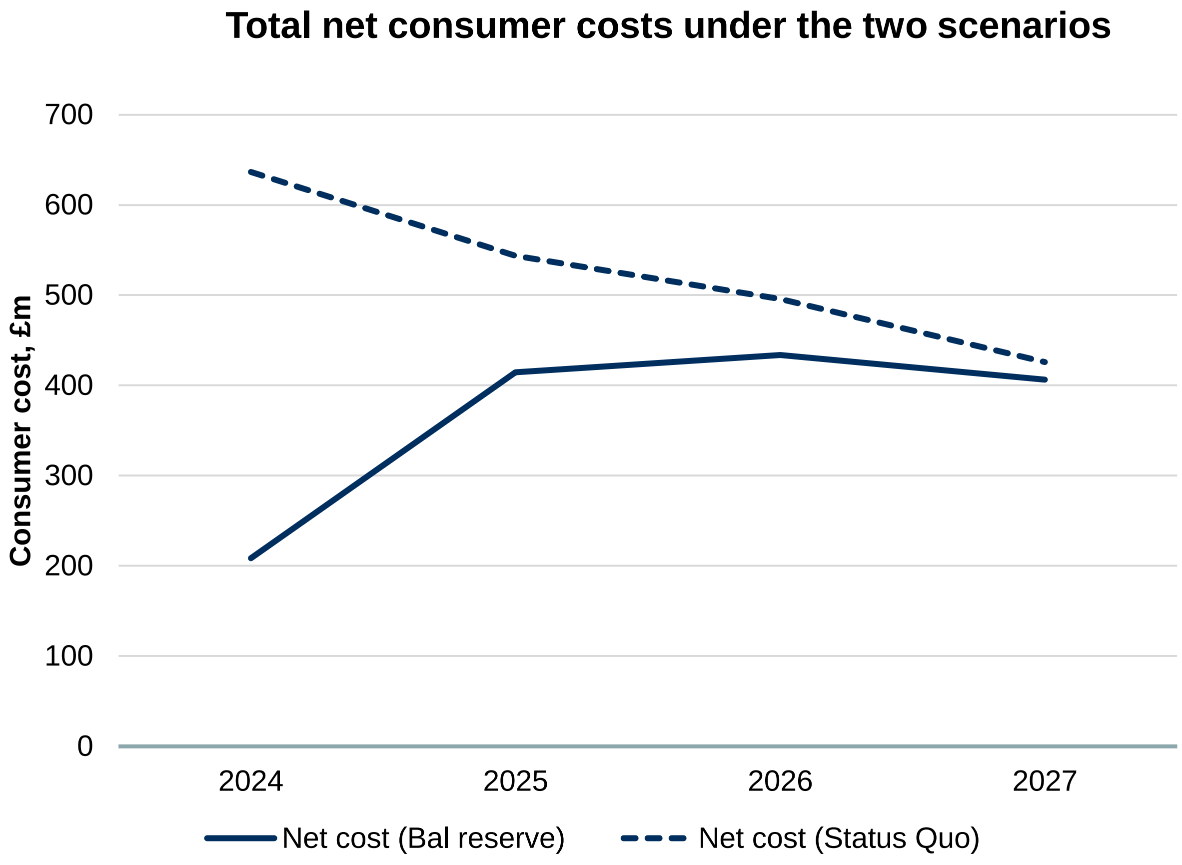
These payments are calculated based on the amount that plant require to recover:

- 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 that 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 met through Balancing Reserve in this scenario.

Results – Base Case

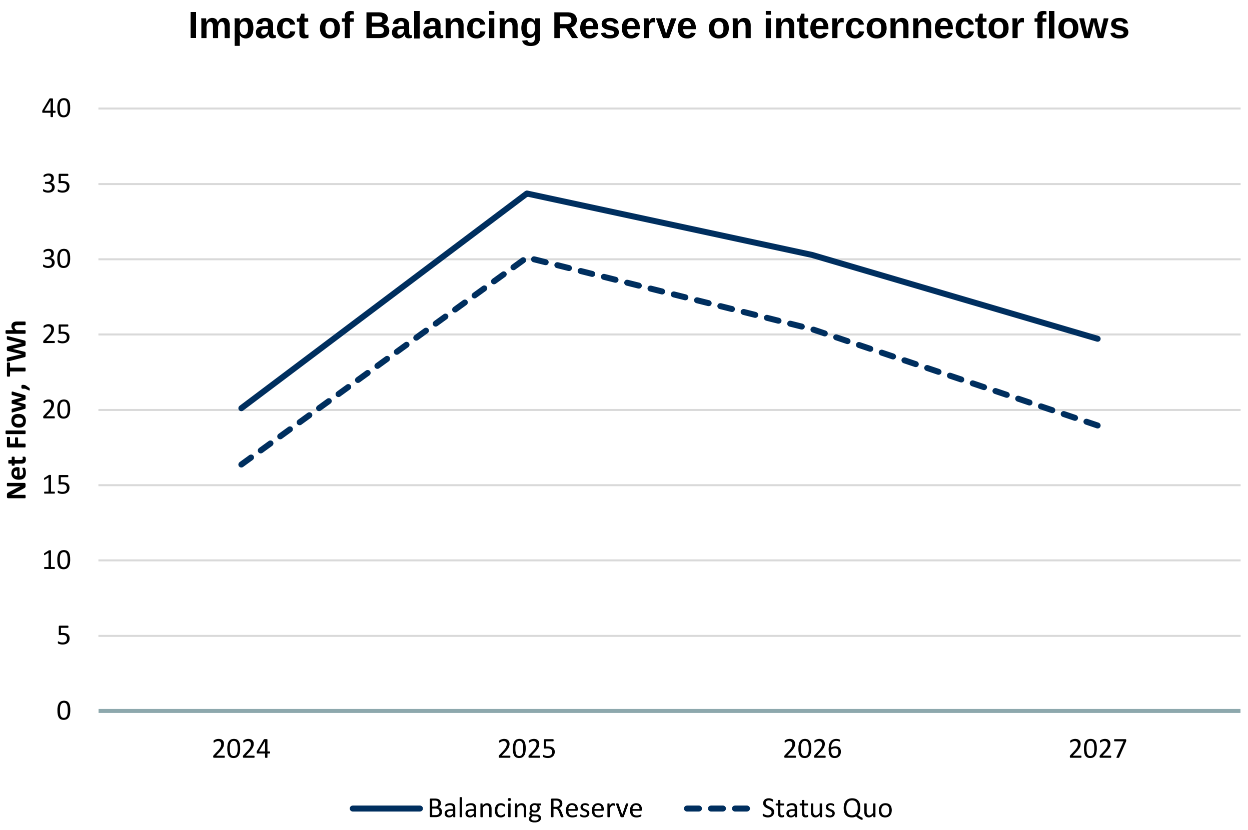
Total consumer cost impact



- The net impact on consumers can then be calculated based on the cost under each scenario
- Overall, Balancing Reserve reduces the total cost to consumers, delivering a net benefit of **£639m** across the four-year period from 2024-27.
- 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, and in the Balancing Reserve scenario this is all procured at the day ahead stage through the new mechanism (i.e. is not targeted to days with expected benefits)
  - Plant SRMC assumptions (full-load efficiency, start-up cost, no-load cost) are based on LCP estimates
  - Some assumptions (part-load SRMC uplift, SEL to MEL ratio) are applied at a fleet-wide level
  - Parameterisation of price uplifts based on historic data – relies on 2022-23 period 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 pricing

Results – Base Case

Impact on interconnector flows

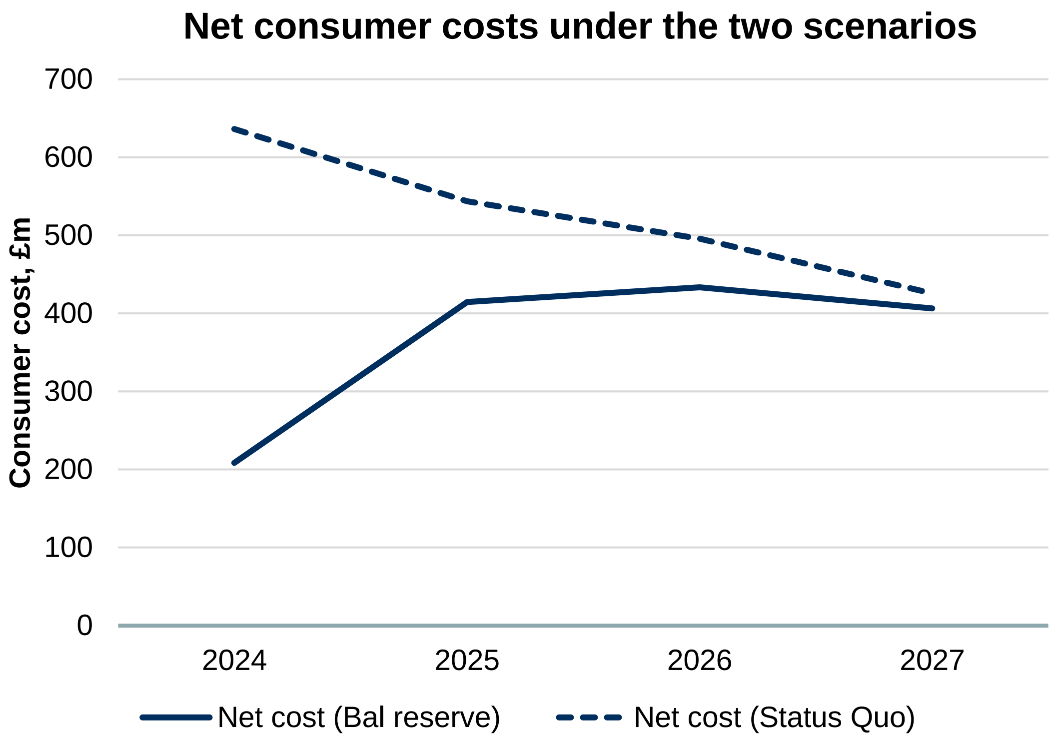


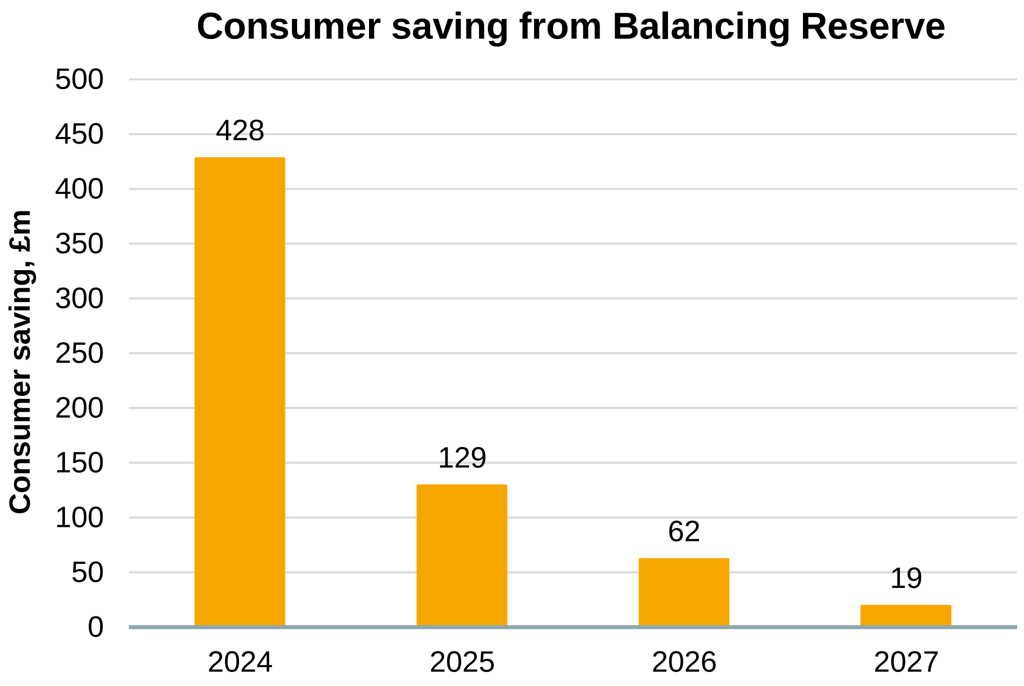
- The increase to wholesale prices under Balancing Reserve sees overall net flow into GB increase in comparison to the status quo, for each of the years in the analysis
- It is expected that this increase in net flows would reduce the need for NGESO to take balancing actions to adjust flows on the interconnectors
- 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)

Results – Base Case

Total consumer cost impact

- **Balancing Reserve** delivers a net benefit to consumers of **£639m** across the four years
- **BM prices** trend downwards over time, reducing the cost of repositioning units to secure reserve under the status quo arrangements
- Meanwhile, the wholesale price impact of **Balancing Reserve** increases due to changes in the generation stack – with the SRMC of mid-merit plant increasing more steeply in 2027 than in 2024

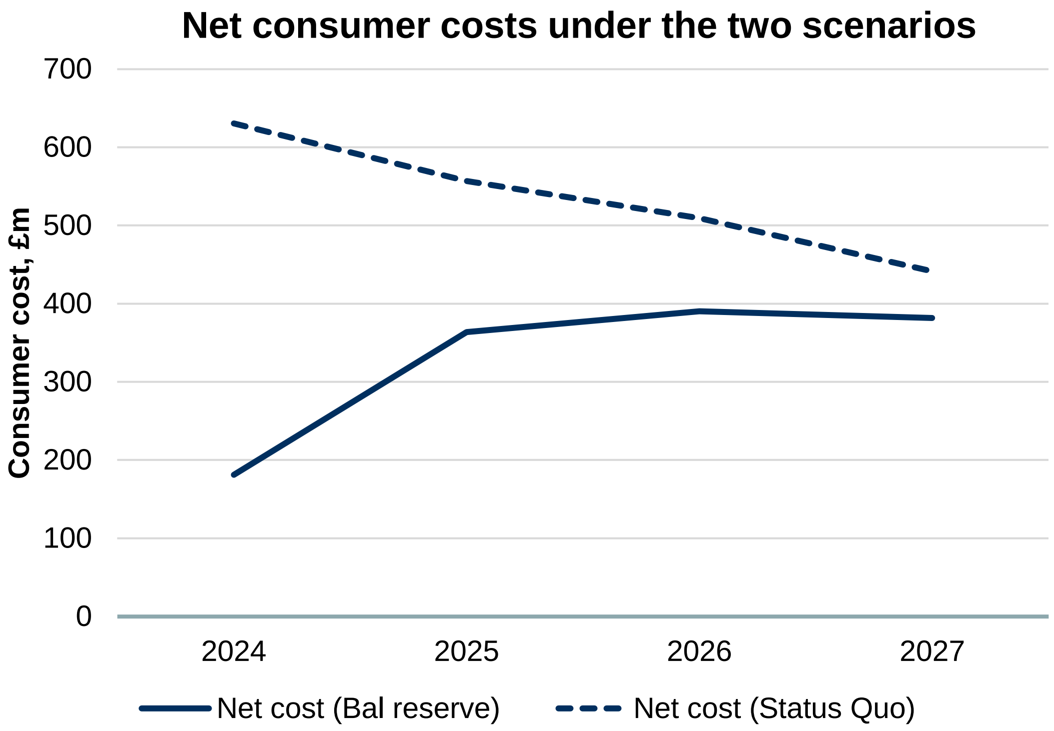


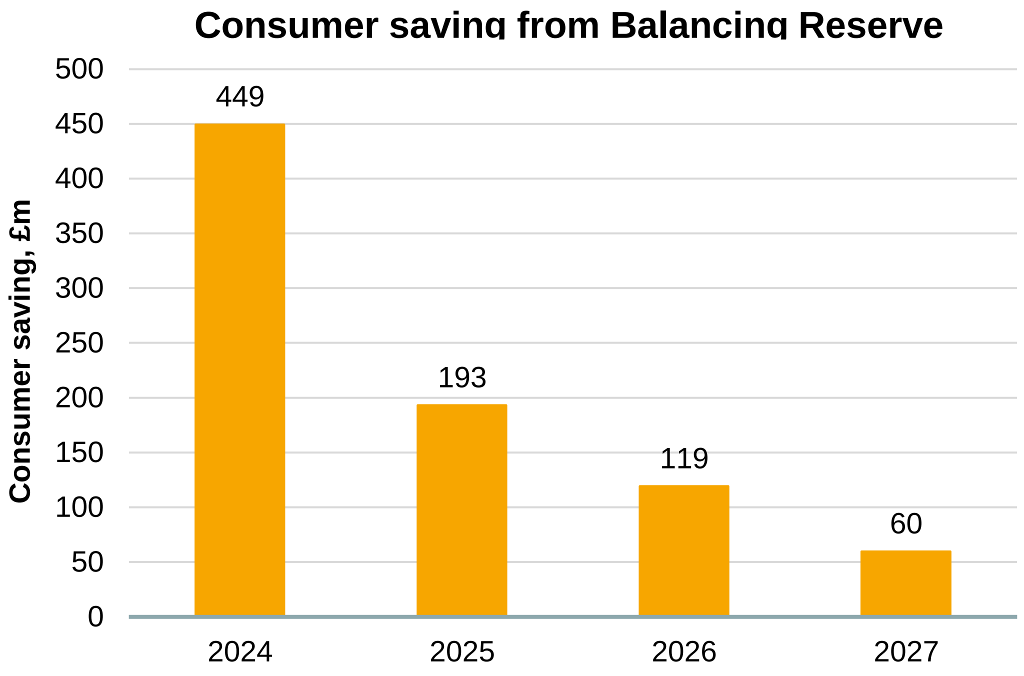


Results – High Case

Total consumer cost impact

- The consumer benefit from implementing Balancing Reserve is clear in the most favourable simulation for each year, delivering a net benefit to consumers of **£821m** across the four years

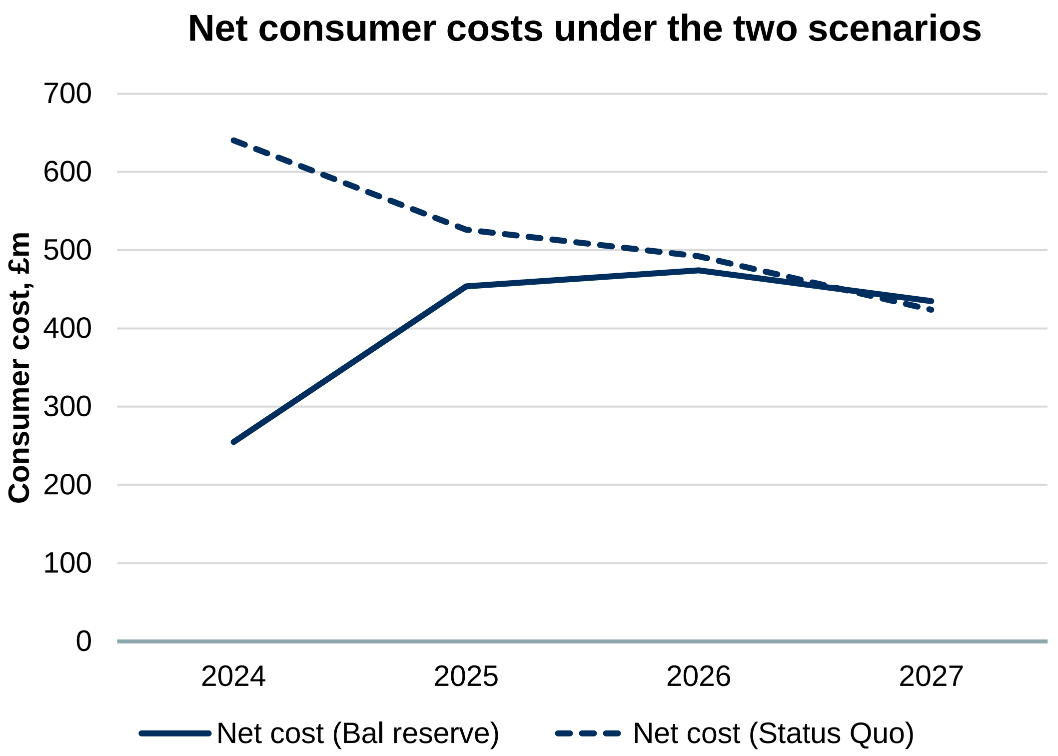


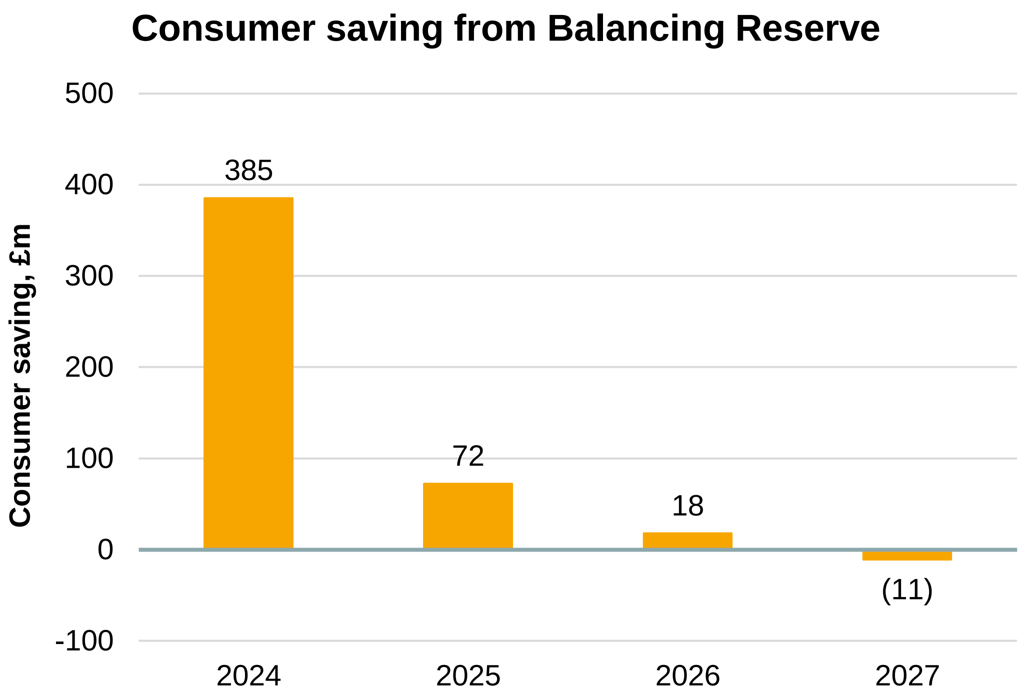


Results – Low Case

Total consumer cost impact

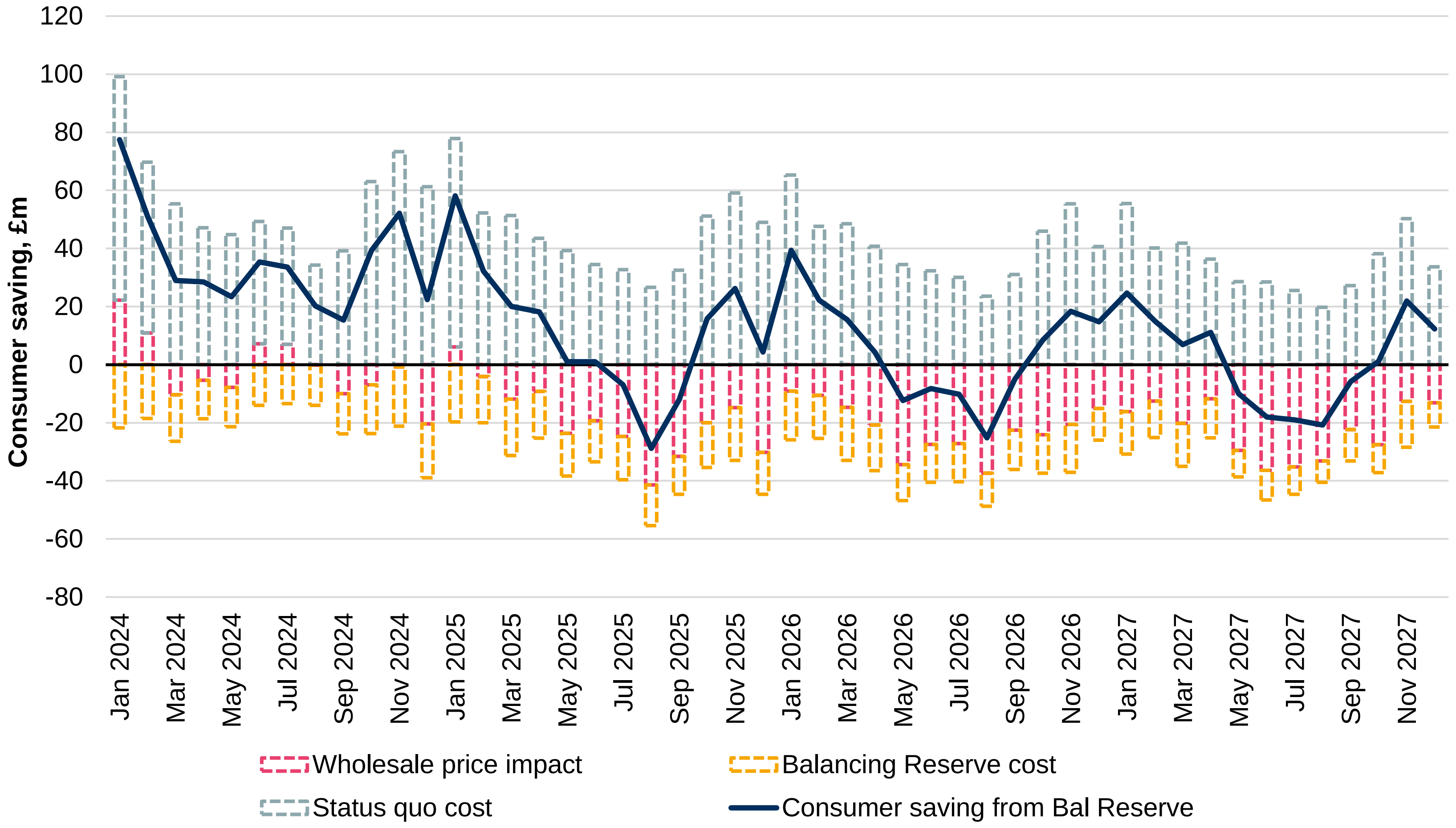
- The consumer benefit from implementing Balancing Reserve is more marginal when looking at the least favourable sim in each year, however there's still a net benefit to consumers of **£465m** across the four years
- The consumer saving can go negative in periods where balancing action prices are closely 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





Results – Base Case

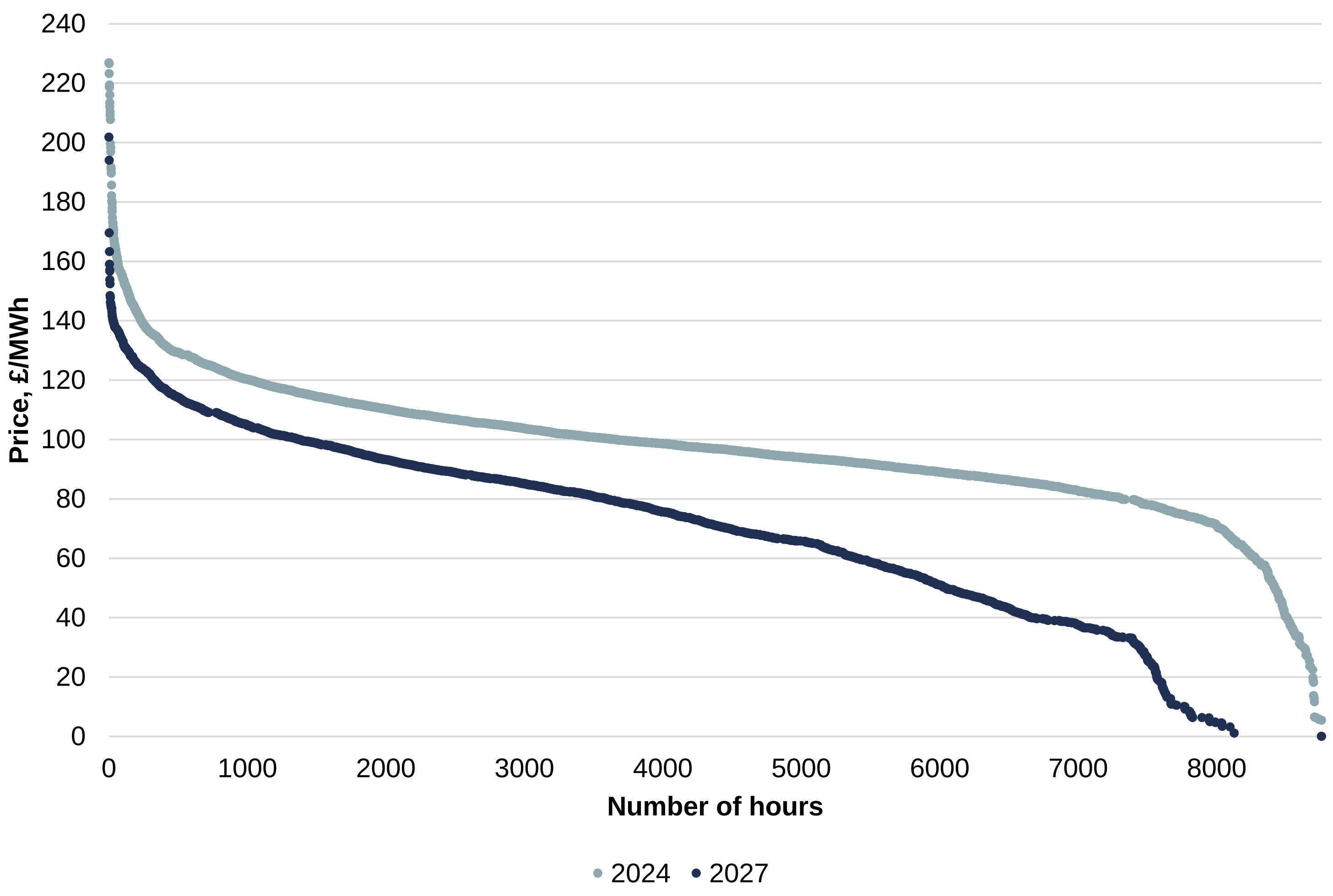
Consumer saving – monthly breakdown



- Our modelling indicates that Balancing Reserve can start delivering benefits for consumers from the outset if introduced in early 2024
- Results show a net consumer saving of £428m across 2024
- From 2025, the savings from Balancing Reserve are concentrated in the winter months
- Additional consumer benefit could be realised by accurately forecasting periods where the wholesale price impact of Balancing Reserve outweighs the balancing cost saving

Results – Base Case

Price duration curve – Wholesale hourly prices



- Prices are lower in 2027, including many more periods priced at ~£0/MWh, than in 2024
- However, after the least expensive 500 hours, prices in 2027 rise more steeply as we progress up the generation stack
- The impact of higher renewable penetration and new sources of flexibility (including new Interconnectors) means there is a wider range of generation sources occupying the margin across the year, and there is a wider gap between the wholesale prices in different hours
- This means that Balancing Reserve has a greater impact on wholesale prices in 2027, as moving up the merit order typically yields a greater price increase for the same amount of volume than it would in 2024

Appendix – Modelling approach and assumptions

- EnVision modelling framework
- Stochastic modelling approach
- Reserve requirements
- Assumptions

Modelling Approach

EnVision model

LCPDelta

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

Modelling Approach

EnVision model

Department for Business, Energy & Industrial Strategy

nationalgridESO

ofgem

LOW CARBON CONTRACTS COMPANY

The EnVision modelling framework:

Developed inhouse at LCP over the past ten years, the EnVision modelling framework has been 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 for 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

Modelling Approach

Stochastic modelling

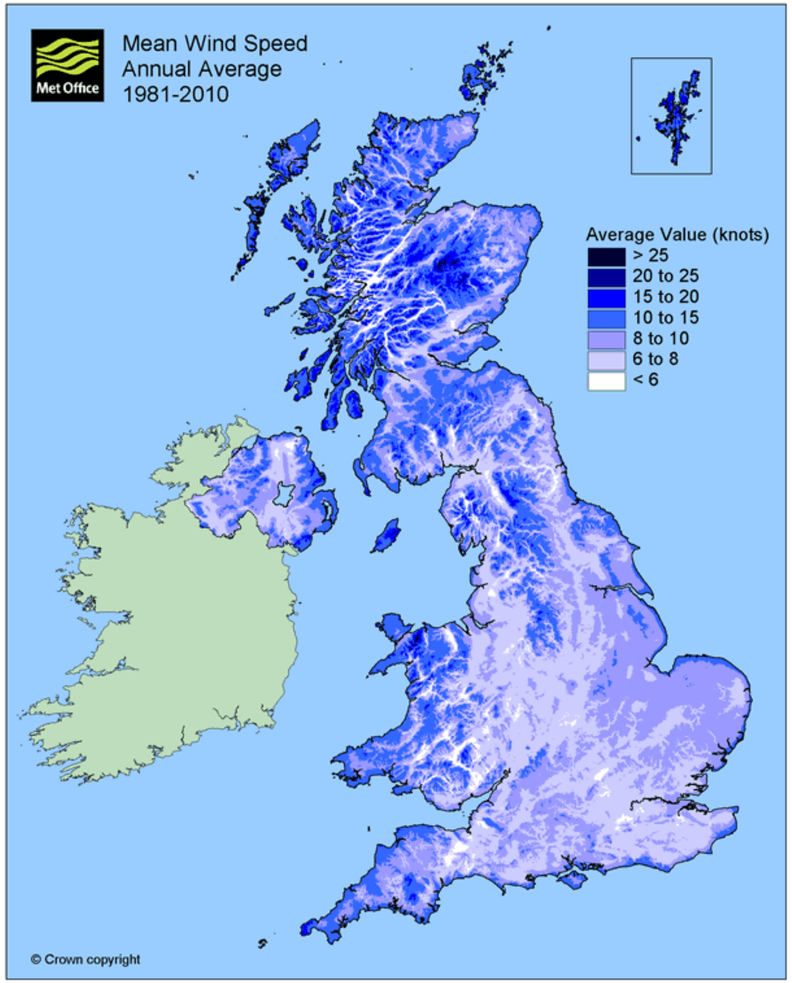
A **stochastic approach** is utilised to model the wholesale, balancing and locational balancing markets.

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.



Reserve Requirement

Varies between 700-2400MW, according to the following factors

Seasonal changes in demand and renewable generation influence 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 potential impact of forecasting errors increases

Reserve Requirement

Basic Requirement

Day type	Minimum Basic Requirement (MW)	Mean Basic Requirement (MW)	Maximum Basic Requirement (MW)
Monday	400	778	1,550
Weekday	400	738	1,150
Saturday	400	601	1,300
Sunday	400	658	1,300

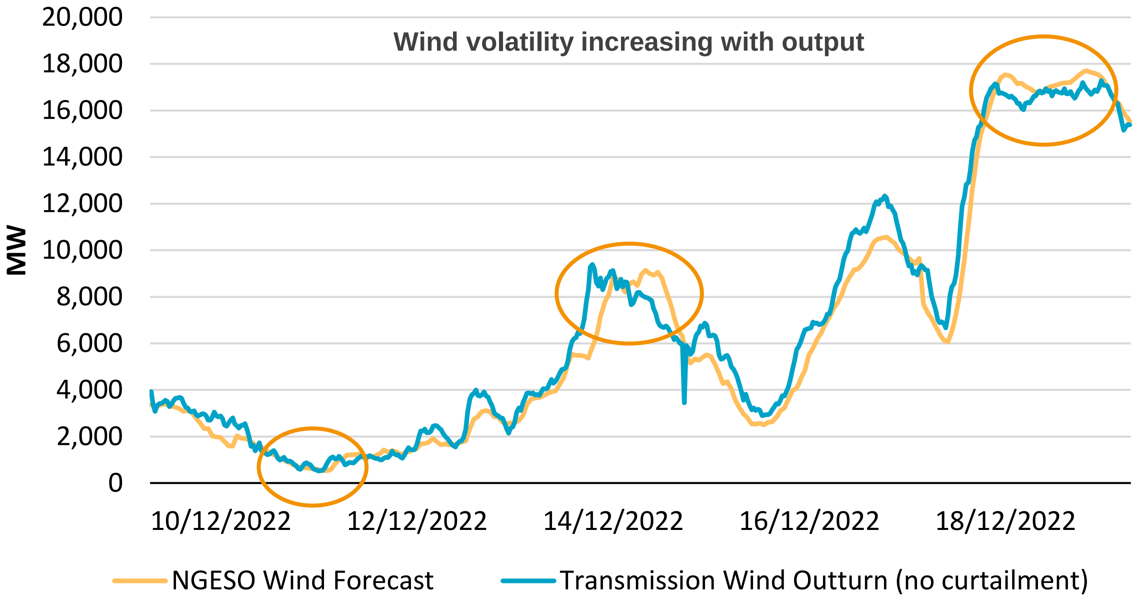
- Varies by time of day – generally increasing and decreasing in line with forecast demand
- Varies by day of the week – this affects the demand shape

Reserve Requirement

Wind generation element

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	840

- 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



Modelling Approach

General assumptions

BSUoS

- Not included as part of generator costs in order to reflect CMP308, which was implemented in April 2023 and sees 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 Balancing Reserve and Status Quo 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

Modelling Approach

Status Quo scenario

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

Modelling Approach
Status Quo scenario

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 Balancing Reserve scenario, 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

Modelling Approach
Balancing Reserve scenario

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 Balancing Reserve 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
<= 600 MW	1.35%
600 - 1,125 MW	2.70%
> 1,125 MW	4.05%

- Note that in both the Balancing Reserve and Status Quo scenarios, 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

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 Balancing Reserve 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

Modelling Approach

Balancing Reserve scenario

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 Status Quo scenario subtracted from the wholesale price in the Balancing Reserve scenario, and $\boldsymbol{D}$ is the demand

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