Department for
Business, Energy
& Industrial Strategy

FOSSIL FUEL PRICE ASSUMPIONS EXPERT PANEL

Final Report

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Executive Summary

Each year the Department for Business, Energy and Industrial Strategy (BEIS) updates its long-term price assumptions for oil, gas and coal. These assumptions are required for long-term economic appraisal and therefore reflect a range of potential long-term trends. They are not forecasts of future energy prices. Forecasting fossil fuel prices into the future is extremely challenging at the best of times and, at present, the levels of uncertainty are particularly high. The process by which BEIS generates its price assumptions focuses on estimates of fundamentals and other available evidence to arrive at a range of future prices. These assumptions then feed into work across Government on appraising the economic impacts of policies.

This year, as in the last three, the Fossil Fuel Price Assumptions Expert Panel (FFPAEP) was convened to work alongside the BEIS team responsible for this work. Last year the BEIS team worked with the supply curves supplied by Wood Mackenzie in 2016, but we did recommend that they consider commissioning a new set of supply curves for 2019. This year the price assumptions are based on a new set of supply curves provided by Rystad Energy. The Expert Panel was involved in the design of the tender and was party to meeting with Rystad Energy and the BEIS team to understand the methodology and underlying assumptions behind the supply curves.

As in previous years, the Panel's deliberations and our report have focused on four tasks: first, reviewing the methodology and data used for both the short-term and the long-term price assumptions; second, reviewing the current context, sources of uncertainty and longer-term drivers and fundamentals relating to each fossil fuel; third, assessing the 'reasonableness' of the initial fossil fuel price assumptions; and fourth, scrutinising the position of the demand assumptions, taken from the IEA, relative to other demand forecasts and scenarios. The Panel also assessed the quality assurance procedures employed by BEIS.

This is now the fourth year that the current methodology has been used and it is now well established. Previous Panel reports have reviewed the methods and data sources in detail and the BEIS report also provides a detailed explanation. As a Panel we are satisfied with the rigour of the process and see no need to explain it in detail here. Rather, our role has been to explore the assumptions and uncertainties that underlie this year's analysis. The long list of uncertainties relating to oil and gas reflect the fact that both fuels are subject to a range of factors, both short-term and medium- to long-term that may influence future price levels. In the oil market, on the supply side, the prevailing concern about the relationship between OPEC supply and the sustainability of US light-tight oil has been significantly complicated by an increasing level of geopolitical instability. On the demand side, the impact of changing demand from the merchant marine in light of climate change and air pollution policy remains unclear, but the state of the global economy in the face of growing trade friction is a far greater threat to future demand. When it comes to natural gas, it is recognised that the winter of 2018/19 was exceptional with low temperatures in the northern hemisphere—where the bulk of global gas demand resides—and surging demand in China, followed by a hot summer. This absorbed the new LNG production that came onto the market. This year, a milder winter and continuing additions to supply have resulted in a fall in prices. The industry view is that the market could tighten by the early to mid-2020s as demand growth absorbs the remaining new supply. In anticipation of this, a new wave of LNG projects is now being sanctioned. What happens thereafter depends on the ability of natural gas to retain market share in mature markets in the face of climate change policy and to remain affordable in emerging markets, where urban air pollution has been a major driver of demand, in the face of competition from renewable power

generation and the continued reliance of coal for reasons of affordability and energy security. In the European market the interplay of economics and geopolitics will remain important and it is unclear how Gazprom will respond to increasing LNG imports, from the United States and elsewhere, and the outcome will have significant implications for the price of gas in Europe. More immediately, there is continuing uncertainty over the role of Ukraine as a transit route for Russian pipeline gas to Europe as the current transit agreement expires at the end of 2019 and the terms of a new agreement remain unclear. Coal, by comparison, is relatively uncomplicated with ample supply available without the need for new investments. The critical issue for coal is its ability to retain a share in the energy mix in the light of climate change policy and air pollution concerns. As our review of the various demand scenarios makes clear, there is a large discrepancy in the fortunes of fossil fuels between now and 2040/50 as portrayed in the analysis of the international oil companies and organisations and the view of climate change science as reported in the recent IPCC report on 1.5°C. The Fossil Fuel Price Assumptions present a range of possible future price levels and we are confident that at a given point in the future the price will be within that range; however, because of the high level of uncertainty in relation to supply and demand, it is essential that users of the price assumptions consider the full range in their analysis.

The Panel reviewed BEIS's quality assurance procedures in relation to the production of its fossil fuel price assumptions. BEIS has developed a detailed and well-documented Quality Assurance (QA) process for their models. This has been applied to the models that have been used to develop the fossil fuel price assumptions. Overall, the QA process is rigorous, and provides significant evidence that BEIS has critically reviewed its processes and the input assumptions that have been used. On the supply side, Rystad Energy has provided a detailed report and we are confident in the rigour of their methodology, though we do not necessarily share their underlying assumptions. On the demand side, BEIS has made the judgement that assumptions taken from the World Energy Outlook 2018 are 'based on high-quality analysis performed by specialist teams within IEA'. Given that the model is documented in some detail, and the World Energy Outlook is subject to significant external scrutiny and peer review, this is a reasonable and well-founded assumption to make. Though we do note that this year some external commentators have called on the IEA to make changes to its Sustainable Development Scenario that underlies the BEIS low price case. We have recommended that BEIS revisit the issue of future demand in more detail next year.

The Panel's overall conclusion is that the process adopted by BEIS to provide external scrutiny of the process by which it generates its fossil fuel price assumptions is now well established and has resulted in a reasonable set of price assumptions that have been arrived at using a straightforward and transparent set of data sources and methods.

The Panel would like to thank the members of the BEIS fossil price assumption team for their efficiency in responding to our requests and their hospitality during our various meetings at BEIS.

1. Purpose and work of the Panel

Each year the Department for Business, Energy and Industrial Strategy (BEIS) updates its long-term price assumptions for oil, gas and coal. These assumptions are required for long-term economic appraisal and therefore reflect a range of potential long-terms trends. They are not forecasts of future energy prices. Forecasting fossil fuels prices into the future is extremely challenging and at present the levels of uncertainty are particularly high. The unknowns include; the prospects for future economic growth across the world, but especially in emerging markets that are the key drivers of future energy demand; the development of new technologies that might make available new reserves and/or constrain carbon emissions; global climate change policies; and the strategies of major resource holders—in particular the OPEC states and Russia. The process by which BEIS generates its price assumptions focuses on estimates of fundamentals and other available evidence to arrive at a range of future prices. These assumptions then feed into work across Government on appraising the economic impacts of policies.

In late 2015 former DECC announced an Invitation to Tender for appoint to the Fossil Fuel Price Projections Expert Panel (FFPPEP) (Tender Reference Number: 1106/11/2016) and in January 2016 the members of the Panel were appointed. The panel was reappointed in Autumn 2017 for a further two years. The panel is comprised: Michael Bradshaw (Chair), Harald Hecking, David Ledesma, Amrita Sen and Jim Watson (short biographies can be found in Annex A of this report). The FFPPEP re-convened in January 2019 to work alongside the BEIS team responsible for this work. This year the work programme was somewhat different, and our early meetings involved discussions with the BEIS team and Rystad Energy in relation to the new set of Fossil Fuel Supply Curves that have been prepared. The outcome of that work is published alongside this report.[1] However, once the supply curves were finalised the FFPPEP followed the same approach as last year and this report can be considered as an update to the reports that were previously published in November of 2016, 2017 and December 2018.[2] In the interests of brevity, this report confines itself to commenting on any adjustments to the underlying assumptions made in previous years and the methodologies employed. The focus of this report is to comment on the resulting price assumptions and the current context and key uncertainties, both in relation to supply and demand. We also comment on the various quality assurance procedures followed by BEIS in the production of its price assumptions.

1.1 Terms of Reference

The tasks of the Panel include (but are not limited to):

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[1] Available at https://www.gov.uk/government/publications/fossil-fuel-price-assumptions-2019

[2] The 2016 report by the FFPPEP is available at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/567251/BEIS_FFPA_2016__-_Final_Expert_Panel_Report.pdf the 2017 report can be found at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/663102/2017_Expert_Panel_Final_Report.pdf and the 2018 report can be found at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/764344/Fossil_Fuel_Price_Assumptions_Expert_Panel_Report_2018.pdf

- Attend all Panel meetings (no delegation is possible);
- Report to Government through formal written reports and informal reports (for example, presentations or written minutes of meetings);
- Review the fossil fuel price assumptions modelling methodology and techniques used and proposed;
- Review the analysis produced by any contractors BEIS uses for the fossil fuel price assumptions;
- Submit informal reports to BEIS on the modelling methodology; contractors' analysis and outputs; and other evidence and data sources used; and
- Submit a formal report for publication in advance of finalisation of each year's fossil fuel price assumptions.

1.2 Work of the Panel

To aid in fulfilling these duties a number of meetings have taken place at BEIS between the Panel and the BEIS team responsible for the price assumptions. This year, the procedure was somewhat different as a number of meetings involved discussions with Rystad Energy and the BEIS team in relation to the new Fossil Fuel Supply Curves.

This year our initial meeting took place on 24th January and involved the BEIS Team, the Expert Panel members and representatives from Rystad Energy. The meeting afforded an opportunity to hear from Rystad Energy about their methodology and the underlying assumptions behind the new Fossil Fuel Supply Curves. A second meeting took place 11th March to assess progress and review the results of the changes to the underlying assumptions resulting from our first meeting. At our third meeting on 29th April, the BEIS Team and Panel reviewed the draft final report supplied by Rystad Energy and the initial results of the 2019 analysis using the new supply curves were discussed. The fourth meeting on 28th May reviewed the draft report from the BEIS team and the first draft of this report.

Last year the BEIS Fossil Fuel Price Assumptions (FFPA) and our report were not published until December. As explained in that report, because of changes over the summer, it was necessary to revisit and revise the price assumptions. This year the situation is just as volatile, largely due to a range of geopolitical factors, as well as the changing sentiment towards tight oil in the US, and it was necessary to revisit the results in November before final publication, which was then delayed by the election.

In summary, the Panel's deliberations and this report focus on three areas.

- Understanding the methodology and assumptions used by Rystad Energy to produce the new Fossil Fuel Supply Curves.
- Reviewing the methodology and data used for both the short-term and the long-term price assumptions, which is essentially the same as last year, with some minor adjustments that are explained in the BEIS report and discussed below.
- Reviewing the current context and longer-term drivers and fundamentals relating to each fossil fuel and then assessing the 'reasonableness' of the initial fossil fuel price assumptions. In the case of the oil price the analysis is global in scope, while the natural

gas and coal assumptions are based on factors influencing the price of natural gas in Europe, although these are increasingly global in scope when it comes to LNG—and the price of seaborne steam coal imports into Europe.

2. BEIS's Methodology and Data Sources

This section considers the data sources used and describes and assesses the methodologies that have been employed to arrive at both the short-term and the long-term price assumptions.

2.1 Data sources and Short-term price assumptions

Oil

As with previous years, the BEIS central case short-term oil price assumption (2019-2020) is based on the forward curve with the low and high cases being derived using an implied volatility analysis. The high and low assumption are derived as a range around this central starting price using data from the Bank of England on options implied distributions, as used by BEIS. The Bank of England is able to generate probability density functions (PDFs) using options prices and extracting information from them under certain assumptions while the futures curve data is reported by Bloomberg, both of which are credible and robust sources of data and methodology. These probabilities can be derived under the assumption that investors are "risk neutral". For these implied distributions, a confidence level of 75% has been chosen which means that that the market attaches a 75% likelihood that the oil price will fall within a certain outcome.

The futures curve is used for two years. The reason for not using futures prices beyond two years is that whilst they reflect expectations of market participants about oil supply and demand, there have been some fundamental changes to the oil market recently that can distort the price discovery mechanism using the futures curve. So, using the futures curve in the current form can underestimate BEIS's long term price assumptions (see last year's report for a detailed explanation of this issue).

The number of geopolitical risks has risen significantly in recent years, and the US has imposed sanctions on a number of key oil-producing countries. This is leading to significant oil price volatility in the near term but is also impacting productive capacity of these countries, posing upside risk to prices one-two years out, making it even more difficult to accurately forecast prices.

Overall, given the range of uncertainties and challenges for forecasting future oil prices, the Panel believes the BEIS approach is reasonable as it uses the most liquid part of the futures curve as guidance for short term prices and a detailed marginal cost curve analysis for the long term (discussed in more detail later). Given these distinctive approaches and the Panel's view that the market is currently out of long-term equilibrium, interpolating between the short- and long-term estimates is appropriate.

Gas

As with the previous years, BEIS's central case short-term gas assumption (2019-2020) is based on the forward curve with the low and high cases being derived using an implied volatility analysis. The liquidity of the UK National Balancing Point (NBP) forward market has, in previous FFPA reports, been viewed as sufficiently high over the initial two-year period to support this approach. In the 2018-2019 report the use of the forward curve was extended to

three years to reflect the uncertainties of new LNG project start-ups. In this year's report it has been decided to revert to two years as there is more certainty over the start-up of new LNG liquefaction capacity and the liquidity of NBP has reduced relative to the Dutch TTF hub. This has resulted in a set of price assumptions that are more in line with the market (year three prices on NBP tend to be derived through inter-year spreads rather than supply/demand factors due to lower liquidity in the later years). This approach is viewed as reasonable.

The NBP price used as the basis for the gas price assumptions is the average NBP price for the 30 trading days prior to the end of August. The average (month+1) price for the 30 trading days prior to the end of August was 37 p/therm ($/4.8 MMBtu).[3] This price, as a starting point for price forecasts over the period to 2020, was in line with the market and lower than the 2018 FFPA price for 2018 of 57 p/therm, which reflects the changes in the market with increased LNG supply and weaker Asian demand.

There is uncertainty in the market on both the supply and demand side. In the short to medium term the pace of new LNG supply start-ups from North America remains unclear, and the pace of growth in demand for LNG in Asia, especially China, remains uncertain. That said, when compared to last year's report, it is demand uncertainty that has increased most while supply uncertainty has reduced. In last year's report the spectre of North American LNG being priced based on US LNG export cash cost price was suggested as sellers sought to secure a market for their LNG (taking the market from European gas pipeline suppliers), to recover at least some of their costs. The likelihood of this still exists but will depend on the pace of LNG demand growth globally. If North American LNG sellers are forced to discount, to reduce prices below total costs, then the price would represent the lowest price at which US exports would be exported[4] and this could be a floor price for NBP gas. The Panel believes that this floor price level should be approximately contained within the low-cost case, assuming a Henry Hub price level of $2.64/MMBtu, as assumed by Rystad Energy.

As with the 2017 and 2018 Fossil Fuel Price Assumptions, the low and high pricing cases have been developed using options volatility calculations that determine the likelihood that the market attaches to future price levels using a 75% confidence level.[5] This assumption is viewed as reasonable.

The BEIS price assumptions are annual average prices. By its nature, the European gas price, that is determined by market supply and demand, will remain volatile. As LNG is the marginal gas supply source, competition from Russia, Norwegian pipeline gas, domestic gas production (including reduced Dutch gas supply from the Groningen gas field until 2030), as well as from other energy sources and renewables; varying gas and LNG demand in Asia and the newly developing LNG importing countries, means that there will be price volatility. That said, the gas price volatility should be contained in the annual average BEIS assumptions.

[3] Converted to pence per therm (p/therm) using the OBR, Economic Fiscal Outlook, March 2019 exchange rate assumption of 1.30 US$/£ for 2019 that is used in the BEIS 2019 FFPA.
[4] This 'floor price' is assumed to be Henry Hub gas price x 1.15 + $0.30 (shipping) + $0.40 (regasification) /MMBtu. This price is deemed a 'floor price' as US LNG will set the marginal gas import price as Russian gas is expected to follow/match the floor price in order to maximise profits without having to sacrifice sales volumes. At a US Henry Hub price of $3.00/MMBtu this should equate to an NBP price of ~ $4.15/MMBtu (32 p/therm) and at a US Henry Hub price of $3.64/MMBtu this should equate to an NBP price of ~ $4.89/MMBtu (38 p/therm).
[5] At a 75% confidence level the market attaches a 75% likelihood that the gas price will rise or fall within a certain outcome.

Coal

The BEIS short-term coal price assumptions are derived from spot and forward prices for ARA CIF from 2019 and 2020 respectively.[6] The methodology is consistent with previous editions of the BEIS FFPA and the best available approach for modelling short-term price assumptions. First, because all information available to market participants and their expectations are reflected in the forward prices; and second, because all opportunities for arbitrage between the Asian and European plus possible physical limitations (e.g. locally limited export or ship capacities) are accounted for. Thus, spot and forward prices represent well recent market developments for both the ARA market and global interdependencies.[7]

In the BEIS analysis the use of spot and forward prices is limited to the next two years (2019 and 2020). This is similar to the approach applied in the oil and gas price assumptions and in the BEIS 2018 FFPA. In coal markets, liquidity is generally lower than in oil and gas, and especially so for those forward products beyond a two-year horizon. Additionally, the information gain from including products for more than two years is limited, as prices are highly correlated with year one plus products.

Thus, the 2019 value for the short-term coal price assumptions in the central scenario is derived from an average of the January 2019 to August 2019 outturn prices, the monthly forward contract for September 2019 and the quarterly forward curve for Q4 2019. The September 2019 and Q4 forward prices have been derived from averaging the prices of the respective front products over a 30-day trading period until end of August 2019. Notably, the methodology is slightly different, but consistent with the 2018 price assumptions where price data until June 2018 were used. Consequently, last year, a 30-day trading period until the end of June was applied to derive Q3 and Q4 forward prices which were then averaged with the Q1 and Q2 outturn prices.

Since data availability and market depth is far more limited for coal than in oil and gas markets, it would not be reasonable to use the option price approach that is applied to oil and gas. Therefore, high and low scenarios for coal prices are derived from historic deviations of forward and realized coal prices for a 10-year period between 2008 and 2018. The high scenario is derived by adding one standard deviation to the central scenario whereas the low scenario subtracts one standard deviation.[8]

Overall, the modelling approach for the short-term coal price assumptions for the years 2019 and 2020 is plausible and is well executed with respect to the choice and use of both methodology and data.

[6] ARA CIF is a coal price notation for coal delivered to the ports of Amsterdam, Rotterdam and Antwerp, Europe's major coal ports. The coal price comprises cost, insurance and freight and refers to a metric tonne of coal at 6000 kcal/kg net as received.

[7] This can be illustrated at the situation of spring 2019: Here, European spot prices were significantly below front year prices (a so-called contango) due to, amongst others, a very mild winter in Europe. Hence traders perceived that situation as a temporary oversupply, however, not as a long-term trend.

[8] For the current year (2019), one standard deviation is only added/subtracted to/from the central scenario forward prices for September and Q4. Since prices from January till August prices are historical outturns and hence not uncertain, they are identical for all three scenarios.

2.2 Data and Long Run Supply Assumptions

Oil

In the previous three reports BIES used Wood Mackenzie's supply curves, this year, as noted above, a new set of supply curves has been commissioned from Rystad Energy. These provide 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.

We note here, however, that compared to the EIA and OPEC and other consensus estimates, Rystad Energy are known to have somewhat of an upward bias in their US crude production figures, partly driven by their view of very sharp decline rates in the rest of the world, such as Russia. So, their US figures are to compensate for falls elsewhere and fill the gap generated by demand.

Year	Rystad Energy	OPEC	EIA
2016	8.19	8.9	8.9
2020	12.82	12.4	10.7
2025	16.78	13.0	11.4
2030	18.68	13.7	11.7
2035	17.99	14.0	11.9
2040	14.35	13.5	11.9

For oil, a few adjustments have been made to Rystad Energy's central supply curve. In particular, the Panel believes that the central supply curve did not consider the 'above ground' constraints in Iran and Venezuela and so BIES was advised to make the following adjustments.

- Iran: The Panel flags the political issues and the long-term limits to technical capacity which cap liquids production at 5 mb/d in the central and high price scenario and 6 mb/d in the low-price scenario.
- Venezuela: The panel flags the uncertainties about long term production prospects, and the fact that even in a high price environment it is hard to envisage production above 2.5 mb/d given the recent damage done to reservoirs.

On 22 April 2019, the Trump administration decided not to renew Significant Reduction Exemptions (SREs) for countries importing Iranian crude and condensate. Any bank that facilitates payment for a purchase of Iranian oil or products will be barred from the US financial

system. The Trump administration can also designate companies involved in oil trades with Iran (shippers, insurance providers and traders as well as the refineries processing the crude), which leads to a range of penalties such as losing access to US markets, being barred from dealing with US banks, and company shareholders/executives being unable to visit the US. Doing business with a sanctioned foreign entity can result in heavy fines if the transaction passes through the US financial system, which the US government has actively enforced in recent years. This significantly inhibits Iran's ability to get funding for maintaining productive capacity in its upstream and even when the prior round of sanctions was lifted, Iranian production struggled to recover past 3.8 mb/d. Compared to the Obama administration, the current sanctions are far more draconian.

For Venezuela, the US government has imposed sanctions limiting the country's ability to sell crude. Recently, a botched uprising has marked a significant shift in the political dimension of the country with implications for long term production. Power cuts are rampant, damaging production facilities and reservoirs, which will make it extremely difficult for Venezuela to quickly turn around their production even if regime change was to be achieved. The poor state of the country's oil infrastructure, limited storage capacity and the lack of naphtha for blending are all denting production. In particular, Venezuela's crude upgraders have largely had to suspend operations due to storage constraints and domestic refineries have been operating at below 10% of capacity, processing just 0.1 mb/d at the start of this month and production has fallen to just 0.5 mb/d from 2 mb/d just 2 years ago.

Furthermore, chronic mismanagement and lack of investment has drained talent from the oil sector workforce and left upstream infrastructure in a very poor state. These structural problems will take years to address. Moreover, Venezuela will need to secure very large inflows of foreign investment to reverse this negative trend. While any opposition leader who replaces Maduro is likely to push through economic reforms, engage the IMF and receive considerable diplomatic and financial support from the US and the Venezuelan diaspora, it will still take time to regain the confidence of foreign companies after all this time—and in view of the political instability that is likely to remain a key feature of Venezuela even after the end of the regime.

Even in ideal conditions (political stability, strong support from the US and the IMF, foreign investment flowing in), there might be only a few quick wins on the production front. The first task would be to halt further production declines, which should be relatively quick, and then fixing the upgraders could increase production by 0.5 mb/d fairly swiftly (up to around 1.6 mb/d). Securing a sustainable increase beyond that will be harder and it would likely take several years to get Venezuelan production back above 2 mb/d even in the best-case scenario.

Another development in 2019 has been the changing expectations around US production. So far in 2019, US crude production growth has not lived up to the very big expectations set at the start of the year and we note the dramatic sentiment shift in the US E&P space, which is gradually being followed by downgrades to US production forecasts across the market. The shift to lighter production also continued across the Permian, with preliminary data for the year-to-date showing the basin's gas-to-oil ratio rising to 3.5 mcf of gas per barrel of oil, versus 3.3 mcf on average in 2018. Meanwhile, to maintain elevated completions amid a strict focus on capital discipline, which has forced companies to rein in spending, US independents have shifted capital away from drilling new wells to completing previously drilled wells instead—the latter stage comprises of around 40% of the total cost of bringing a well online versus 60% of total costs for the drilling stage. Drilling activity has nosedived this year, as evident in the continuously falling rig count. By early November, Baker Hughes reported 684 oil rigs in the US, the lowest in three years. Well productivity gains have also started to fall. Preliminary data

show that peak average production rates of horizontal wells in the Permian only improved by 9% y/y in the year-to-date, compared to 16% in 2018, 15% in 2017, 21% in 2016, and 24% in 2015. Some basins even suffered outright declines, such as the DJ, where productivity has fallen by 4% y/y so far this year. Overly tight well spacing, particularly in the Permian—widely known as the parent-child issue—is also resulting in the loss of productivity with child wells underperforming their parents by more than 20% and risking permanently reducing the production of the parent well. The shale sector has its back against the wall as it attempts to lure the generalist investor back into energy and the small/mid-cap producers are particularly vulnerable. There is growing downside risk to US shale crude production for the coming years.

Gas

The gas price for the North West European market is based on gas supply/demand with the lowest cost gas and LNG supplier setting the marginal supply price in Europe.[9] As with last year, the BEIS central case gas price assumption assumes that the gas market is moving towards a long-term equilibrium based on the expected cost of marginal gas supplied to Europe, at projected levels of European gas demand. This year the analysis uses a new set of gas supply cost curves that have been developed in 2019 by Rystad Energy which have been used together with the IEA New Policies demand scenario. The BEIS long-term analysis also includes a downside "low prices" case that reflects demand weakness as a result of greater renewables penetration (that uses the IEA Sustainable Development Scenario demand level) and an upside "high prices" case where gas demand rises reflecting greater use of gas as an alternative to coal and oil (that uses the IEA Current Policy Scenario demand level).

The Rystad Energy report (page 36) sets out an allocation mechanism for the treatment of uncontracted volumes. As a high-level assumption, Rystad Energy has assumed that when existing long-term contracts expire in Asia they will not be extended, and buyers will secure gas supplies using short-term or spot volumes (the "uncontracted LNG"). Under its allocation mechanism, Rystad Energy assumes that part of the uncontracted LNG will be "locked" to Asian buyers to meet their demand and also other buyers in the Middle East, North America, South America and Asia will similarly have LNG "locked" to their markets.[10] The balance is available to Europe and to meet other marginal demand in the growing traded LNG market. Not all uncontracted volumes will therefore be available to Europe. The approach taken by Rystad Energy is viewed as reasonable even though the uncontracted LNG volumes may increase, and Asian buyers will likely secure volumes on more flexible contracts to ensure competitive prices but available volumes.

LNG is the marginal gas supply source for Europe and the key questions facing the short to medium term LNG market are; a) the timing of additional LNG supply from LNG projects under construction and b) the level of LNG demand in alternative markets, especially Asian markets which have limited alternative gas supply sources apart from LNG and will always be able to pay a higher price than European markets for LNG cargoes. The LNG market is moving from a fixed long-term structure towards a fully traded market, but the pace of this transition and the timing of when the traded market will be reached is not known.[11] Currently the market is in

[9] In 2018, the IGU estimated that 96% gas sold in North-West Europe was market priced based (gas on gas competition). For whole of Europe this figure reduces to 76%.
[10] Previous Expert Panel Reports have described the structure of the LNG business; "Firm" and "Flexible" markets
[11] Oxford Institute for Energy Studies. "New Players New Models", March 2019
https://www.oxfordenergy.org/publications/new-players-new-models/

transition and during this period LNG buyers will seek greater contract flexibility under a range of contracts of varying lengths.

The Rystad Energy report assumes that gas production from the Dutch Groningen gas field will cease by 2030 in line with the decision made by the Dutch Government. Since the Rystad Energy report was prepared, the Dutch government announced (in September 2019) that the Netherlands will halt gas production at Groningen by 2022, eight years earlier than planned.[12] The Rystad Energy analysis also assumes that pipeline gas supply from Russia to Europe will be on a cost basis, regardless of market conditions.[13] In last year's report it was noted that a key uncertainty was the behaviour of the Russian gas supplier Gazprom, which has historically been the largest gas supplier to Europe. Specifically, with rising LNG supplies, the question remains, will Gazprom sell its gas to maintain market share (that would result in lower gas prices until US LNG hits a price floor) or seek to maintain higher prices through reducing gas pipeline supply, allowing US LNG to be imported until LNG export plants hit a maximum export capacity? The cost-based approach used by Rystad Energy assumes that it will be the market, and the cost of supply, that will determine the volumes of Russian gas supplied. It is also assumed by Rystad Energy that sufficient pipeline capacity will be available to move the gas to the European market and that it will not be disrupted by political events (i.e. gas transit renegotiations between Russia and Ukraine and the start-up of the Nordstream 2 and Turkstream pipelines).

The resultant Rystad Energy cost curves imply that for Europe in 2035, assuming the gas demand level set by the IEA New Policies Demand Scenario, a gas price of $10/MMBtu. The cost of gas supply for the period up to 2035 is lower indicating lower gas prices in Europe. Delivered gas costs, therefore, rise as the cost curves shift upwards with time and the lower potential supply from the lower cost groups reduces.[14] It should be noted that Rystad Energy's forecast gas production for the costs curves is based on today's technology. If there are technology advancements in the future, then future gas production costs could be lower than forecast in the cost curves. The rising gas supply costs set out in Rystad Energy's cost curves are reflected in the BEIS gas price assumptions.

From 2035-2040 gas prices are flat-lined due to the uncertainty over gas supply conditions post 2035. During this period, as identified in last year's report, energy efficiency, greater renewables penetration and enhanced use of technology should mitigate the need for new, expensive sources of gas supply. In the low demand case, this will lead to lower gas prices that should be nearer to the 'low prices' case.

Coal

As discussed above, the time horizon of BEIS FFPA 2019 has changed compared to last year. As such the anchor point for the long-term coal price assumptions has changed from 2030 to 2035, implying that also in the medium term the time horizon has changed to 2021 to 2035. The medium-term prices are derived by a linear interpolation of the 2020 short term prices and the 2035 long-run anchors, assuming that after 2020 the coal market moves towards its long-term equilibrium.

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[12] https://www.reuters.com/article/us-netherlands-gas/netherlands-to-halt-groningen-gas-production-by-2022-idUSKCN1VV1KE

[13] In its report Rystad refers to Shtokman as a potential gas supply source to Europe. Even if this field is not developed, it is viewed that other gas fields, such as those in the Yamal Peninsular, could be developed instead

[14] Available gas supply with a breakeven below $3/MMBtu declines from 160 Bcm in 2025 to 15 Bcm in 2040.

The 2035 long run price anchors have been derived in an approach consistent with the prior BEIS FFPA. A low/central/high coal demand case is intersected with a high/central/low supply cost curve. The resulting equilibrium prices are used as the low/base/high coal price assumptions for the year 2035.

This year the BEIS FFPA are based on new supply cost curves for coal (as well as oil and gas as discussed above) derived by Rystad Energy. These cost curves are derived from an extensive and highly granular dataset using a reasonable modelling approach. They cover the most relevant supply side uncertainties that could potentially affect the European coal market such as costs, coal quality changes or a change in behaviour of the swing supply countries such as South Africa or Russia.

For the years between 2035 and 2040 all scenarios assume a flat development of coal prices reflecting that there is no information available that justifies any other price development.

2.3 Long-term demand data sources and assumptions

As was the case for previous versions of the assumptions, future demand projections have been taken from the latest International Energy Agency World Energy Outlook (WEO). This was published in November 2018. This publication is an established and respected annual source of global analysis, which uses the IEA's World Energy Model to explore scenarios for the global energy system. The IEA is sometimes considered to be relatively conservative with respect to their analysis of renewable energy deployment. Whilst this has been addressed to some extent, successive outlooks by IEA have continued to underestimate the rapid growth of renewable energy.

The IEA develops and publishes three scenarios for the global energy system each year that represent a range of potential futures. These include a 'current policies scenario' in which the energy system continues to develop on a business as usual trajectory, shaped by policies that have been implemented by mid-2018; and a 'new policies scenario' that assumes future planned policies to reduce emissions are implemented. The new policies scenario includes the IEA's assessment of policies within the (intended) nationally determined contributions (NDCs) that were submitted for the Paris Agreement. These policies fall far short of limiting emissions to meet the 2°C target. The more ambitious third scenario in the 2017 WEO was different to that in previous years and was carried forward to 2018. This 'sustainable development scenario' is designed to meet the sustainable development goal of universal access to electricity and clean cooking by 2030 – and the Paris Agreement's objective to limit the average global temperature increase to 'well below 2°C'.

BEIS have compared the demand for fossil fuels within the IEA scenarios to demand in other global scenarios or projections. As was the case 2018, this includes a range of comparators, including scenarios published by:

- Oil companies: BP, Shell, Equinor (formerly Statoil) and ExxonMobil;
- The US government's Energy Information Administration;
- Independent research organisations: The Institute of Energy Economics Japan, Aurora Energy Research and UCL/UK Energy Research Centre; and
- Other organisations: DNV GL and OPEC.

The BEIS report summarises these comparisons in Annex B, using standardised units for each fuel. For the case of oil, most comparisons are expressed in terms of total liquids demand, which includes biofuels as well as oil.

Perhaps a more important comparator for the IEA scenarios are global scenarios that are compatible with limiting global warming to 1.5 degrees. The UCL/UK Energy Research Centre scenarios included in the BEIS comparison are designed to do this. In addition, a wider range of other global scenarios have recently been published for inclusion in the Intergovernmental Panel on Climate Change (IPCC) Special Report on Global Warming of 1.5°C.[15] These scenarios are produced using integrated assessment models. The publication of the IPCC report has led to some criticism of the IEA scenarios – particularly the sustainable development scenario.[16]A group of 60 representatives from academia, businesses and NGOs wrote to the IEA to ask it to make the sustainable development scenario more ambitious (so that it has a 66% probability of limiting warming to 1.5 degrees). They also called for a more cautious approach to negative emissions technologies within this scenario.

Some caution should be exercised when comparing scenarios since they use different methodologies and assumptions. It is important to bear in mind that some long-term scenarios are produced by organisations that have specific commercial interests – and these interests are very likely to influence their views on the outlook for particular fuels or technologies.[17] For example, it is not surprising that oil company 'business as usual' scenarios are more optimistic on oil and gas demand, and more pessimistic on electric vehicle uptake, than scenarios that are designed to explore how to meet ambitious climate change goals.

Table 1 summarises fossil fuel demand within four scenarios produced for the IPCC 1.5 degrees report. The table shows that in most cases, global fossil fuel demand in these scenarios is significantly lower than demand in the IEA's Sustainable Development Scenario. The only exception is global oil demand in the IPCC scenario 'S5 – fossil fuelled development', a scenario in which negative emissions technologies are deployed on a very large scale to compensate for relatively high use of fossil fuels. Whilst some of the 1.5-degree scenarios include some extremely ambitious assumptions (particularly the Low Energy Demand scenario), they illustrate the importance of considering futures where fossil fuel demand by mid-century is well below the levels in the IEA scenarios.

Table 1 Global fossil fuel demand in 2040 in IEA scenarios and IPCC 1.5-degree scenarios

	Oil (mb/d)	Gas (bcm)	Coal (mt)
IEA World Energy Outlook 2018:			
Current Policies	124	5847	4769

[15] IPCC (2018) Special Report on Global Warming of 1.5°C, can be found here: https://www.ipcc.ch/sr15/
[16] A letter to the IEA that sets out these criticisms, plus the IEA's response, can be found here: https://www.iea.org/newsroom/news/2019/april/dr-birol-weo-letter.html
[17] For example, a critique of oil company scenarios by Greenpeace and Oil Change International highlights some potential sources of bias within these scenarios. However, this critique should also be viewed with caution, given that it comes from a leading environmental NGO. Greenpeace and Oil Change International (2017) Forecasting Failure; https://secure.greenpeace.org.uk/page/-/ForecastingFailureMarch2017.pdf

New Policies	111	5399	3809
Sustainable Development	77	4184	1597
IPCC 1.5 degree report:			
Low Energy Demand	26	1233	431
S1 - Sustainability	54	1461	1014
S2 - Middle of the Road	48	3629	817
S5 - Fossil fuelled development	119	2469	510

Sources: IEA World Energy Outlook 2018; scenarios published in IPCC (2018) Special Report on Global Warming of 1.5°C (figure 2.15).

With respect to oil, most other scenarios for liquids demand in 2030 and 2040 are within the range of the IEA scenarios (77 to 124 million barrels per day in 2040). As noted above, the exceptions are scenarios that are designed to limit global warming to either 'well below 2 degrees' or to 1.5 degrees. If the much lower levels of oil demand from the IPCC 1.5-degree scenarios are combined with the high supply curve from Rystad Energy, it would suggest a long run price that is much lower than $55/barrel (the BEIS low price scenario for 2019). However, it is very unlikely that global oil demand would be low enough to lead to a long run price that is lower than the BEIS stress test price of $35/barrel.

The BEIS comparison of global gas demand scenarios for 2035 and 2040 shows that the IEA current policies scenario has the highest demand of all scenarios (5366bcm in 2035 and 5847bcm in 2040). However, at the lower end, there are a large number of scenarios with global gas demand that is lower than the IEA sustainable development scenario (4298 bcm in 2035 and 4184bcm in 2040). These include scenarios from BP, Shell and UCL/UKERC. As shown in table 1 above, scenarios included in the IPCC 1.5 degrees report include global gas demand that is usually much lower than the levels in the IEA scenarios.

As was the case in 2018, the IEA scenarios include a relatively narrow range of medium-term gas demand in China. Gas demand ranges from 432 mtoe to 460 mtoe in 2030, up from 198 mtoe in 2017. These levels of demand for 2030 are significantly higher than in the 2018 World Energy Outlook, reflecting the increase in demand in 2018. However, the range of demand in the IEA scenarios may not capture the significant uncertainty about how Chinese demand might change in the medium- and long-term.

The important comparison is between the gas demand figures for Europe in these scenarios. It remains the case that disaggregated data to make this comparison is not always available, and that different organisations use different definitions of 'Europe'. If European gas demand is significantly lower than the level in the IEA Sustainable Development Scenario, the resulting low-price assumption would also be lower (see Figure 5 in the BEIS report). BEIS note that European gas demand could be more constrained in a scenario where stringent climate targets are met – but also that there is a lot of uncertainty about the extent of this effect. This uncertainty is reflected in the scenarios summarised in table 1. Whilst the impact of lower demand on prices is very uncertain, this suggests that the possibility of a long run price that is lower than 43 p/therm should be seriously considered.

The comparisons of coal demand scenarios in the BEIS report are more limited than those for oil and gas. The Aurora Energy Research scenarios for global coal demand in 2030 and 2040 are within the range of the three IEA scenarios. However, as noted above, global demand in scenarios published in the IPCC 1.5 degrees report include much lower global coal demand than any of the IEA scenarios.

For the coal price assumptions, the important comparison to make is with European import demand for coal in the IEA scenarios. Disaggregated data is not available from the integrated assessment models used for the IPCC report. BEIS have included a comparison with BP scenarios. This includes the BP rapid transition scenario which has very low demand for European coal imports in 2030 and 2040 – much lower than in the IEA sustainable development scenario. If this BP scenario were to unfold, it could lead to lower prices than in the low-price assumption for coal. Since the relevant supply curve is flat at the point where it intersects demand, the difference would need to be significant for there to be an impact on the low-price assumption.

Overall, the IEA scenarios cover a wide range of long-term demand for oil, gas and coal. In almost all cases, this range includes the high demand scenarios produced by other organisations. However, there is much more uncertainty at the lower end of the IEA range. At a global level, a significant number of other scenarios include much lower demand than the IEA sustainable development scenario. Many of these scenarios have been designed to explore futures that limit global temperature increase to 1.5 degrees. Comparisons for Europe are much more difficult due to limited disaggregation within some non-IEA scenarios. However, the available data reinforces the conclusion from the 2018 panel report that there is a continuing need to consider much lower demand scenarios, and their consequences for the price assumptions.

3. Fossil Fuel Price Assumptions

This section examines each fossil fuel price assumption. It follows a common format that starts with a discussion of the current context; it the identifies common uncertainties; and it concludes by assessing the 'reasonableness' of BEIS's fossil fuel price assumptions.

3.1 Oil Price Assumptions

Context

The oil market is on tenterhooks amidst an array of rising geopolitical risks. Firstly, the Trump Administration announced it would no longer renew waivers for countries importing Iranian crude or condensate after they expire at midnight on 1 May, in an unprecedented development. Secondly, the administration is also sanctioning Venezuela, hoping to oust President Maduro, which has failed miserably so far. Finally, President Trump has also given his support to General Haftar's offensive in Libya that could fragment the country deeply and reduce oil production yet again.

Spare capacity in the oil market is thin, however, and its ability to cope with all these disruptions is non-existent. Using operable short-term spare capacity for Saudi Arabia as 11.2 mb/d (the highest sustained production by the Kingdom has only been 11 mb/d for a month in November 2018), OPEC spare capacity should fall below 2 mb/d from June onwards and down to as low as 0.6 mb/d by Q4 19 as Saudi Arabia starts to raise production to compensate for falling Iranian volumes. The industry typically defines spare capacity as volumes that are available within 30 days and can be sustained for 90 days. This would immediately exclude volumes from Iran and Venezuela (unless the sanctions were to be removed, and in the case of Venezuela production growth would still be slow). For all intents and purposes, if Saudi production is at 11 mb/d, the UAE at 3.4 mb/d and Russia back to November 2018 highs of 11.7 mb/d, the world will not have any real spare capacity left. So, while OPEC+ could probably absorb a substantial drop in Iranian exports, it would eliminate most, if not all, of the world's spare capacity, leaving the market with little to deal with any additional outage just when the world is looking at likely disruptions across Venezuela, Libya and Nigeria.

So even though US production continues to grow rapidly at around 1.5 mb/d y/y, the oil market is tight, especially given the growing mismatch in the quality of crude. And now US production growth itself is being questioned. Indeed, 80% of the Permian production growth is above 50 API crude, effectively condensates, when global refining capacity additions continue to focus on medium and heavy crudes. Saudi Arabia for instance has mostly tied up its Arab Heavy and Arab Medium grades in new refinery start-ups in China and Malaysia this year. The bulk of the spare capacity held by Saudi Arabia today is Arab Light and Arab Extra Light and almost all of Saudi Aramco's near-term development plans through 2025 focus on light crude production. Meanwhile, the UAE can increase exports of the new medium sour Umm Lulu grade but, like Saudi Arabia, the bulk of the UAE cuts to Asia in the last few months have been in light sour Murban. So even if the world (namely Saudi Arabia, Russia and the US) manages to match the volume of lost Iranian exports and meet slowing but still growing demand, it will be unable to match the quality, creating wide distortions between light and heavy crude prices.

Key uncertainties

The last three Fossil Fuel Price Assumptions set out a full list of uncertainties, this report updates the points made in previous reports.

Supply: In addition to the US withdrawal from the nuclear deal with Iran (JCPOA), sanctions on Venezuela and the precarious supply outlook in Libya are also added uncertainties for supply. There is nothing in the sanctions legislation that would prevent the Trump Administration from deciding to issue waivers again. But this would entail a significant political climbdown for President Trump and, thus, there is likely a high hurdle for such a development (e.g. a sharp surge in oil prices). The Iranian regime could prove to be much more durable than some Iran hawks believe. Yes, economic pressure on Iran has been ratcheting up since the re-imposition of US sanctions last year, with GDP falling, inflation rising, and real wages declining. As such, any financial handouts/subsidies to forestall the risk of large-scale, anti-government protests will be less affordable as oil revenues fall. However, the Islamic Republic of Iran has existed in a hostile external environment for 40 years and knows how to survive by using both the carrot and stick, the latter in the form of a security service that is not afraid to violently break up protests. Export revenues are expected to fall as exports plummet, but they will not fall to zero, so funds will still arrive. Furthermore, Tehran signed multi-billion-dollar loans from Asian lenders in 2017, specifically China, and has a sovereign wealth fund worth a reported $92 billion, suggesting it should be able to mitigate the pressure. The slowdown in US crude output poses another supply uncertainty.

Demand: Following multi-year highs of over 1.8 mb/d of y/y growth in 2015 and 1.7 mb/d in 2016 and in 2017, oil demand growth has slowed materially not just as we enter the late business cycle but also as the US is waging a significant trade war with China. The Trump Administration shocked the market by raising the tariff on some $200 billion-worth of Chinese goods from 10% to 25%. The news has caught the market by surprise, after months of being told that both sides were incredibly close to a ‘historic’ agreement. China reciprocated by pushing tariffs on $60 billion worth of US goods to 25% and seems to be hunkering down for a prolonged fight.

China is unlikely to significantly alter the role of the state in the economy or give up the country’s industrial ambitions. Whether the deal that China allegedly reneged on had resolved these structural issues remains unclear. The main sticking point currently revolves around technology transfer and where cloud data will reside. The US negotiating team believes that China had initially agreed that there would be legislation introduced to address these concerns.

Beijing will accelerate its efforts to support the Chinese economy through stimulus measures. Advisers to China’s central bank reportedly estimate the impact on the Chinese economy ‘within a controllable range’ of 0.3 percentage point drop in GDP growth this year, given the offsetting impact of the support measures already rolled out. To be sure, estimates regarding the impact on the Chinese economy vary widely but there is undoubtedly downside risk to demand.

As more tariffs are introduced, they will likely have a dampening effect on the Chinese economy and on global growth—even if a deal is reached at a later stage. The impact of this will be felt more acutely starting in 2020, though Beijing will step in to support growth through a more aggressive combination of fiscal and monetary policy. Stress-testing an extreme case that Chinese GDP growth would fall below 5%, the impact on oil demand growth could be as high as 0.35-0.40 mb/d, with China accounting for half of the hit, taking demand growth over the next few years to well below 1 mb/d.

Add to this, uncertainties around Brexit and other European elections together with a growing backlash against plastics by governments around the world, and there are several uncertainties around medium term and long-term demand.

The impact of the changing value of the US dollar on oil markets is also thought, by some, to be a major driving force in oil price determination. Where this factor leads us in the next few months depends on: how well commodity-dependent economies and net oil-importing economies have adjusted to lower prices; whether commodities prices have truly bottomed out as some believe; and, on changes to interest rates.

Geopolitics: In the wake of the announcement by the US to no longer issue waivers to buyers of Iranian crude, Iran's proxies have become more active across the region and in mid-May, the market got a first real taste of what is likely to come. First were reports early in the week that four tankers had been attacked at the port of Fujairah in an act the Saudi Energy Minister called terrorism, but what the UAE and others continue to cite as sabotage. Two of the tankers were Saudi owned. The damage was very focused, enough to side line the tankers, but not so much to render them junk. There are still very limited details regarding this incident with Saudi and UAE officials not disclosing much as their investigation is ongoing.

The second incident was a weaponised drone attack on a pumping station on the East-West pipeline north of Riyadh. Iran-allied Houthi rebels in Yemen claimed responsibility for the attack. The Kingdom also denounced it as an act of terrorism. The attacks on the Saudi oil industry drove home to traders that the Kingdom is vulnerable.

As a result of these two incidents and other intelligence, the Trump Administration ordered a partial withdrawal of its diplomats from Iraq, as Washington warned of heightened threats from Iran and Tehran-backed Shiite militias. Germany has also suspended its training operations in Iraq, and the UK has now raised the threat level for all UK forces and diplomats in Iraq and has started contingency planning in case the UK decides it has to remove personnel from Iraq, Saudi, Kuwait or Qatar. Iran has denied all of the allegations and has accused the Trump Administration of staging these events, trying to pull Iran into a war with the US and its regional allies.

IMO 2020 – regulatory changes: The switch to 0.5% sulphur bunker fuels from 1 January 2020 mandated by the International Maritime Organisation (IMO) in late 2016 is rapidly moving to becoming a reality. All product specification changes cause shifts in prices and volatility and IMO 2020 may well be one of the biggest ever. IMO 2020 eviscerates the last big sulphur sink in the refined products world and will force refiners to produce a greater proportion of clean products than ever before, at the same time as getting rid of fuel oil—which is an insurmountable challenge in the near term. Getting more clean products out of the same refineries means greater competition among all products for space in secondary units such as hydrotreaters. Effectively, this means the marine fuel sector will soon be in competition with other consumers of clean fuels, be they gasoline consumers or diesel consumers. This means higher prices.

Moreover, the ability of the global refining system to make more diesel is limited due to the growing volume of US tight oil which are low on distillate cuts. So, in order to make more diesel for ships (estimates vary between 1-3 mb/d of incremental demand), refiners need to run more crude (this would equate to 2-7 mb/d more crude) in a market that is already short of crude. This could lead to a huge price shock in 2020, possibly pushing the world to a recession.

Assessment

Notwithstanding the current high level of political uncertainty discussed above, the basis and factors behind the calculation of BEIS's 2019 Oil Price Assumptions are viewed as sound. The use of the Brent forward curve in the short term (two years), then increasing in line with a linear interpolation to the long-term equilibrium price based on the marginal cost of oil supply developed through the Rystad Energy cost of supply analysis, including a few adjustments to Iran, Venezuela and US shale, seems a reasonable approach.

3.2 Gas Price Assumptions

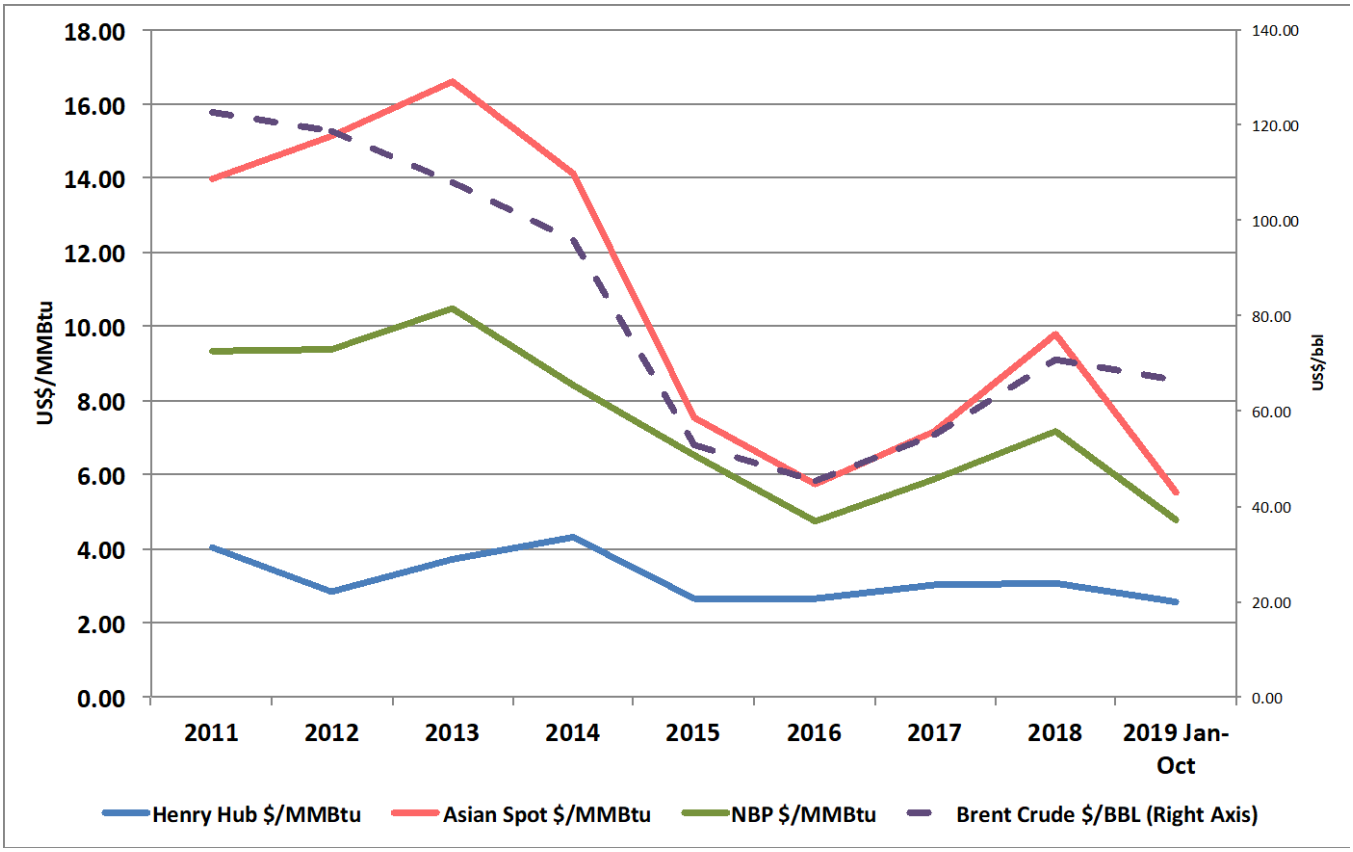

Figure 1: Trends in natural gas prices 2011 to end October 2019

Source: Heren

Context

With no global price for gas and LNG, gas price formation is based on regional markets. That said, the volume of LNG traded on a spot basis has increased; in 2018 the volume of 'pure spot trades' represented 25% of LNG traded, up from 15% in 2015.[18] The impact of this has been a rise in cross regional LNG flows, enabling gas to move easily between basins linking supply points with markets. This has led to increasing price convergence, as shown in Figure

[18] 'The LNG Industry GIIGNL Annual Report 2019', GIIGNL, March 2019. pure spot trades are defined as cargoes delivered within three months of the transaction date.

1. It also means that LNG is becoming a truly global commodity, with cargoes moving to the market that pays the highest price. This increased liquidity is supported by additional LNG being produced and sold from plants based in North America where cargoes are priced on the basis of the Henry Hub gas hub price (the most liquid hub in the world) and under more flexible contracts.[19] This, together with the growth of financial instruments to manage Asian LNG price, has enabled companies to manage price risk effectively and support greater trading and cross basin arbitrage. The growth of Asian paper swaps contracts has been remarkable. In April 2019 Platts reported that 57 full LNG cargo equivalents (~ 3.3 million tonnes) were traded based on the JKM swaps price, up from almost zero in 2014.[20] Though this still only represents a small volume vs. total LNG trade, it does provide an important financial instrument, supporting the increase in LNG trading.

With increased liquidity in the LNG market gas convergence between regional prices has been realised. That said, there will be regional variations. For example, unexpectedly high Chinese gas/LNG demand in 2018 led to higher than expected Asian LNG spot prices. As set out in previous Fossil Fuel Price Assumptions reports there is a direct linkage between Asian gas and LNG demand for short-term cargoes and the available LNG cargoes and market-based gas price level in North West Europe. This linkage may reduce slightly over the next 12-24 months as additional volumes of North American LNG start production from plants currently under construction. Uncertainty over the timing of this new LNG supply and gas/LNG demand will mean that price volatility is expected as short-term demand fluctuations pull LNG to specific markets.

In previous reports it has been noted that the impact of global LNG being priced in US Dollars and GB gas prices in pence per therm has meant that the constantly changing US$/Sterling exchange rate has impacted on the level of BEIS's NBP price forecasts.[21] The 2018 Fossil Fuel Price Assumptions report used a market exchange rate based on the average of 10 days forward exchange rates in June when the report was finalised, the resultant rate was £1 = US$1.42. In 2019 BEIS has used the exchange rate from the OBR (Economic and Fiscal outlook – March 2019) for the period 2018-2023 and Oxford Economics' forecasts for the period 2035-2040 (flatlined) with a linear interpolation between OBR 2023 and Oxford Economics 2035 for the intervening years. The exchange rate for 2020 is, therefore, assumed to be £1 = US$1.32, for 2025 £1 = US$1.39 and for 2030 £1 = US$1.45. The impact of these exchange rates, when compared to those used in last year's report, is to marginally reduce the NBP price by ~ 5% in the early years, while increasing by a similar percentage in later years. It is viewed that the impact of the changing exchange rate from last year to this year's price assumptions is, therefore, marginal. As previously noted, further exchange rate volatility will correspondingly increase or reduce the cost of gas in GB, in local currency, adding additional uncertainty to GB domestic gas prices.

Global gas supply and demand is facing considerable uncertainty. In 2018, global output of LNG was 430 Bcm (314 million tonnes),[22] 8.3% higher than 2017. This increase in supply was not as rapid as was expected due to delays in project start-ups in North America. By 2020 the industry is expected to be producing 535 Bcm (390 million tonnes) LNG with half of this new

[19] All LNG from the USA has no contractual destination restrictions
[20] JKM – Platts Asian LNG spot reported LNG price the 'Japan Korea Marker'. https://www.spglobal.com/platts/en/market-insights/latest-news/natural-gas/050218-jkm-lng-swaps-liquidity-hits-new-33-million-mt-record-in-apr.
[21] Global LNG is priced is US$/MMBtu and domestic gas prices priced in local currency. For the UK gas market in p/therm, so the Sterling/US Dollar exchange rate is important in developing price assumptions for UK gas prices.
[22] GIIGNL "The LNG Industry in 2019."

supply coming from North American LNG supply projects that also bring more contractual flexibility than traditional LNG contracts with ~ 40-45% all cargoes traded in 2020 being contractually flexible. This will drive more liquidity and shorter-term LNG cargo trading. For the period 2025+ commentators estimate of LNG demand growth vary but lie in a range 615-685 Bcma (450-500 million tonnes per annum). The chart included in Annex D of the Rystad Energy report sets out its LNG demand forecasts against those of other external sources. Rystad Energy forecasts that global LNG demand will grow from 430 Bcm in 2018 to 930 Bcm in 2040. It should be noted that this compares to a range of 680 and 940 Bcm from other external sources, so is at the higher end of the external forecasts by 2040.

This increase in LNG supply is happening at a time of global energy demand uncertainty. The dramatic percentage growth in Chinese gas and LNG demand in 2017/early 2018 was not continued over the whole year 2018. This was due, in part, to the announcement by the Chinese Government in August 2018 that it was planning to impose 25% import tariffs on imports of LNG from the USA and also to reduced Chinese economic growth.[23]. In Japan, the world's largest LNG market, deregulation in its energy market, the pace of renewables penetration, the impact of energy saving measures and the timing of nuclear start-ups means that the level of future LNG demand is not clear. Likewise, LNG demand growth in Korea, Taiwan and South East Asian countries is also uncertain, as is the potential for growth in the Indian market that is extremely price sensitive. The newer markets of, Pakistan and Bangladesh have given some demand support.

As new North American LNG export projects commence production during 2019, 2020 and 2021, prices could fall as sellers seek to secure markets. The NBP price could fall to the lower end of the FFPA range, on an annual average basis, especially if global LNG demand does not rise as planned.

Post 2022/23, there could be a shortfall of LNG unless new LNG production capacity is constructed. To be online in time, companies must take FID[24] by 2019/20, in a period of potentially low prices. In parallel, new countries are seeking to import LNG for economic reasons, moving away from oil, and for environmental benefits. New LNG FID's in West Canada, USA (Golden Pass) and Mozambique LNG shows that projects can be developed during this period of price, demand and contractual uncertainty. They do, however, require long-term commitments from buyers or equity partners to underpin the financing of the new project.

Key uncertainties

The last three Fossil Fuel Price Assumptions set out a full list of uncertainties, this report updates the points made in those reports and raises a few additional points:

Global gas demand: Natural gas is expected to grow faster than oil and coal, growing by 1.7% p.a.[25] to 2040 supported by low-cost supplies and growing supplies of LNG. Demand growth is expected to be from the power and industrial sectors with transport recording the fastest growth in percentage terms, albeit with small volumes. This growth could be undermined by the pace and structure of the energy transition to lower carbon fuels with, for

[23] The impact of tariffs on LNG imports into China could also be to push China to increase its imports of gas via pipeline which would reduce additional LNG imports into China in the long-term
[24] Final Investment Decision - the date on which the project sponsors decide to make a binding financial decision to proceed with the project. Also known as FID date.
[25] Source: 2019 "BP Energy Outlook."

example, a jump directly to renewables from oil not transitioning via gas. In order for all demand growth to be realized, the necessary infrastructure must be in place or constructed.

Asian LNG demand growth: If Asian LNG demand does not grow in line with additional LNG production, then this could drive further price weakness, for example in the short to medium term, lower economic growth in Asia could result in lower energy demand resulting in surplus LNG cargoes being moved to the European market. It is not known, at the time of writing this report, if Chinese tariffs on imported US LNG will remain in force in the long run and how the market will balance.

Short-term demand changes: Weather and other unexpected events can cause short-term changes in LNG demand. As long as these are only short-term in nature then the impact should be managed by the market effectively.

Gazprom's strategy: As LNG supply into Europe increases in 2019/21, Gazprom's strategy with respect to its pipeline gas exports to Europe is not clear. If it decides to maintain market share, then this could lead to additional price weakness in Europe. Likewise, a price-based strategy may result in higher price levels. Uncertainty over Nordstream 2, Turkstream and the future of gas transit through Ukraine could mean potential price volatility if Russian gas pipeline imports are disrupted.

US LNG production: Downward pressure on European gas prices will mean that US LNG capacity holders could sell their LNG on a cash cost basis to maintain production. Should prices fall so low that they do not support even the cash cost levels then, if US LNG is not economic, it may not be produced.

Changes in European domestic gas production: The impact of the earlier than planned shutdown of the Groningen gas field in 2022 (not 2030 that was previously planned).

Coal prices: Rising coal prices, or the introduction of legislative controls on coal resulting in higher carbon prices in Europe, would make gas more economic vs. coal in power production. This could lead to higher use of gas in power, and therefore increased imported LNG.

Rising oil prices: Should oil prices stay above $60/bbl (and Henry Hub gas prices remain below $3/MMBtu), then oil priced LNG in Asia would rise to a level higher than the fully built up cost of US LNG. This would pull short-term cargoes of LNG away from the North West European market as Asian buyers seek to reduce term LNG and replace with lower priced spot/short-term cargoes. This would, therefore, reduce LNG supply to the European and GB markets.

Sterling / US Dollar exchange rate: Further weakness of Sterling would result in higher imported gas costs in Sterling terms. Volatile exchange rates create price uncertainty.

Disruptions to the market: Short-term disruptions to the market due to political and market restructuring events—such as conflict in the Gulf—could also impact on global gas and LNG supply/demand. The drone attacks on Saudi oil facilities in May 2019 has further increased political tensions in the Middle East and again raised the potential for a closure of the Straits of Hormuz, by Iran, thus preventing LNG exports from Qatar and Abu Dhabi. In 2018 LNG exported from these two countries represented 26% LNG imports so if supplies though the Straits were stopped, it would cause a global shortage of LNG and higher prices.

LNG supply 2025+: If significant new investment decisions are not taken on additional LNG export capacity by end 2019/20 then this could result in a supply shortfall. Qatar, and other

LNG supply countries, have ambitious plans to develop new LNG production capacity. Such projects need to be underpinned by market demand and it is expected that only the lowest cost LNG projects, and those with political support, will move ahead. The continued role of large company aggregators underpinning new capacity with long-term contracts is not known though the moves by Qatar to export from both the US (through its planned Golden Pass facility) and from the Middle East indicate a more global LNG world. Rystad Energy assumes that 20% Qatari LNG exports will be supplied to Europe (based on actual volumes over the past few years). This assumption is reasonable.

Pace of technology: Rystad Energy assumes no advancement in technology in its cost curves. As noted earlier in this report, if technology advancements were to happen then costs could be lower in the future. There is a risk though that the recent fast technology changes slow down and the industry may not see some the cost reductions that some companies were expecting.

Corporate restructuring: If there is continued consolidation in the LNG sector then this could undermine market competition as the number of industry players is reduced.

Assessment

The basis and factors behind the calculation of BEIS's 2019 Gas Price Assumptions are viewed as sound. The use of the NBP forward curve in the short term (two years), then increasing in line with a linear interpolation to the long-term equilibrium price based on the marginal cost of gas supply developed through the Rystad cost of supply analysis, seems a reasonable approach.

The exchange rate assumptions used in BEIS's analysis seem reasonable, with little change from the previous year's analysis.[26]

For the period 2019-2021, the low-price case is roughly in line with the US LNG export cash cost price (assuming the Rystad Henry Hub price of $3.64/MMBtu). From 2022 the low case assumption is above this level. So, in circumstances of oversupply of LNG then prices may fall lower, but it is viewed as unlikely on an annual average price basis. In all cases at a lower price Henry Hub price level of $3/MMBtu (which may be more reflective if US shale gas production increases to 20 Bcm by 2040), then the cash cost price of US LNG would fall below the low-price case (as it does under Rystad Energy's low Henry Hub price case of $2.64/MMBtu). That said, in Annex E of its report, Rystad Energy compares different forecasts of Henry Hub prices. In the majority of the IEA and EIA price cases (and the mid and high Rystad Energy price cases) the Henry Hub price will be above $3/MMBtu in all years post 2025.

The period post 2030 remains uncertain as the role of gas in global and European energy transition to a low carbon economy is uncertain and, from 2035 the price has been flatlined, which as noted in last year's FFPA report by BEIS, is a simplification. This seems a reasonable approach.

There are several uncertainties listed above, from a demand and supply perspective, which are echoed by Rystad Energy in its report. On supply, in the long-term, the market must pay the

[26] BEIS has used the OBR (Economic and fiscal outlook – March 2019) exchange rate forecasts for the period 2018-2023 and Oxford Economics' forecasts for the period 2035-2040 (flatlined) with a linear interpolation between OBR 2023 and Oxford Economics 2035 for the intervening years.

full cost of new marginal LNG supply otherwise investment in new supply capacity will not be made. If these LNG FIDs are not taken then gas prices could well rise to the higher end of the price ranges. The level of the BEIS central long run gas price assumption of 59 p/therm, 2019 prices in 2030 ($8.5/MMBtu) should support the economics of new LNG capacity FIDs.

In the longer-term, the energy transition and the future role of gas in a de-carbonising world is not clear. The later years of the assessment may see some price weakness if the pace of growth in renewables and other clean energies increases and gas's role reduces.

Despite the uncertainties set out in this section, UK gas prices should be contained, on an annual average price basis, within the high and low gas price range set out in the price assumptions, unless US gas prices falls to $3/MMBtu and below and low global LNG demand forces North American LNG sellers to cash cost their sales prices. Even if this was to happen, it is not clear if this would be below the low case prices on an annual basis, though may go below the assumed low-price levels on a cargo by cargo basis.

3.3. Coal Price Assumptions

Context

Since Q3 2018, global coal prices and especially European coal prices have been declining. This development marked the end of two years of bullish coal prices, in which the European price marker ARA CIF (spot) had reached up to $100/t in October 2018. By April 2019, ARA CIF (Spot) coal prices were even below $60/t, where they have more or less stayed at least until autumn 2019.

The recent prices are partly based on short-term developments, but also the longer-term trend pointed downwards. As a short-term factor, the very mild winter made European thermal coal demand plummet. Coupled with low gas prices (similarly affected by the warm winter) and high prices for allowances in the EU Emissions Trading System (EU-ETS), reaching EUR 25/t and more, coal-fired power generation had a difficult position against gas. Rising coal stocks in Europe gave traders the signal of a very oversupplied thermal coal market and hence low spot prices. Forward prices were more than $10/t stronger, e.g., in Spring 2019. That contango situation indicated that part of the recent price decline was substantially driven by short term developments. However, there are also longer-term bearish market signals, as the declining forward prices of the front year product suggest, such as stronger Chinese domestic production lowering the needs for imports. As the last years have shown, developments around China are crucial also for European coal prices. As such, China introduced production restrictions (e.g. by reducing the working days for coal miners) in 2016 making prices in Asia and Europe soar immediately.

It is to be expected that coal prices in Europe will remain fundamentally linked with the Asian market, and China in particular. Generally, since transport costs of coal are rather low compared to the price of the good, developments in Asia immediately affect European coal prices because of arbitrage opportunities. Lower freight rates, as observed recently, foster the arbitrage potential. Nonetheless, the European coal market has its own dynamics such as exceptionally low demand during the last 12 months. Thus, prices between Europe and Asia decouple from time to time as seen recently in 2019 when European prices were substantially below Asian prices.

Whereas the example shows that price deviations of European and Asian coal prices are temporarily possible, the equilibrium situation especially in the long term is rather coupled prices. Therefore, European coal prices must be seen in the context of global developments. Hence, many of the following key uncertainties for the European coal price address global trends.

Key Uncertainties

Chinese coal market: One major, if not the major, source of uncertainty for European coal prices is the Chinese coal market. Its steam coal demand alone is more than three times bigger than the global seaborne market volume. Connected to the European market via interregional arbitrage, every trend concerning China's domestic supply and demand affects coal prices globally and in Europe as the recent years have shown. Uncertainties on the demand side arise from increasing air pollution measures, higher ambitions to diversify energy carriers, GDP growth or power demand. Concerning production, structural changes in the mining sector as well as policy intervention are among the main uncertainties: As an example, China's National Development and Reform Commission (NDRC) has announced the goal of keeping prices within a determined price corridor. New policy measures are always conceivable and, often, these have the potential to strongly affect global coal prices.

Policies on coal generation in Europe: Policies on coal generation are a key uncertainty for European coal demand and prices. Many countries have announced the phase out coal-fired generation during the next decade such as the UK, the Netherlands, France, Italy and Finland. Recently, in Germany, Europe's largest coal consumer, the so-called "Coal Commission" has agreed to end coal power generation by 2038, a vote on which will be held over the next few months by the German government. Besides national policies, the EU-ETS puts pressure on coal as recent prices of about EUR 25/t have shown. During the last couple of years, several measures have been introduced to strengthen the price (e.g. cancellation of certificate oversupplies) or to counteract the "waterbed effect" (i.e. the effect that national decarbonisation policies becoming ineffective due to the EU-ETS).

Global coal demand: Especially in the long-term, global coal demand is highly uncertain. On the one hand, coal is coming under greater pressure politically and in the finance sector given global decarbonisation needs. On the other hand, coal is cheap and abundant and for many countries still the most important energy carrier to fuel national GDP growth. Especially in India and Southeast Asia, coal-fired generation is often the main option to satisfy increasing power demand. Similar to China, global coal demand trends have a direct impact on European coal prices.

Productivity gains versus decreasing coal qualities: Global coal supply has seen substantial cost reductions earlier that decade at times of depressed prices. Even though supply costs kept stabilized over the last years, productivity gains (e.g. digitalization) are possible in the future, which would imply lower mining costs. As an opposing trend, coal quality is expected to decline on a global average implying higher costs. Besides productivity and geology, input factor prices in the coal value chain are another source of uncertainty for European coal prices. As such, shipping freight rates, diesel, machinery, dynamite, labour or currency exchange rates have an important impact on coal supply costs.

Assessment

The methodology to derive coal prices in the BEIS Fossil Fuel Price Assumptions 2019 is consistent with that of its previous editions. Two major changes were applied: First, the time horizon of the long-term price anchor was moved from 2030 to 2035. Second, a new set of

coal supply cost curves developed by Rystad Energy laid the basis for deriving the 2035 coal price assumptions.

The short-term coal price assumptions for the years 2019 and 2020 have been modelled reasonably. Using spot and forward prices and their historical deviations between traded prices and outturn is a sound way to model the central, high and low scenario for the short term as discussed in Section 2.1. Likewise, and discussed in Section 2.2., it is a sound approach to assume for the medium term (2021-2035) that as of 2021 markets tend towards their long-term equilibrium, and hence to interpolate the 2020 values up to 2035.

At this point it is worth noting, that the very low coal prices (spot and forward) as seen in 2019 strongly affect the medium-term scenarios (downwards) as discussed in the BEIS report. The methodology is applied correctly and consistent to the previous editions. However, there is a considerable path dependency of the medium-term assumptions regarding the current price level. Especially in years with exceptional circumstances leading to very low or very high prices (e.g. warm weather), these affect the medium-term price assumption although they are not a fundamental trend. It is worth considering adapting the methodology in next year's edition of the Fossil Fuel Price Assumptions making it more robust regarding temporary price outliers.

The long-term coal price anchors for 2035 are modelled from deriving different market equilibria of an updated set of long-term coal supply costs for the European coal market and future European thermal coal import demand for three scenarios for the year 2035. Methodologically consistent with the previous editions (but with updated data input), this is a sound and well-known approach for modelling long-term price assumptions.

As explained above, the IEA's World Energy Outlook 2018 and its three scenarios CPS, NPS and SDS lay the foundation for the European thermal coal import demand scenarios. IEA's scenarios cover a variety of policy developments and are therefore well-suited to capture the most relevant uncertainties affecting European coal demand. Since the WEO 2018 focuses on overall EU coal demand (including lignite, steam and metallurgical coal) and domestic production, an additional methodological step is required to derive European thermal coal import demand. Consistent with the recent years, BEIS corrects European coal demand for domestic European coal production as well as European lignite and metallurgical coal demand which is a reasonable approach.

Long-term supply costs are based on a set of three different supply cost curves for the year 2035 provided by Rystad Energy (see Section 2.2). These supply cost curves account for a wide range of uncertain developments regarding mining capacities and costs. Rystad Energy models its supply costs for the European market, whereas the Asian market is not accounted for in order to limit complexity. The arbitrage potential of swing producers (e.g. Russia or South Africa) optimizing sales according to price differences between Asia and Europe is thus modelled in a static approach, i.e. volumes available to Europe are fixed exogenously. To cope with uncertainties, these numbers are varied among the scenarios. Even though the modelling does not automatically derive arbitrage opportunities between the Asian and European market, it is a reasonable approach with a very high data quality.

Lastly, the Panel supports the decision to flat line price projections between 2035 and 2040 since there is no additional information available for this time frame, which would justify modelling a certain price movement.

The BEIS's coal price assumptions lie in between external price projections in the long-term. For the short-term they are in most considerably below, as they include the recent low-price environment. For the central case, price assumptions are ca. $10-20/t below IEA WEO 2018

(NPS). For the low-price scenario, 2030 to 2040 prices are again $10/t below IEA WEO 2018 (SDS). They are similar to 2030 external projections but until 2040 external projections are significantly dropping whereas the BEIS assumptions remain constant due to differing long-term scenario assumptions. In the short term, the 2020 BEIS price assumptions are ca. $40/t lower resulting from newer data reflecting recent price drops and BEIS' forward curve approach and subtracting one standard deviation from current forward prices. In the high price scenario BEIS's price assumptions are similar to IEA WEO 2018 (CPS). Overall, the comparison with external price projections seems acceptable with differing prices resulting from different methodologies and scenarios applied.

4. BEIS's Quality Assurance Process

We have assessed the Quality Assurance (QA) process for the models BEIS uses to generate the fossil fuel price assumptions. The BEIS team have developed three Excel models to generate these assumptions for gas, oil and coal respectively. They shared the models with the panel.

The guidance notes included within the models explain how they work in detail, including guidance about how to change input data, adjust the supply curves and demand scenarios. It is also clear how this data is used to generate the short and long run price assumptions. Whilst our experience of working with BEIS shows that some of the knowledge required to generate price assumptions can be difficult to codify, the models now provide very clear guidance. It should help to minimise any problems that could arise due to a loss of knowledge when there are staff changes in the team.

An important limitation of the methodology that has been used is that the long-term demand and supply assumptions that are used are provided by external organisations (the IEA and Rystad Energy respectively). In each case, models and other methodologies are used by these organisations. As we have stated in previous years, it is important for BEIS to ensure that sufficient attention has been paid to QA of those models.

The IEA World Energy Outlook, which is the source of the energy demand scenarios used by BEIS, is produced using the IEA World Energy Model.[27] This model is large and complex and depends on a number of more specific models. It is a partial equilibrium simulation model, for which the documentation is available, the structure has a number of standard elements that link energy supply through to energy service demands. It calculates energy supply, demand, prices, investment and emissions on an annual basis. Exogenous input assumptions include GDP, CO2 prices, policies, demographics and technological change. In some other models, some of these inputs' assumptions are endogenous. Demand is mediated through stock models for end use sectors (e.g. vehicles or housing). The World Energy Outlook is subject to significant external scrutiny and peer review. It is therefore reasonable to conclude that the demand scenarios have been derived through a rigorous process. However, it is important for these scenarios to be compared with other scenarios to ensure they cover a reasonable range of possible outcomes. As discussed in section 2.3 of this report, this range does not cover some of the lower scenarios for fossil fuel demand that have been produced recently for the IPCC 1.5 degrees report.

For the 2019 price assumptions, BEIS commissioned a new set of supply curves for oil, gas and coal from Rystad Energy. They were commissioned because the previous set of curves from Wood Mackenzie were increasingly out of date. The panel were fully engaged in the process of developing the new supply curves, and were given an opportunity to comment on the invitation to tender and draft results – and to discuss results and methodologies with the Rystad Energy team.

[27] IEA (20182016) World Energy Model Documentation 2018 Version.2016. Paris: OECD/IEA. Available with more detailed explanations of specific aspects of the World Energy Model here: http://www.worldenergyoutlook.org/weomodel/documentation/

During this process, Rystad Energy provided clear explanations of their data sources, methods and assumptions. Their overall approach is relatively simple and transparent, and focuses on establishing future break-even prices for each asset in a global database (oil or gas field, or coal mine). Some of their assumptions (e.g. on discount rates) were adjusted following feedback from the Panel. Overall, this process helped to give the panel confidence that the supply curves are robust enough to be used to generate the BEIS price assumptions.

5. Conclusions and Recommendations

5.1 Conclusions

The Panel continues to believe that there is great value in having external experts review the process by which BEIS arrives at its fossil fuel price assumptions. There is currently a large amount of uncertainty on global energy markets, which is reflected in increased volatility. This past year the role of geopolitics has become particularly significant, with the imposition of various sanctions on oil producing states threatening supply and trade frictions challenging economic growth and energy demand. Longer term there is growing conviction that action on climate change will constrain future fossil fuel demand. In such an environment, testing the reasoning and methodologies behind the fossil price assumptions is particularly important and our concern is whether or not future uncertainty will be captured within the range between the high and low-price assumptions.

This the fourth year in a row that the current methodologies have been used and the Panel considers them well established and the resultant the fossil price assumptions to be reasonable, straightforward and transparent.

This year Rystad Energy has supplied BEIS with a new set of supply curves. The Expert Panel was involved in the initial tender and attended a series of meetings with Rystad Energy and the BEIS team to discuss the underlying methodology and the resultant supply curves. The Panel is confident in the rigour and transparency of this process and BEIS has published a detailed report from Rystad Energy that makes clear how the cost curves were produced.[28]

The Panel supports the methodologies that have been used to make both the short-term price assumptions based on the futures/forward curve and long-term price assumptions based on long run marginal costs, as well as the use of 'flat lining' and/or interpolating to link the two. As in the past, the pricing of natural gas in pence per therm focuses attention of the US Dollar exchange rate. This year a different source was used for the exchange rate and the implications of this are discussed in the natural gas section of this report.

This year there was detailed discussion of the uncertainties around current and future production of light tight oil and shale gas in the United States and their potential medium-term impact on the oil price and LNG supplies to Europe. The Panel notes that Rystad Energy has a very positive view of the future sustainability of production of US oil and gas, even in a low-price regime.

The Panel is satisfied with the quality of the data that has been used to conduct the short-term analysis and supports the use of the IEA's World Energy Outlook 2018 and its three scenarios to generate future demand scenarios. The Panel appreciates the work done by the BEIS team to 'sense test' the IEA's scenarios against a wider range of available energy forecasts and scenarios.

Annex A of the BEIS report provides a comparison of the 2019 FFPA with those of 2018. As noted elsewhere in this report, caution is needed when comparing the 2018 and 2019 prices assumptions, the methodology remains the same, but the underlying supply curves are

[28] Available at https://www.gov.uk/government/publications/fossil-fuel-price-assumptions-2019

different, and a different source has been used for exchange rates. However, we are confident that the difference between the 2018 and 2019 are artefacts of changing market conditions, rather than the use of different data. The lower short-term oil prices reflect the potential trade-off between weaker economic growth and growing geopolitical uncertainty, the lower gas prices reflect the impact of cold weather in 2018 and the growth in global LNG supply, and finally, the coal prices are lower reflecting changing market sentiment towards coal in Europe.

Finally, we would like to commend the BEIS team for the quality of their work this year. We also note that the procedures to manage staff changes have worked well. The Panel was supplied with information in good time and the BEIS team also responded to our questions in a timely manner. A number of face-to-face meetings with Rystad Energy, when appropriate, and the BEIS team added greatly to our confidence in the price assumption process this year.

5.2 Recommendations

Here we reflect on the recommendations that we made last year and suggest some issues to consider for the 2019 price assumptions exercise.

First, we note that as this is the fourth year that BEIS has worked with an Expert Panel to oversee the price assumptions exercise, the approach is now well established, and the majority of our earlier concerns have been acted upon. This year, despite the added complication of the involvement of Rystad Energy, the process ran smoothly, to time, the quality assurance procedures remain effective, and we are able to maximise the benefits of face-to-face meetings between the BEIS team and the Panel. We note that, as last year, it was necessary to revisit the price assumptions in the autumn; this is because of the time between the finalisation of the initial report in May and its planned publication in November (further delayed by the election). This suggests that BEIS either publish the May report earlier or push back the completion of the analysis to the end of the summer to reduce the lag between the analysis and publication.

Second, last year we recommended that if BEIS decided to source new supply curves it would be good to involve the Panel at the beginning of the process so that they understand fully the underlying assumptions behind the production of curves. We also recommended that the quality assurance expectations should be made clear in any future tender. Both these recommendations were acted on and the Panel is very positive about the processes involved in securing the new supply curves and the resulting report.

Third, we note that the growing global recognition of the need to address climate change, coupled with the falling cost of renewable power, is generating significant uncertainty in relation to the future demand for fossil fuels. As noted, in section 2.3, in the last year some external commentators have called for the IEA to make changes to its sustainable development scenario.[29] Our report highlights the difference between those scenarios and those produced in the recent IPCC 1.5 degrees report. This year the focus was on updating the supply side of the equation, we recommend that next year more attention be paid to flexing the demand side beyond the IEA scenarios. Of course, the IEA itself may respond to its critics in the 2019 edition of the World Energy Outlook.

[29] The IEA's response can be found at: https://www.iea.org/newsroom/news/2019/april/dr-birol-weo-letter.html?utm_content=bufferf859e&utm_medium=social&utm_source=twitter.com&utm_campaign=buffer

Finally, given the high level of uncertainty in global energy markets, we repeat our endorsement of the information now supplied to users of the price assumptions to stress test against the full range of assumptions.

Annex A: Biographies of Panel Members

Professor Michael Bradshaw is Professor of Global Energy at Warwick Business School at the University of Warwick. His research focuses on the interface between economic and political geography, energy studies, and international relations. He is a Fellow of the Royal Geographical Society, where he formerly served as Vice President and is currently a member of Council, and a Fellow of the Academy of Social Sciences. He is an Honorary Senior Research Fellow at the Centre for Russian, European and European Energy Studies at the University of Birmingham and a Senior Visiting Research Fellow at the Oxford Institute of Energy Studies. His recent outputs include: *Global Energy Dilemmas* (2014) published by Polity Press and the co-edited book *Global Energy: Issues, Potentials and Policy Implications* (Oxford University Press, 2015; with Paul Ekins and Jim Watson) and co-author of *Energy and Society: A Critical Perspective* (2018, Routledge). He is currently completing a UKERC project on the global impact of unconventional fossil fuels and on future UK gas security and the potential impact of Brexit and working on a new NERC-ESRC funded project on Assessing and Monitoring the UK Shale Gas Landscape.

Dr Harald Hecking is a German energy expert with substantial research conducted in the fields of the sector coupling, the international natural gas and coal markets and the German Energiewende. As such, Harald Hecking has been the leading scientific advisor assessing pathways of the German Energiewende towards 2050 in a cross-sectoral study launched by the German Energy Agency (dena). Additionally, he analysed the economic impacts of a German coal-phase out, the costs of CO2 abatement on the heat and electricity market, the future potentials of power-to-x in Germany, the economics of long-term gas contracts as well as the security of natural gas supply in Europe. Furthermore, Dr. Hecking contributed to the Medium-Term Coal Market Report while working for several months at the International Energy Agency in Paris. Dr. Hecking holds a PhD in Economics and Master degrees in Geoinformation Sciences and Economics.

David Ledesma is an independent gas and LNG consultant focusing on gas and LNG strategy along the value chain including the structuring of commercial arrangements, financing and markets for pipeline gas and LNG projects. He is an experienced commercial manager with hands-on experience of developing and closing commercial gas transactions as well as developing business strategy. During thirty years in the energy and utility sector, David has worked on the development of complex integrated energy projects, been involved in negotiations at government level, and in the management of joint ventures. From 2000 to 2005, as Director of Consulting then Managing Director of the Gas Strategies Group (formally EconoMatters Ltd), David worked on and managed LNG and gas consulting assignments around the world. David is Chairman of the Natural Gas Programme, at the Oxford Institute for Energy Studies and has co-authored several gas and LNG books, and research papers. In May 2013, David was appointed as a Non-Executive Director of Pavilion Energy, a subsidiary of the Singapore investment firm Temasek Holdings and in summer 2017 he was invited to become an advisor to the fuels advisory board for Japanese LNG and utility company JERA. David writes on gas and LNG and presents regularly at conferences.

Amrita Sen is the founding Partner and Chief Oil Analyst at Energy Aspects. Amrita leads Energy Aspects' analysis and forecasting of crude and products markets. Her specialism is in energy commodities, particularly oil and oil products. Amrita's deep understanding of the complex relationships within the global energy sector, her wealth of industry contacts and 10 years of experience, allow for a unique perspective on market outlook. She holds an MPhil in Economics from Cambridge University, a BSc in Economics from the University of Warwick,

and is pursuing a PhD in Economics at the School of Oriental and African Studies, University of London. She is a Non-resident Senior Fellow at the Atlantic Council, a Research Associate at the Oxford Institute of Energy Studies and was formerly Chief Oil Analyst for Barclays Capital. She is frequently featured in leading media outlets, including the Financial Times, BBC News, Reuters, Bloomberg, CNBC, Wall Street Journal, and Sky News, and at leading industry events as a speaker, and is regarded as a leading authority on oil markets.

Professor Jim Watson is Director, UK Energy Research Centre and Professor of Energy Policy at the UCL Institute for Sustainable Resources. He has 20 years' research experience on climate change, energy and innovation policy. His recent outputs include co-edited books: *New Challenges in Energy Security: The UK in a multipolar world* (Palgrave, 2013; with Catherine Mitchell) and *Global Energy: Issues, Potentials and Policy Implications* (Oxford University Press, 2015; with Paul Ekins and Mike Bradshaw). He was an advisor to the Government Office for Science for a Foresight project on energy (2007-08), a member of the DECC and Defra social science expert panel (2012-16) and has been a Specialist Adviser with three Parliamentary committees. His international experience includes over ten years working on energy scenarios and energy innovation policies in China and India, and a period as a Visiting Scholar at the Kennedy School of Government, Harvard University. He is a member of the Strategic Advisory Group for the Global Challenges Research Fund and a judge for the Queens Awards (sustainable development).

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