



Department for
Energy Security
& Net Zero

Fossil Fuel Price Assumptions 2023

Final Report

August 2023



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Executive Summary

This publication presents the 2023 Fossil Fuel Price Assumptions (FFPA) produced by the Department for Energy Security and Net Zero. It outlines the methodology used and explains best practice for using and interpreting the results.

1.1 Overview

Each year the Department for Energy Security and Net Zero, formerly the Department for Business, Energy and Industrial Strategy, updates its long-term price assumptions for oil, gas and coal. These are assumptions for the wholesale fossil fuel prices that are relevant for the UK economy and which are set in international markets. These assumptions are required for long-term economic appraisal and therefore reflect a range of potential long-term trends. They are not forecasts of future energy prices.

Making assumptions about fossil fuel prices into the future is extremely challenging at the best of times and, at present, the levels of uncertainty are particularly high. The process by which the Department generates its price assumptions focuses on estimates of fundamentals and other available evidence to arrive at a range of future prices. These assumptions then feed into work across Government on appraising the economic impacts of policies.

The 2023 FFPA presents assumed annual wholesale prices for Gas, Oil, and Coal, from 2023 to 2050. This analysis is intended to support modelling of future policy decisions by providing a range of possible prices and the ability to stress-test policy options. It does not provide government's view of future prices, either in the short or long term.

A range of three assumptions for future prices based on assumptions about future global markets have been produced for each fuel. We encourage users to consider the full range of possible values when making an assessment based on these results, and not to take a single value as representative of what is most likely to occur.

A report by Rystad Energy accompanies this report, which details their assumptions and methodologies behind the fossil fuel supply curves that form part of this model.

Due to the Covid-19 pandemic, the last full FFPA was published in 2019. An interim publication was produced for internal use in 2022 that only updated the short-term assumptions. This is included in Annex A.

1.2 FFPA Methodology Summary

This section provides an overview of how the assumptions are calculated. The Methodology section contains a more in-depth explanation of the calculations and assumptions.

Methodology to calculate Short Term assumptions.

Short term prices from June 2023 to December 2025 are calculated from market forward prices. The forward prices provide a market assumption of what the price will be in a given future month, with a certain amount of volatility factored in. The monthly forwards are then aggregated to produce annual values, with actual prices from January 2023 to June 2023 also taken into account for that year.

A high and low threshold from this figure is calculated using the volatility assumed for that period, resulting in three sets of assumptions for each fossil fuel. There are some differences between the fossil fuels for how short- term prices are calculated, these are outlined further in the main Methodology section.

Methodology to calculate Long Term assumptions.

For the years 2026 to 2050, assumptions about annual supply and demand are intersected at set future years out to 2050, known as **Anchor Years**, to estimate the break-even wholesale price for each fossil fuel.

The Department for Energy Security and Net Zero commissioned Rystad to produce supply assumptions for this analysis. The detailed supply curve methodology is published alongside this paper. Rystad provided central, high and low supply curve assumptions which align with the three sets of assumptions produced for the short term.

The Rystad supply curves were fitted to their demand curves and made assumptions around the timing of supply coming on board that weren't compatible with the WEO STEPS demand curve. This was leading to lower prices in the medium term and higher prices in the longer term. Consequently we asked for a higher demand oil supply curve from Rystad. This additional supply curve was an updated version of the base case and to provide a new high curve we took an average of the original high supply curve and the new high demand supply curve.

The long-run assumptions are based on demand curves from the International Energy Agency's World Energy Outlook 2022 scenarios¹

Stated Policies Scenario (STEPS) Used for Assumption C – shows the trajectory implied by today's policy settings. This results in a 2.5-degree temperature increase by 2100 relative to 1990.

Announced Pledges Scenario (APS) Used for Assumption B - assumes that all aspirational targets announced by governments are met on time and in full, including their long-term net zero and energy access goals. This results in a 1.7-degree temperature increase by 2100 relative to 1990.

Net Zero Emissions by 2050 Scenario (NZS) Used for Assumption A - maps out a way to achieve a 1.5°C stabilisation in the rise in global average temperatures, alongside universal

¹ [World Energy Outlook 2022 scenarios](#)

access to modern energy by 2030. This results in a 1.5-degree temperature increase by 2100 relative to 1990.

The three sets of demand assumptions – Assumed Policies, Stated Policies, and Net Zero Emissions by 2050 scenario were intersected against Rystad’s central, high, and low supply assumptions respectively at the anchor years. The intersecting demand and supply assumptions provides a breakeven price in that year.

Linear interpolation is used between the short-term results and the first anchor year, and between subsequent anchor years. This means that the intra and inter year volatility is assumed to be smoothed out.

Due to the uncertainty in assuming prices so far out, prices are flatlined after 2040, meaning that prices are assumed to be unchanged from 2040 to 2050. The short term and long-term models are connected to form one unbroken series from 2023 to 2050. Prices are adjusted using GDP deflators (link) in order to account for inflation and produce the price as it would be in the last full calendar year of 2022. This is known as the real price.

This model is based on existing data and assumptions and does not model potential future shocks to the global market. It provides a smoothed representation of assumptions of future prices, as such it will not account for intra and inter year volatility. Testing Policy against all three assumptions offers the best approach to understanding how choices may fare in different market conditions, as between Assumption A and C is the likely bound of prices.

Fossil Fuel Price Assumptions 2023

2.1 Overview

The Fossil Fuel Price Assumptions (FFPA) by Department for Energy Security and Net Zero are used in modelling and analysis across the department and HMG.¹ A previous full update of the FFPA was conducted in September 2019 (published February 2020). An interim partial update (for the short-term assumptions) was undertaken in 2022, and is now published alongside the latest full update.

This 2023 update represents the latest full update of these assumptions. The previous interim assumptions can be found in Annex x– and the 2019 assumptions can also be found online².

The FFPA methodology is in two parts:

- 1 The short-run assumptions use forward prices with a confidence interval for the high and low range. For 2023 these were taken on market close 5th July, to ensure they were as up to date as possible.
- 2 The long-run assumptions involve intersecting estimated demand in an anchor year against supply curves for each fuel. The Anchor years used for each fossil fuel are outlined in each section. Years between Anchors, and between the short-run assumption and the first anchor year, are linearly interpolated.

2.2 Quality Considerations

This model is based on existing data and assumptions and does not model potential future shocks to the global market. It provides a smoothed representation of assumptions of future prices, as such it will not account for intra and inter year volatility. Testing Policy against all three assumptions offers the best approach to understanding how choices may fare in different market conditions, as between Assumption A and C is the likely bound of prices.

2.3 Users and Uses of FFPA

The Fossil Fuel Price assumptions are used by publications across the Department for Energy Security and Net Zero, and HMG. The results are not used in isolation, but are used as inputs into further modelling by these teams. Notable publications that use these results are:

1. Energy Emissions and Projections
2. Dynamic Dispatch Model
3. Supplementary Guidance

2.5 2023 Gas FFPA

Gas Results

The 2023 FFPA update offers 3 three gas price assumptions out to 2050. A 2030 and 2040 anchor is used for gas. All assumptions are flatlined from 2040 onwards, as it was determined that there was too much uncertainty after that point for a robust assumption.

The figures shown in Table 1 are wholesale annualised average prices.

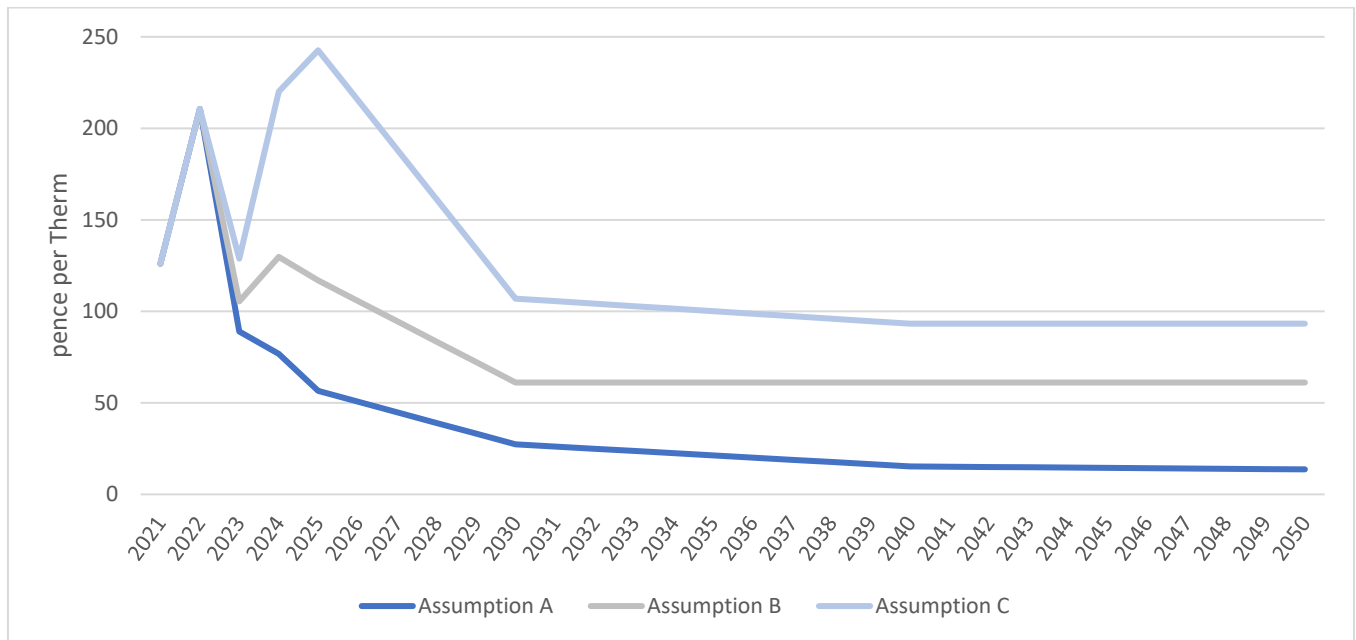
Table 1: 2023 Gas Fossil Fuel Price Assumptions: 2021 - 2050

| p/Therm | A | B | C |
|------------------|-----|-----|-----|
| Real 2023 Prices | | | |
| 2021 | 126 | 126 | 126 |
| 2022 | 211 | 211 | 211 |
| 2023 | 89 | 105 | 129 |
| 2024 | 77 | 130 | 220 |
| 2025 | 57 | 117 | 243 |
| 2026 | 51 | 106 | 216 |
| 2027 | 45 | 95 | 188 |
| 2028 | 39 | 83 | 161 |
| 2029 | 33 | 72 | 134 |
| 2030 | 27 | 61 | 107 |
| 2031 | 26 | 61 | 106 |
| 2032 | 25 | 61 | 104 |
| 2033 | 24 | 61 | 103 |
| 2034 | 23 | 61 | 101 |
| 2035 | 21 | 61 | 100 |

| | | | |
|------|----|----|----|
| 2036 | 20 | 61 | 99 |
| 2037 | 19 | 61 | 97 |
| 2038 | 18 | 61 | 96 |
| 2039 | 16 | 61 | 95 |
| 2040 | 15 | 61 | 93 |
| 2041 | 15 | 61 | 93 |
| 2042 | 15 | 61 | 93 |
| 2043 | 15 | 61 | 93 |
| 2044 | 15 | 61 | 93 |
| 2045 | 14 | 61 | 93 |
| 2046 | 14 | 61 | 93 |
| 2047 | 14 | 61 | 93 |
| 2048 | 14 | 61 | 93 |
| 2049 | 14 | 61 | 93 |
| 2050 | 14 | 61 | 93 |

Source: BEIS Model Quality Assurance FFPA JanDec High Gas Price Options Database.xlsb:
'Final Results' Table 2

Chart 1: 2023 Gas Assumptions: 2021 – 2050



Gas Narrative

Following the spike in European gas prices seen in 2022, the short-term trend shows a sharp dip towards 105 pence per therm for assumption B, and 129p per therm for assumption C as an average for 2023, before rising to 117 and 243 respectively by the end of the short term run in 2025. Assumption A drops to around 57p per therm.

Under assumption B prices fall to 61p per therm by 2030. Assumption C remains around 100p per therm.

Considering further the short-term wholesale price assumptions, wholesale prices are expected to remain high over 2024 and 2025, as global gas supply remains tight. This is due to restricted Russian pipeline supply, which could fall further, and no new LNG supply entering the market until 2025-2026.

The key variables that will affect short-term prices will include:

1. The type of winter experienced – with El Nino year bringing potential for a colder UK and European Winter than in 2023/23.
2. How European Storage fairs, with current expectation that it will be depleted coming out of Winter 23/24.
3. The extent of Asian Demand Rebound.

2.6 2023 FFPA Oil

Oil Results

The 2023 FFPA update offers three oil price assumptions out to 2050. A long-term anchor was used for 2040 for oil. All assumptions are flatlined from 2040 onwards, as it was determined that there was too much uncertainty after that point for robust assumptions.

The figures shown in Table 1 are wholesale annualised average prices.

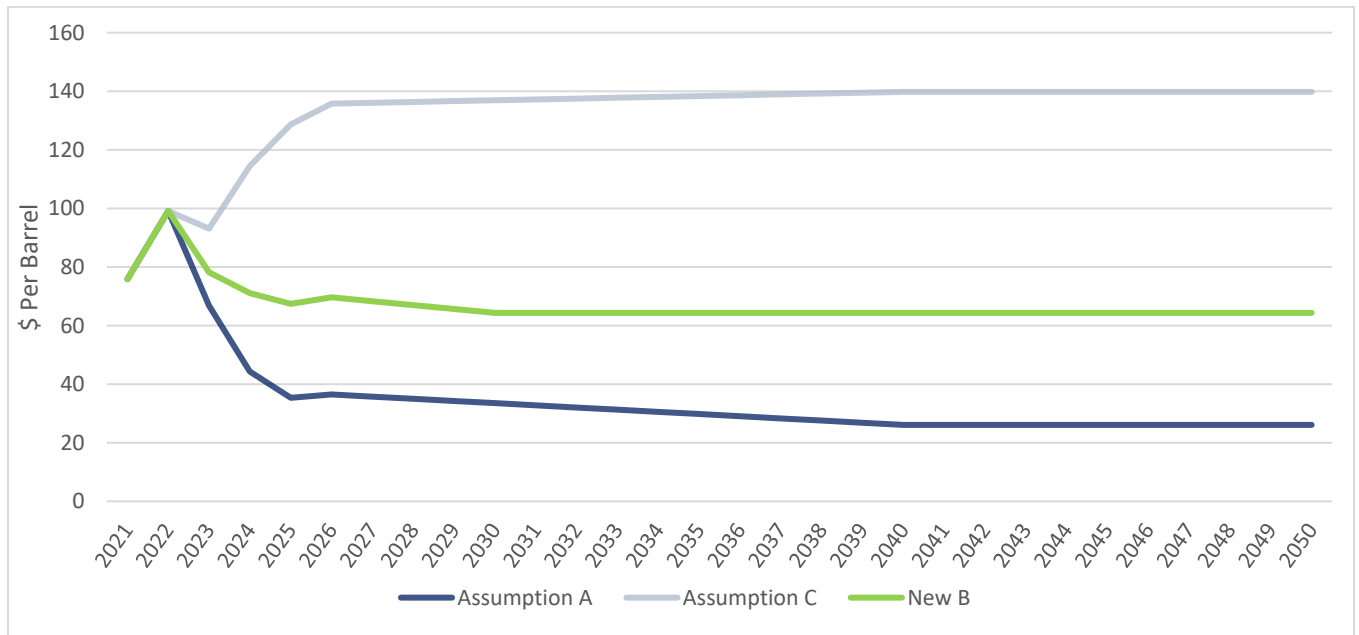
Table 2: 2023 DESNZ Oil Fossil Fuel Price Assumptions

| \$/bbl | A | B | C |
|------------------|----|----|-----|
| Real 2023 Prices | | | |
| 2021 | 76 | 76 | 76 |
| 2022 | 99 | 99 | 99 |
| 2023 | 67 | 78 | 93 |
| 2024 | 44 | 71 | 114 |
| 2025 | 35 | 67 | 129 |
| 2026 | 37 | 70 | 136 |
| 2027 | 36 | 68 | 136 |
| 2028 | 35 | 67 | 136 |
| 2029 | 34 | 66 | 137 |
| 2030 | 34 | 64 | 137 |
| 2031 | 33 | 64 | 137 |
| 2032 | 32 | 64 | 138 |
| 2033 | 31 | 64 | 138 |
| 2034 | 31 | 64 | 138 |
| 2035 | 30 | 64 | 138 |

| | | | |
|------|----|----|-----|
| 2036 | 29 | 64 | 139 |
| 2037 | 28 | 64 | 139 |
| 2038 | 28 | 64 | 139 |
| 2039 | 27 | 64 | 140 |
| 2040 | 26 | 64 | 140 |
| 2041 | 26 | 64 | 140 |
| 2042 | 26 | 64 | 140 |
| 2043 | 26 | 64 | 140 |
| 2044 | 26 | 64 | 140 |
| 2045 | 26 | 64 | 140 |
| 2046 | 26 | 64 | 140 |
| 2047 | 26 | 64 | 140 |
| 2048 | 26 | 64 | 140 |
| 2049 | 26 | 64 | 140 |
| 2050 | 26 | 64 | 140 |

Source: BEIS Model Quality Assurance FFPA JanDec High Oil Price Options Database.xlsb: 'Final Results' Table 2.

Chart 2: 2023 Oil Assumptions: 2021 – 2050



Oil Narrative

Assumptions A and B show prices falling at a constant rate until 2040, where the series is flatlined. Under Assumption A (based on demand projections in the IEA’s Net Zero Scenario) the price remains at around \$25 per barrel, while under Assumption B (based on the Announced Pledges Scenario) it stays in the \$60s.

Under Assumption C, which is based on the IEA’s Stated Policies Scenario, prices rise in the short term to around \$132 bbl by 2026. A gradual decrease over the next decade will see prices return below the 2019 assumptions by 2040.

2.7 2023 Coal FFPA

Coal Results

The 2023 FFPA update offers three coal price assumptions out to 2050. A long-term anchor was only used for 2040 for coal. All assumptions are flatlined from 2040 onwards, as it was determined that there was too much uncertainty after that point for a robust assumption.

Table 3: 2023 DESNZ Coal Fossil Fuel Price Assumptions

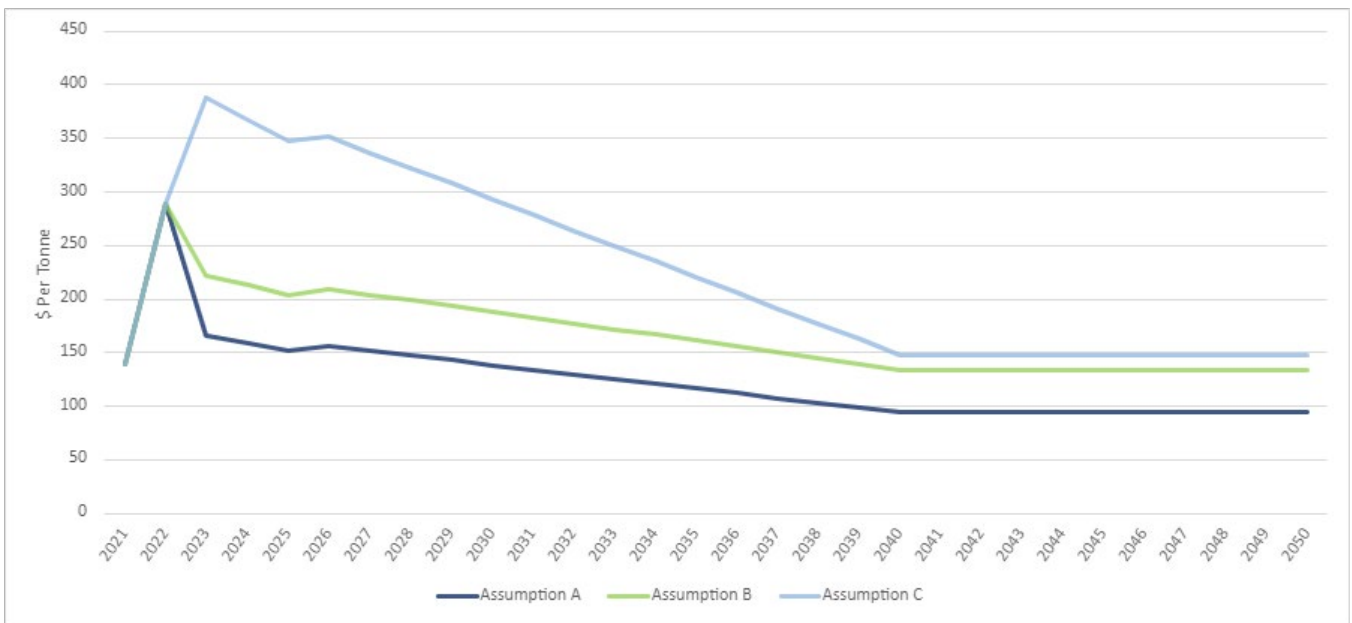
| | | | |
|-----------|---|---|---|
| | | | |
| USD/Tonne | A | B | C |

| Real 2023 Prices | | | |
|------------------|-----|-----|-----|
| 2021 | 139 | 139 | 139 |
| 2022 | 289 | 289 | 289 |
| 2023 | 166 | 222 | 388 |
| 2024 | 159 | 213 | 368 |
| 2025 | 152 | 204 | 348 |
| 2026 | 156 | 210 | 351 |
| 2027 | 152 | 204 | 337 |
| 2028 | 147 | 199 | 322 |
| 2029 | 143 | 193 | 308 |
| 2030 | 138 | 188 | 293 |
| 2031 | 134 | 183 | 279 |
| 2032 | 130 | 177 | 264 |
| 2033 | 125 | 172 | 250 |
| 2034 | 121 | 167 | 235 |
| 2035 | 116 | 161 | 221 |
| 2036 | 112 | 156 | 206 |
| 2037 | 108 | 150 | 192 |
| 2038 | 103 | 145 | 177 |
| 2039 | 99 | 140 | 163 |
| 2040 | 94 | 134 | 148 |
| 2041 | 94 | 134 | 148 |
| 2042 | 94 | 134 | 148 |
| 2043 | 94 | 134 | 148 |

| | | | |
|------|----|-----|-----|
| 2044 | 94 | 134 | 148 |
| 2045 | 94 | 134 | 148 |
| 2046 | 94 | 134 | 148 |
| 2047 | 94 | 134 | 148 |
| 2048 | 94 | 134 | 148 |
| 2049 | 94 | 134 | 148 |
| 2050 | 94 | 134 | 148 |

Source: BEIS Model Quality Assurance FFPA JanDec High Coal Price Options Database.xlsx: 'Final Results' Table 2

Chart 3: 2023 Coal Assumptions: 2021 – 2050



Coal Narrative

All three scenarios show a decrease towards 2040 although this is in part to be expected due to the linear interpolation used between 2025 and 2040. Generally, a return to post Invasion and Covid prices are seen by 2040, which then remain relatively steady. Under assumption A (Net Zero demand Scenario) prices drop to around \$94 a tonne, with Assumption C at the high range at just under \$150.

3.0 Methodology

3.1 Short Run Methodology

For the short run update, the 2023 FFPA uses forward curve prices for the next three years (2023, 2024 and 2025) as well as the Black-Scholes volatility formulae (as per previous FFPA iterations) to give a 75% confidence interval for the high and low scenarios.

Short Term Model Calculations (Gas and Oil only)

Forward prices for each month from May 2023 to December 2025 were collected on 6th July for oil and gas, which were up to date as of market close 5th July. In previous versions of the model forward prices from 07th March to 18th April were taken and averaged. However due to the lag in time between collection and completion of the model, it was decided to use data from 5th July to ensure it was up to date. The trade-off was that it was one day of collection rather than 28 days. Comparative analysis showed that the revised model was very similar to that seen in the 28-day period, but with slightly lower prices reflecting a change in the market since April.

For the first collection from 7th March to 18th April, each price had a corresponding volatility value, expressed as a percentage. The higher the percentage, the more assumed volatility for that month's price. The data from 5th July did not contain this volatility data. An average of the volatility seen from the period 7th March to 18th April for each month was applied to the 5th July data, as an estimate of what volatility in that month would be.

Using the following formula, the price and the volatility for each month was used to construct a high and low price for that month, assuming a 75 percent confidence interval for the calculation.

$$E(f_{t,k}) > f_{t,k} * \exp(-z_{\alpha/2} * \sigma_k \sqrt{t}) \text{ for the lower limit}$$

$$E(f_{t,k}) > f_{t,k} * \exp(z_{\alpha/2} * \sigma_k \sqrt{t}) \text{ for the upper limit}$$

where

$E(f_{t,k})$ = Expected month k price at expiration date t

$f_{t,k}$ = Month k futures price at day t

σ_k = implied volatility for option on month k futures contract

t_k = Time to expiration for month k futures contract (in years)

$z_{\alpha/2}$ = Standardized normal distribution value for (1 - α) confidence level

For each month from May 23 to December 25, there is now a Base price, a High limit, and a Low Limit. These are aggregated to get the average for each year. These are then adjusted using the GDP deflator to 2022 prices and used as the short-term assumptions in the model.

For Oil 2023 Forward data was taken from Bloomberg, as with previous iterations of FFPA. Gas 2023 Forward data was taken from ICIS, however extensive comparative analysis was undertaken to ensure these were comparable with Bloomberg and with many other external forecasters, and to maintain confidence in their use.

Short Term Model Calculation (Coal)

For the short term, a linear interpolation between real May 2021 prices, and the 2040 anchor year in the long-run was used. This was due to a lack of available data on forward prices.

3.2 Long Run Methodology

For the medium and long-run values, Rystad supply curves for high, medium, and low price scenarios were intersected with the International Energy Agency's World Energy Outlook 2022 three demand scenarios for the anchor years.

Although there were data points available for a 2050 anchor, it was felt that there was too much uncertainty in assuming prices that far out, so all three series were flatlined in 2040. The model does not therefore account for any changes to prices that might occur from Net Zero or other policies post 2040.

High supply from Rystad was matched with current policy scenarios (STEPS); medium supply was matched with the Announced Policy Scenario (APS); low supply scenario was matched with the Net Zero scenario (NZS). These were updated for inflation using the UK Deflator as prices were in pence per therm.

For the years between the anchors, and for between the short-term model and 2030, linear interpolation was used to estimate the values.

Rystad have provided a methodology document which explains their assumptions about future supply in detail; this will be published alongside the results. The supply curves are provided in real terms in 2022 prices (assuming an average inflation rate of 2.5%). Consequently the long-term assumptions are in 2022 prices without the need for adjustment.

Linear Interpolation Formula

$$Y = Y1 + \frac{(Y2 - Y1)}{(X2 - X1)} * (X - X1)$$

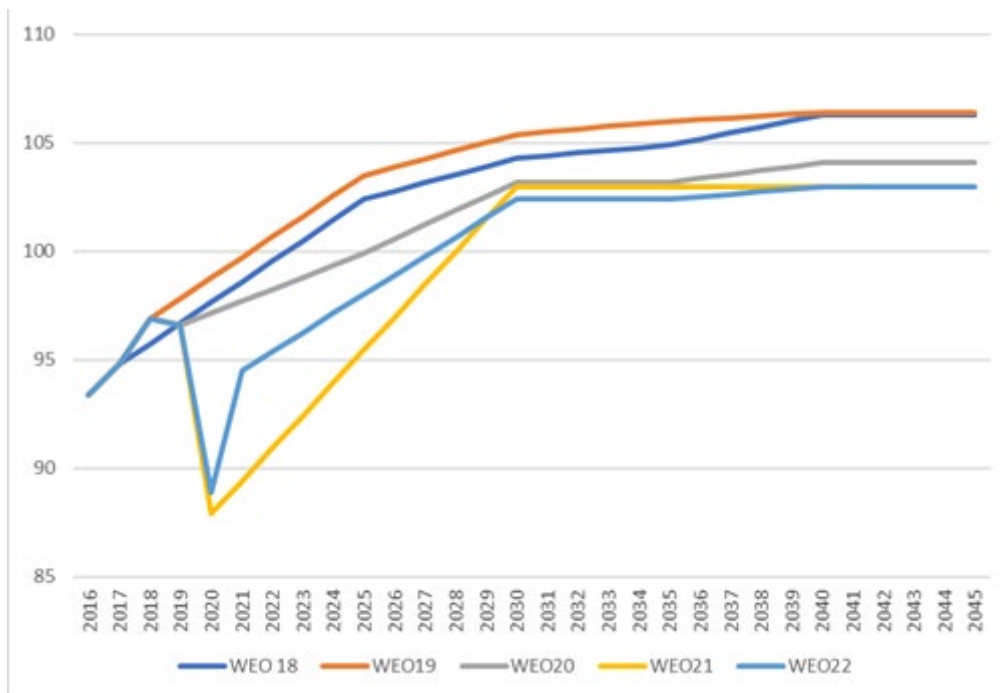
where

- Y = Annual Price being linearly interpolated*
- Y1 = Annual Price at first Anchor Year*
- Y2 = Annual Price at second Anchor Year*
- X = Year for Annual Price being linearly interpolated*
- X1 = First Anchor Year*
- X2 = Second Anchor Year*

3.3 Demand Comparative Analysis

The difference between the 2019 and the 2023 assumptions has been investigated further for oil. The main reason for this is the significant drop in demand estimates from WEO scenarios – caused by the drop in demand due to the response to Covid-19 in 2020. This has resulted in an ongoing drop in demand which is assumed to persist, there have also been significant advancements in electric vehicle markets since 2018.

Chart 3: Comparison of WEO Demand Scenarios 2018 -2022



Annex A 2022 FFPA Interim Results

Interim price assumptions were produced in 2022. These did not update the long-term supply and demand curves but did use updated forward prices up to 2024. An update was required to ensure that teams in DESNZ and across HMG used Gas price assumptions that are more reflective of recent events than the 2019 FFPA, to feed into modelling and long-term energy analysis.

Additionally, a fourth scenario was included that assumed prices would not return to post-energy crisis levels. This will not be included in the 2023 update.

Table 2: 2022 interim Gas FFPA results

| Table 1: 2022 interim Gas FFPA results | | | | |
|--|-------------------|-------------------|-------------------|-------------------|
| Year | 2022 Assumption A | 2022 Assumption B | 2022 Assumption C | 2022 Assumption D |
| Real 2022 Prices | | | | |
| 2010 | 54 | 54 | 54 | 54 |
| 2011 | 70 | 70 | 70 | 70 |
| 2012 | 73 | 73 | 73 | 73 |
| 2013 | 81 | 81 | 81 | 81 |
| 2014 | 59 | 59 | 59 | 59 |
| 2015 | 50 | 50 | 50 | 50 |
| 2016 | 40 | 40 | 40 | 40 |
| 2017 | 51 | 51 | 51 | 51 |
| 2018 | 67 | 67 | 67 | 67 |
| 2019 | 38 | 38 | 38 | 38 |
| 2020 | 26 | 26 | 26 | 26 |
| 2021 | 118 | 118 | 118 | 118 |

| | | | | |
|------|----|-----|-----|-----|
| 2022 | 92 | 201 | 489 | 489 |
| 2023 | 48 | 117 | 311 | 311 |
| 2024 | 37 | 75 | 150 | 150 |
| 2025 | 39 | 66 | 118 | 150 |
| 2026 | 40 | 58 | 85 | 150 |
| 2027 | 40 | 60 | 86 | 150 |
| 2028 | 41 | 61 | 87 | 150 |
| 2029 | 42 | 63 | 88 | 150 |
| 2030 | 43 | 64 | 89 | 150 |
| 2031 | 44 | 65 | 91 | 150 |
| 2032 | 44 | 66 | 92 | 150 |
| 2033 | 45 | 67 | 93 | 150 |
| 2034 | 46 | 68 | 94 | 150 |
| 2035 | 46 | 69 | 95 | 150 |
| 2036 | 46 | 69 | 95 | 150 |
| 2037 | 46 | 69 | 95 | 150 |
| 2038 | 46 | 69 | 95 | 150 |
| 2039 | 46 | 69 | 95 | 150 |
| 2040 | 46 | 69 | 95 | 150 |

Table 2: 2022 interim Oil FFPA results

| \$/bbl | A | B | C | D |
|------------------|----|----|----|----|
| Real 2022 Prices | | | | |
| 2021 | 72 | 72 | 72 | 72 |

| | | | | |
|------|----|----|-----|-----|
| 2022 | 64 | 78 | 104 | 104 |
| 2023 | 54 | 91 | 159 | 159 |
| 2024 | 43 | 80 | 151 | 151 |
| 2025 | 45 | 78 | 134 | 151 |
| 2026 | 47 | 75 | 116 | 151 |
| 2027 | 50 | 78 | 120 | 151 |
| 2028 | 51 | 81 | 122 | 151 |
| 2029 | 52 | 83 | 125 | 151 |
| 2030 | 53 | 85 | 127 | 151 |
| 2031 | 54 | 87 | 129 | 151 |
| 2032 | 55 | 89 | 133 | 151 |
| 2033 | 57 | 93 | 135 | 151 |
| 2034 | 58 | 95 | 138 | 151 |
| 2035 | 59 | 97 | 140 | 151 |
| 2036 | 59 | 97 | 140 | 151 |
| 2037 | 59 | 97 | 140 | 151 |
| 2038 | 59 | 97 | 140 | 151 |
| 2039 | 59 | 97 | 140 | 151 |
| 2040 | 59 | 97 | 140 | 151 |

Table 2: 2022 interim Coal FFPA results

| Table 2: 2022 interim Coal FFPA results | | | | |
|---|---|---|---|---|
| \$/tonne | A | B | C | D |
| Real 2022 Prices | | | | |

| | | | | |
|------|-----|-----|-----|-----|
| 2021 | 128 | 128 | 128 | 128 |
| 2022 | 140 | 254 | 406 | 406 |
| 2023 | 83 | 201 | 507 | 507 |
| 2024 | 58 | 162 | 488 | 488 |
| 2025 | 57 | 119 | 297 | 488 |
| 2026 | 55 | 77 | 106 | 488 |
| 2027 | 56 | 78 | 109 | 488 |
| 2028 | 57 | 80 | 110 | 488 |
| 2029 | 58 | 80 | 112 | 488 |
| 2030 | 59 | 81 | 114 | 488 |
| 2031 | 60 | 82 | 117 | 488 |
| 2032 | 62 | 83 | 118 | 488 |
| 2033 | 63 | 84 | 120 | 488 |
| 2034 | 64 | 85 | 122 | 488 |
| 2035 | 66 | 86 | 123 | 488 |
| 2036 | 66 | 86 | 123 | 488 |
| 2037 | 66 | 86 | 123 | 488 |
| 2038 | 66 | 86 | 123 | 488 |
| 2039 | 66 | 86 | 123 | 488 |
| 2040 | 66 | 86 | 123 | 488 |

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