Department for
Energy Security
& Net Zero

Fossil Fuel Price Assumptions 2023

Final Report

Contents

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

The Department for Energy Security and Net Zero, formerly the Department for Business, Energy and Industrial Strategy, regularly 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.

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 their potential development over time to arrive at a range of possible future prices. 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. They are not forecasts of future energy prices and do not provide government's view of future prices, either in the short or long term.

The 2023 FFPA presents assumed annual wholesale prices for gas, oil, and coal, from 2023 to 2050. Three sets of price assumptions are presented based on varying assumptions about future supply and demand curves 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 B.

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 Energy to produce supply assumptions for this analysis. The detailed supply curve methodology used by Rystad Energy is published alongside this report. Rystad Energy provided central, high and low supply curve assumptions.

The demand curves intersected with these supply curves to produce the long-run assumptions are based on demand curves from the International Energy Agency's World Energy Outlook (WEO) 2022 scenarios[1]:

- The WEO 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.

- The WEO 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.

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

The above demand scenarios are used as a basis for demand assumptions in particular years for the anchor years. As such the long-term price assumptions may not correspond to the above degree targets outlined in the WEO scenarios.

Due to the uncertainty in assuming prices so far into the future, prices are flatlined after specific anchor years of 2030 and 2040 (depending on the assumption set), meaning that prices are assumed to be unchanged from 2030/2040 to 2050. For example, while Assumption

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[1] World Energy Outlook 2022 scenarios

B uses the WEO APS to calculate an anchor long-term price, due to market uncertainty in the medium to long-term, the gas and oil price assumptions are flatlined from 2030.

The short term and long-term models are connected to form one unbroken series from 2023 to 2050. Prices are adjusted using GDP deflators in order to account for inflation and produce the price as it would be in the last full calendar year of 2023. This is known as the real price.

The FFPA model is based on existing data and assumptions and does not model potential future shocks to the global market. Linear interpolation is used between the short-term results and the anchor year, and between any subsequent anchor years. This means that the intra and inter year volatility is assumed to be smoothed out. Testing policy against all three assumptions offers the best approach to understanding how choices may fare in different market conditions.

Fossil Fuel Price Assumptions 2023

2.1 Overview

The Fossil Fuel Price Assumptions (FFPA) produced by the Department for Energy Security and Net Zero are used in modelling and analysis across the department and HMG. 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 in Annex B of this report.

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 2023.

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 the respective sections of this report. 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.

2.3 Users and Uses of FFPA

The Fossil Fuel Price Assumptions are used in 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

2.4 2023 Gas FFPA

The 2023 FFPA update offers three Gas price assumptions out to 2050. The figures shown in Table 1 are wholesale annualised European average prices.

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

p/Therm	Assumption A	Assumption B	Assumption C
Real 2023 Prices			
2021	122	122	122
2022	203	203	203
2023	90	102	125
2024	75	127	216
2025	55	114	236
2026	54	110	232
2027	51	101	215
2028	47	92	198
2029	43	83	181
2030	40	73	164
2031	38	73	163
2032	37	73	162
2033	35	73	162
2034	34	73	161
2035	33	73	161
2036	31	73	160
2037	30	73	159

p/Therm	Assumption A	Assumption B	Assumption C
2038	28	73	159
2039	27	73	158
2040	26	73	158
2041	26	73	158
2042	26	73	158
2043	26	73	158
2044	26	73	158
2045	26	73	158
2046	26	73	158
2047	26	73	158
2048	26	73	158
2049	26	73	158
2050	26	73	158

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

Chart 1: Gas Assumptions: 2023 - 2050
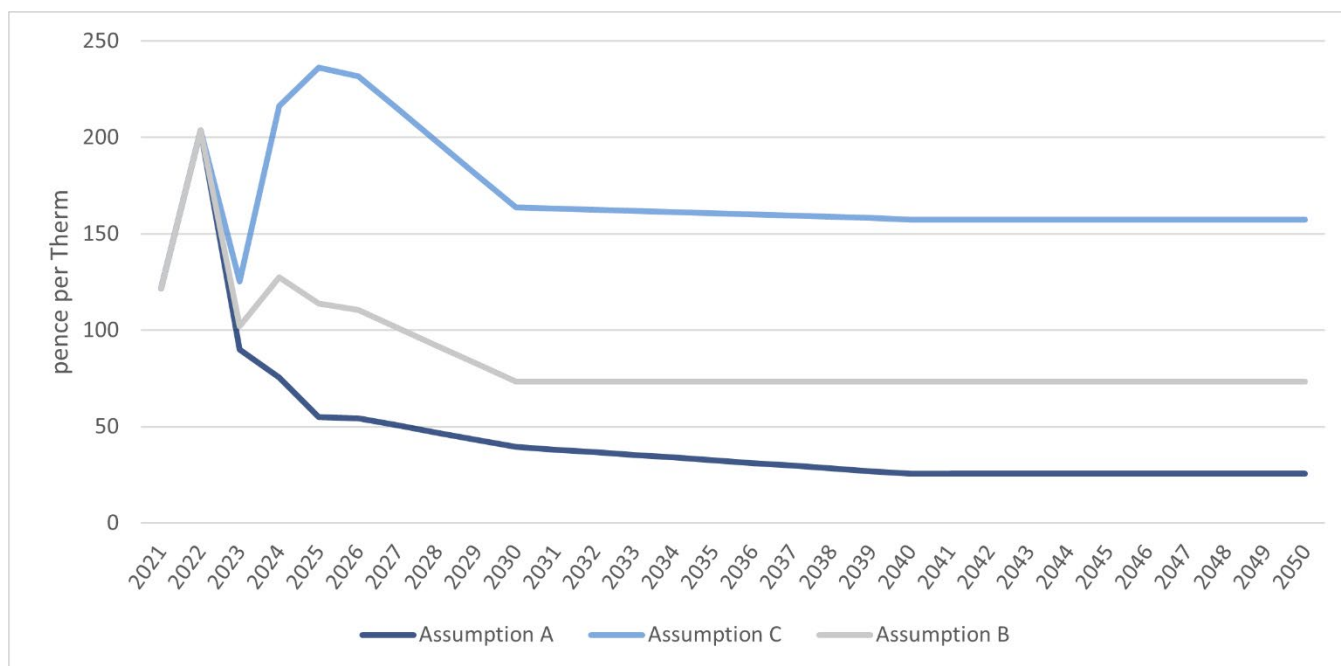
Following the spike in European gas prices seen in 2022, the short-term trend shows a sharp dip towards 102 pence per therm for Assumption B, and 125p per therm for Assumption C as an average for 2023, before rising to 114p per therm and 236p per therm respectively by the end of the short term run in 2025. Assumption A drops to 55p per therm. Under Assumption B prices fall to 73p per therm by 2030. Assumption C assumes prices stay higher falling to 164p per therm by 2030 while under Assumption A prices drop to 40p per therm over this period.

Wholesale prices are expected to remain relatively high over 2024 and 2025, as global gas supply remains tight. This is likely to reflect the market's view of restricted Russian pipeline supply, which could fall further, and no new LNG supply entering the market until 2025-2026. However, prices are expected to be below the peaks seen in 2022 and it is important to remember these wholesale prices are not reflective of what the corresponding retail prices for consumers may be.

The key variables that are likely to affect short-term wholesale prices will include:

1. Winter weather, in particular how cold and windy it is both in the UK, Europe and Asia;
2. How European gas storage fairs following the winter heating seasons; and,
3. The levels of gas demand in Asian markets.

The long-term price assumptions are based on an anchor year in 2030 for all three assumption sets, with a linear interpolation from the short-term assumptions. For Assumption B the 2030 price is flatlined out to 2050 to avoid speculation given the significant long-term uncertainty and volatility that fossil fuel markets are currently experiencing. A second anchor is applied for Assumptions A and C in 2040 as this helps to provide a direction of travel for the upper and lower price assumption bounds. 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.

2.5 2023 FFPA Oil

The 2023 FFPA update provides three oil price assumptions out to 2050. The figures shown in Table 2 are global crude oil (Brent) annualised average prices.

Table 2: 2023 Oil Fossil Fuel Price Assumptions: 2021 - 2050

$/bbl	Assumption A	Assumption B	Assumption 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

$/bbl	Assumption A	Assumption B	Assumption C
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: Oil Assumptions: 2023 - 2050
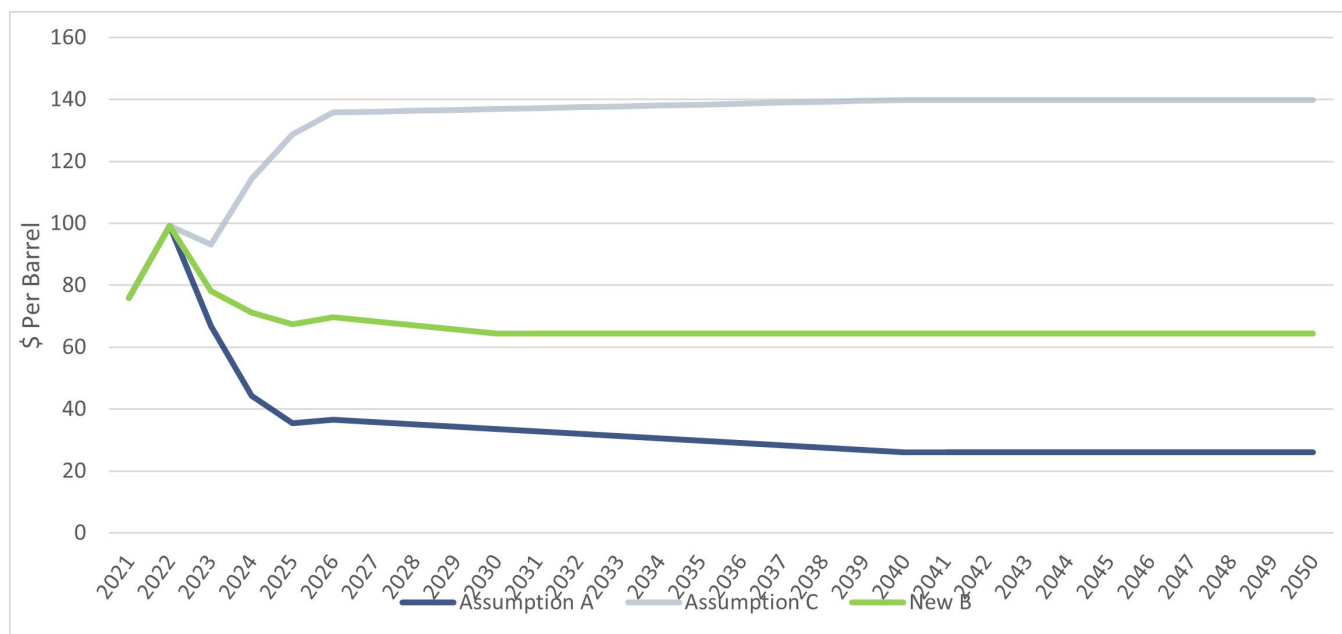
Assumptions A and B show prices falling in the short-term to 2025 before plateauing and remaining relatively stable out to 2050. Under Assumption A (based on demand projections in the IEA's WEO 2022 Net Zero Scenario) the price is around $34 per barrel in 2030 and is then flatlined at $26 per barrel from 2040 to 2050. Under Assumption B (based on the IEA's WEO 2022 Announced Pledges Scenario) the price is around $64 per barrel between 2030 and 2050.

Under Assumption C (based on the IEA's WEO 2022 Stated Polices Scenario) prices rise from today to around $137 per barrel by 2030 and stay high at around $140 between 2040 and 2050.

Market commentators are uncertain about the short-term direction of crude oil prices as there is both upward pressure from restricted supply but also downward pressure from lower-than-expected demand growth. However, prices are expected to come down from their peak in 2022 and it is important to remember these crude prices are not reflective of what the corresponding retail prices for consumers may be.

The long-term price assumptions are based on an anchor year in 2040 for all three assumption sets, with a linear interpolation from the short-term assumptions. For Assumption B the 2030 price is flatlined out to 2050 to avoid speculation given the significant long-term uncertainty and volatility that fossil fuel markets are currently experiencing. For Assumptions A and C the price is flatlined from 2040 as this helps to provide a direction of travel for the upper and lower price assumption bounds. 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.

2.6 2023 Coal FFPA

The 2023 FFPA update offers three Coal price assumptions out to 2050. The figures shown in Table 3 are annualised average European coal prices.

Table 3: 2023 Coal Fossil Fuel Price Assumptions: 2021 - 2050

USD/Tonne	Assumption A	Assumption B	Assumption 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

Fossil Fuel Price Assumptions 2023

USD/Tonne	Assumption A	Assumption B	Assumption C
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.xlsb: 'Final Results' Table 2

Chart 3: Coal Assumptions: 2023 - 2050
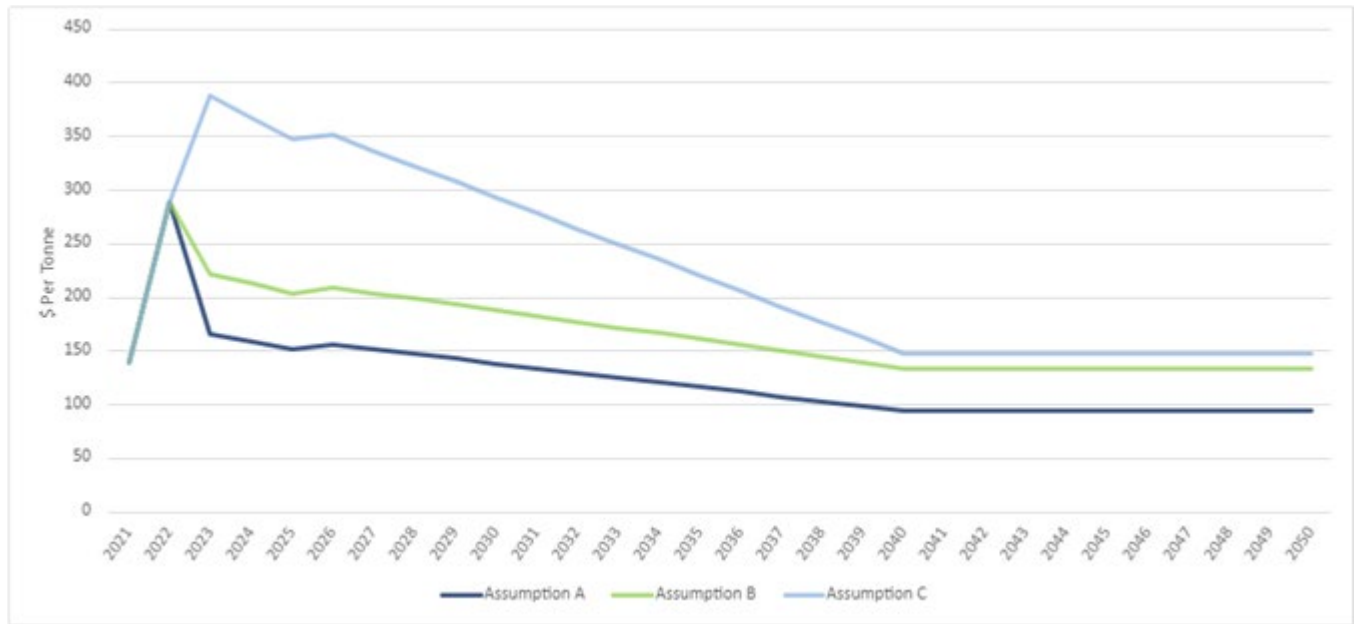
All three scenarios show a decrease towards 2040 although this is in part a reflection of the methodology which uses a linear interpolation between 2025 and the 2040 anchor year then prices are flatlined out to 2050. Generally, a return to prices seen before the invasion of Ukraine and the Covid-19 pandemic are seen by 2040, which then remain relatively steady. Under assumption A prices drop to around $94 a tonne, with Assumption C at the high range at just under $150 per tonne.

Annex A: Detailed Methodology

Detailed 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)

Forward prices for each month from May 2023 to December 2025 were collected on 6th July 2023 for oil and gas, which were up to date as of market close 5th July 2023.

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 (as volatility data was not included in the 5th July data download).

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.

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

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

$$where$$

$$
\begin{aligned}
E(f_{t,k}) &= \text{Expected month k price at experiation date t} \\
f_{t,k} &= \text{Month k futures price at day t} \\
\sigma_k &= \text{implied volatility for option on month k futures contract} \\
t_k &= \text{Time to experiation for month k futures contract (in years)} \\
z_{\alpha/2} &= \text{Standardized normal distribution value for } (1-\alpha) \text{ confidence level}
\end{aligned}
$$

For each month from May 23 to December 25, this produced a Base price, a High limit, and a Low Limit. These were aggregated to get the average for each year which were then adjusted using the GDP deflator to 2023 prices and used as the short-term assumptions in the model.

For the Oil short-term assumptions, forwards data was taken from Bloomberg, as with previous iterations of the FFPAs. Gas forwards data was taken from ICIS; comparative analysis confirmed this to be comparable with Bloomberg and with other external forecasters.

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 price

Detailed Long Run Methodology

For the medium and long-run values, Rystad Energy 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 across all three fuels are flatlined from either 2030 or 2040. The model does not therefore account for any changes to prices that might occur from Net Zero or other polices post 2030 or 2040 depending on the anchor year.

High supply from Rystad Energy was matched with the WEO 2022 current policy scenarios (STEPS); medium supply was matched with the WEO 2022 Announced Policy Scenario (APS); and the low supply scenario was matched with the WEO 2022 Net Zero scenario (NZS).

However, the anchor year for oil Assumption C in 2040 is based on an adjusted high supply curve intersecting the WEO STEPS demand assumption. The Rystad Energy supply curves were fitted to their demand curves and made assumptions around the timing of supply coming on board that were not compatible with the WEO STEPS demand curve for oil. This was leading to lower prices in the medium term and higher prices in the longer term. Consequently, Rystad Energy produced an additional higher demand oil supply curve. This additional supply curve was an updated version of the base case and to provide a new high curve an average of the original high supply curve and the new high demand supply curve was produced.

For the years between the anchors, and for between the short-term model and 2030, linear interpolation (formular shown further below) was used to estimate the values.

These were updated for inflation using the UK Deflator as prices were in pence per therm.

Rystad Energy has provided a methodology document which explains their assumptions about future supply in detail; this has been published alongside the results. The supply curves are provided in real terms in 2023 prices (assuming an average inflation rate of 2.5%). Consequently the long-term assumptions are in 2023 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

Annex B: 2022 FFPA Interim Results

Interim short-term 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. The short-term prices were then linearly interpolated out to the previous 2019 FFPA price anchor of 2035 (adjustment to 2022 prices) then flatlined out to 2040. This interim update was required to ensure modelling and analysis within government was based on assumptions that were more reflective of topical short-term market events than the 2019 FFPA.

In the interim results, a fourth assumption was included in which prices did not return to the levels seen prior to the invasion of Ukraine and the ensuing energy crisis.

Table 2: 2022 interim Gas FFPA results

p/therm	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

Fossil Fuel Price Assumptions 2023

p/therm	2022 Assumption A	2022 Assumption B	2022 Assumption C	2022 Assumption D
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	2022 Assumption A	2022 Assumption B	2022 Assumption C	2022 Assumption 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

$/tonne	2022 Assumption A	2022 Assumption B	2022 Assumption C	2022 Assumption 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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