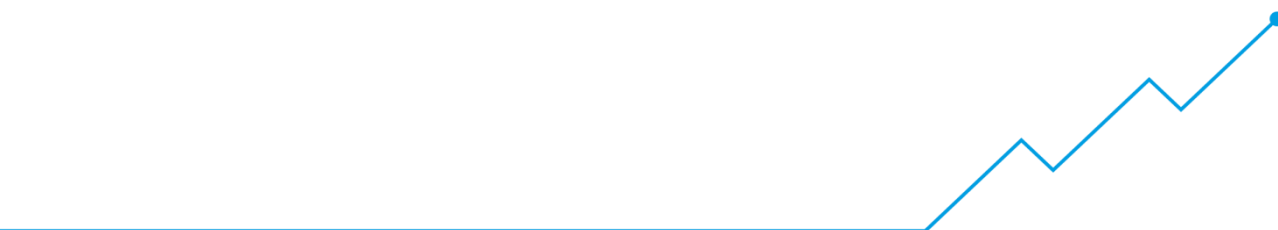




Department for
Business, Energy
& Industrial Strategy

BEIS 2016 FOSSIL FUEL PRICE ASSUMPTIONS



November 2016

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Any enquiries regarding this publication should be sent to us at fossilfuelspriceassumptions@beis.gov.uk.

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Introduction

1. This note presents an update to BEIS's long-term price assumptions for oil, gas and coal.
2. Making assumptions about fossil fuel prices far into the future is – needless to say – very challenging, as they depend on a large number of 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 so as 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.
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. This year 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 document¹.

¹ At <https://www.gov.uk/government/publications/fossil-fuel-price-assumptions-2016>

Methodology and Approach

Overall Methodology and Approach

1. The overall approach for each fuel is :
 - a market based view over the short-term using futures and options² 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.
2. 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 discovery³.
3. 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) methodology for policy appraisal. Long term fossil fuel price assumptions are intended to reflect average price levels over a decade or more.
4. This year we commissioned Wood Mackenzie to produce long run supply curves for each fuel and detail the underlying assumptions. See their report at⁴. The ITT and Wood Mackenzie's proposal can be found here⁵. The aim of the analysis was to depict long run supply curves for fossil fuels, which when combined with projections of demand generate assumptions for long term fossil fuel prices consistent with the full long-run costs of the marginal sources of supply. This included a plausible range of uncertainty around the supply curves (and demand for fossil fuels) sufficient to construct low and high as well as central assumptions for long term fossil fuel prices. A key element of the requirement and proposal included imposing the assumption that from a long term perspective, with all factors of production flexible, higher prices would incentivise exploration and development activity and bring forward supply. Wood Mackenzie have therefore adjusted their in-house view to fit BEIS' requirements.

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 issued forward prices for the first two years of the assumptions.

⁴ At <https://www.gov.uk/government/publications/fossil-fuel-price-assumptions-2016>

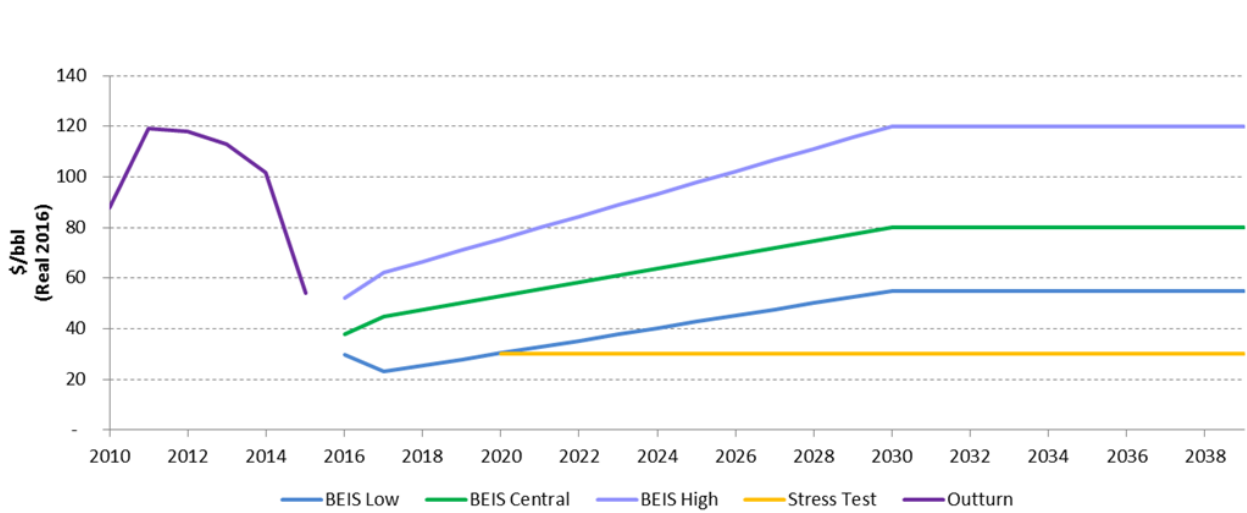
⁵ <https://www.contractsfinder.service.gov.uk/Notice/ba3320e9-d216-497c-9eba-aaddfcb50dfa>

5. For each fuel we have combined the three long term supply outlooks (from Wood Mackenzie) with three demand projections (from three long term scenarios by the International Energy Agency (IEA)). 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 450 Scenario. The New Policies Scenario is their central scenario and takes into account policies and interventions that have been adopted as of mid-2015 in addition to other relevant declared policy interventions. The Current Policies simply takes into account policies already enacted (as of mid-2015). The 450 Scenario depicts a pathway to the 2°C climate goal 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 450 Scenario for low demand assumptions.
6. Combining high supply with the low demand 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 projections and supply outlooks are from different sources, we considered these combinations to be plausible for each fuel.
7. The price assumptions for intermediate years 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

	2016 BEIS oil price assumptions			
\$/bbl (Real 2016)	Stress test	Low	Central	High
2016		30	38	52
2017		23	45	62
2018		25	48	67
2019		28	50	71
2020	30	30	53	75
2021	30	33	56	80
2022	30	35	58	84
2023	30	38	61	89
2024	30	40	64	93
2025	30	43	67	98
2026	30	45	69	102
2027	30	48	72	107
2028	30	50	75	111
2029	30	53	77	116
2030	30	55	80	120
2031	30	55	80	120
2032	30	55	80	120
2033	30	55	80	120
2034	30	55	80	120
2035	30	55	80	120
2036	30	55	80	120
2037	30	55	80	120
2038	30	55	80	120
2039	30	55	80	120
2040	30	55	80	120

Figure 1: BEIS Oil Price Assumptions



Context

8. By early 2015 the oil price had fallen by roughly 60% from its June 2014 high above \$115/bbl for front-month ICE Brent to below \$46/bbl in January 2015. The price drop was driven by a combination of stronger than anticipated non-OPEC supply, namely US light tight oil, and weaker than expected demand growth. In late November 2014 prices dropped further as OPEC (Saudi Arabia) signalled to the market that it would not act to restrain output, indicating market expectations adjusted to this confirmation that there would be no immediate balancing of the market to dampen the excess supply.
9. Prices rose from mid- January 2015 to May 2015 but fell in the second half of 2015 as expectations of when the market might balance shifted, as OPEC supply increased during 2015 and the outlook for global economic growth softened. Prices ended 2015 around \$35/bbl amidst a growing expectation that prices will stay low for some time as excess supply persists. Prices remained volatile in early 2016, averaging \$35/bbl in the first quarter.

Cycles and Volatility

10. In the short term, as both supply and demand are fairly unresponsive to prices, they can be very volatile in response to unexpected shocks. The three key uncertainties we see affecting prices in 2016 (short term) are the rate of global growth, the rate of contractions in non-OPEC supply—particularly US shale oil--and continuing uncertainty surrounding the volume and timings of additional Iranian production.
11. In general price cycles and volatility over the medium term can be fed by feedback loops both on the demand and on the supply side. Persistently 'high' oil prices can dampen oil demand through income and price effects and can be a drag on economic growth for oil importers which in turn puts downward pressure on oil demand. On the supply side high prices induce more investment in the sector albeit with a lag. These serve to make long run prices well above marginal costs of production unsustainable and prices exhibit volatility in the short and medium term. Conversely, persistently low prices can induce feedback mechanisms that can act to maintain a floor on prices as demand responds and investment in future supply is discouraged. The set of BEIS assumptions captures a range of these plausible oil market dynamics through periods of relative looseness/tightness, but does not attempt to model price cycles.

Approach

12. The approach used to create BEIS's oil price assumptions combines: (a) futures prices and options data for the short term and (b) evidence on the long run costs of oil production and estimates of long run oil demand to arrive at a long run equilibrium price. The reason for using futures prices over the short term (2016-2017) is that they reflect expectations of market participants about oil supply and demand over this time horizon. In the long run the price assumptions are anchored at the expected cost of marginal oil supplies at projected levels of global oil demand. This is a long run market equilibrium condition. The table below summarises the approach which is explained in more detail subsequently.

	Short term (2016-2017)	Medium term (2018-2030)	Long term 2030-2040
Stress Test	Remains flat at \$30		
Low	Using Options implied distribution to derive range	Interpolate to Long Run Low	IEA 450 scenario demand intersected with BEIS high supply curve
Central	Futures curve	Interpolate to Long Run Central	IEA New Policies scenario demand intersected with BEIS central supply curve
High	Using Options implied distribution to derive range	Interpolate to Long Run High	Inelastic portion of the low supply curve

13. The assumptions based on this evidence are compared with demand projections and price forecasts of other organisations (see Annex B and C) which BEIS uses to shape its judgement. Whilst it is beyond the scope of this report to analyse the projections 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 2016 US Dollars. Long run values are rounded to the nearest multiple of US\$5.

Short Term

14. For the central assumption, the oil price in 2016 (starting value) is based on the Brent futures curve for 2016 (combining the average during March 2016 of the nine monthly contracts for April to December 2016 and the average outturn price for one month Brent from 1st January to 31st March). The 2017 central assumption is based on the corresponding twelve monthly futures contracts for January to December 2017 (averaging over data from March 2016 as a whole).

15. Whilst evidence suggests that futures prices provide only very imprecise forecasts of future spot prices, they are likely to reflect expectations of market participants of the path of these future prices. Part of their poor forecasting performance is that often 'exogenous' or unexpected developments in the market result in outturn prices being far off from a priori expectations. We use the futures curve on the premise 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. We have opted to use the futures curve for the first two forecast years, because beyond this horizon liquidity (the volume of traded contracts) begins to fall and therefore may not offer the same opportunity for price discovery. In any case, using the futures beyond 2017 suggests a profile similar to the central assumption we have used.

16. High and Low assumption starting prices for 2016 and 2017 are derived as a range around this central price using estimated implied probability distributions from options provided by the Bank of England⁶ based on data available at the end of March 2016. Using these implied distributions we have selected a confidence level of 75% i.e. suggesting that at the end of March 2016 the market attached a 75% likelihood that the oil price will fall within the implied range for each of 2016 and 2017. The choice of the 75% confidence interval is designed to reflect plausible alternative outcomes for the oil price rather than focusing on the extremes (which would result for example from using a 95% confidence interval). For example, using a 75% confidence interval means that in three years out of four we would expect actual prices to remain within the high to low range, whereas as a 95% confidence interval would on average capture developments in 19 out of 20 years.

Medium Term

17. Prices for high, central and low assumptions from 2018 to 2030 are linearly interpolated to the long run prices. These prices are explained in more detail below.

Long Term

18. In the long term we assume that oil supply is responsive to price and that any large rents in the market would incentivise increased exploration activity and production that would compete away at least some of these excess profits. This assumption is consistent with recent experience in the market.

19. We use data from Wood Mackenzie to derive supply curves⁷ with which we intersect estimates of demand to arrive at an implied long run (2030) equilibrium price. This is a simple framework, but one that is designed to capture the condition that in the long run the price will equal the long run marginal cost of extraction at the given level of demand. In this framework all factors of production are considered variable and there is full mobility of labour and capital. To capture the uncertainty over the long term and a plausible range of alternative supply cases Wood Mackenzie derived sensitivities around the central supply curve to establish a 'low supply' and a 'high supply' case.

20. The uncertainties and sensitivities that have been flexed by Wood Mackenzie to capture the uncertainty over the composition of the supply curve have three key elements.

- a. *Investment intensity in low cost barrels predominantly in the Middle East.* An important structural characteristic of the oil market is that the majority of the low cost producers are in the Middle East (and members of OPEC) and face production costs well below the marginal sources of supply. While it is widely

⁶ 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>

⁷ See the Wood Mackenzie report at <https://www.gov.uk/government/publications/fossil-fuel-price-assumptions-2016>

assumed that non-OPEC suppliers behave competitively, OPEC suppliers, largely National Oil Companies, may choose alternative production and investment strategies to meet strategic domestic priorities and take advantage of their relatively low production costs. As a result the assumed production and investment profile of low cost producers is an important consideration when analysing the implied supply curve as it ultimately determines the shape. The central case illustrates a view of productive capacity from OPEC, with no significant constraints on production in the long run⁸. The 'high supply' case assumes the same level of OPEC production as the central. The 'low supply' case assumes some OPEC spare production capacity is held or OPEC does not pursue as aggressive an investment strategy as the central/high supply cases.

- b. *Light tight oil production growth.* Tight oil production in the USA has consistently exceeded prior expectations and was a significant contributing factor to the fall in the price in 2014. Moreover, its relative resilience in a low price environment has also 'surprised' the market. Given tight oil production remains a relatively new phenomenon, the outlook for tight oil production is particularly uncertain and the volume of production from tight oil has been treated as a key source of variation in the Wood Mackenzie supply curves. The 'low supply' case assumes that light tight oil production is lower than anticipated relative to the base case whilst the 'high supply' case assumes the reverse.
- c. *Exploration and development of the resource base.* Over the long term a key uncertainty is the volumes that are likely to come from as yet non-producing fields and will be driven by exploration intensity. The 'low supply' case assumes 20% lower exploration from the base case whilst the 'high supply' case assumes 20%⁹ more exploration and corresponding volumes from non-producing fields.

21. To derive our long run equilibrium price we combine the 2030 supply curves provided by Wood Mackenzie with the following 2030 IEA demand projections from their World Energy Outlook 2015:-

- Current Policy Scenario: 110mb/d
- New Policy Scenario: 103mb/d
- 450 Scenario: 92mb/d

Central Price Assumption

⁸ This is a difference from Wood Mackenzie's in-house view. See the Oil Supply Cost Curves – Additional Assumptions section of the Wood Mackenzie report for the adjustments to the Wood Mackenzie in-house base case made to create the base case for BEIS.

⁹ 20% was arrived at through discussions with Wood Mackenzie to derive a credible sensitivity that captured a sufficient range of uncertainty

22. For the 2030 Central price assumption we combine the IEA New Policies demand scenario with the central supply curve for 2030 produced for BEIS. We have therefore assumed for the central assumption that in the long run the supply side is relatively flexible and responsive to any periods of relatively high real oil prices, in line with recent experience. In addition, following advice of the expert panel, we have adjusted the central supply curve to reflect the risk that geopolitical factors and other above ground constraints can serve to restrict supply below that implied by the overall production potential in the Wood Mackenzie supply curve. As a result we have risked the volume of production from some producer countries to reflect these potential constraints and loss of long run productive capacity. This adjustment totals 3mb/d¹⁰. This has the effect of increasing the long run price by around \$5/bbl.

Low Price Assumption

23. The low price assumption is illustrative of a world where there is substantial demand reduction due to for example aggressive policy action to mitigate climate change or much lower oil intensity than expected. For the 2030 Low price assumption we combine low demand with high supply: the IEA 450 scenario demand (the lowest level of oil demand of the three IEA scenarios) and the 'high supply' case provided by Wood Mackenzie.

High Price Assumption

24. The 2030 High price assumption reflects a world where supply is less responsive to prices than the central assumption, such as given by the 'low supply' case provided by Wood Mackenzie combined with relatively high demand, for example in a range of 100-110mb/d (the IEA Current Policy scenario is towards the top of that range). The 'low supply' case assumes a lower proportion of 2030 liquids production comes from undiscovered fields and that tight oil growth is lower than the central case. Altering these assumptions shifts the supply curve inwards and there are less infra-marginal barrels produced.

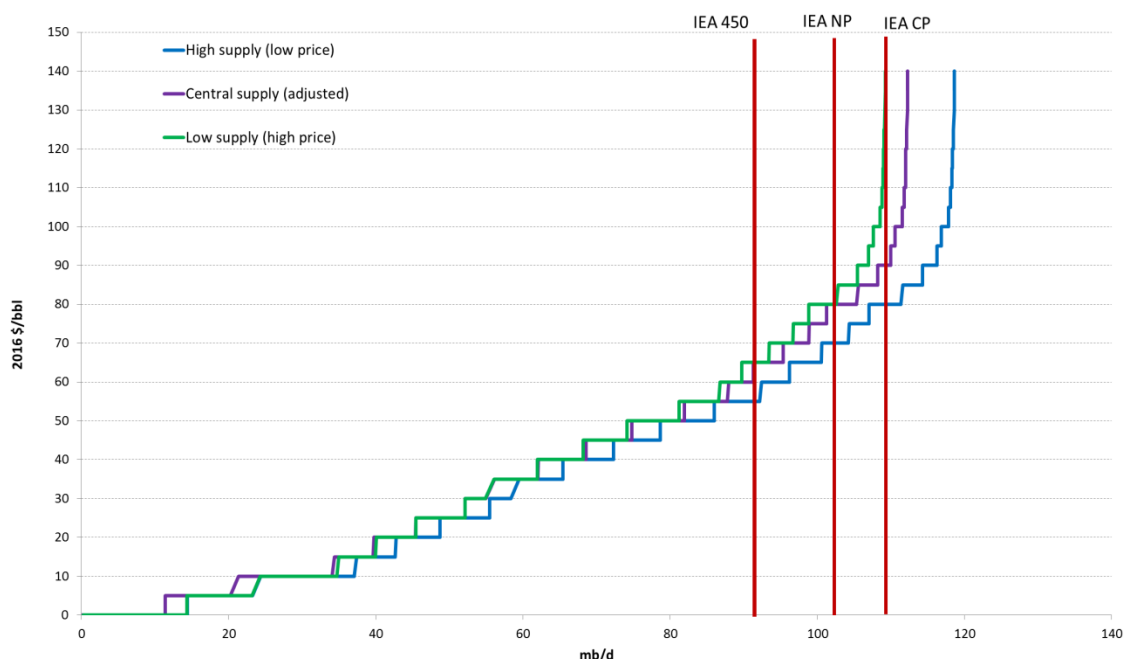
25. At levels of demand in the range 100-110mb/d the 'low supply' curve is increasingly steep. As the Wood Mackenzie report notes there are some caveats around these sections of the supply curves. "As you move towards the right of the curve the price increases and this price increase will have the tendency to introduce further additional investment above the Wood Mackenzie base view which could increase lower cost supply beyond that modelled. Moreover – the shape of the supply curve at the extreme is largely a function of expectations. In a world of higher expected prices, over the long run we would expect the supply curve to extend and to continue to be responsive to price". It is difficult, however, to quantify this impact as the resources that would become considered for development in a world of persistently high prices may not be currently under detailed consideration and there may be less or little data and evidence on them. Nevertheless, it is also important to note that that a modelled long run

¹⁰ The countries that have been adjusted to reflect loss of productive capacity are Nigeria, Libya and Venezuela all by around 1mb/d each.

equilibrium price on the very steep sections of the supply curves, for example above \$120/bbl, is unlikely to reflect the long run potential for supply to respond to price and is therefore unlikely to be a stable price in practice.

26. The supply curves and relevant IEA demand projections are illustrated below.

Figure 2: Long run oil supply curves provided by Wood Mackenzie¹¹ with IEA demand projections



Source: Wood Mackenzie, IEA and BEIS inference

27. The assumptions for years 2018 to 2030 are linearly interpolated to long run prices and remain flat thereafter. This trajectory is clearly a simplification, and the market is likely to see much more complex dynamics. However, a key focus of the BEIS assumptions is on the long run level of the real oil price rather than shorter term market dynamics.

Low “Stress Test”

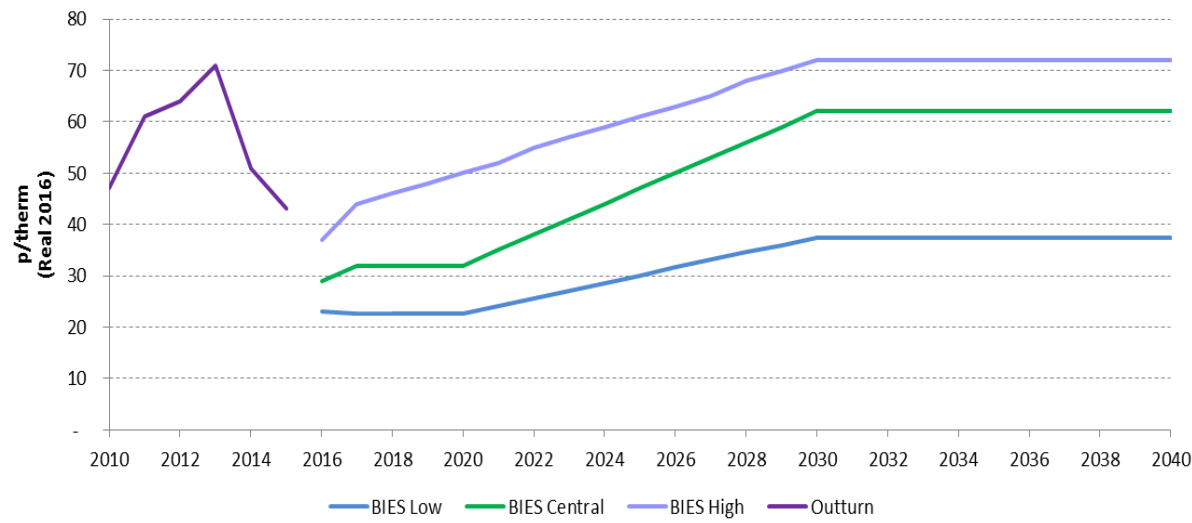
28. The “low stress test” price scenario is designed to assess policies in a world of sustained low oil prices. It reflects the historical experience that the oil price can deviate from the evidence on long run equilibrium values for long periods, as it did from the mid-1980s (following a significant change in Saudi supply strategy) after which it did not recover until the early years of this century (with growing Asian demand). The stress test assumes oil prices stay flat in real terms at around \$30 (the average level of the real oil price during the period 1986 to 2003). However, the cost structure of the industry appears to have increased significantly since this period.

¹¹ Aggregating to \$5 tranches.

Gas Price Assumptions

p/therm	Low	Central	High
2016 prices			
2016	23	29	37
2017	23	32	44
2018	23	32	46
2019	23	32	48
2020	23	32	50
2021	24	35	52
2022	26	38	55
2023	27	41	57
2024	29	44	59
2025	30	47	61
2026	32	50	63
2027	33	53	65
2028	35	56	68
2029	36	59	70
2030	38	62	72
2031	38	62	72
2032	38	62	72
2033	38	62	72
2034	38	62	72
2035	38	62	72
2036	38	62	72
2037	38	62	72
2038	38	62	72
2039	38	62	72
2040	38	62	72

Figure 3: BEIS 2016 Natural Gas Price Assumptions



Context

29. Gas markets have traditionally been regional in nature with three separate major gas markets: North America where gas prices are largely set at the liquid trading hubs (e.g. Henry Hub), Europe where long-term contracts (oil-linked and hub-based) dominate the market, and the Asian market where gas is largely supplied through long term oil-linked contracts¹².
30. The differences in regional gas prices reflect primarily different demand and supply balances, different pricing systems and a lack of physical connection due to limitations in transporting gas. According to the International Gas Union in 2014 43% of total world gas consumption was priced using gas-on-gas competition. Oil price linked mechanisms accounted for 17%.
31. The UK is strongly connected to European gas markets through major infrastructure links which combined with the impact of LNG imports have resulted in price convergence between UK and North West European gas markets. In 2014, the European¹³ natural gas market was supplied by domestic production including Norway (about 55%), piped gas primarily from Russia (30%), North Africa (5%) and LNG (10%), primarily from Qatar¹⁴. Over time, Europe's gas import dependency is set to increase due to declining domestic production and a moderate recovery in demand¹⁵.
32. The European market is linked to other gas markets, particularly Asian gas markets through LNG trading. Over the past 12 months increasing LNG export capacity and weaker than anticipated demand in Asia has led to a loosening of the LNG market resulting in increased volumes of LNG becoming available to Europe. European LNG import infrastructure is under-utilised at present implying that there is potential to increase imports in the future. A number of new LNG export projects are currently under construction, including in Australia and the US - these will become operational over the next few years, and will further build on the existing strong global supply.
33. The UK gas wholesale spot price has fallen over the last three years: averaging 43p/therm during 2015, compared with 51p/therm in 2014 and 71p/therm in 2013¹⁶. Falls in the gas price are a result of strong LNG supplies including projects coming on line in Australia (with further projects to come on line in 2016 in the US), mild weather, weak demand in Europe and Asian markets, and lower oil prices.
34. There is uncertainty about how European gas prices could develop over the medium and long term as they are influenced by a number of factors. Global LNG capacity is expected to grow strongly to 2020 and therefore even with demand growth the market is likely to be well supplied into the early 2020s. However, there are major uncertainties

¹² IGU World LNG Report 2016 and IGU 2015 Wholesale Gas Price Survey

¹³ Including Norway. See definition of Europe used for this work in Annex E .

¹⁴ IEA, Natural Gas Information 2015

¹⁵ IEA, World Energy Outlook 2015

¹⁶ Argus Direct – Real 2016 prices

around Russia's pricing strategies and developments in US and Asian demand, which in turn could affect the amount of LNG available to enter the European market.

35. Other uncertainties include production in Norway and North Africa, which will also impact European prices. Norwegian production is estimated by the IEA to fall by around 30% from 2013 to 2040. That said, despite maturing major natural gas fields in the North Sea, Norway has been able to continue to increase natural gas production over the last two decades¹⁷. This combined with Norway's proximity to the European market, suggests that Norway will continue to play an important role in the European gas market. The IEA's outlook for North Africa has deteriorated, given the political instability in Libya and slow progress in developing new sources of Algerian gas production.

Approach

36. 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 a long run implied equilibrium price.

37. The reason for using forward prices over the short term (2016-2017) 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. The table below summarises the approach which is explained in more detail in subsequent sections.

¹⁷ EIA Norway country review & Gassco announcement on 5th April 2016 to increase production capacity by 5.7 mcm per day

	Short term (2016-2017)	Medium term (2018-2030)	Long term 2030-2040
Low	Using Options volatility to derive range	Flatline to 2020 then interpolate to Long Run Low	IEA 450 scenario demand intersected with BEIS high supply curve
Central	Forward curve	Flatline to 2020 then interpolate to Long Run Central	IEA New Policies scenario demand intersected with BEIS central supply curve
High	Using Options volatility to derive range	Interpolate to Long Run High	IEA Current Policy scenario demand intersected with BEIS low supply curve

38. The assumptions based on this evidence are compared with the demand projections and price forecasts of other organisations (see Annex B and C) which BEIS uses to inform its judgement. Whilst it is beyond the scope of this report to analyse the projections 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 2016 prices (pence/therm).

Short Term

39. The central gas price assumption for 2016 is calculated as a weighted¹⁸ average of NBP spot prices for Q1 2016 and the quarterly forward curves for Q2, Q3 and Q4 2016, averaging the data over the period from 11th February 2016 to 23rd March 2016. The 2017 central assumption is based on the average of the corresponding four quarterly forward contracts (Q1, Q2, Q3 and Q4 2017) using the same data period.

40. Whilst evidence suggests that forward curves provide only very imprecise forecasts of future spot prices, they are likely to reflect expectations of market participants of the path of these future prices. Part of their poor forecasting performance is that often 'exogenous' or unexpected developments in the market result in outturn prices being far

¹⁸ The weights are represented by the number of months (e.g. the weight for Q2 is 3/12).

off from a priori expectations. We use the forward curve on the premise 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. On the advice of the expert panel, we have opted to use the forward curve for the first two forecast years, because beyond this horizon liquidity (the volume of traded contracts) begins to fall and therefore may not offer the same opportunity for price discovery.

41. High and Low prices are derived as a range around the 2016 and 2017 central price assumptions using data on NBP options volatility (see Annex D for more information). Using implied volatility, we have selected a confidence level of 75% i.e. suggesting that the market at March 2016 attached a 75% likelihood that the gas price will fall within the implied range for each of 2016 and 2017. The choice of the 75% confidence interval is designed to reflect plausible alternative outcomes for the gas price rather than focusing on the extremes (which would result for example from using a 95% confidence interval).

Medium Term

42. For the central and low price assumptions, we flat line prices in 2018 to 2020 at their 2017 level. In the short term the market is considered to be out of (long term) equilibrium. Forward prices and external projections imply this will take longer than 2 years to resolve, as seems consistent with for example the increased LNG supply due to be commissioned over the rest of this decade. Flat lining for 2018-2020 allows more time for the market to start to adjust towards the long term prices. We have flat lined rather than using the forward curve for 2018 to 2020 as given limited market liquidity for these years, we judge that 2017 forward prices are a more reliable data point and guide to market future expectations for this period.
43. We also tested the low price assumptions for this period against a potential “price floor” of short term US LNG export cash costs – this reflects a floor price at which US LNG imports would be curtailed which would be expected to support prices. While there are some uncertainties in estimating this floor price¹⁹, the values suggested are similar to our low price assumptions.
44. After 2020 the central and low price assumptions are linearly interpolated to their long run equilibrium values in 2030.
45. For the high price assumption, we assumed faster adjustment of prices towards the (higher) long term equilibrium, for example reflecting more rapid growth in demand tightening the market more quickly, and therefore the high price assumption has been constructed by linearly interpolating from 2018.

¹⁹ Cash cost breakdown of US LNG to Europe suggested by the Panel members: Henry Hub price + 15% per contracts + \$0.3 for shipping costs + \$0.4 regasification costs + \$0.0 liquefaction cost. Based on Henry Hub prices at around \$2, the price floor is estimated to be around \$3/mmbtu (or 20p/therm).

Long Term

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 markets²⁰. The supply curves have been built up from breakeven costs for investment/long run marginal costs for the key categories of supply.

47. Wood Mackenzie captured some of the uncertainty of the composition of the supply curve by varying three key variables:

- a. *Russia's market strategy*: Russia has traditionally held a high share of the European gas market and this dominant position allows it some flexibility in terms of the price it charges for its gas. However, recent dynamics in the global gas market (e.g. more competition from other gas suppliers) means that Russia may need to rethink its pricing strategy to either retain market share or maximise its revenue.²¹

Wood Mackenzie considered three possible Russian pricing strategies: target price, marginal cost and a hybrid strategy. Under a target price strategy, Russia targets profitability above market share. A marginal cost strategy would allow Russia to maximise its market share. Under the Hybrid strategy, gas is priced at marginal cost for supplies that are on-stream and under development, while Russia targets a price for future developments which allows Russian probable supply to come into Europe at a price that balances a pure profit based approach with the need to ensure volumes in the market to deter a loss of market share to competitors (i.e. just below the cost of marginal competitors for future developments).

- b. *US LNG prices*: US LNG is a key uncertainty as to how the European gas market will evolve in the medium and long term. The IEA expect the US market to be very dynamic for global production, with abundant availability of relatively cheap gas entering the global market over the next decade. However, from the mid-2020s, the IEA expect a gradual depletion of the US resource base leading to a rise in Henry Hub prices. The potential size of US exports, their pricing flexibility²², 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 Henry Hub price plus the price of delivery to Europe – this includes liquefaction, shipping and re-gasification. Wood Mackenzie have assumed Henry Hub prices to be around \$ 4.8/mmbtu for the central case and have flexed long run US LNG prices by assuming the

²⁰ At <https://www.gov.uk/government/publications/fossil-fuel-price-assumptions-2016>

²¹ In fact, despite Russian pipeline gas been generally sold using long term oil-linked contract, in recent years it has shown a level of flexibility by offering rebates and discounts.

²² The US allows contract buyers to source gas on a Henry Hub rather than an oil-indexed price basis. They also allow buyers complete destination flexibility to respond to prevailing global spot price signals.

2030 Henry Hub price could be \$1/mmbtu higher or lower than the central assumption.

- c. *Extra LNG available to enter the European market:* As the gas market is becoming more global, the amount of LNG available to Europe is affected by demand for LNG in other markets, particularly in the Asian market. Wood Mackenzie estimated that in a high supply scenario an additional 85 bcm of LNG could enter the EU market compared with the central case. The US would account for 40% of it, Qatar for 20% and a combination of other suppliers for the rest.

48. Based on the long run market balancing condition that the market price that consumers are willing to pay must cover the cost of the marginal supply if investment in that capacity is to be made, we anchored 2030 price projections around the point at which the estimated costs of marginal supplies meet projected levels of European gas demand. European gas demand is based on regionally-adjusted projections from the three IEA scenarios. See Annex E for more information on how we adjusted IEA demand projections.

Central Price Assumption

49. For the 2030 Central price assumption we combine the IEA New Policies scenario demand with the central 2030 supply curve Wood Mackenzie produced for the former DECC. We have therefore assumed for the central assumption that in the long run the supply side, in particular 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.

Low Price Assumption

50. The Low price assumption is illustrative of a world where there is substantial demand reduction for fossil fuels including gas due to for example aggressive policy action to mitigate climate change. For the 2030 Low price assumption we combine low demand with high supply: the IEA 450 scenario demand (the lowest level of gas demand of the three IEA scenarios) and the 'high supply' case provided by Wood Mackenzie.

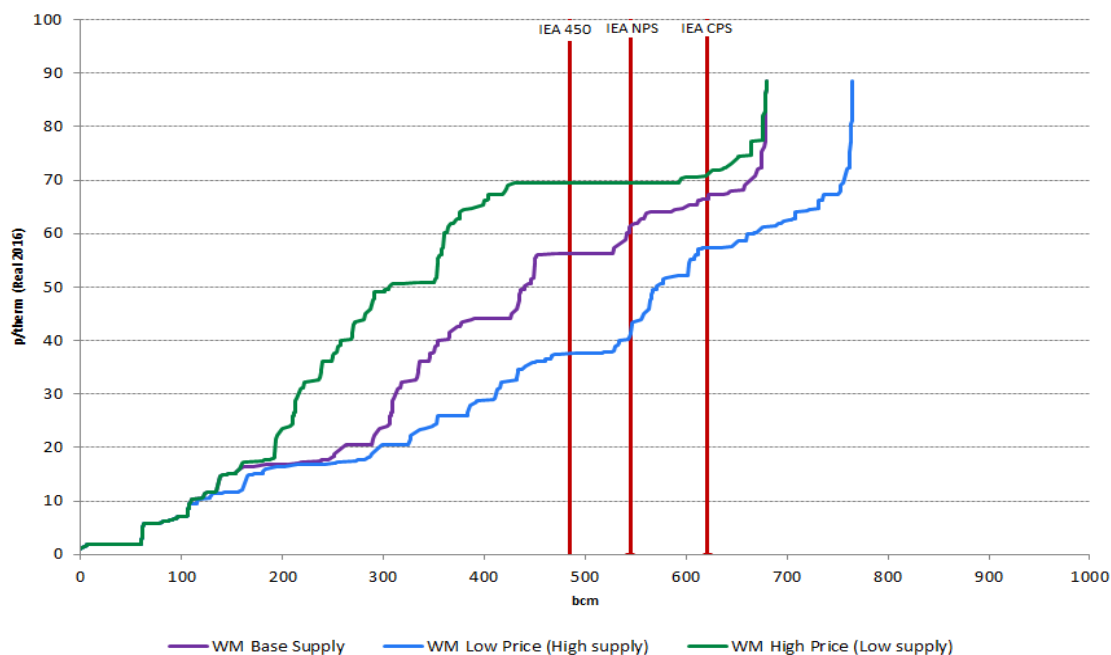
51. This demand and supply combination is plausible because if gas demand is low, it's plausible that US wholesale gas prices and US LNG costs would be lower and that Russia would be driven towards competing on price to maintain volumes.

High Price Assumption

52. For the 2030 High price assumption we combine the IEA Current Policies scenario demand level with the 'low' 2030 supply curve Wood Mackenzie produced for the former DECC. 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.

53. This demand and supply combination is plausible because if gas demand is high it is plausible that US wholesale gas prices and US LNG costs would be higher and that Russia would be able to target a price just below (higher) marginal US LNG costs to maximise profits without having to sacrifice volumes.
54. For the low, central and high assumptions, a flat line for gas prices in the period 2030-2040 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.
55. The figure below presents the implied prices by combining Wood Mackenzie supply curves and adjusted IEA OECD Europe gas demand estimates. All data are in real 2016 p/therm. The supply curves provided by Wood Mackenzie were in real 2015 \$/mmbtu, these were converted to p/therm using BEIS's standard exchange rate assumptions²³ (1.529 GBP:USD constant based on the 2015 annual average) and to 2016 prices using the OBR March 2016 forecast²⁴.

Figure 4: Long run gas supply curves provided by Wood Mackenzie combined with IEA demand projections



Source: Wood Mackenzie, IEA and BEIS inference

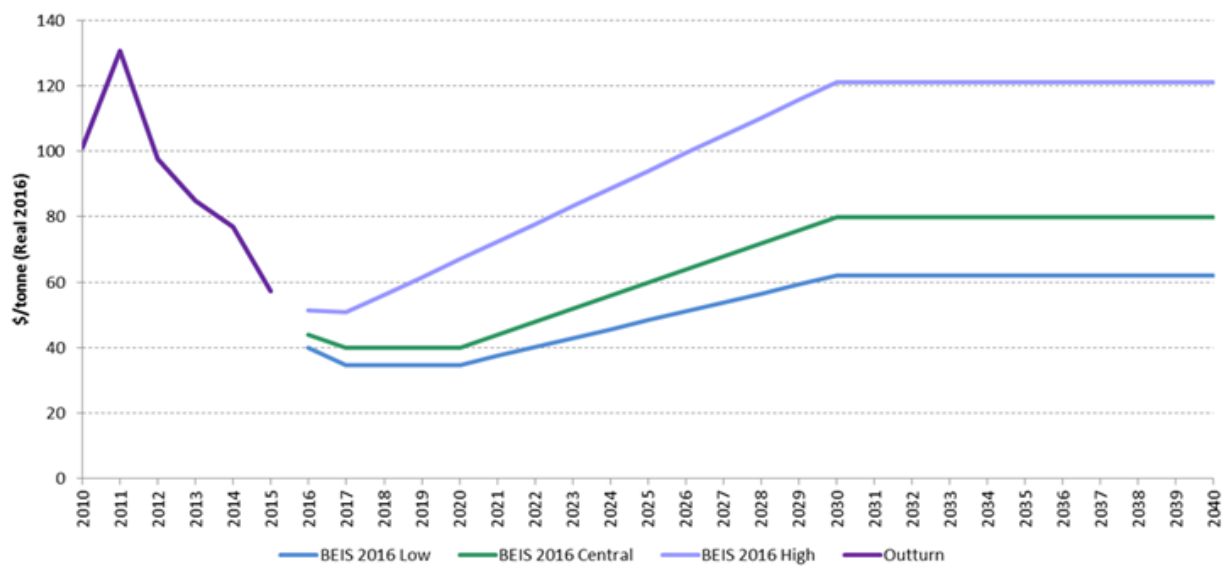
²³ <https://www.gov.uk/government/publications/valuation-of-energy-use-and-greenhouse-gas-emissions-for-appraisal>

²⁴ https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/509245/GDP_Deflators_Budget_2016_update.csv/previ
[ew](#)

Coal Price Assumptions

	2016 BEIS coal price assumptions		
\$/tonne (real 2016)	Low	Central	High
2016	40	44	51
2017	35	40	51
2018	35	40	56
2019	35	40	62
2020	35	40	67
2021	37	44	72
2022	40	48	78
2023	43	52	83
2024	46	56	89
2025	48	60	94
2026	51	64	99
2027	54	68	105
2028	57	72	110
2029	59	76	116
2030	62	80	121
2031	62	80	121
2032	62	80	121
2033	62	80	121
2034	62	80	121
2035	62	80	121
2036	62	80	121
2037	62	80	121
2038	62	80	121
2039	62	80	121
2040	62	80	121

Figure 5: BEIS 2016 Coal Price Assumptions



Context

56. These scenarios show price assumptions for steam coal, which is the predominant type of coal used in the UK's power sector and is the most traded type of coal. Whilst lignite coal is also used in the power sector, its low calorific value means international trade in lignite is very limited²⁵. The price assumptions assume a delivery point of ARA (Amsterdam-Rotterdam-Antwerp), the most commonly traded coal index in North West Europe, and allow for cost, insurance and freight (CIF).
57. Poland and Germany account for the majority of European coal production. According to the IEA, OECD European thermal and lignite coal production equated to 48% of thermal and lignite coal demand in the region in 2013 (World Energy Outlook 2015). Seaborne coal supplies to Europe are predominantly imported from South Africa, Columbia, Russia, the US and Mozambique.
58. The coal market does not experience swings in the cost of supply to the extent seen in gas and oil markets. This is down to a number of reasons; coal's low cost of extraction and the high proportion of total costs accounted for by marginal costs reduce the extent of the investment cycle; whilst less scope for technological innovation and limited strategic supplier behaviour also play a role. The price variation that does occur is typically driven by fluctuations in demand, productivity improvements and infrastructure bottlenecks (in the rail freight sector, for example). Not only does aggregate global coal demand affect coal prices, but, increasingly, disparities in demand growth rates between regions can cause suppliers to switch production from one region to another to take advantage of arbitrage opportunities, driving further price changes.
59. Environmental legislation is increasingly impacting regional coal demand, and uncertainty over the extent of future environmental legislation is a key driver of uncertainty over the future coal demand. In the EU, for example, the Industrial Emissions Directive (IED) is driving coal plant closures, and the future EUETS trajectory will be a key determinant of coal demand in the 2020s and beyond.
60. Coal prices are currently significantly lower than in previous years. Demand has been lower than expected due to the economic slowdown in China, tighter regulation of coal in Europe, and fuel switching from coal to gas in the US power sector. Supply has not yet corrected itself, with coal producers aggressively defending market share which has forced higher cost operators to sell coal at a loss. Whilst forward prices suggest that coal market participants expect prices to remain depressed in the short term, such low prices are unlikely to be sustainable in the long term. Price increases in the long term could be supported either by increasing global demand or by higher cost coal operators cutting back their supply (or entering bankruptcy).

²⁵ IEA Medium Term Coal Outlook 2015

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. Forward prices are used in the short term (2016-17) because they reflect price expectations of market participants over this period, and because short term prices can stray from prices implied by long run supply and demand fundamentals. However BEIS considers that long run marginal costs at projected levels of European coal demand is the best estimator of coal prices in the long run, and therefore assumes prices will return to long run fundamentals by 2030.

62. The table below summarises the approach taken in the low, central and high price scenarios; the methodology is explained in more detail in subsequent sections. 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 (2016-2017)	Medium term (2018-2030)	Long term (2030-2040)	Key Assumptions
Low	Using historic forecast errors using forwards to derive range	Flatline to 2020 then interpolate to Long Run Low	IEA 450 scenario demand intersected with BEIS high supply curve	Increased South African supply to Europe (50%). Demand based on IEA 450 scenario.
Central	Forward price curve	Flatline to 2020 then interpolate to Long Run Central	IEA New Policies scenario demand intersected with BEIS central supply curve	10% of South African and 5% of Mozambican coal available to Europe. Demand based on IEA new policies scenario.
High	Using historic forecast errors using forwards to derive range	Interpolation to long run high	IEA Current Policy scenario demand intersected with BEIS low supply curve	Decreased Western Russian supply available to Europe (90%). Demand based on IEA current policies scenario.

Short Term

63. The central coal price estimate in 2016 is derived from a weighted average of CIF ARA spot prices in Q1 2016, and the quarterly forward curve for Q2, Q3 and Q4 2016, averaging over the data from Q1 2016. The 2017 central coal price estimate is derived from the average of year ahead forward prices for 2017 traded over the same period (Q1 2016). 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. High and low coal prices are estimated from the historic deviation between the quarterly and year ahead forward curves and respective outturn prices between 2007 and 2015.²⁶ The high price scenario is based on one standard deviation of historic forward price errors, whilst the low price scenario is based on 0.5 of the standard deviation of historic errors. BEIS took this asymmetric approach because coal prices are already significantly depressed, and therefore considers that there is less scope for coal prices to decrease further (rather than increase) in the short term. The low and high price assumptions are also designed to reflect plausible alternative outcomes for the coal price rather than focusing on the extremes.

Medium Term

65. For the central and low price assumptions, we assume prices remain at their 2017 level between 2017 and 2020. In the short term the market is out of (long term) equilibrium. Forward prices and external projections imply this will take longer than 2 years to resolve. Flat lining for 2018-2020 allows for that and allows more time for the market to start to adjust towards the long term equilibrium. We have flat lined rather than using the forward curve after 2017 because given limited market liquidity we judge that 2017 forward prices are a more reliable guide to market future expectations for this period.
66. After 2020 the central and low price scenarios are linearly interpolated to their long run equilibrium values in 2030.
67. The high price scenario is linearly interpolated towards its long term 2030 equilibrium value from 2018. This reflects the possibility that coal prices may return towards the long run marginal cost of supply more rapidly, which could occur if, for example, there is an increase in the rate at which higher cost coal operators cut back their production or face bankruptcy.

Long Term

68. Based on the long run market balancing condition 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 anchored price scenarios around

²⁶ BEIS does not consider that coal price options markets are sufficiently liquid to provide a basis for estimates of uncertainty around the central price scenario, so takes a different approach to estimate high and low scenarios to that used for oil and gas.

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.

69. On the supply side, the former DECC appointed Wood Mackenzie to produce scenarios for future seaborne coal supplies to Europe. The supply curves have been built up from breakeven costs for investment/long run marginal costs for the key categories of supply. The supply curves reflect variation in the technical/ geological/country characteristics and have been built up using a mine by mine analysis. Breakeven costs have been 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 this publication.
70. The key driver of long run European supply variation between the three scenarios 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.
71. Estimates of coal demand are derived from the 'new policies', 'current policies' and '450 degree' scenarios in the IEA's World Energy Outlook 2015. The IEA provides forecasts 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 obtain demand for coal imports; BEIS uses projections of coal production in OECD Europe from the IEA's World Energy Outlook 2015 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. Metallurgical coal is netted off using the estimate of the proportion of European coal demand accounted for by metallurgical coal in 2019 from the IEA Medium Term Coal Outlook 2015 (2019 is used as this report does not predict trends beyond this year). Lignite coal demand is assumed to be 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 coal to OECD European countries via rail.

Central Price Assumption

72. Wood Mackenzie constructed long run supply in their central case using central assumptions for factors such as economic growth and the intensity of coal usage in the energy sector. In the central case, Colombia is expected to be the key supplier of low cost coal in to Europe, with Russia offering the majority of higher cost supplies. Smaller levels of coal of varying cost is expected from the US and South Africa, with Venezuela and Mozambique offering small levels of relatively expensive coal supplies.
73. Long term Asian coal demand is forecast to grow, led by growth in coal-fired power generation in China, India and southeast Asia, meaning 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.

74. 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 falling European demand from increased environmental regulation makes the Asian market more attractive for these suppliers. This is consistent with the percentages of total exports that South Africa and Mozambique make available to Europe.

Low Price Assumption

75. 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.

76. Demand is estimated using the IEA '450 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 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

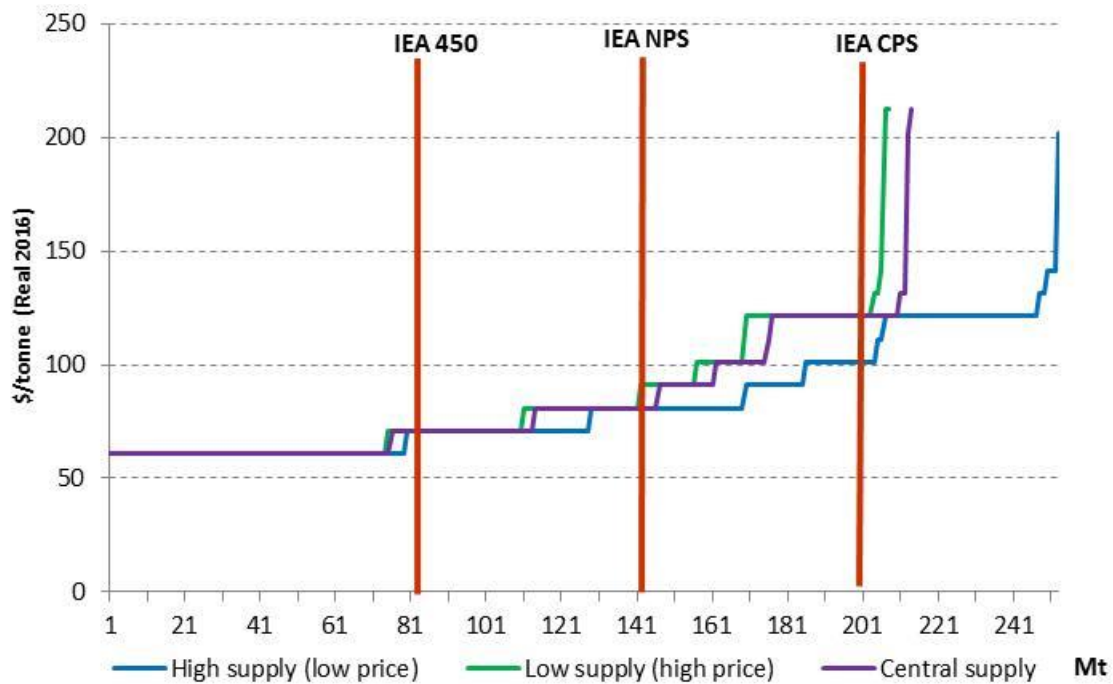
77. Long run supply for the high price/low supply case is constructed assuming that 10% of western Russian coal is exported to Asia; in the central case all Western Russian coal is exported to Europe. This would be consistent with potential transport infrastructure developments going ahead in Russia to increase its capacity to export coal eastwards, and increased economic growth in Asia²⁷.

78. Demand in the high scenario 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. Again, an adjustment is made to account for European coal production and non-steam coal demand in the current policies scenario. This higher demand scenario could materialise simultaneously with lower supply to Europe if, for example, stunted European environmental regulation is

²⁷ In the high price scenario, supply is modelled as becoming very steep just to the right of the intersection of supply and demand. This is a result of the supply modelling methodology, which does not fully account for the reactions of swing suppliers as European coal prices increase. In reality, increasing prices would incentivise increased supply in to Europe, resulting in a flatter supply curve.

combined with increased rates of Asian economic growth, which attract greater proportions of coal supply to Asia.

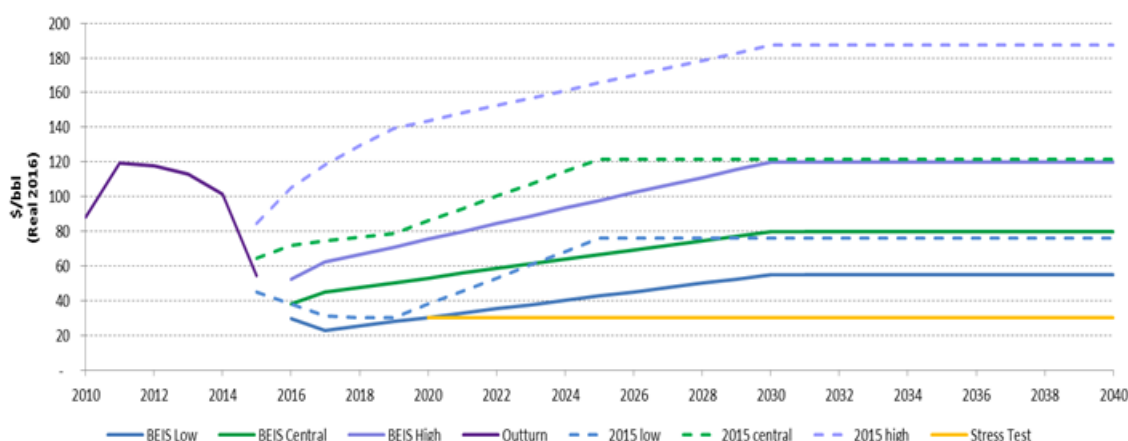
Figure 6: Long run Coal supply curves provided by Wood Mackenzie combined with IEA demand projections



Annex A – Comparison with 2015 DECC Fossil Fuel Price Assumptions

Oil Price Assumptions

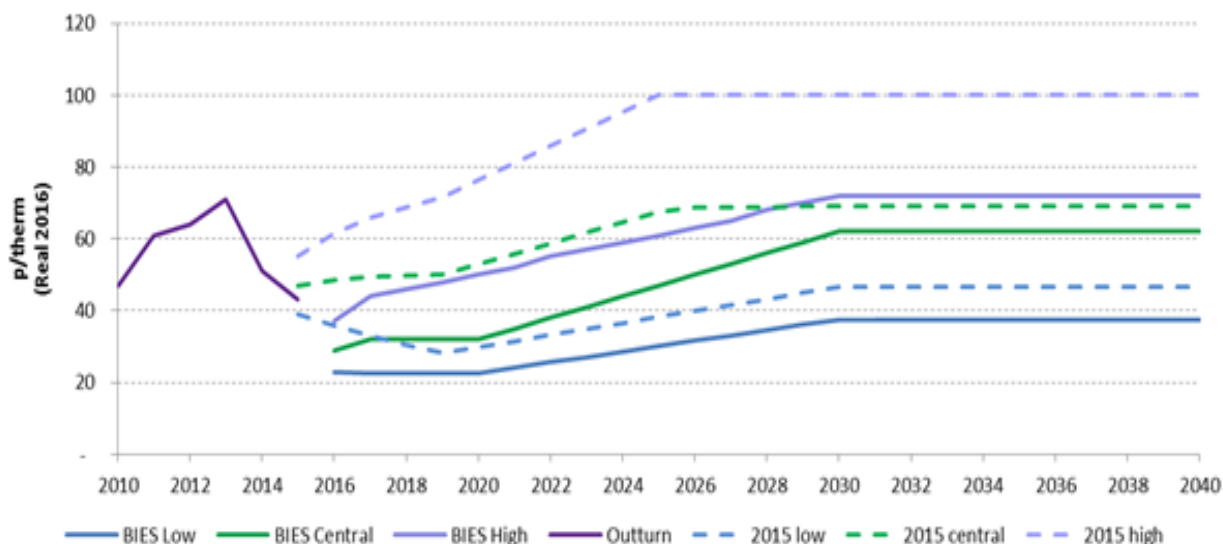
The 2016 Oil Price assumptions are lower than the 2015 assumptions due to market developments in the short term and new evidence on the long run marginal cost of oil supply. The reduction from last year in part reflects the change to the cost structure of the industry which has undergone significant cost cutting in the last 18 months as companies and countries alike seek to find efficiencies in a world of lower (current) prices. Levels of investment in low cost (OPEC) barrels and volumes of tight oil that come to the market remain significant uncertainties over the long run.



Gas Price Assumptions

The 2016 Gas Price assumptions are lower than the 2015 assumptions due to market developments in the short term and new evidence on the long run marginal cost of gas supply. US LNG remains the key marginal source of supply in the long run. The price drop compared to last year can be explained by the drop in Henry Hub price projections primarily as a result of high production levels and weaker demand. The high and low scenarios are not symmetric in the long run as they are based on different assumptions around Russia's strategy, Henry Hub prices and LNG available to the European market. In addition, for the central and low price assumptions, we flat line prices in 2018 to 2020

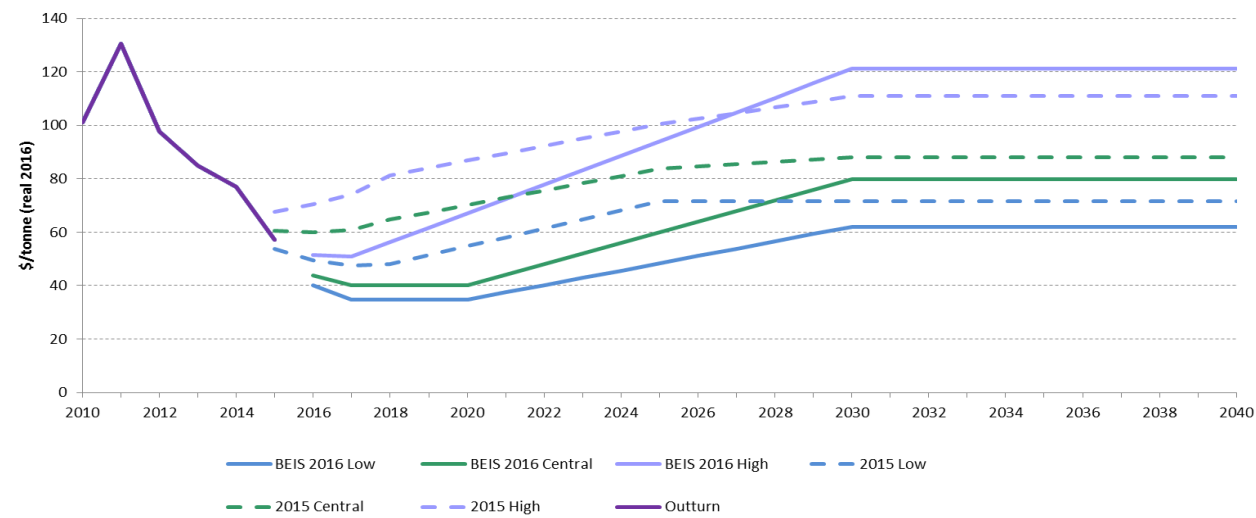
at their 2017 level. We have flat lined rather than using the forwards curve for 2018 to 2020 as given limited market liquidity for these years, we judge that 2017 forward prices are a more reliable data point and guide to market future expectations for this period.



Coal Price Assumptions

The 2016 Coal Price assumptions are lower than the 2015 assumptions due to market developments in the short term and new evidence on the long run marginal cost of coal supply. Spot and forward prices have continued to fall, with some coal suppliers willing to operate at a loss in the short term in order to protect market share. However there appears to be limited scope for prices to fall further, so we have reduced the uncertainty range for our low Coal Price assumption in the short term.

In the long run, our 2016 low and high Coal Price assumptions take more account of the impact of the Asian coal market on the European coal market, which leads to the wider range between the price assumptions.



Annex B – Demand Projections

The tables below compare demand projections from key energy institutions and companies where information is publically available²⁸. Whilst we acknowledge that there are significant uncertainties with demand projections we have chosen to use IEA demand numbers as they are internationally recognised as a leading institution in energy demand and supply projections.

Oil

Total Liquid Demand (mb/d)				
Source	Published	2020	2030	2040
IEA MTO 2015	Feb-15	99		
IEA MTO 2016	Feb-15	101		
EIA International 2015	Mar-16			
EIA Annual 2015 (Low oil price)	Apr-15	100	112	125
EIA Annual 2015 (High oil price)	Apr-15	96	108	124
EIA Annual 2015 (Reference)	Apr-15	98	109	121
OPEC WOO 2015	Dec-15	97	104	110
BP Outlook 2015	Feb-15	99	107	
BP Outlook 2016	Feb-15	94	103	
IEA WEO 2015 (New Policies)	Nov-15	98	103	108
IEA WEO 2015 (450)	Nov-15	96	92	83
IEA WEO 2015 (Current policies scenario)	Nov-15	100	110	121
IEA WEO 2015 (low oil price)	Nov-15	99	105	110
ExxonMobil 2016 energy outlook	2016		107	111
Statoil	Jun-15	102	108	103
Shell (high)	2016	98	107	112
Shell (low)	2016	96	102	71
Aurora	2016	93	101	

²⁸ As at 31 March 2016.

Gas

Global Gas Demand Projections (bcm)						
Source	Published	2020	2025	2030	2035	2040
IEA WEO 2015 (New Policies)	Nov-15	3,849	4,153	4,486	4,837	5,160
IEA WEO 2015 (450)	Nov-15	3,770	-	4,070	-	4,073
IEA WEO 2015 (Current policies scenario)	Nov-15	3,914	-	4,713	-	5,617
BP Outlook 2016	Feb-16	3,912	4,304	4,595	4,920	-
ExxonMobil 2016 energy outlook	2016	-	4,210	-	-	5,014
Statoil	Jun-15					
Shell (high)	2016	4,345	-	5,480	-	6,566
Shell (low)	2016	4,293	-	4,911	-	5,437

Coal

External projections of European import demand for thermal coal, 2020-2040 ²⁹				
Source	Published	2020	2030	2040
IEA WEO 2015 (New Policies)	Nov-15	178	142	105
IEA WEO 2015 (450)	Nov-15	157	85	77
IEA WEO 2015 (Current Policies)	Nov-15	194	201	168
EIA Annual 2015 (Reference)	Apr-15	206	197	188

²⁹ The IEA figures presented are OECD Europe total coal demand, adjusted by BEIS to reflect European import demand for thermal coal.

Annex C – Comparison of prices with key external projections

The tables below compare price projections of different institutions focusing on those that present a range of price assumptions and where information is publically 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 central assumptions fall within the range of views presented by other institutions. However, relative to others, BEIS's low and high oil price assumptions are 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 2016\$/bbl				
	BEIS low	EIA low	IEA 450 scenario	
2020	30	60	80	
2030	55	72	100	
2040	55	79	98	
	BEIS central	EIA reference	IEA New Policies	OPEC reference
2020	53	82	82	81
2030	80	110	116	94
2040	80	146	131	
	BEIS high	EIA high	IEA Current Policies	
2020	75	155	85	
2030	120	202	133	
2040	120	262	153	

IEA publication: WEO 2015

EIA publication: AEO 2015

OPEC publication: WOO 2015

Gas

2016 prices (p/therm)				
	BEIS Low	IEA 450 scenario		
2020	23	50		
2030	38	63		
2040	38	59		
	BEIS Central	IEA New Policies	External Projections	
2020	32	52	46	35
2030	62	75	52	65
2040	62	83	57	
	BEIS High	IEA Current Policies		
2020	50	54		
2030	72	84		
2040	72	92		

IEA: WEO 2015

*Aurora (Jan 2016) and Wood Mackenzie (Dec 2015)

Coal

	BEIS Low	External projection	
2020	34	49	
2030	62	37	
2040	62		
	BEIS Central	External Projections*	
2020	39	58	67
2030	80	63	89
2040	80	-	-
	BEIS High	External projection	
2020	66	66	
2030	121	98	
2040	121	-	

*Aurora (Jan 2016) and Wood Mackenzie (Dec 2015)

Annex D – Short term ranges (Gas)

The short run ranges around the forward curve have been constructed based on the Black and Scholes formula combined with the EIA analysis on how to calculate confidence intervals³⁰.

Replicating the EIA approach, we derived confidence intervals around expected futures prices³¹ using the “implied volatilities” of options. Implied volatility is defined as the standard deviation of the change in the spot gas price embedded in options prices, which Bloomberg provide.

The range of the confidence interval is determined by the confidence level. We have chosen a 75% confidence level.

The advantage of this method is that it produces an assessment of future price uncertainty based directly on current market data and informed market participants’ expectations.

We used data from 11th February 2016 to 23rdth March 2016. The data sample is relatively small as it was not possible to download historical option prices.

³⁰ http://www.eia.gov/forecasts/steo/special/pdf/2009_sp_05.pdf

³¹ ICE Futures Europe

Annex E - Adjusting IEA European Union gas demand projections

An adjustment was applied to the IEA “OECD Europe” gas demand projections to allow us to combine IEA gas demand with Wood Mackenzie’s long run supply curves.

This was to account for the difference in region coverage between the IEA OECD Europe and Wood Mackenzie’s “Europe”. 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 (2014) gas consumption for each country included in the region list. This means that we have made the assumption that gas demand for the additional countries will change over time by the same proportion as the IEA projects for the EU.



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Department for Business, Energy & Industrial Strategy

3 Whitehall Place, London SW1A 2AW

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