

Winter Outlook 2026/27

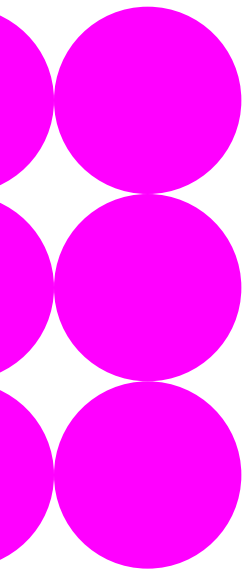
Technical Workbook and Methodology

October 2026



Table of Contents

Introduction	3
01 Adequacy Metrics	4
02 Modelling Variability	7
Weather variability	8
Demand variability	9
Supply variability	10
Interconnector variability	11
03 Scenario and Sensitivity Modelling	12
Get in Touch	14



Introduction

Welcome to the National Energy System Operator (NESO) Winter Outlook 2026/27 Technical Workbook and Methodology covering November 2026 to March 2027. This document provides supplementary information on the data, assumptions and modelling methods underpinning the *Winter Outlook 2026/27* report.

This document is intended for readers seeking a deeper understanding of how NESO assesses electricity supply and demand, system margins and operational risks for the winter ahead. It covers both the seasonal system margin assessment and the operational analysis used to identify periods when electricity supply margins may become tight.

There is significant uncertainty when modelling winter electricity security of supply on a season-ahead timescale because both demand and available generation are strongly influenced by factors that can vary widely when forecast several months in advance.

Weather is the largest source of uncertainty, affecting electricity demand through temperature-driven heating requirements while also influencing wind and solar generation output. In addition, the availability

of conventional generation, storage assets and interconnectors can change due to delayed construction, unplanned outages, rescheduled maintenance or operational constraints that emerge during winter.

Cross-border electricity flows are also uncertain, as they depend on weather, market conditions and system stress in neighbouring countries.

Our security of supply assessment therefore considers a wide range of sensitivities and credible scenarios to understand the potential range of winter outcomes rather than trying to predict a single definitive margin.

This document focuses on how we incorporate variability and uncertainty into our modelling and the metrics used to capture the corresponding risks.

We want to ensure the Winter Outlook 2026/27 Technical Workbook and Methodology provides the right information, and we welcome feedback on how it could be improved to help industry understand our analysis. You can email us at marketoutlook@neso.energy, join us at the NESO Operational Transparency Forum or connect with us on X at [@NESO_energy](https://twitter.com/NESO_energy).



Adequacy Metrics



In our *Winter Outlook 2026/27*, we assess system adequacy using both the de-rated margin and operational surplus. This section provides further detail on how we incorporate variability and uncertainty in supply and demand into these models.

De-rated margin assessment

The *Winter Outlook 2026/27* margin assessment evaluates whether sufficient capacity is expected to be installed and available to meet Great Britain's electricity demand from November to March. It covers national adequacy across transmission-connected, embedded and microgeneration resources, including conventional generation, wind, storage, demand-side response and interconnectors. It excludes regional network constraints and short-term operational matters such as maintenance and outage scheduling.

The assessment compares each resource's contribution to security of supply with underlying end-consumer demand plus the reserve requirement.

As described on page 9, the assessment uses 17 years of corresponding half-hourly demand and wind data from 2005 to 2022 to represent a range of possible winter weather conditions.

As indicated in the *Winter Outlook 2025/26* and *Early View of Winter 2026/27*, we have updated our Capacity Assessment (CA) model process and related tools for this winter to better reflect observed correlation between renewable generation availability and demand. We have embedded this in a standalone alternative process. Under the previous approach, the CA model converted demand and wind observations into separate probability distributions. It then applied a linear scaling adjustment to reduce assumed wind output during the highest-demand periods. This reflected evidence that the cold, high-pressure conditions associated with peak winter demand correlate with lower wind output.

In this year's *Winter Outlook*, we use a new approach that calculates demand net of wind by subtracting wind output from demand in each corresponding historical half-hour. Pairing observations from the same historical periods directly reflects the relationship between

demand and wind more consistently rather than applying a separate adjustment. This provides a more evidence-based representation of their correlation and aligns the *Winter Outlook 2026/27* more closely with the approach used in the *Electricity Capacity Report*.

The assessment's principal outputs are the de-rated margin, which measures expected capacity headroom, and loss of load expectation (LOLE), the probability-weighted average number of hours per year when demand may exceed available supply. Together, these provide complementary views of capacity headroom and winter adequacy risk.

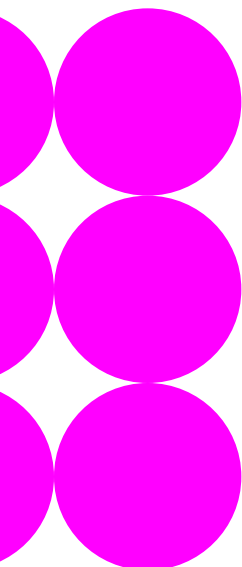
The model first produces a probability distribution of demand net of wind. This is necessary to preserve their weather-driven relationship.

The model then combines the demand-net-of-wind distribution with the availability distribution of the remaining supply to estimate the probability and scale of capacity surpluses and shortfalls. The part of the resulting probability distribution that represents a shortfall is then used to calculate LOLE and expected energy unserved (EEU), the probability-weighted volume of demand that may not be met. These metrics complement the de-rated capacity margin by describing the frequency and potential depth of shortfalls, rather than expected capacity headroom alone.

Operational surplus

The operational surplus provides a day-by-day analysis of supply and demand on the transmission system throughout the season. It represents the operational view before the Electricity National Control Centre (ENCC) takes any action. On the supply side, we assess the transmission-connected generation, including conventional generation, wind, storage and interconnectors. This modelling excludes regional network constraints but includes short-term operational matters such as maintenance and outage scheduling.

The assessment compares available generation with National Demand plus the reserve requirement. We use a Monte Carlo approach to capture the full range of possible conditions. We can therefore provide a probabilistic view of operational surplus and quantify the probability of low-surplus days.



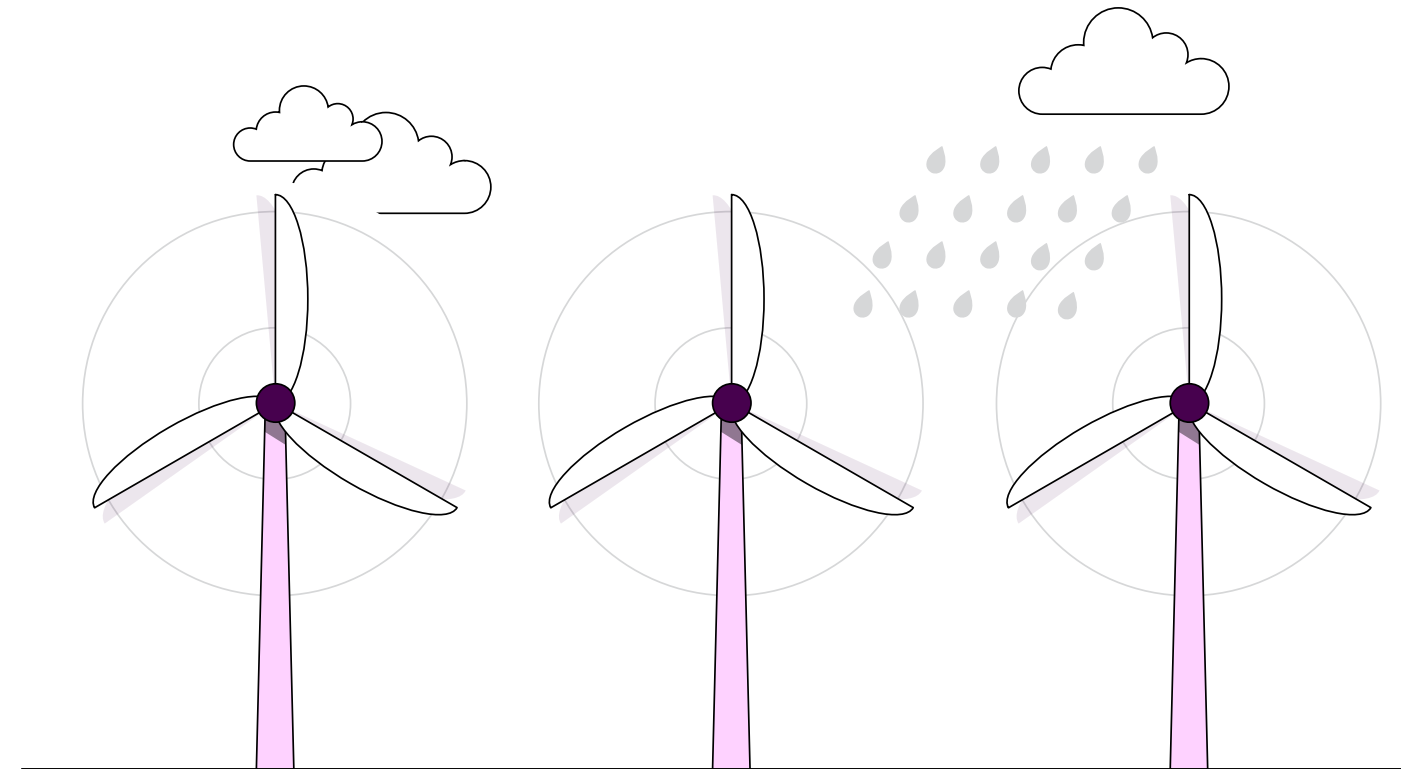
We assess the operational surplus using a Monte Carlo model that randomly combines simulations of electricity demand, wind generation and solar generation, derived from 30,000 weather scenarios, with 5,000 simulations of conventional generator availability. This creates 30,000 simulations of the season ahead. The approach captures the combined effects of weather variability and plant outages on system adequacy.

In our *Winter Outlook 2026/27*, we present this analysis as a day-by-day view of the central forecast of the operational surplus, plus the credible range, defined as the range between the 5th and 95th percentiles. To provide additional insight outside this range, we also present the probability that the initial excess supply available from the market falls below the reserve requirement on each day. This metric highlights periods when the margin between available supply and reserve requirements becomes tight, providing a complementary view of system risk beyond the operational surplus distribution.

The changing nature of capacity adequacy risk

As variable renewables and duration-limited storage increase, adequacy risk may become more concentrated in infrequent but severe periods of high demand, low renewable output and constrained storage duration. In such a system, the de-rated capacity margin alone will not fully describe the range or nature of adequacy risks.

LOLE adds a probabilistic view but measures only the probability-weighted average number of hours with a shortfall. It does not show whether risk is concentrated in a small number of severe weather years, nor the depth or duration of potential shortfalls. Complementary metrics such as EEU and weather-year-conditional analysis are therefore needed to describe the likelihood, concentration and severity of future adequacy risks more fully. We intend to publish these complementary metrics in future Winter Outlook publications.



Modelling Variability





Weather variability

A key input, underpinning all our winter modelling, is the weather dataset. To account for weather variability in the coming winter, we do not rely on long-range operational weather forecasts, as these have limited predictive skill at seasonal timescales.

Instead, we use weather reanalysis data to represent a plausible range of conditions based on data dating back to 1987 from NASA’s Modern-Era Retrospective analysis for Research and Applications, Version 2 (MERRA-2) database.¹

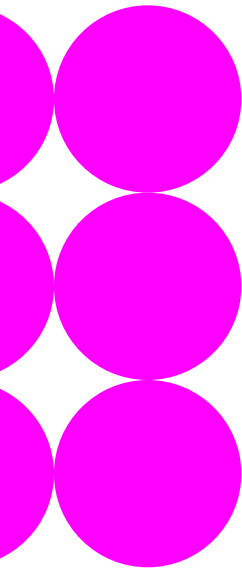
We use reanalysis weather data because it provides the most complete and consistent representation of historical weather conditions by combining observations with meteorological models. Reanalysis datasets offer hourly, spatially coherent, gridded weather variables over several decades, allowing us to analyse the combined response of demand, wind generation and solar output under a wide range of conditions.

We can also analyse weather conditions in neighbouring countries simultaneously. This is important because weather patterns can be correlated across countries. For example, periods of low wind can affect Great Britain, Ireland, France, Germany and the North Sea region at the same time.

Given the relatively long period covered by this dataset, this approach captures a wide range of weather variability, including periods influenced by climate patterns such as El Niño and different phases of the North Atlantic Oscillation (NAO).

Depending on the application, we sample from this historical dataset in different ways. In some cases, we analyse all the historical years. When considering the average cold spell (ACS)² peak demand or operational surplus, we sample the data to generate many alternative weather years and assess the resulting range of system outcomes. This means our analysis is not limited to the specific historical weather years in the dataset.

Looking ahead, we are working closely with the Met Office to develop weather datasets that will enable us to assess plausible weather events outside the historical record using the UNprecedented Simulated Extremes using Ensembles (UNSEEN) method. This will strengthen our understanding of low-probability weather risks. We also continue to explore ways to incorporate seasonal and sub-seasonal weather forecasts into our operational tools.



¹ Global Modeling and Assimilation Office (GMAO), [Modern-Era Retrospective analysis for Research and Applications, Version 2 \(MERRA-2\)](#), NASA.

² NESO, [Average Cold Spell Methodology](#), June 2026.



Demand variability

In our *Winter Outlook 2026/27* modelling, we use two main approaches to assess system adequacy: the de-rated margin and operational surplus.

This section provides further detail on how we account for weather variability and other uncertainties in these two approaches. The de-rated margin assesses adequacy based on underlying end-consumer demand, while the operational surplus is based on National Demand.

For both definitions of demand, our modelling approach aims to capture: (1) structural changes in peak electricity demand driven by factors such as economic or population changes and (2) natural diurnal, weekly, seasonal and weather-related variability.

Underlying end-consumer demand used in the de-rated margin and LOLE assessment

To account for structural changes in demand, we directly use projections for underlying ACS peak demand from NESO's Future Energy Scenarios (FES) 10 Year Outlook.

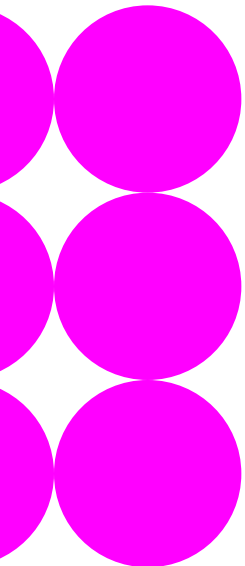
To account for variability associated with calendar and weather effects, we use historical half-hourly outturn demand data for the 17-year period from 2005 to 2022. These historical demand patterns are scaled to the winter-ahead ACS peak forecast from the FES 10 Year Outlook. Each weather year represents a plausible weather-driven demand pattern that could occur in the winter ahead.

National Demand used in the operational surplus modelling

For our operational surplus modelling, we create 30,000 simulations of the winter ahead that show the daily peak demand throughout the season. We do not model National Demand directly; instead, we use a model of virtual demand. Virtual demand is defined as National Demand plus total embedded wind and solar generation. This provides a better view of underlying demand, which is easier to model because demand patterns have a clearer relationship with our explanatory variables (such as temperature and day of the week). It also allows us to incorporate changes in embedded wind and solar capacity into our modelling. We fit a statistical model of peak virtual demand using three years of historical data and a set of relevant explanatory variables. These include both weather and calendar effects.

Since future winter weather conditions are inherently uncertain, we do not attempt to predict a single outcome. Instead, we generate 30,000 plausible winter weather scenarios, following the process outlined in the ACS methodology. These represent a wide range of potential conditions. The fitted model is then applied to each weather scenario to produce a corresponding estimate of peak virtual demand. We also forecast embedded wind and solar generation for each weather scenario (see page 10) and subtract this from peak virtual demand to estimate National Demand in each scenario.

The results are summarised using key quantiles. For each day, we calculate the 5th percentile (P5), median (P50) and 95th percentile (P95) demand values. These statistics describe the range of plausible outcomes and form the basis of the National Demand projections reported in the *Winter Outlook 2026/27*. We also investigate more extreme demand days (above the 95th percentile) and include all demand scenarios in our operational surplus assessment.



Supply variability

Our winter modelling aims to capture variability in electricity supply. Weather conditions strongly influence renewable output, particularly wind and solar generation. The availability of conventional generation, storage assets and interconnectors can also change due to delayed commissioning, unplanned outages, rescheduled maintenance or operational constraints that emerge during winter.

Wind and solar generation

We preserve the relationship between supply and demand by using the same historical reanalysis weather data to model wind and solar generation. This modelling is based on the current geographical distribution of wind and solar capacity in Great Britain.

We fit statistical models for wind and solar generation that include informative weather variables. For wind, we use wind speed at the spatial locations and hub heights of each wind farm. For solar, we use regional solar radiation and temperature, weighted by solar photovoltaic (PV) capacity. We model total generation from wind and solar from both embedded and transmission-connected units.

Using the same weather scenarios as those used for peak demand – historical data from 2005–2022 for margin modelling and 30,000 simulations for operational surplus – we predict wind and solar output during the winter.

Solar PV is allocated a 0% de-rating factor in the de-rated margin assessment, as winter peak demand generally occurs after dark when solar generation is unavailable. Its contribution to system adequacy is indirectly captured through its effect on the Equivalent Firm Capacity (EFC) of the storage fleet.

Variable and duration-limited generation

Wind, solar, storage and interconnectors are variable resources whose contribution depends on weather, duration or wider system conditions. Wind, solar and storage are valued using EFC, defined as the amount of perfectly reliable capacity that could replace the resource without changing system adequacy risk. EFC measures a resource's contribution during periods of scarcity, not its average energy production, and changes with the resource mix and system conditions. This modelling also captures interactions between technologies. For example, solar generation can allow storage to conserve energy and deploy slightly later during the evening peak.

Conventional generation

When calculating our margin assessment, our supply forecast for conventional generation uses winter-ahead capacity assumptions from NESO's FES 10 Year Outlook, updated before publication when material new information becomes available. We value supply resources by their expected contribution to security of supply, not their nameplate capacity. Conventional generation and demand-side response use de-rating factors derived from historical availability. We model each resource as available or unavailable due to an unexpected outage, with its de-rating factor representing the probability it will be available. The de-rating factors for the various generation technologies are taken from NESO's annual *Electricity Capacity Report*. Larger generation units connected at transmission level are represented individually, while embedded generation and microgeneration sites are aggregated by technology type.

When calculating our operational surplus, our supply forecast for conventional generation considers all dispatchable generation available to NESO to meet National Demand. We incorporate uncertainty in conventional generation and interconnector availability using

a probabilistic asset reliability model informed by historical generator performance. We include known planned outages using the latest market information, while future unplanned outages are represented through Monte Carlo simulations using a Markov model of breakdown and repair behaviour. For our operational surplus modelling, we run 5,000 simulations using our breakdown model, each detailing available generation throughout the season. This produces a wide range of plausible availability outcomes, allowing our assessment to capture both more favourable and more challenging scenarios.

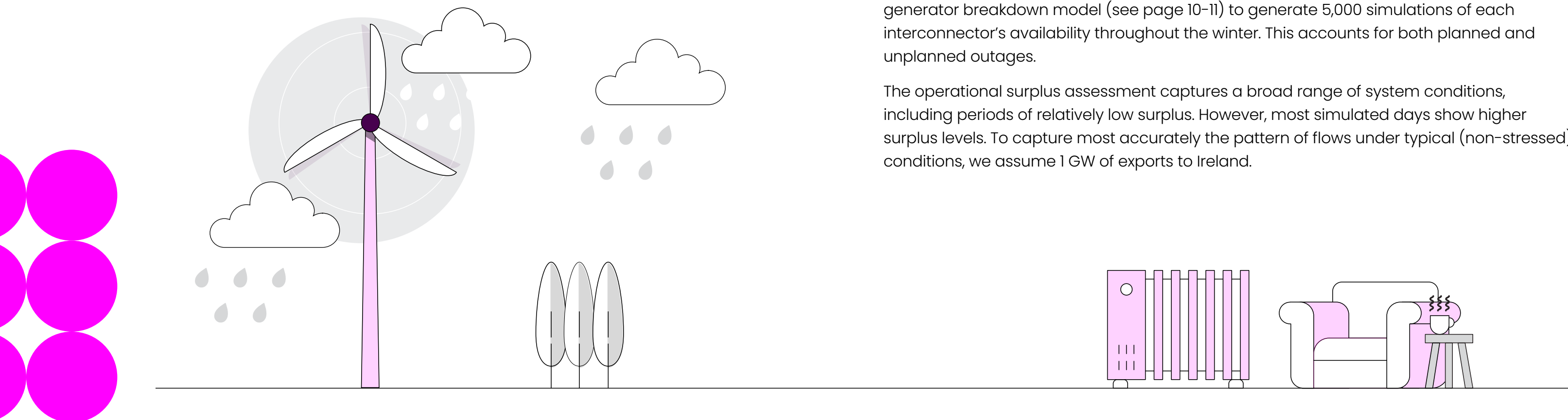
Interconnector variability

Electricity flows across interconnectors, including during times of system stress, are driven by price differentials between connected markets. These prices reflect short-term market conditions in each country, such as weather, geopolitics and generation availability.

Our margin assessment assumes that all interconnectors will perform in line with their Capacity Market de-rating factor obligations during periods of stress. The assessment represents their contribution using the de-rating factors applied to their Capacity Market agreements. These de-rating factors are informed by an EFC assessment in NESO's *Electricity Capacity Report*.

In our operational surplus modelling, we assume that interconnectors with Continental Europe will import electricity in line with their Capacity Market agreements. We use our generator breakdown model (see page 10–11) to generate 5,000 simulations of each interconnector's availability throughout the winter. This accounts for both planned and unplanned outages.

The operational surplus assessment captures a broad range of system conditions, including periods of relatively low surplus. However, most simulated days show higher surplus levels. To capture most accurately the pattern of flows under typical (non-stressed) conditions, we assume 1 GW of exports to Ireland.



Scenario and Sensitivity Modelling





Our *Winter Outlook* modelling approach allows us to account for the main sources of variability where historical evidence provides a basis for assigning probabilities.

By representing factors such as weather-driven demand, renewable generation and generator availability probabilistically, we can assess a wide range of plausible winter conditions and quantify the likelihood of different security-of-supply outcomes.

Our modelling cannot capture all sources of uncertainty in the same probabilistic way. Some risks are difficult to quantify from historical observations because they are rare, unprecedented or highly dependent on wider economic and geopolitical circumstances. These include significant economic changes, global events, shocks to international energy markets, supply-chain disruption and other unexpected events that could materially affect electricity demand, generation availability or energy imports. We can nevertheless explore these uncertainties within the same probabilistic framework by using scenarios that change selected initial assumptions. This allows us to assess how the range and likelihood of security-of-supply outcomes could change under different plausible circumstances, without assigning a probability to the scenario itself.

The main results presented in our *Winter Outlook* are based on our base case, which represents our best view of how the energy market is expected to operate over the season ahead. It reflects the assumptions we consider most appropriate at the time of publication and provides the central basis for our assessment of security of supply. We complement this with alternative scenarios that vary the main assumptions to explore uncertainties that cannot be reliably assigned probabilities from historical evidence.

Table 1 in the *Winter Outlook* (reproduced here) shows how the de-rated margin and LOLE for winter 2026/27 vary under illustrative sensitivities. We have included generation downside sensitivities, in which 2 GW, 3 GW and 4 GW of de-rated conventional generation or interconnector imports are assumed to be unavailable. All supply scenarios are based on ACS peak demand. The LOLE remains within the Reliability Standard in each case. In addition, Figure 1 shows the daily operational surplus throughout the season with 2 GW less generation or interconnector imports.

Table 1: Impact of illustrative sensitivities on de-rated margin and associated LOLE

Scenario	De-rated Margin	Associated LOLE (Hours/Year)
Base case	5.9 GW (9.5%)	<0.1
High demand (peak demand is at the 90th percentile of our forecast)	4.7 GW (7.3%)	<0.1
2 GW less de-rated generation or interconnector imports	4.4 GW (7.1%)	<0.2
3 GW less de-rated generation or interconnector imports	3.7 GW (6.0%)	<0.4
4 GW less de-rated generation or interconnector imports	3.1 GW (5.0%)	<1

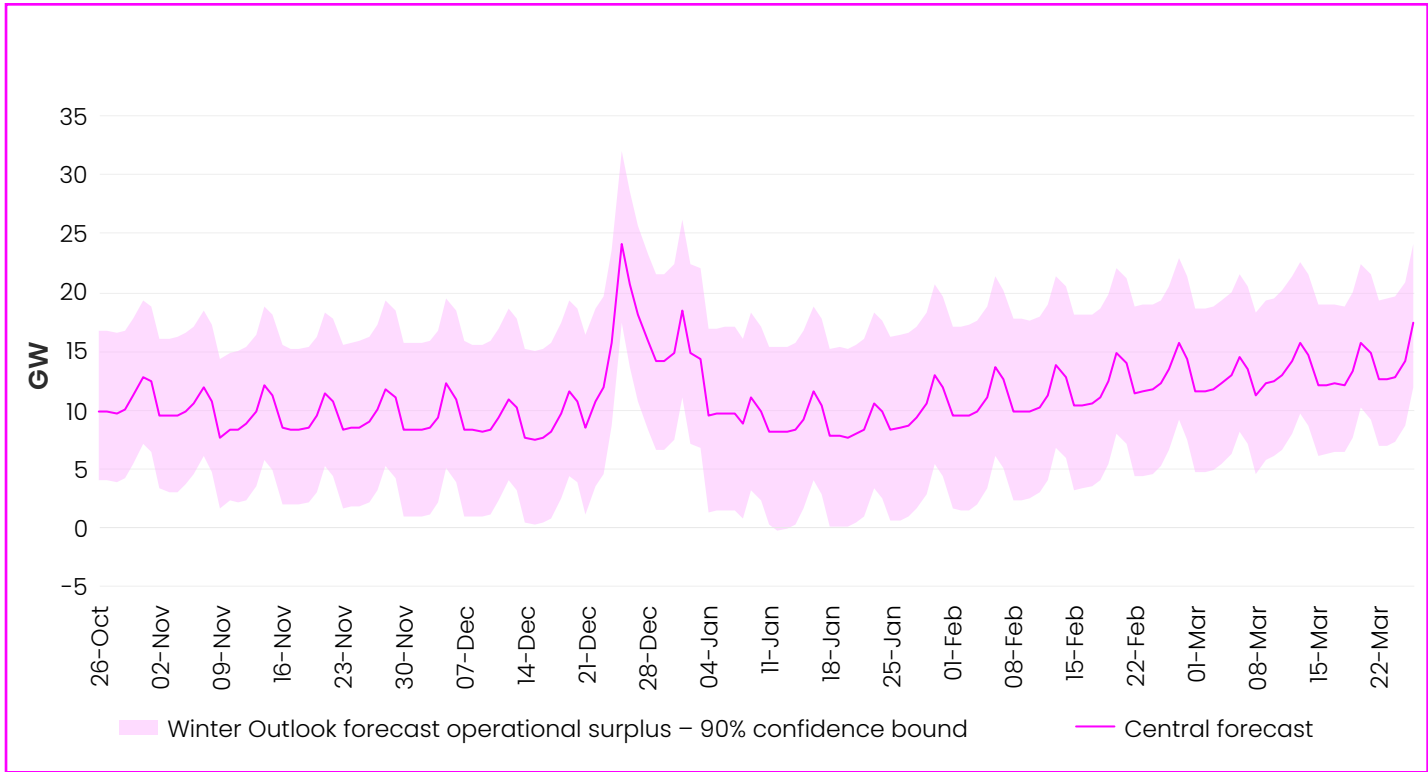


Figure 1: Range of outcomes for the daily operational surplus in a scenario of 2 GW less generation or interconnector imports under different supply and demand conditions. This is the 90% confidence level and we therefore expect days when the operational surplus falls below the shaded range.



Get in Touch

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