Department for
Business, Energy
& Industrial Strategy

BEIS 2018 FOSSIL FUEL PRICE ASSUMPTIONS

November 2018

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BEIS 2018 FOSSIL FUEL PRICE ASSUMPTIONS

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Introduction

1. This note presents an update to BEIS's 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. For the oil price, which is set in a global market, this is the 1-month Brent price, which is quoted in US $/barrel. For the gas price, which reflects European gas market conditions, with the European market linked to other regional markets (especially North America and Asia), this is the GB National Balancing Point (NBP) spot price, which is quoted in pence/therm. For the coal price, this is the Amsterdam/Rotterdam/Antwerp (ARA) price[1], quoted in US $/tonne, which reflects European coal market conditions, again with regional links.

2. Making assumptions about fossil fuel prices far into the future is – needless to say – very challenging, as they depend on many unknowns (e.g. future economic growth rates across the world, development of new technologies, global climate change policies, technological developments and strategies of resource holders). BEIS produces a set of price assumptions based on available evidence around these fundamentals and their potential development over time to yield a plausible range for future prices. These assumptions are required for long-term modelling of the UK energy system and economic appraisal. They are not forecasts of future energy prices. To capture these uncertainties, analysts should use the High and Low assumptions for sensitivity analysis rather than just using the Central assumption.

3. While the BEIS assumptions feed into policy appraisal and modelling work across Whitehall, estimates of public finances are made independently by the Office for Budget Responsibility (OBR) using their own fuel price assumptions. The OBR produces these assumptions for the short and medium term, but not long term. To the extent that the BEIS and OBR assumptions overlap, similar methodologies are used.

4. The price assumptions have been subjected to peer review by a panel of external experts appointed by the former DECC who have impartially scrutinised the analysis used for the fossil fuel price assumptions. The panel's report is published alongside this document.

[1] Cost, Insurance and Freight (CIF) price.

Methodology and Approach

Overall Methodology and Approach

5. The overall approach for each fuel is:
   - a market-based view over the short-term using futures and options[2] prices to aggregate price and volatility expectations from market participants; and
   - a long-term fundamentals-based view that anchors the long-term price at the expected future full economic cost of supply.

6. Over the short term the use of futures/forwards curves is a market-based approach for aggregating the information of market participants. The OBR and Bank of England follow the same approach for their short-term price assumptions. We recognise that at any point in time futures/forward curves may have embedded risk premia, so they are not perfect representations of market expectations. Limited market liquidity may also curb the quality of the price discovery[3].

7. Across all three fuels the futures/forward curves were calculated averaging the data resulting from a 30 days market trading period to 29 June 2018. After initial analysis in April, given the short-term market changes for all three fuels the analysis was revisited in July using a more recent period for futures/forward prices in comparison to previous years.

8. Anchoring the long-term price at the expected future full economic cost of production is a transparent and economically sound approach that is consistent with Treasury (Green Book) principles for policy appraisal. Long term fossil fuel price assumptions are intended to reflect average price levels over a decade or more.

9. In 2016 we commissioned Wood Mackenzie to produce long run supply curves for each fuel including a plausible range of uncertainty (a low and high as well as a base case view)[4].

10. Part of this year's process included assessing whether the supply curves provided by Wood Mackenzie and their underlying assumptions were still appropriate to use in computing this year's long run price assumptions. Underlying assumptions were analysed and discussed with our expert panel members. A conclusion was reached that there were no fundamental changes in the long-term outlook for supply for each fuel, although we have made some specific adjustments to the supply curves which are detailed in the separate fuel chapters.

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[2] For coal data on options prices was not available and historical forecast errors used instead.

[3] For this reason, we like the OBR and as advised by the Expert Panel have only used forward prices for the first two years of the oil and coal assumptions. We use it for the first three years of gas assumptions, discussed in the gas section of the report.

[4] At https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/565992/BEIS_WM_Fossil_Fuel_Supply_Curves_Final_Report.pdf

11. For each fuel we have combined the three updated long-term supply outlooks (from Wood Mackenzie) with three demand assumptions (based on the three long term scenarios from the International Energy Agency (IEA), adjusted as required). The IEA model three core scenarios for global energy demand, which differ in their assumptions about the evolution of energy-related government policies: The New Policies Scenario; the Current Policies Scenario; and the Sustainable Development Scenario. The New Policies Scenario is their central scenario and considers policies and interventions that have been adopted as of mid-2017 in addition to other relevant declared policy interventions. The Current Policies Scenario simply takes into account policies already enacted (as of mid-2017). The Sustainable Development Scenario depicts a pathway to the 2°C climate and other international goals that can be achieved by fostering technologies close to being available on a commercial scale. We use the New Policies Scenario for central demand assumptions, Current Policies for high and Sustainable Development Scenario for low demand assumptions.

12. Combining the high supply and low demand assumptions and low supply with high demand to construct the long term low and high price assumptions for each fuel yields long term price assumptions that span a wide range of possible outcomes. While the long-term demand and supply assumptions are from different sources, we consider these combinations to be plausible for each fuel.

13. With the global energy transition to a low carbon economy, the very long-term outlook for fossil fuels demand is to peak and then decline[5], although the timing is very uncertain[6]. This suggests downward pressure on fossil fuel prices in the very long term, although absent technological improvement this might be countered by supply curves moving up over time as the easiest to extract resources are exhausted. Moreover, if supply curves are relatively elastic in the very long term, as for example most of the 2016 Wood Mackenzie supply curves are around our long-term price assumptions, the impact of lower demand on very long-term prices could be limited. Complicating factors include: the possibility of technological breakthroughs that significantly reduce the cost of extracting fossil fuels; or a change in the strategic behaviour of major resource holders faced with the prospect of leaving reserves in the ground[7]; but modelling either of these considerations is highly speculative. Another possibility is a "disruptive transition"[8] where a more rapid shift away from fossil fuels unanticipated by investors leaves some upstream assets "stranded". This could result in a possibly prolonged period where oil prices fell below long run costs, the oil "stress test" could be indicatively used to reflect such a scenario.

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[5] For example see the joint IEA IRENA 2017 study https://www.iea.org/publications/insights/insightpublications/PerspectivesfortheEnergyTransition.pdf

[6] Global coal demand may peak much earlier.

[7] Discussed in "Peak Oil Demand and Long-Run Oil Prices", Dale and Fattouh, 2018 https://www.oxfordenergy.org/publications/peak-oil-demand-long-run-oil-prices/ although they argue any change in strategic behaviour will be delayed

[8] For example see the joint IEA IRENA 2017 study

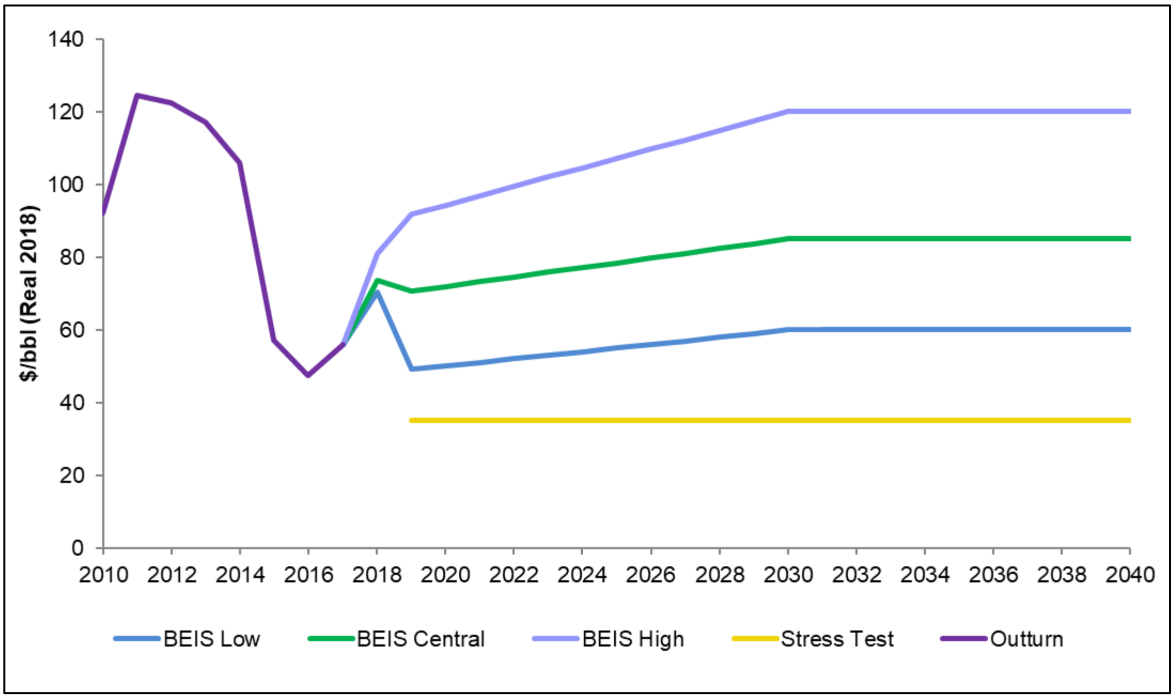
14. The price assumptions for intermediate years (between the short term and long term) are simple linear interpolations. We do not attempt to model detailed dynamics or price cycles. Our primary focus is on a range of long term price levels for fossil fuels.

Oil Price Assumptions

Table 1: 2018 BEIS Oil price assumptions

$/bbl	2018 BEIS Oil price assumptions			
Real 2018 prices	Low	Central	High	Stress Test
2018	70	74	81	
2019	49	71	92	35
2020	50	72	94	35
2021	51	73	97	35
2022	52	75	99	35
2023	53	76	102	35
2024	54	77	105	35
2025	55	78	107	35
2026	56	80	110	35
2027	57	81	112	35
2028	58	82	115	35
2029	59	84	117	35
2030	60	85	120	35
2031	60	85	120	35
2032	60	85	120	35
2033	60	85	120	35
2034	60	85	120	35
2035	60	85	120	35

Figure 1: BEIS Oil Price Assumptions



Modelling approach

15. The approach used to create BEIS' oil price assumptions combines: (a) futures prices and options data for the short term and (b) evidence on the long run (2030) costs of oil production and estimates of long run oil demand to arrive at a long run equilibrium price. For the purposes of creating the oil price assumptions, BEIS considers demand and supply of total oil liquids (for simplicity, hereafter: "oil") which includes crude oil, Natural Gas Liquids (NGLs), and biofuels.

16. The reason for using futures prices over the short term (2018-2019) is that, as frequently traded contracts, they contain all current information available to the market and so provide a measure of market expectations of the path of prices. Beyond this horizon, market liquidity is lower and may not offer the same opportunity for price discovery. On this basis we linearly interpolate between 2019 and our long run (2030) anchor to generate price assumptions for the intermediate years.

Table 2: Summary of BEIS approach for Oil Price Assumptions

	Short term (2018-2019)	**Medium term (2020-2030)**	**Long term (2030 onwards)**
Stress Test	Flat at $35		
Low Prices	Derive value from Options Pricing implied probability distribution	Interpolate to Long Run Low oil FFP	IEA Sustainable Development Scenario demand for 2030 intersected with BEIS high supply curve
Central Prices	Average of Futures curves prices or turnout prices (for 2018)	Interpolate to Long Run Central oil FFP	Adjusted IEA New Policies Scenario demand for 2030 intersected with BEIS central supply curve
High Prices	Derive value from Options Pricing implied probability distribution	Interpolate to Long Run High oil FFP	Adjusted IEA Current Policies Scenario for 2030 intersected with BEIS low supply curve

17. BEIS assumptions are intended to capture a range of plausible oil market dynamics through periods of relative looseness and tightness, but do not attempt to model price cycles. Table 2 summarises the approach, which is explained in more detail in the following paragraphs. All data are in real 2018 US Dollars. Long run values are rounded to multiples of US$5[9].

[9] We aggregate the long run oil supply curves provided by Wood Mackenzie to $5 tranches (rounding up).

Short Term Assumptions

18. The Central oil price assumption for 2018 is calculated as an average of the closing prices for i) the outturn price for January to June monthly contracts ($73/bbl) and ii) monthly futures contracts for July to December 2018. For 2019, we averaged the daily closing prices for monthly futures contracts from January to December 2019. All averages were calculated on the closing prices of each future contract over the period 21 May 2018 to 29 June 2018 (30 trading days).

19. For the High and Low-price assumptions for 2018 and 2019 we used the Bank of England's data on the pricing of options and implied volatility available at the end of June 2018[10]. To determine the High and Low prices we selected a confidence level of 75% i.e. we estimate that at the end of June 2018 the market attached a 75% likelihood that the oil price will fall within the High-Low price range for each of 2018 and 2019. The confidence interval is designed to reflect plausible alternative outcomes for the oil price rather than focusing on more extreme outcomes (which would result for example from using a 95% confidence level).

20. Our short-term oil price assumptions are higher than the previous ones published in 2017 across all the three cases. This reflects higher outturn prices and higher market expectations for future prices driven by concerns about the impact of US sanctions on Iran, decreasing supplies from Venezuela and optimism around prospects for economic growth. Forward prices are lower in 2019 than 2018 and volatility is higher than last year, with the 2018 premium reflecting market perceptions of geopolitical risk.

21. The Low-price assumption reflects a case where the US Light Tight Oil (LTO) production keeps increasing beyond expectations while OPEC cohesion falters, as compliance slips among member and non-member countries who do not agree further supply cuts beyond 2018. The High price assumption reflects an outcome where OPEC strategic management produces substantial market tightness and continues beyond end 2018 and US sanctions on Iran significantly reduce Iranian exports, whilst US LTO faces production and infrastructure constraints in areas such as the Permian Basin which further limit the opportunity to compensate the market shortness.

Medium and Long-Term Assumptions

22. To obtain the Low, Central and High oil price assumptions for the 2020-2030 period we linearly interpolated from the 2019 values to the long run 2030 price levels. Beyond 2030 we maintained the price levels unchanged, given the long-term uncertainties. This trajectory deliberately simplifies the complex market dynamics, as BEIS focuses on generating assumptions for long run oil prices, and not on generating market scenarios or modelling cycles. To derive the 2030 price assumptions, we intersected different supply and demand curves to arrive at implied long run equilibrium prices, as described below.

[10] More detail can be found in the technical appendix of Bank of England working paper: Recent developments in extracting information from options markets (2000). http://www.bankofengland.co.uk/archive/documents/historicpubs/qb/2000/qb000101.pdf

Oil supply curves

23. In 2016 Wood Mackenzie provided estimates of long run oil supply curves including sensitivities around the base case supply curve to establish a 'high supply' case (i.e. a supply curve with higher volumes of oil produced at any given price level), and a 'low supply' case (i.e. a supply curve with lower volumes provided at any given price level) to capture the uncertainty over the long term and a plausible range of alternative supply cases[11]. On the advice of the expert panel, we agreed that the supply curves were still a reliable basis to inform the 2018 fossil fuel price assumptions.

24. The original Wood Mackenzie supply estimates have been modified to reflect the latest developments in the oil sector. On the advice of the expert panel we have retained in the 2018 supply curve the supply adjustments that the Panel suggested in 2016[12] and 2017[13]. The production outlook for Venezuela has been further reviewed, in light of the most recent developments. In the central supply curve, the expected productive capacity for Venezuela for 2030 is set around 2.6 million barrels of oil per day (mb/d) – a reduction of 0.5 mb/d compared to our 2017 outlook for 2030. For the high price supply curve, we have reduced the expected output to around 2.8 mb/d – a reduction of 1.5 mb/d compared to our 2017 outlook. We have left unchanged our outlook for the low-price supply curve at 1.7 mb/d. All these scenarios imply a substantial recovery of Venezuela's production level in comparison to current performance.

Oil demand curves

25. The 2030 oil demand assumptions have been derived from the three scenarios in IEA's World Energy Outlook 2017 (WEO 2017): The Current Policies Scenario (CPS), the New Policies Scenario (NPS) and the Sustainable Development Scenario (SDS). On the advice of the expert panel, the 2030 levels of oil demand for the Current Policies Scenario and the New Policies Scenario have been uplifted, so that the 2017 oil demands implied in the WEO[14] is aligned with the most recent 2017 outturn data reported in the monthly Oil Market Report of IEA. This is to allow for the more rapid than anticipated growth in oil demand in recent years. No adjustment has been made to the Sustainable Development Scenario demand level as it is aligned with meeting emission reduction targets. The resulting 2030 demand volumes are:

- High (adjusted Current Policies Scenario): 112.7 mb/d
- Central (adjusted New Policies Scenario): 106.7 mb/d
- Low (Sustainable Development Scenario): 92.4 mb/d

[11] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/565992/BEIS_WM_Fossil_Fuel_Supply_Curves_Final_Report.pdf

[12] Page 9 of the 2016 BEIS Fossil Fuel Assumptions: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/576542/BEIS_2016_Fossil_Fuel_Price_Assumptions.pdf

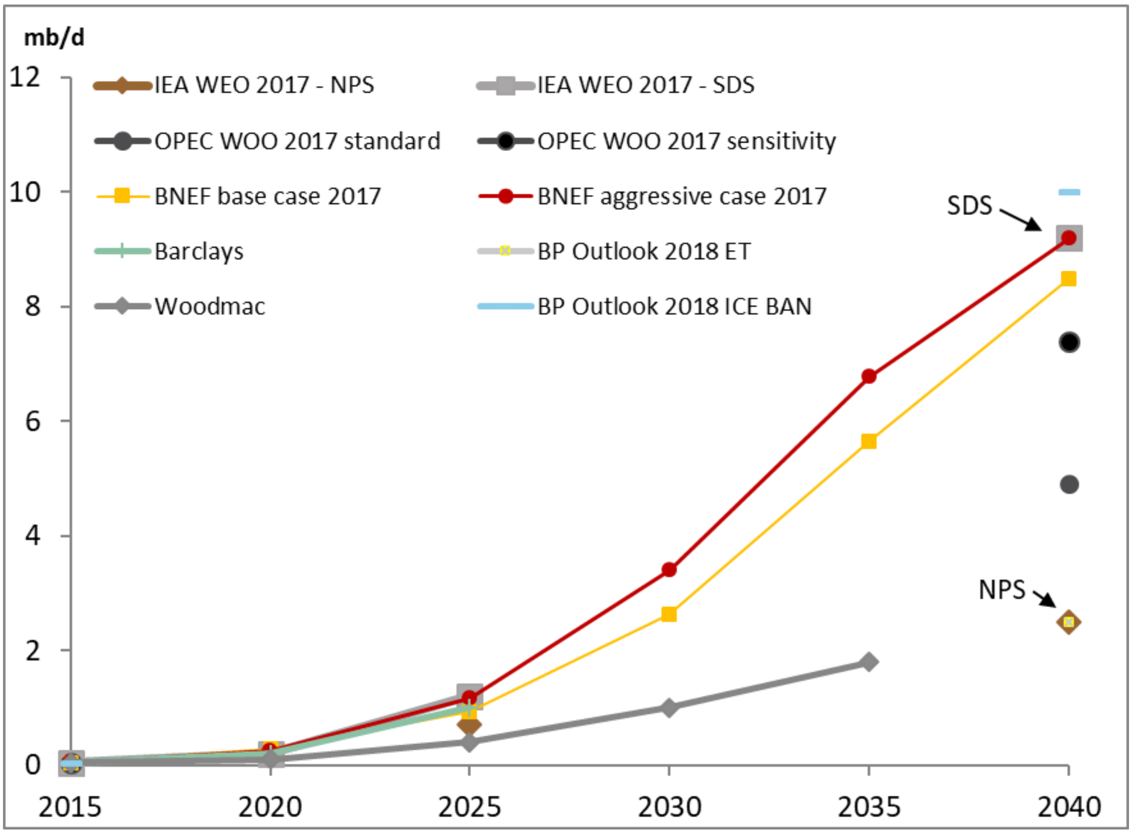
[13] Page 9 of the 2017 BEIS Fossil Fuel Assumptions https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/663101/BEIS_2017_Fossil_Fuel_Price_Assumptions.pdf

[14] By interpolating between the published 2015 and 2025 data points.

26. On the advice of the expert panel, we have compared the IEA demand scenarios (inclusive of adjustments) to those of other organisations that release in the public domain equivalent analysis (see Annex B). In addition, we have reviewed how IEA scenarios reflect uncertainties about three key drivers of future oil demand: the increase in demand from the petrochemicals sector; energy efficiency improvements in transportation; and the uptake of electric vehicles. Overall, we conclude that the range of views for future oil demand is broadly equivalent to last year's assessment, and that the IEA oil demand scenarios adequately reflect them.

27. With regards to the petrochemical sector, the latest IEA demand scenarios broadly reflect the range found across different external organisations. IEA scenarios are also adequate to capture different assumptions about future energy efficiency. The scenarios for vehicle fleets oil demand in transportation are broadly aligned with the range released by other organisations. Finally, the IEA scenarios satisfactorily capture the key uncertainties around oil demand displaced by the uptake of electric vehicles (see Figure 2). The Sustainable Development Scenario (SDS) and New Policies Scenario (NPS) scenarios reflect the upper and lower range of the view on EV uptake that we found in other organisations' scenarios.

Figure 2 Crude oil displacement from electric vehicles



Medium and long-term oil price assumptions

28. The medium and long term BEIS oil price assumptions capture a plausible range of oil prices until 2030. Overall, the variation captured in the High and Low-price assumptions reflects uncertainty around future OPEC policies, the strength of US oil production, key geopolitical uncertainties and the prospects for demand (closely linked to global economic growth and global action on emissions reductions).

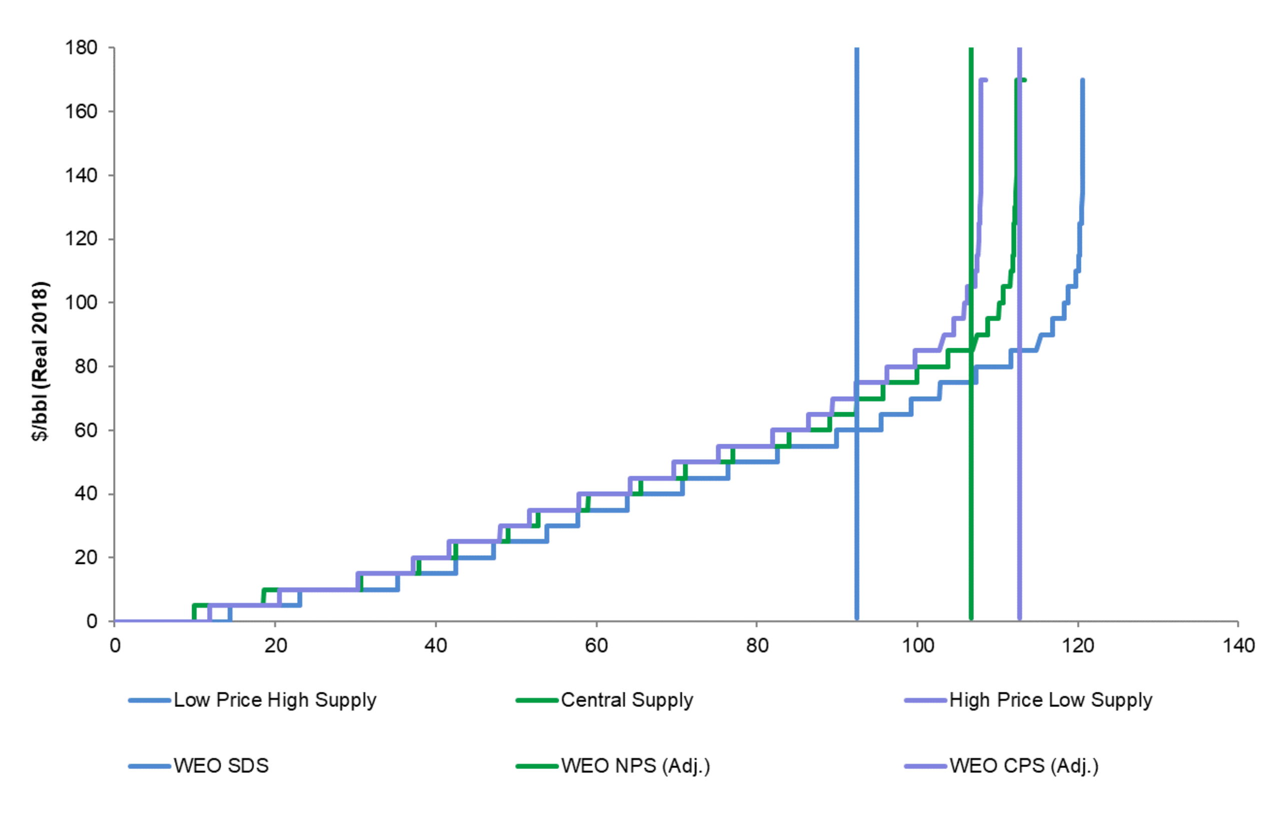
29. The Central oil price assumption results from intersecting the adjusted IEA New Policies Scenario demand with the central supply curve. As a result, the 2030 Central price is set at $85/bbl (per barrel) in real prices, $5 higher than the 2017 assumption. This reflects the slight (0.5 mb/d) reduction in the long run supply outlook, a slightly stronger long run demand outlook compared to the 2017 assumptions, and uprating to a 2018 price base.

30. The Low-price assumption combines the IEA Sustainable Development Scenario demand and the ‘high supply’ case and is also increased by $5 barrel, at $60/bbl. This could reflect a world where low prices are driven by limited demand and relatively more competitive OPEC supplies (which also limits the growth in US LTO production).

31. The High price assumption combines the adjusted IEA Current Policies Scenario demand with the ‘low supply’ case. This could reflect a world where supply is less responsive to high prices, due to lower technological improvement and higher costs of production, combined with a world where action to fight climate change progresses at a slower pace than currently expected.

32. The adjusted IEA Current Policies Scenario demand and the ‘low supply’ supply curve do not intersect (see Figure 3) and therefore do not generate a long run price assumption. On the advice of the panel, we have assumed a long run high price of $120/bbl price in real terms. This reflects a judgement that beyond $120/bbl it is plausible to assume that the oil industry can significantly increase productive capacity to meet demand, and that there would be structural adjustments to demand towards alternative sources of energy.

Figure 3: Supply curves and IEA Demand Scenarios



Source: IEA, Wood Mackenzie

The Low “Stress Test"

33. The Low “Stress Test” price assumption is designed to assess policies in a world of sustained very low oil prices. The stress test reflects the historical experience that the oil price can deviate from the evidence on long run equilibrium values for long periods, as it did from the mid-1980s to early 2000s. To derive the 2018 Low “Stress Test” price we have used the same methodology developed in 2016[15], which results in a price of $35/bbl. The value is unchanged from 2017.

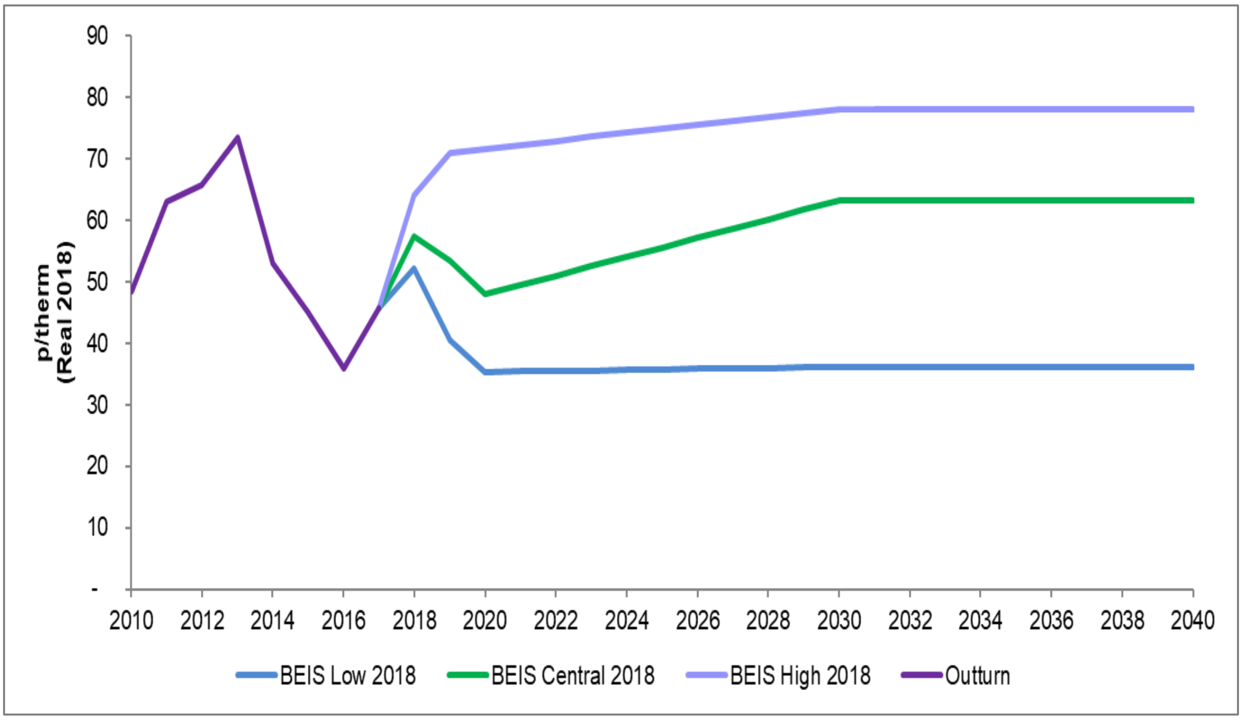
[15] Oil prices flat in real terms at their average from 1986 to 2003. See para 28 https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/576542/BEIS_2016_Fossil_Fuel_Price_Assumptions.pdf

Gas Price Assumptions

Table 3: 2018 BEIS Gas price assumptions

p/therm	2018 BEIS Gas price assumptions		
Real 2018 prices	**Low**	**Central**	**High**
2018	52	57	64
2019	40	53	71
2020	35	48	72
2021	35	49	72
2022	35	51	73
2023	36	52	74
2024	36	54	74
2025	36	56	75
2026	36	57	75
2027	36	59	76
2028	36	60	77
2029	36	62	77
2030	36	63	78
2031	36	63	78
2032	36	63	78
2033	36	63	78
2034	36	63	78
2035	36	63	78

Figure 4: BEIS Gas Price Assumptions



Modelling approach

34. The approach used to create BEIS's gas price assumptions combines: (a) forward prices and options data for the short term and (b) evidence on the long run costs of gas production and estimates of long run gas demand to arrive at long run implied equilibrium prices.

35. The reason for using forward prices over the short term (2018-2020) is that they reflect expectations of market participants about gas supply and demand over this time horizon. In the long run the price assumptions are anchored at the expected cost of marginal gas supplies to European markets at projected levels of European gas demand. This is a long run market equilibrium condition. We recognise that the gas market is an increasingly global one and that the approach of modelling a European gas market is a modelling abstraction. The table below summarises the approach which is explained in more detail in subsequent sections.

Table 4: 2018 BEIS Gas price assumptions approach summary

	Short term **(2018-2019)**	**Medium term** **(2020-2030)**	**Long term** **2030 onwards**
Low Prices	Using Options volatility to derive low range	Using Options volatility to derive low range for 2020 and then interpolate to Long Run Low	IEA Sustainable Development Scenario demand intersected with BEIS high supply curve
Central Prices	Forward curve	Forward curve for 2020 and then interpolate to Long Run Central	IEA New Policies Scenario demand intersected with BEIS central supply curve
High Prices	Using Options volatility to derive high range	Interpolate to Long Run High	IEA Current Policy Scenario demand intersected with BEIS low supply curve

36. The assumptions based have been compared with the demand scenarios and price assumptions[16] of other organisations (see Annexes B and C) which BEIS uses to inform

[16] The organisations may describe them as price forecasts, projections or scenarios.

its judgement. Whilst it is beyond the scope of this report to analyse the assumptions of other institutions in detail, it is clear that there is a wide range of views and BEIS's Central assumption lies within that range. All data are in real 2018 prices (pence/therm).

Short Term Assumptions

37. The Central gas price assumption for 2018 is calculated as an average of outturn GB NBP day-ahead prices January 2018 to June 2018 (56 p/therm) and the quarterly forward contracts for Q3 and Q4 2018, averaging the market data over the period from 18 May 2018 to 29 June 2018 (30 trading days). The 2019 and 2020 Central assumptions are based on the average of the corresponding four quarterly forward contracts (Q1, Q2, Q3 and Q4 2019 and 2020) using the same market data period.

38. The forward market shows prices falling between 2018 and 2020, in part reflecting increasing global supplies of Liquefied Natural Gas (LNG). Short term market prices out to 2020 are higher than the 2017 set of assumptions reflecting tightening fundamentals. This is partly due to recent strength in the wider energy complex (higher coal, oil and carbon prices) and expectation of continued rising Asian demand for LNG. The LNG market can indirectly impact European prices through competition for cargoes.

39. In contrast to previous years, we have opted to use the forward curve for the first three years rather than flatlining. The Panel's view has been that beyond two years liquidity drops such that it is considered that there may be insufficient liquidity to support the use of forward curve prices for future gas prices assumptions. However, after revisiting the analysis in July the central case and low case produced a set of short-term prices that were at odds with market sentiment and we therefore agreed that the use of the forwards curve would be extended to 2020. Engagement with the panel suggested this approach resulted in a set of assumptions that are more in line with the market and external views. Given the uncertainty over new LNG supply, demand growth and the number of alternative views, this change deemed appropriate for this year's assumptions.

40. High and Low-price assumptions are derived as a range around the 2018 and 2019 Central price assumptions using data on NBP options volatility[17]. The 2020 Low assumption was also derived using data on NBP options volatility around the Central price assumption. Using implied volatility, we have selected a confidence level of 75% i.e. suggesting that the market at June 2018 attached a 75% likelihood that the gas price will fall within High-Low price range for each of 2018 and 2019. The choice of the 75% confidence interval is designed to reflect plausible alternative outcomes for the gas price rather than focusing on more extreme outcomes (which would result for example from using a 95% confidence level).

Medium Term Assumptions

[17] Replicating an Energy Information Administration (EIA) approach, we derived confidence intervals around expected futures prices using the "implied volatilities" of options. Further information can be found in Annex D of the BEIS 2016 Fossil Fuel Assumptions report.
https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/576542/BEIS_2016_Fossil_Fuel_Price_Assumptions.pdf

41. For the Central and Low-price assumptions, we use the forward curve to the end of 2020, which shows prices falling over that period. This is consistent with a narrative for example that the considerable increase in LNG supply due to be commissioned over the rest of this decade (in particular in the United States) will outpace the rate of demand growth.

42. We also tested the Low-price assumptions for this period against a potential “price floor” range of short term US LNG export cash costs to Europe. This reflects a floor price at which US LNG imports would be curtailed (the price would just cover the short run marginal costs of supply) which would be expected to support prices. While there are some uncertainties in estimating this price floor range,[18] our Low-price assumptions fall within the range.

43. After 2020 the Central and Low-price assumptions are linearly interpolated to their long run equilibrium values in 2030.

44. For the High price assumption, we have assumed faster adjustment of prices towards the (higher) long term equilibrium. This, for example, reflects more rapid growth in demand which would tighten the market more quickly. The High price assumption has therefore been constructed by linearly interpolating from 2019.

Long Term Assumptions

45. There is uncertainty about how European and UK gas prices could develop over the medium and long term as they are influenced by several factors. Global LNG capacity is expected to grow strongly to 2020 and therefore even with global gas demand growth the market is likely to be well supplied into the early 2020s. However, there are major uncertainties around Russia’s pricing strategies and developments in US and Asian demand, which in turn could affect the amount of LNG available to the European market.

46. To inform the 2016 fossil fuel price assumptions, we appointed Wood Mackenzie to produce scenarios for the evolution of long run supply curves for gas to European markets.[19] The supply curves were built up from breakeven costs for investment/long run marginal costs for the key categories of supply. Some of these uncertainties mentioned above have been captured in the composition of the supply curves. On the advice of the expert panel, it was agreed that it remained reasonable to use the supply curves to inform the 2018 fossil fuel price assumptions as there had been no fundamental changes in the long run supply outlook.

47. For the 2018 update, the only change we made to the supply curves has been the assumptions on the costs of US LNG supply to Europe. The potential size of US LNG exports, their pricing flexibility, and the proximity to Europe (compared to Asia) means US LNG has the potential to be a key driver of European gas prices. The cost of US LNG is assumed to be the US Henry Hub price plus the cost of delivery to Europe – this includes liquefaction, shipping and re-gasification. We have revised down the \$4.2/mmbtu (million British Thermal Units) long term assumption for Henry Hub prices

[18] Cash cost breakdown of US LNG to Europe suggested by the Panel members: Henry Hub price + 15% per contract + \$0.3 for shipping costs + \$0.4 regasification costs. Based on range of short run Henry Hub price assumptions, of which the lowest was \$2.6 and highest was \$3.8, the price floor range is estimated to be between \$4/mmbtu and \$5/mmbtu (or ~30p/therm and 40p/therm).

[19] At https://www.gov.uk/government/publications/fossil-fuel-price-assumptions-2016

used for the 2017 Central gas price assumption to $3.9/mmbtu for the 2018 Central gas price assumption, which is aligned with Wood Mackenzie's December 2017 Henry Hub assumption for 2030. This reflects the continuing drop in US gas production costs and abundant low-cost resource available in North America. As in 2017, we have assumed the 2030 Henry Hub price could be $1/mmbtu higher or lower than the central assumption for the Low and High gas price assumptions.

48. In 2017 Qatar announced its intention to lift the 2005 moratorium on LNG export expansion and bring an additional 31 bcm[20] of LNG production online by the end of 2023. This potential incremental supply growth could increase exports destined for Europe and this may have implications on long run prices. However, after assessing the possible impact on long run supply we concluded no adjustments were required. Qatari gas will flow depending on market prices and therefore there are large uncertainties over the incremental volumes that would head to Europe. The long run supply curves are relatively "elastic" around the long run price assumptions (see Figure 5 below) and therefore marginal changes in assumptions around long run Qatari supply to Europe would not materially change the calculated long run price assumptions.

49. The long-term gas price assumptions combine the three updated long-term supply outlooks with the three long term demand scenarios for European gas demand from the IEA World Energy Outlook 2017. The geographical coverage of "Europe" used for the Wood Mackenzie gas supply curves provided to BEIS differs from the IEA's and we have therefore adjusted the IEA's demand scenarios to allow for the difference in coverage.[21]

50. Figure 5 presents the implied price assumptions by combining our supply curves and adjusted IEA OECD Europe gas demand scenarios. All data are in real 2018 p/therm. The supply curves provided by Wood Mackenzie were in real 2015 $/mmbtu. These were converted to p/therm using a long-run exchange rate assumption of 1.42 USD: GBP. We used a market-based approach for assumptions for the exchange rate similar to the OBR[22]. **The exchange rate assumptions are the main driver behind the changes in this year's long run gas price assumptions (See Annex A).**

Central Price Assumption

51. For the 2030 Central price assumption we have combined the IEA New Policies Scenario demand with the central 2030 supply curve. We have therefore assumed for the Central assumption that in the long run the supply side, specifically US LNG supply, is relatively flexible and responsive to price although we have also assumed Russia continues to price strategically, albeit constrained by supplies from other sources including US LNG.

[20] ICIS Heren – 23 million tonnes per annum * 1.36 = 31 billion cubic metres (bcm)

[21] Wood Mackenzie's "Europe" region had additional countries, which included: Albania, Bosnia, Bulgaria, Canary Islands, Croatia, Latvia, Lithuania, Macedonia, Romania and Serbia. The adjustment was applied based on historical 2016 gas consumption for these addional countries. Further information on the methodology for adjustments to IEA demand scenarios can be found in Annex E of the BEIS 2016 Fossil Fuel Price Assumptions.

[22] We took an average of forward exchange rates (market data) over the period 18 to 29 June 2018 (10 trading days)

Low Price Assumption

52. The Low-Price assumption is illustrative of a world where there is substantial demand reduction for fossil fuels including gas due to for example increased policy action to mitigate climate change. For the 2030 Low Price assumption we combine low demand with high supply i.e. the IEA Sustainable Development Scenario demand (the lowest level of gas demand of the three IEA scenarios) and the 'high supply' case provided by Wood Mackenzie.

53. This demand and supply combination is plausible because if gas demand is low, it is plausible that US wholesale gas prices and US LNG costs would be lower, and that Russia would be driven towards competing on price to maintain sales volumes.

54. The energy transition remains an enormous challenge, and it is uncertain which combination of existing and future technologies will provide our energy services in the long term. The prospects for gas demand could be adversely affected by either weaker or stronger environmental policies.

55. Many organisations publish long-run energy scenarios and outlooks. Comparison of these outlooks helps to highlight differences of view and areas of uncertainty with some organisations projecting lower long-term gas demand than the IEA's Sustainable Development Scenario (Annex B).

56. For example, some studies conclude that for the EU, fossil fuels, including natural gas, can have no substantial role in an EU energy system consistent with climate targets beyond 2035[23] implying dramatic drops in gas demand. However, other studies find that gas demand can be sustained around current levels out to at least 2040 in scenarios consistent with climate targets[24]. This demonstrates the level of long term uncertainty.

57. However, the long run "high supply/low price" supply curve is relatively flat around the low-price assumption. Therefore, it would require quite a significant drop in demand to result in a substantial change in our calculated low gas price assumption. Another possible driver of lower prices is substantial structural cost reductions, e.g. through efficiency gains, technological improvement, but modelling these would be speculative.

High Price Assumption

58. For the 2030 High Price assumption we combine the IEA Current Policies Scenario demand level with the 'low supply' 2030 supply curve. We have therefore assumed higher US wholesale gas prices limit the competitiveness of US LNG which in turn enables Russia to sustain a higher price for its gas supplies.

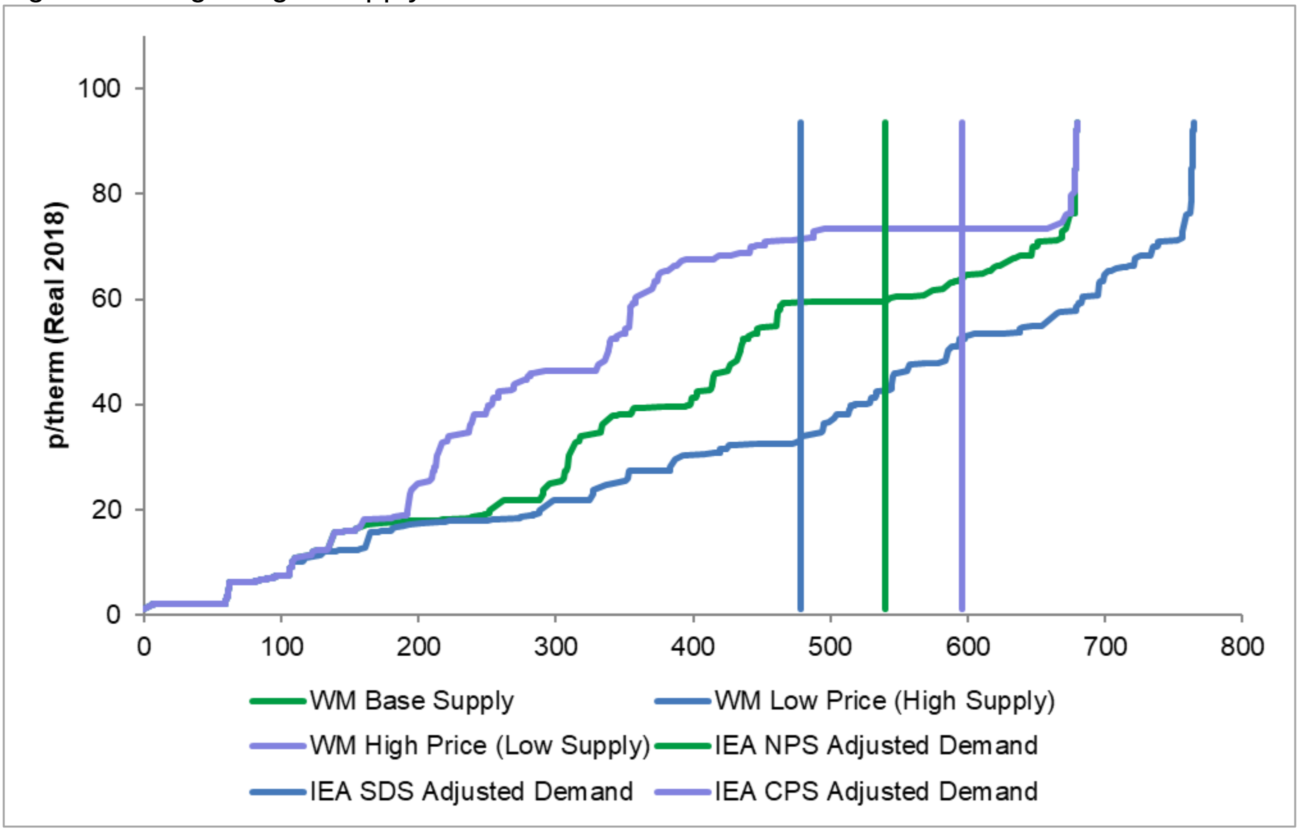
59. This demand and supply combination is plausible because if gas demand is high US wholesale gas prices and US LNG costs could be higher allowing Russia to be able to

[23] For example, Anderson, K. and Broderick, J. (2017) Natural gas and climate change. Manchester: Tyndall Manchester Climate Change Research

[24] For example, BP's Energy Outlook 2018 shows gas demand growing between 2016-2040 in most of their scenarios. Their "Even Faster Transition Scenario" shows gas demand growth of -0.1% per annum, which is a scenario that follows the same broad decline in carbon emissions as the IEA's 'Sustainable Development Scenario', with emissions falling by almost 50% by 2040.

target a price just below (higher) marginal US LNG costs to maximise profits without having to sacrifice sales volumes.

Figure 5: Long run gas supply curves combined with IEA demand scenarios



Source: Wood Mackenzie, IEA and BEIS analysis

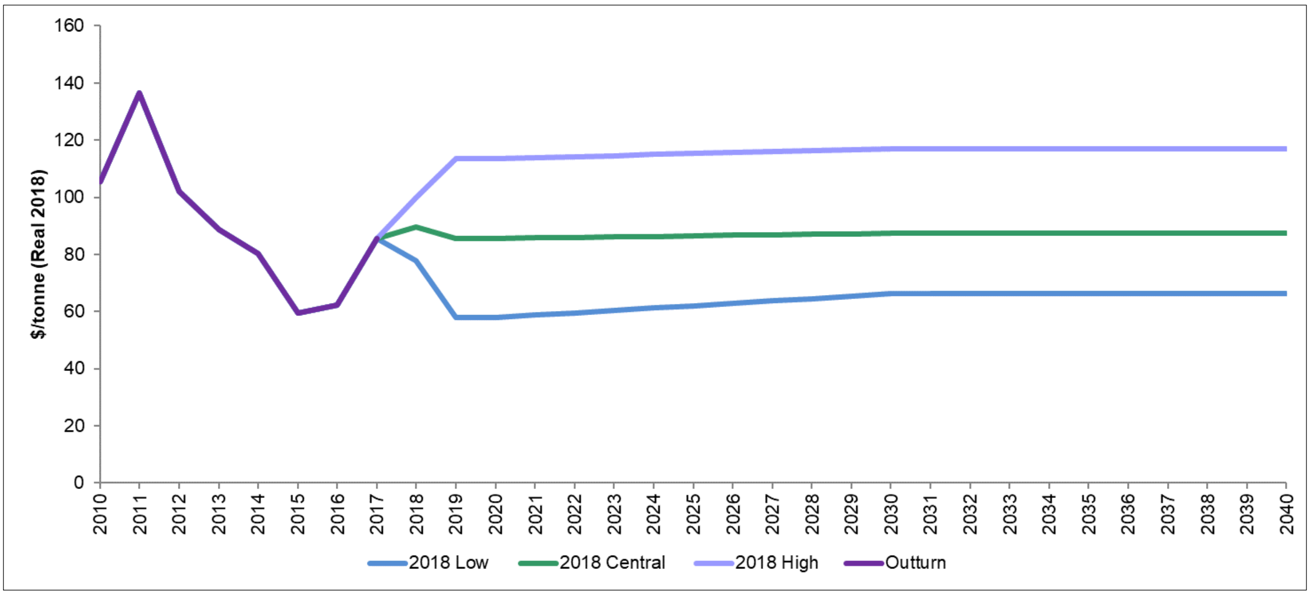
60. For the Low, Central and High price assumptions, a flat line for gas prices in the period after 2030 has been assumed. This trajectory is clearly a simplification, with the possibility that very long-term prices could trend up reflecting the need to access more expensive sources of supply, or trend down reflecting technological improvement or declining demand. However, given there is less visibility on potential gas supply conditions post 2030, we have chosen to anchor our long-term assumptions based on evidence for 2030.

Coal Price Assumptions

Table 5: BEIS 2018 Coal price assumptions

$/t	2018 BEIS Coal price assumptions		
Real 2018 prices	**Low**	**Central**	**High**
2018	78	90	100
2019	58	86	113
2020	58	86	113
2021	59	86	114
2022	60	86	114
2023	60	86	115
2024	61	86	115
2025	62	86	115
2026	63	87	116
2027	64	87	116
2028	65	87	116
2029	65	87	117
2030	66	87	117
2031	66	87	117
2032	66	87	117
2033	66	87	117
2034	66	87	117
2035	66	87	117

Figure 6: BEIS Coal Price Assumptions



Modelling approach

61. The approach used to derive BEIS's coal price assumptions combines (a) forward prices and errors of historic forward prices for the short term and (b) evidence on the long run costs of coal production and long run coal demand to arrive at a long run implied equilibrium price.

62. The table below summarises the approach taken for the Low, Central and High price assumptions. The methodology is explained in more detail in subsequent sections[25].

Table 6: Summary of BEIS approach for coal price assumptions

	Short term **(2018-2019)**	**Medium term** **(2020-2030)**	**Long term** **(2030 onwards-2040)**	**Key Assumptions**
Low Prices	Forward prices adjusted downwards.	Flatline to 2020 then a linear interpolation to long run low price assumption.	IEA Sustainable Development Scenario demand intersected with BEIS high coal supply curve.	Increased South African supply to Europe (50%). Demand based on IEA Sustainable Development Scenario.
Central Prices	Based on forward price curve.	Flatline to 2020 then a linear interpolation to long run central price assumption.	IEA New Policies Scenario demand intersected with BEIS central coal supply curve.	10% of South African and 5% of Mozambican coal available to Europe. Demand based on IEA New Policies Scenario.
High Prices	Forward prices adjusted upwards.	Flatline to 2020 then a linear interpolation to long run central price assumption.	IEA Current Policies Scenario demand intersected with BEIS low coal supply curve.	Decreased Russian supply available to Europe (90%). Demand based on IEA Current Policies Scenario.

[25] In all coal price scenarios, the quality of coal has been standardised to the benchmark ARA specification of 6322 kcal/kg gross as received (gar) / 6000 kcal/kg net as received (nar).

Short term Assumptions

63. The Central coal price assumption for 2018 is derived from a weighted average of CIF ARA outturn prices for January 2018 to June 2018 ($88/tonne), and the quarterly forward curve for Q3 and Q4 2018, averaging over the data resulting from the 30 days trading period to 29 June 2018. The 2019 central coal price assumption is derived from the average of year ahead forward prices for 2019 traded over the same period. Forward prices aggregate the future price expectations and insights of market participants; as such, they are taken to be the best indicator for short term coal price movements.

64. Coal prices for 2018 are higher than in last year's assumptions. After declining in the first half of 2017, coal spot and forward prices increased in the second half of 2017, with higher prices sustained in the first half of 2018, driven by robust demand coming from China, the world's top consumer. Coal demand from northern Asia was strong more generally, and combined with some shipping issues in Indonesia, spurred prices higher. Because coal consumption in the largest consumers such as China and India dwarfs European import demand and due to the arbitrage opportunities stemming from the ease of coal transport, changes in demand in these countries can cause large price movements in the European coal market. China has relaxed the production constraints put into place in 2016, allowing its domestic coal mines to increase the number of days of operation per year. Although China does intend to continue to reduce capacity over the next few years, putting the country on track to beat its long-term targets as part of an effort to achieve "blue skies", it has suggested it will not return to a blanket 276-day limit on mines. Instead it will use other measures to target a price of Rmb500-575/tonne ($75-86/t)[26][27]. Forward markets show coal prices falling in 2019 with fewer trades taking place, reflecting the relatively high coal stocks in the major centres of demand.

65. For many countries in Europe, coal is falling down the rankings as part of the energy mix as a growing number of countries have closed or made closure plans for coal-fired power generation. In addition to the UK's commitment to phase out unabated coal, France, Italy and Finland have made a policy commitment to phasing out coal use. A number of other countries are approaching the end of coal use and Belgium ceased coal power generation in 2016. Even with higher natural gas prices, the combination of carbon dioxide (CO2) emission prices and efficient gas plants can make gas-fired generation competitive with coal[28]. The future of coal-fired generation in Europe is therefore more dependent on policies and ambitious decarbonisation targets than on fuel costs. The decrease in coal demand forecast in Europe will be tied to further policy decisions in future.

66. High and Low coal price assumptions are estimated from the historic deviation between the quarterly and year ahead forward curves and respective outturn prices between 2007 and 2017. Both High and Low-price assumptions are calculated on the basis of one standard deviation of historic forward price errors. The Low and High price assumptions

[26] Using an exchange rate of 1 Rnb=0.15 USD

[27] National Development and Reform Commission (NDRC), People's Republic of China

[28] IEA, Coal 2017

are designed to reflect plausible alternative outcomes for the coal price rather than focusing on the extremes.

Medium term Assumptions

67. For the Low, Central and High price assumptions, we assume prices remain at their 2019 level in 2020. We consider there is too little liquidity in the coal forward price curve beyond 2019 to act as a reasonable forecast of future prices. Given the current global spare capacity in coal markets we continue as last year to assume coal prices do not adjust to their long run "equilibrium" values until after the end of the decade.

68. After 2020 the Low, Central and High price assumptions are linearly interpolated to their long run equilibrium values in 2030.

Long term Assumptions

69. The long run market balancing condition requires that the market price that consumers are willing to pay must cover the full cost (i.e. including capital costs) of the marginal supply if investment in that capacity is to be made. We have therefore anchored price assumptions around the estimated long run marginal cost of seaborne steam coal imports to Europe in 2030 given an estimated level of demand for coal imports, with a delivery point of ARA.

70. We have used the same set of supply curves as for last year's coal price assumptions, as we consider the fundamentals of long run coal supply have not materially changed in the past year. The supply curves were built up from breakeven costs for investment/long run marginal costs for the key categories of supply. They reflect variation in the technical/ geological/country characteristics and were based on a mine by mine analysis. Breakeven costs were also categorised by country and type of resource and exclude sunk and committed investment costs. Further detail on the construction of the long run coal supply curves is provided in the Wood Mackenzie report published alongside 2016's assumptions[29].

71. The key driver of long run European supply variation between the three assumptions is the proportion of coal that 'swing suppliers' such as South Africa and Russia export to Asia rather than Europe. This in turn is affected by the level of Asian coal demand, driven by factors such as environmental regulation, the level of non-coal power generation capacity and electricity demand.

72. Estimates of coal demand are derived from the 'New Policies', 'Current Policies' and ''Sustainable Development' Scenarios in the IEA's World Energy Outlook 2017. The IEA provides scenarios of coal demand for OECD Europe. This region matches the region that would consume the seaborne supplies of coal to Europe estimated by Wood Mackenzie. However, two adjustments to the IEA demand estimates are required to match coal supply and demand to derive price estimates for European steam coal imports. First, European coal production must be netted off coal demand in order to

[29] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/565992/BEIS_WM_Fossil_Fuel_Supply_Curves_Final_Report.pdf

obtain demand for coal imports. We have used scenarios for coal production in OECD Europe from the IEA's World Energy Outlook to do this. Second, the demand for steam coal must be separated from demand for other types of coal such as lignite and metallurgical coal in order to be consistent with supply estimates.[30]

Central Price Assumption

73. In the central case, Columbia is expected to be the key supplier of low-cost coal in to Europe, with Russia offering the majority of higher cost supplies. Lower levels of coal of varying cost are expected from the US and South Africa, with Venezuela and Mozambique offering small amounts of relatively expensive coal supplies.

74. This level of coal supply is consistent with Asian coal demand in the IEA's 'New Policies Scenario', where demand grows primarily in India and southeast Asia. This in turn means that only 10% of South African coal and 5% of Mozambican coal is expected to be available to Europe, with the remainder being exported to the Pacific basin.

75. European coal demand for the long run Central price assumption is estimated from the IEA's 'New Policies Scenario'. In this scenario, the EU ETS develops in accordance with the 2030 Climate and Energy framework, with emissions reductions targets in this framework leading to strengthened support for renewable electricity generation. This demand scenario is consistent with the proportion of coal that swing suppliers sell to Europe falling from their current levels, as the decrease in European demand makes the Asian market more attractive for these suppliers.

76. The growth prospects for coal, as identified in the 'New Policies Scenario' are expected to be somewhat dampened over the coming decades compared to the recent experience. An average annual growth rate of 0.2% between 2016 and 2040 is much reduced from the 2% per year rate experienced over the past 25 years. Despite weak global demand growth, taking into account the capital expenditures requirement to maintain and offset depletion for mines and supply infrastructure leads to a long-term price assumption which is somewhat higher than the level assumed in the short term.

Low Price Assumption

77. The high supply/low price supply curve is constructed on the same basis as in the central case, with the difference that 50% (rather than 10%) of South African coal is available to the European market. This assumption is based on lower Asian demand which would be consistent with, for example, a prolonged economic slowdown in China, and tighter environmental regulation in Asia.

78. Demand is estimated using the IEA 'Sustainable Development Scenario' for OECD Europe, which is lower than demand in the New Policies Scenario. This scenario assumes that the EU ETS is strengthened in line with the 2050 roadmap for Europe, as well as greater support for renewables than in the 'New Policies Scenario'. Combining

[30] Metallurgical coal is netted off using the estimate of the proportion of European coal demand accounted for by metallurgical coal in 2022 from the IEA Coal 2017 publication (2022 is used as the report does not predict trends beyond this year). Lignite coal demand has been removed by netting off European coal production, as trading of lignite is very limited due to its low energy content relative to its weight. This approach towards estimating seaborne coal import demand implicitly assumes that there are no net imports/exports to/from OECD Europe by rail, which is reasonable as Russia is unlikely to supply significant quantities of coal to OECD European countries via rail.

this low demand scenario with a high supply curve is plausible, but, as noted above, would likely require a significant increase in environmental action from governments in Asia.

High Price Assumption

79. Long run supply for the high price/low supply case is constructed assuming that 10% of western Russian coal is exported to Asia; in the central case all western Russian coal is exported to Europe. This would be consistent with potential transport infrastructure developments going ahead in Russia to increase its capacity to export coal eastwards and increased economic growth in Asia.

80. Demand in the high case is estimated using the IEA 'Current Policies Scenario'. Policies such as the EU ETS and renewables subsidies are assumed to remain in line with the 2020 Climate and Energy Package, and other policy commitments such as the Industrial Emissions Directive are continued.

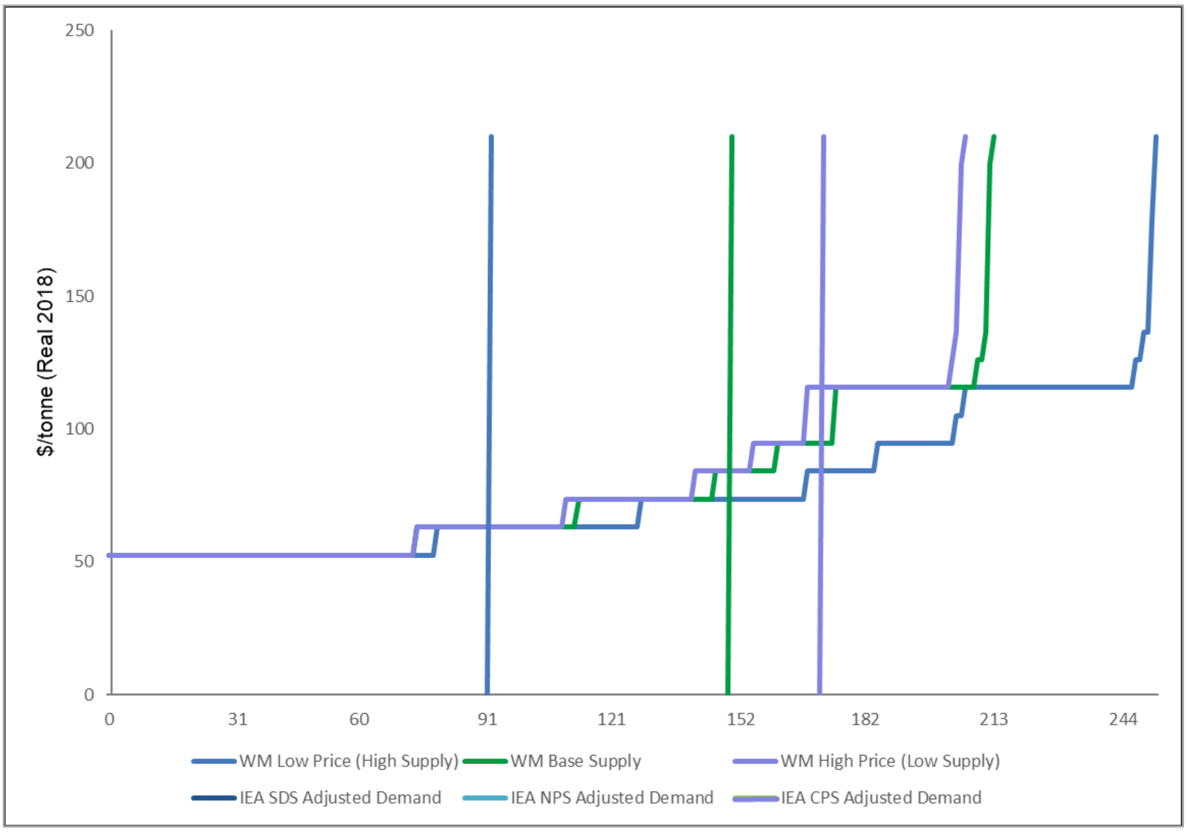
81. This higher demand scenario could materialise simultaneously with lower supply to Europe if, for example, lower European environmental regulation is combined with increased rates of Asian economic growth, which attract greater proportions of coal supply to Asia.

82. The ARA coal price for 2030 in the IEA's 'Current Policies Scenario' is lower than our 2018 High price coal assumption. In practice, higher prices could incentivise extra European supply, reducing Europe's demand for coal imports below the 'Current Policies Scenario' level and limiting the extent to which prices would rise[31].

83. Beyond 2030 we maintain the price levels unchanged, given the long-term uncertainties.

Figure 7: Long run European thermal coal import supply curves combined with IEA demand scenarios

[31] See the discussion in the 2017 Assumptions document. We have adjusted the methodology slightly for the high coal price assumption in the 2018 Assumptions. In the 2017 Fossil Fuel Assumptions, BEIS made a reasonable adjustment to model a higher European coal production in the high price scenario. Implicitly, it was assumed that additional coal production from Poland would be triggered when prices reach a price level of $115-120 USD/tonne. Without the adjustment coal prices in the high price scenario would have reached an unsustainable level due to the modelling approach of the supply cost curves to Europe. However, since at higher prices, European coal production would rise, this would set a reasonable upper limit to coal prices. In this year's Assumptions, the same adjustment was applied. However, since the European coal demand is lower in the high price scenario this year, the high price scenario reaches a level, where no substantial increase of European coal production would be expected. Hence, no significant increase of European coal production is observed in this year's high price Assumptions.

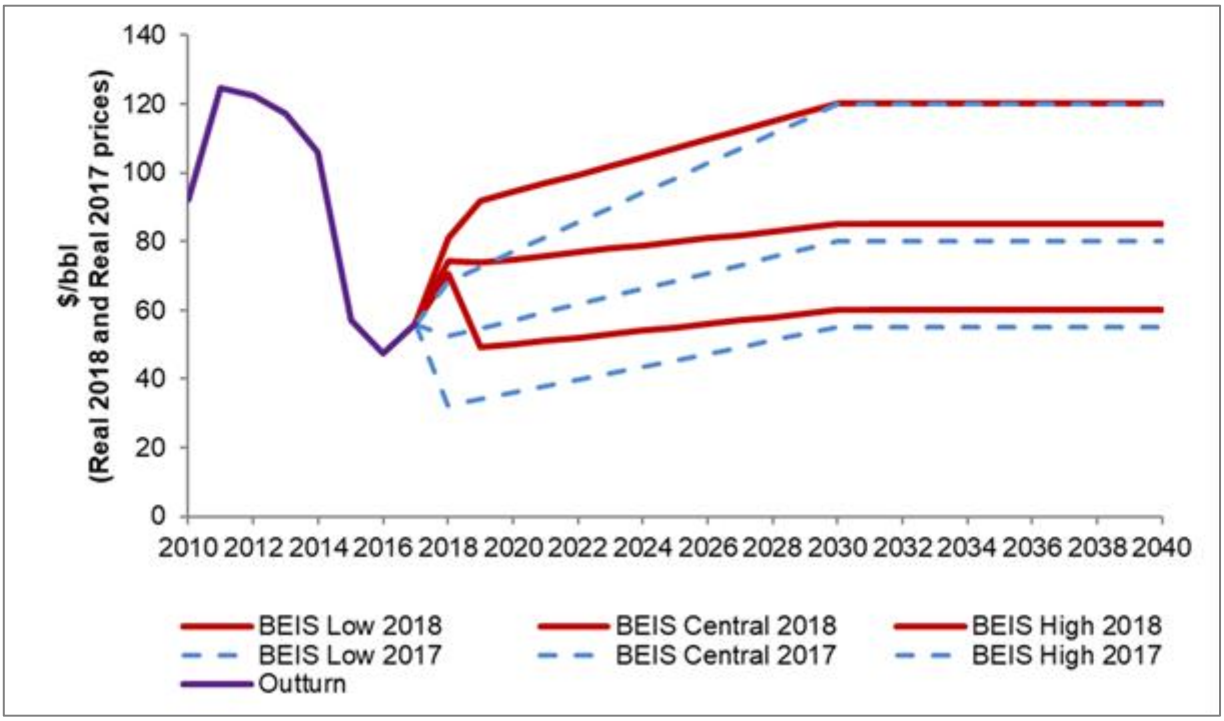


Source: IEA, Wood Mackenzie

Annex A – Comparison with 2017 BEIS Fossil Fuel Price Assumptions

Oil Price Assumptions

The short and long term 2018 Oil Price Assumptions differ from the 2017 Assumptions. The short-term assumptions have increased due to market perceptions of increased geopolitical risk, particularly a result of new US sanctions against Iran, together with more optimistic prospects for economic growth, which have pushed prices higher and increased volatility. Additional supplies from the US LTO have been counterbalancing this tightening trend, but pipeline infrastructure constraints later in the year could begin to weigh on US supply growth. The long-term demand outlook to 2030 appears slightly stronger than 2017 but does not radically change the overall view. On the supply side the only substantial change is a worsened outlook for Venezuela production. These changes have slightly increased the long run price outlook we see in the Low and Central assumptions.



Gas Price Assumptions

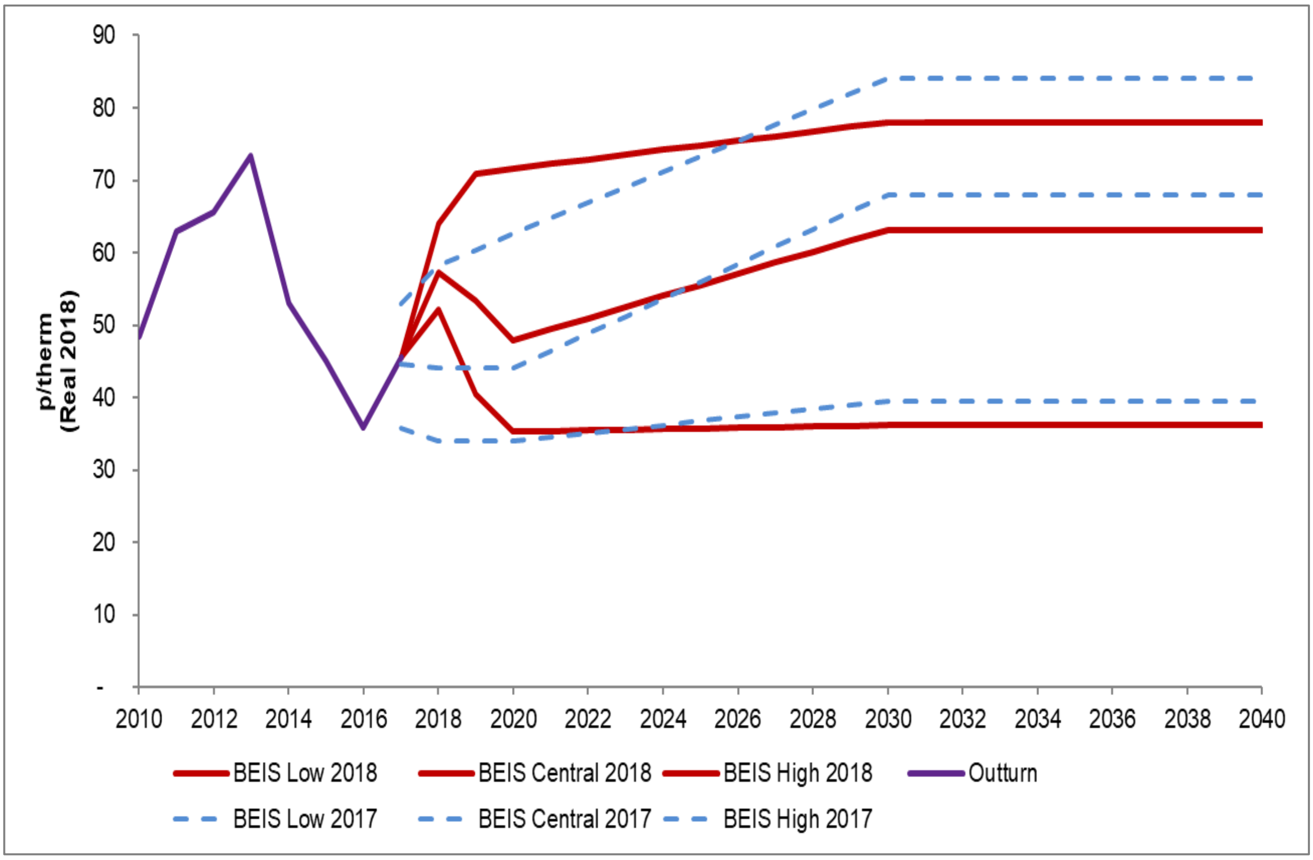
The short term 2018 Gas Price assumption are higher than the 2017 set of assumptions. Outturn NBP prices over H1 2018 have been strong partly reflecting a cold snap across North West Europe which sparked a surge in gas price volatility and several outages at Norwegian and British gas infrastructure sites.

Further along the forward curve low levels of gas in store have supported prices for the remainder of the year. Compared to last year's set of assumptions expectations of a tighter LNG market has also strengthened due to increased Asian demand and delays to LNG export projects.

Evidence on the long run marginal cost of supply in $/mmbtu has not changed significantly. The change in pence/therm between the 2017 and 2018 long term gas price assumptions mainly reflects the change in the exchange rate assumption. The 2018 long run gas price assumptions were converted to pence/therm using an exchange rate assumption of 1.42 USD: GBP for 2030 which compares to the 1.31 USD: GBP assumption used for the 2017 gas price assumptions. The table below compares the 2017 long run gas price assumptions with the 2018 assumptions in terms of $/mmbtu.

Long term (2030) gas price assumptions			
$/mmbtu (Real 2018 prices) *	BEIS Low	BEIS Central	BEIS High
FFPA 2017	5.20	8.90	11.00
FFPA 2018	5.12	8.96	11.07

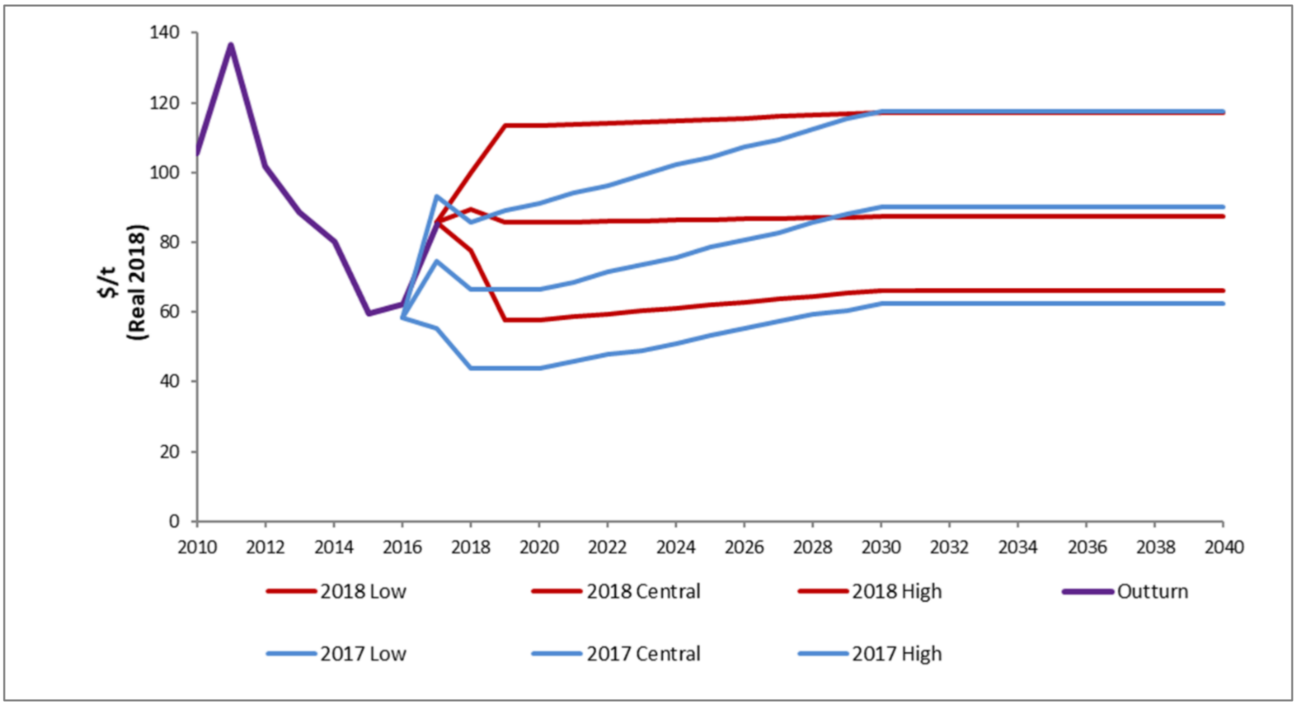
*rounded to nearest 10 cents


p/therm
(Real 2018)
90
80
70
60
50
40
30
20
10
-
2010
2012
2014
2016
2018
2020
2022
2024
2026
2028
2030
2032
2034
2036
2038
2040
BEIS Low 2018
BEIS Central 2018
BEIS High 2018
Outturn
BEIS Low 2017
BEIS Central 2017
BEIS High 2017

Coal Price Assumptions

The 2018 Coal Price assumptions are higher than the 2017 assumptions in the short term due to an increase in coal spot and forward prices in the second half of 2017, which was sustained in the first half of 2018. This market movement resulted from tighter coal supplies, particularly in China. Price arbitrage opportunities have led coal exporters to divert supplies from Europe to Asia, thus increasing the European ARA coal price.

The long run Central coal price assumption has decreased slightly due to lower import demand scenarios for OECD Europe from the IEA, resulting from a fall in expected domestic European coal demand. The high case assumption remains the same after allowing for different price bases, although the methodology has been revised, with a faster fall in coal demand than in coal production for Europe forecast in the WEO 2017 'Current Policies Scenario'. The low assumption in the long run remain largely unchanged. OECD European import demand scenarios from the IEA's SDS scenario have declined from the previous year due after the effects of a reduction in expected European production and demand are accounted for.



Annex B – Demand Scenarios

The tables below compare demand scenarios from key energy institutions and companies where information is publicly available[32]. Whilst we acknowledge that there are significant uncertainties with demand scenarios we have chosen to use IEA demand scenarios as they are internationally recognised as a leading institution in energy market analysis. In addition, the IEA WEO 2017 demand range broadly captures most external demand scenarios across the fuels.

[32] As of 31 March 2018.

Oil

Oil Demand Scenarios (mb/d)						
Source	**Published**	**2020**	**2025**	**2030**	**2035**	**2040**
	Total liquids					
IEA WEO 2017 (New Policies)	Nov-17	-	103	105	107	109
IEA WEO 2017 (Sustainable Development)	Nov-17	-	96	92	-	80
IEA WEO 2017 (Current Policies)	Nov-17	-	106	112	-	122
EIA IEO 2017 (Reference)	Sep-17	100	102	104	108	113
EIA IEO 2017 (High oil price)	Sep-17	95	98	101	105	110
EIA IEO 2017 (Low oil price)	Sep-17	102	106	108	112	117
OPEC WOO 2017 (Reference)	Oct-17	101	104	107	110	111
BP Outlook 2018 ET Scenario*	Feb-18	102	106	109	110	109
BP Outlook 2018 FT Scenario*	Feb-18	-	-	101	-	92
BP Outlook 2018 EFT Scenario*	Feb-18	-	-	96	-	80
Statoil - Low demand - Renewal scenario	Jun-17	-	-	93	-	-
Statoil - Reference demand - Reform scenario	Jun-17	-	-	109	-	-
Statoil - High demand - Rivalry scenario	Jun-17	-	-	115	-	-
IEEJ Reference Scenario*	Oct-17	-	-	111	-	129
IEEJ Advanced Technologies Scenario*	Oct-17	-	-	102	-	102
ExxonMobil Outlook for Energy**	Feb-18	102	108	112	115	117
Winning et. al (2018)[33] NDC Scenario***	May-18	99	106	111	115	116
Winning et. al (2018) B2D Scenario***	May-18	99	93	86	82	75
Winning et. al (2018) T15 Scenario***	May-18	99	88	81	78	72
Shell Sky Scenario****	Mar-18	105	110	106	103	101
	Crude oil					
DNV GL Energy Transition Outlook 2017	Sep-17	83	83	81	76	68
Carbon Tracker High Demand*	Feb-17	92	-	95	-	92
Carbon Tracker Medium Demand*	Feb-17	90	-	89	-	82
Carbon Tracker Low Demand*	Feb-17	88	-	88	-	79

* Data provided in MToe and converted using a MToe to mb/d of 0.02

[33] Winning M., Pye S., Glynn J., Scamman D., Welsby D. (2018) How Low Can We Go? The Implications of Delayed Ratcheting and Negative Emissions Technologies on Achieving Well Below 2 °C. In: Giannakidis G., Karlsson K., Labriet M., Gallachóir B. (eds) Limiting Global Warming to Well Below 2 °C: Energy System Modelling and Policy Development. Lecture Notes in Energy, vol 64. Springer, Cham

** Data provided in QBTU and converted using a QBTU to mb/d conversion factor of 0.54
*** Data provided in PJ and converted using a PJ to mtoe conversion factor of 0.024
**** Data provided in EJ and converted using an EJ to mtoe conversion factor of 23.9

Gas

The different geographical coverage of "Europe" by other organisations make it difficult to compare demand scenarios on a like for like basis. BEIS have conducted analysis comparing adjusted European demand which has been tested with the Expert Panel to allow for the difference in coverage. Table below shows Global Gas Demand scenarios where comparisons can be made.

Global Gas Demand Scenarios (bcm)						
Source	**Published**	**2020**	**2025**	**2030**	**2035**	**2040**
IEA WEO 2017 (New Policies Scenario)	Nov-17	3635	4174	4545	4950	5304
IEA WEO 2017 (Current Policies)	Nov-17	3635	4270	4720	-	5704
IEA WEO 2017 (Sustainable Development Scenario)	Nov-17	3635	4127	4269	-	4217
BP Outlook 2018 - ET Scenario*	Feb-18	3927	-	4609	-	5229
BP Outlook 2018 - FT Scenario*	Feb-18	-	-	4088	-	4056
BP Outlook 2018 - EFT Scenario*	Feb-18	-	-	3763	-	3464
ExxonMobil Outlook for Energy 2018**	Feb-18	3824	4164	4473	4705	4908
EIA International Energy Outlook 2017***	Sep-17	3591	3908	4206	4596	5013
Statoil Energy Perspectives 2017 Renewal Scenario	Jun-17	-	-	3652	-	-
Statoil Energy Perspectives 2017 Reform Scenario	Jun-17	-	-	4188	-	-
Statoil Energy Perspectives 2017 Rivalry Scenario	Jun-17	-	-	4167	-	-
DNV GL Energy Transition Outlook 2017	Sep-17	4116	4361	4395	4394	4311
IEEJ Reference Scenario*	Oct-17	-	-	4272	-	5056
IEEJ Advanced Technologies Scenario*	Oct-17	-	-	3982	-	4418
Carbon Tracker High Demand*	Feb-17	4239	-	4559	-	5736
Carbon Tracker Medium Demand*	Feb-17	4256	-	4431	-	5015
Carbon Tracker Low Demand*	Feb-17	4217	-	4646	-	4622
Winning et. al (2018) NDC****	May-18	3747	4216	4642	4861	5034
Winning et. al (2018) B2D****	May-18	3747	3752	4106	3953	3789
Winning et. al (2018) T15****	May-18	3747	3418	3744	3514	3340
Shell Sky Scenario*****	Mar-18	3967	4397	4590	4598	4372

* Mtoe converted to bcm using a conversion factor of 1.11
** QBTU converted to bcm using a conversion factor of 28
*** tcf converted to bcm using a conversion factor of 28.32
**** PJ converted to bcm using a conversion factor rate of 0.026
***** EJ converted to bcm using a conversion factor rate of 26

Coal

External Scenarios of European demand for coal, 2025-2040 (Mt)[34]				
Source	**Published**	**2025**	**2030**	**2040**
IEA WEO 2017 (New Policies)	Nov-17	447	382	285
IEA WEO 2017 (Sustainable Development)	Nov-17	306	218	155
IEA WEO 2017 (Current Policies)	Nov-17	501	456	406
EIA International Energy Outlook 2017 (Reference)*	Sep-17	500	491	487
IEEJ 2018 Outlook (Reference)**	Oct-17	-	685	615
AER Global Energy Market Forecasts (Reference)	Mar-18	423	366	310
AER Global Energy Market Forecasts (High)	Mar-18	422	358	284
AER Global Energy Market Forecasts (Burnout)	Mar-18	396	324	234

* EIA figures exclude non-OECD Europe

** IEEJ figures include Eurasia

[34] To note: These figures represent scenarios of overall European coal demand, including steam, lignite and metallurgical coal. By contrast, Figure 7 above details scenarios for European demand (and supply) for thermal coal imports.

Annex C – Comparison of prices with key external organisations

The tables below compare price assumptions of different institutions focusing on those that present a range of price assumptions and where information is publicly available. Clearly there is a wide range of views driven by alternative views on states of the world and underlying assumptions. What is clear, however, is that in general BEIS Low assumptions fall within the range of views presented by other institutions. However, relative to others, BEIS's Central and High oil price assumptions are generally lower than others as the fundamental underlying assumption is that the supply side will be responsive to high prices in the long run and drive prices towards marginal costs of extraction.

Oil

Prices in 2018 $/bbl					
	BEIS Low	**IEA Sustainable Development**	**EIA low oil price**	**External Assumptions***	
2020	50	69	33	56	
2030	60	72	39	52	
2040	60	67	47	33	
	BEIS Central	**IEA New Policies**	**EIA Reference**	**External Assumptions***	
2020	72	75	73	64	64
2030	85	98	97	77	77
2040	85	116	110	75	
	BEIS High	**IEA Current Policies**	**EIA high oil price**	**External Assumptions***	
2020	94	78	128	68	
2030	120	118	193	101	
2040	120	142	220	121	

Sources:
IEA World Energy Outlook 2017
EIA International Energy Outlook 2017
**Wood Mackenzie (Dec 2017) and Aurora Energy Research (July 2018)*

Gas

Prices in 2018 p/therm				
	BEIS Low	**IEA Sustainable Development**	**External Assumptions***	
2020	40	46	46	
2030	36	54	64	
2040	36	58	73	
	BEIS Central	**IEA New Policies**	**External Assumptions***	
2020	53	49	51	31
2030	63	62	71	61
2040	63	70	77	
	BEIS High	**IEA Current Policies**	**External Assumptions***	
2020	72	50	56	
2030	78	68	91	
2040	78	77	109	

Sources:
IEA World Energy Outlook 2017
**Wood Mackenzie (Dec 2017) and Aurora Energy Research (July 2018)*

Coal

Prices in 2018 $/tonne				
	BEIS Low	**IEA Sustainable Development**	**External Assumptions***	
2020	58	73	76	
2030	66	67	57	
2040	66	67	29	
	BEIS Central	**IEA New Policies**	**External Assumptions***	
2020	86	76	74	73
2030	87	83	71	73
2040	87	85	70	
	BEIS High	**IEA Current Policies**	**External Assumptions***	
2020	113	77	77	
2030	117	89	98	
2040	117	99	119	

Sources:
** Aurora Energy Research (July 2018) and Wood Mackenzie (Dec 2017)*