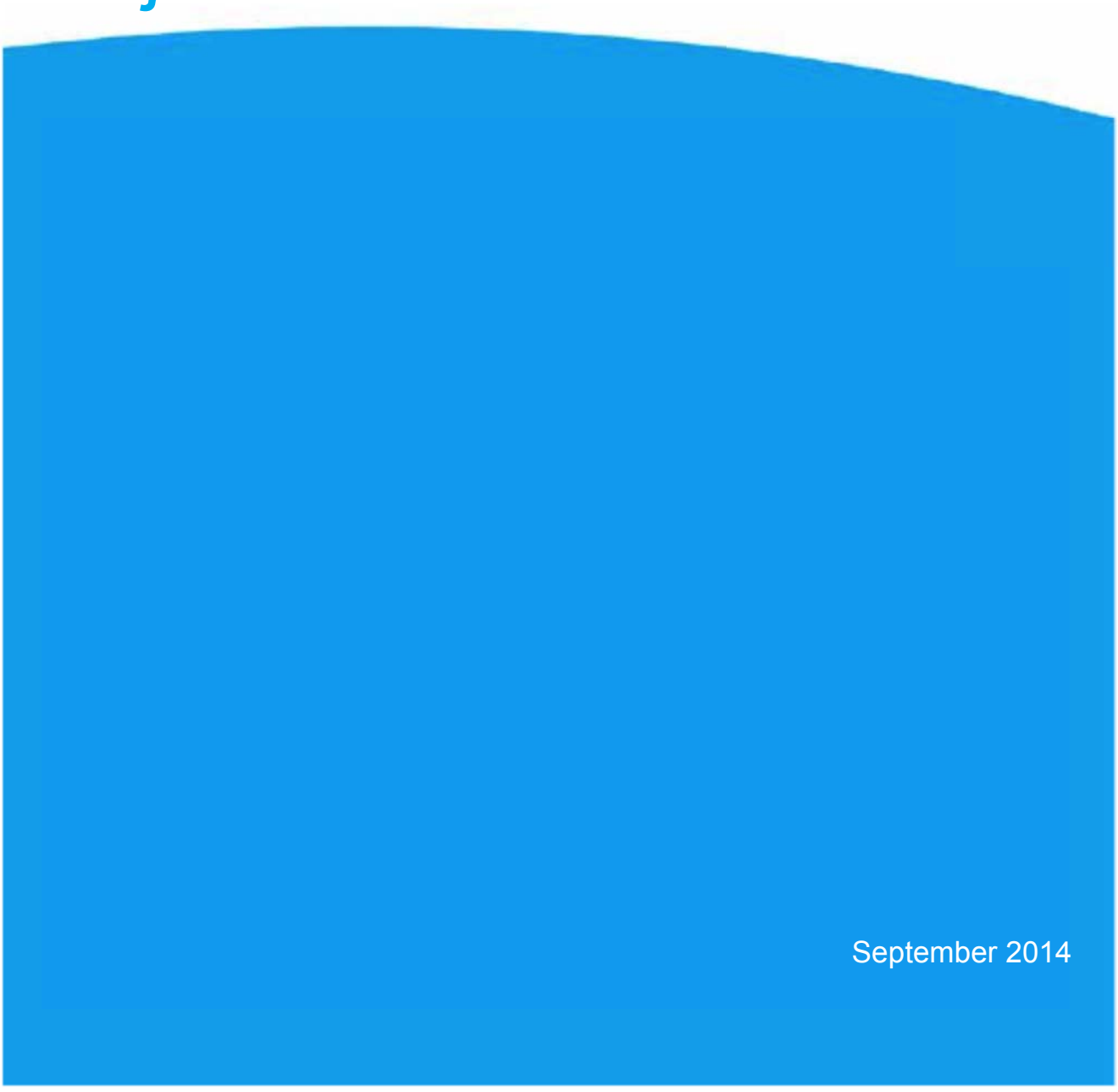
Department of Energy & Climate Change

DECC Fossil Fuel Price Projections



September 2014

URN 14D/351

Any enquiries regarding this publication should be sent to us at fossilfuelspriceprojections@decc.gsi.gov.uk.

Introduction

1. This note presents an update to DECC's long-term price projections for oil, gas and coal.

2. These projections are required for long-term economic appraisal and therefore reflect long-term trends.

3. These are not forecasts of future energy prices. Forecasting fossil fuel prices far into the future is extremely challenging, as it depends on a large number of unknowns (future economic growth rates across the world, development of new technologies, global climate change policies, strategies of resource holders, etc.). DECC has instead generated a set of projections based on estimates of fundamentals and other available evidence that represents a plausible range for future prices. No probabilities are attached to any of the scenarios.

4. These new projections will feed into work across Whitehall on appraising economic impacts of policies. Estimates of public finances are made independently by the Office for Budget Responsibility (OBR) using their own fuel price assumptions. The OBR does not produce these assumptions for the long time periods required for economic appraisal of policy so DECC requires its own projections.

5. Each set of price projections (across oil, gas and coal) has been subjected to peer review, in which an expert with expertise in the given fuel type provided scrutiny to the methodologies behind the projections. The peer review reports are being published alongside this document.

DECC 2014 Oil Price Projections

All prices are in 2014 US dollars per barrel

	Low	Central	High	Notes
2014	90.0	105.0	120.0	**Central Projection**
2015	89.2	96.4	122.7	2014 based on futures curve.
2016	88.5	92.5	125.4	2015-2020 average of external forecasts.
2017	87.7	91.3	128.1	2035 based on the long term (2035) central projections of the IEA and EIA.
2018	86.9	92.5	131.0	
2019	86.2	93.6	133.9	2021-2034 interpolation between the 2020 and 2035 values.
2020	85.4	96.2	136.8	
2021	84.7	98.4	139.9	**High Projection (Zero Supply Growth)**
2022	84.0	100.7	143.0	2014 based on historical error from forecasting short term prices using futures curve.
2023	83.2	103.0	146.1	
2024	82.5	105.3	149.4	2035 based on DECC modelling of the impact of zero supply growth 2014-2035.
2025	81.8	107.7	152.7	
2026	81.1	110.2	156.0	2015-2034 interpolation between the 2014 and 2035 values.
2027	80.4	112.7	159.5	
2028	79.7	115.3	163.0	**Low Projection (LRMC Price Floor)**
2029	79.0	117.9	166.6	2014 based on historical error from forecasting short term prices using futures curve.
2030	78.3	120.6	170.3	
2031	77.7	123.4	174.1	2035 based on estimates of Long Run Marginal Cost of non-OPEC production.
2032	77.0	126.2	177.9	
2033	76.3	129.0	181.9	2015-2034 interpolation between the 2014 and 2035 values.
2034	75.7	132.0	185.9	
2035	75.0	135.0	190.0	

Methodology

6. The methodology used to create DECC's oil price projections consists of reviewing: (a) external forecasts; (b) predictions from a supply and demand model; and (c) reviewing evidence on the long run marginal costs of oil production. All data are in real 2014 US Dollars. All starting and end values are rounded to multiples of US$5.

7. The main changes between the 2013 and 2014 projections are: the extension of the projection horizon to 2035; the use of an average of external forecasts as the basis for the central projection; and developing a simple structural supply and demand model as the basis for the high long term projection.

Starting prices for the scenarios

8. **Central scenario starting price**: The starting price is based on the Brent futures curve for 2014 (the average of the twelve monthly contracts covering the next 12 months averaged across the first three trading days in January 2014).

9. High and Low scenario starting prices are derived as a range around this central starting price based on the average (absolute) percentage error from using the futures curve to predict prices for the coming 12 months between January 2000 and January 2014. This results in a range of plus or minus $15.

10. **High scenario starting price**: The high scenario starts from a price $15 above the central 2014 price, in-line with the description above.

11. **Low scenario starting price**: The low scenario starts from a price $15 below the central 2014 price, in-line with the description above.

Central Scenario

Medium term projection

12. Between 2015 and 2020 the central scenario is an average of 11 expert external projections (including consultants and market participants)[1].

13. For those organisations that publish a narrative alongside their projection, rising non-OPEC production during this decade increasing global supply is a key driver behind the medium term outlook for prices. Despite this apparent consensus on the medium term drivers of the oil price, the implied range as early as 2015 is over $10/bbl (around 10% of the current oil price).

Longer term projection

14. To extend the central scenario beyond 2020 we are guided by the long term projections for the oil price of the IEA and the EIA. The long term is taken as 2035 for these projections. The projection for years between 2020 and 2035 is then interpolated (using a constant compound growth rate).

High Scenario (Zero Supply Growth)

15. We have derived the 2035 high and low scenario prices, as in previous years' projections, by varying the assumptions on long run supply conditions.

16. For the high scenario we use a supply and demand model (see annex) and run a sensitivity of zero global supply growth in oil over the period to 2035. With zero global supply growth in oil annual price growth is closer to the model's 'underlying' trend rate of growth in the real oil price of approximately 3¾%. The only dampening effect is the assumed exogenous reduction in demand after 2020 (which is consistent with the IEA's

[1] IEA, EIA, WoodMac and 8 financial institutions. Not all forecast for all years.

projection for demand growth). This results in projected annual real growth in the oil price of approximately 2¾% and a 2035 price of $188 (rounded to $190).

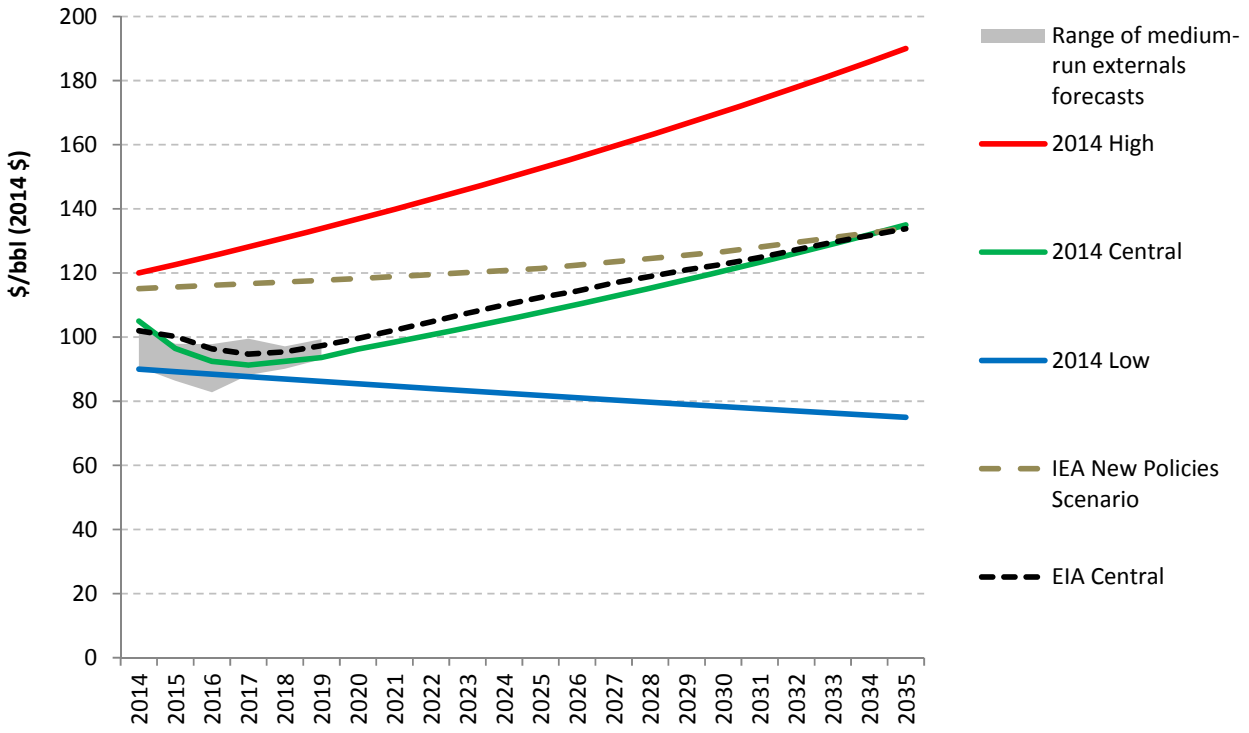
Low Scenario (LRMC Price Floor)

17. The low scenario 2035 price is based on an assessment of the long-run marginal cost curve for oil, based primarily on IEA estimates, choosing a level at which the majority of sources of non-OPEC unconventional oil will remain economic. This results in a 2035 low scenario oil price projection of $75.

Comparison with external projections

All prices are in 2014 US dollars per barrel

Figure 1: Comparison with External Oil Price Projections



Annex

A simple supply and demand model

18. To aid in our understanding of the consensus long term upward trend in oil prices from the external projections, and to provide a tool for sensitivity analysis we have developed a simple structural supply and demand model, and populated it with parameter estimates drawn from external analysis. It is important to be clear that the elasticity estimates are not based on our own statistical analysis of historical data, but are based on the findings of existing studies.

19. The future change in global demand for oil is projected as a function of the oil price, the growth in global GDP and other trend or exogenous changes in demand (for example due to technological change or climate change policy). We have used the following specification for demand:

(1) $\Delta \ln Q_t = \alpha \Delta \ln p_t + \beta \Delta \ln GDP_t + D_t$

Where p_t = oil prices
GDP_t = world GDP
D_t = exogenous change in demand
α = price elasticity of demand
β = income elasticity of demand

20. The future change in global supply of oil is modelled as a function of the oil price and other trend or exogenous changes in supply (for example due to technological change or the production decisions of strategic producers).

(2) $\Delta \ln Q_t^s = \phi \Delta \ln p_t + S_t$

Where p_t = oil prices
S_t = exogenous change in supply
ϕ = price elasticity of supply

21. Equating changes in supply and demand generates the following expression for the projected change in price over any period:

(3) $\Delta \ln p_t = 1/(\alpha - \phi).(\beta \Delta \ln GDP_t + D_t - S_t)$

22. In practice there is considerable uncertainty over income and price elasticities, including whether they are constant over time, even before considering the possible impact of technological change on either the demand or supply side, or countries' future policies. We have however, constructed a 'reference case' set of parameters for these variables, broadly reflecting our understanding of a base case view of the likely evolution of supply and demand factors over the next 20 years.

23. The 'reference case' set of parameters are as follows:
α (price elasticity of demand) = -0.34
β (income elasticity of demand) = 0.4
ϕ (price elasticity of supply) = 0
S_t (exogenous change in supply) = 0.112 (equivalent to a 11.9% increase)

D_t (exogenous change in demand) = -0.069 (equivalent to a 6.7% decrease)

24. The exogenous change in demand parameter has been calibrated to result in a projected 2035 oil price of $135.

25. Given assumed average annual growth in global GDP of 3.2% 2014-2035, the price and income elasticities by themselves imply an underlying trend rate of growth in the real oil price of approximately 3¾% (3.2%*0.4/0.34). Over the period 2014-2035 however the (exogenously modelled) growth in supply and the (exogenously modelled) reduction in the growth in demand after 2020 reduce the average annual growth in the real oil price to 1.2% in the Reference Case.

26. Reflecting uncertainty over the appropriate reference assumption for the long run price elasticity of supply, we considered an alternative reference case long run price elasticity of supply of 0.5 as suggested by a previous IMF study[2]. In this case with supply responding positively to price the exogenous supply would be 'turned off'. However, this would have made little difference to modelled supply (global supply would be 93.2 million b/d compared to 92 million b/d in the reference case).

[2] IMF April 2005 World Economic Outlook Appendix 4.1
http://www.imf.org/external/pubs/ft/weo/2005/01/pdf/chapter4.pdf

DECC 2014 Gas Price Projections

(in 2014 p/th)	Low	Central	High	Notes
2014	47.5	55.8	64.2	***Central scenario***
2015	46.8	62.1	80.8	2014-2015 – based on forward curve.
2016	46.0	63.9	82.6	2016-2019 – an average of external forecasts.
2017	45.3	61.5	84.4	
2018	44.6	58.7	86.3	2020-2024 – linear interpolation
2019	43.9	58.0	88.2	2025-2030 – linkage to US price (Henry Hub)
2020	43.2	60.3	90.1	2030-2035 – flat-lined
2021	43.2	62.6	92.1	
2022	43.2	64.9	94.2	***Low scenario***
2023	43.2	67.2	96.2	2014 – based on historical error from forecasting short term prices using forward curve
2024	43.2	69.4	98.4	
2025	43.2	71.7	100.5	2015-2019 – linear interpolation
2026	43.2	72.5	102.7	2020-2035 – low estimate of long-run marginal cost of supply
2027	43.2	73.4	105.0	
2028	43.2	74.1	107.3	
2029	43.2	75.1	107.8	***High scenario***
2030	43.2	76.4	107.8	2014 – based on historical error from forecasting short term prices using forward curve
2031	43.2	76.4	107.8	
2032	43.2	76.4	107.8	2015-2029 – oil-linked prices
2033	43.2	76.4	107.8	2030-2035 – flat-lined
2034	43.2	76.4	107.8	
2035	43.2	76.4	107.8	

Methodology

Central scenario

27. The methodology for DECC's Central gas price scenario has been revised since the 2013 published projections to take account of developments in global gas markets which,

in summary, suggest reduced pressure on prices in the medium term compared to the 2013 projections. These projections are for the average wholesale day-ahead gas price as traded over the National Balancing Point (NBP) delivered to GB over a given year.

28. The projections for 2014 and 2015 are based respectively on an average of spot NBP prices and NBP forward prices observed in 2014.

29. From 2016-2019 prices are an average of a basket of six external expert projections (including consultancies and market participants) for NBP prices[3]. These projections are consistent with a medium term outlook of downward pressure on global gas markets in the second half of this decade as large sources of LNG[4] supply are due to come online during this period, increasing global LNG capacity by up to 45%.

30. The long-run (2025 onwards) price projection is anchored against the cost of LNG exported from the US. This reflects the likelihood of substantial US LNG exports over that horizon. We expect that these volumes will provide a check to incumbent suppliers at the margin, and thus the cost of US gas can be used as a price reference. For this reason we have linked GB prices to US prices (Henry Hub) from 2025, adding a margin to allow for costs (liquefaction, transport and regasification) required to ship US gas to the GB system.

31. Estimates of the long run cost of US LNG exports are higher than the average of external forecasts for NBP for 2019. With robust global demand growth the market is likely to tighten with global gas prices rising to provide sufficient incentive for further large scale LNG investment. The timescale over which this happens is uncertain and during the interval 2020-2024 we have interpolated between the price projection for 2019 (the last year in which external projections are used) and the 2025 price projection (when we link GB prices to US prices, as explained above).

32. Beyond 2030 the ability to project market developments significantly diminishes, hence we flat-line from 2030-2035 to indicate this level of uncertainty.

Low scenario

33. Unlike the Central scenario, the Low price projection has not been substantially amended since the 2013 publication.

34. The low price in 2014 uses a range around the forward price based on historical deviations between forward prices and outturn prices.

35. From 2015 onwards the low price projection assumes gas prices decrease from their current levels, reaching a floor price of 43.2p/th in 2020. This might reflect a scenario in which global LNG supplies are plentiful (as liquefaction projects come on-stream and Asian demand growth is subdued), European economic growth remains weak and European gas markets quickly become much more competitive. A long-run price at this level represents the lower end of estimates of the long-run marginal cost of gas supplies to Europe.

---

[3] Three of the six project from 2014 to -2030: Wood Mackenzie, IHS CERA, National Grid. The other three, projections from three financial institutions sourced through Bloomberg, project from 2014 to 2017. Projections as of April 2014.

[4] Liquefied Natural Gas

High scenario

36. The High price projection has been updated to reflect DECC's 2014 High oil price projection.

37. As with the Low price projection, prices begin at a level based on historical deviations between forward prices and outturn prices.

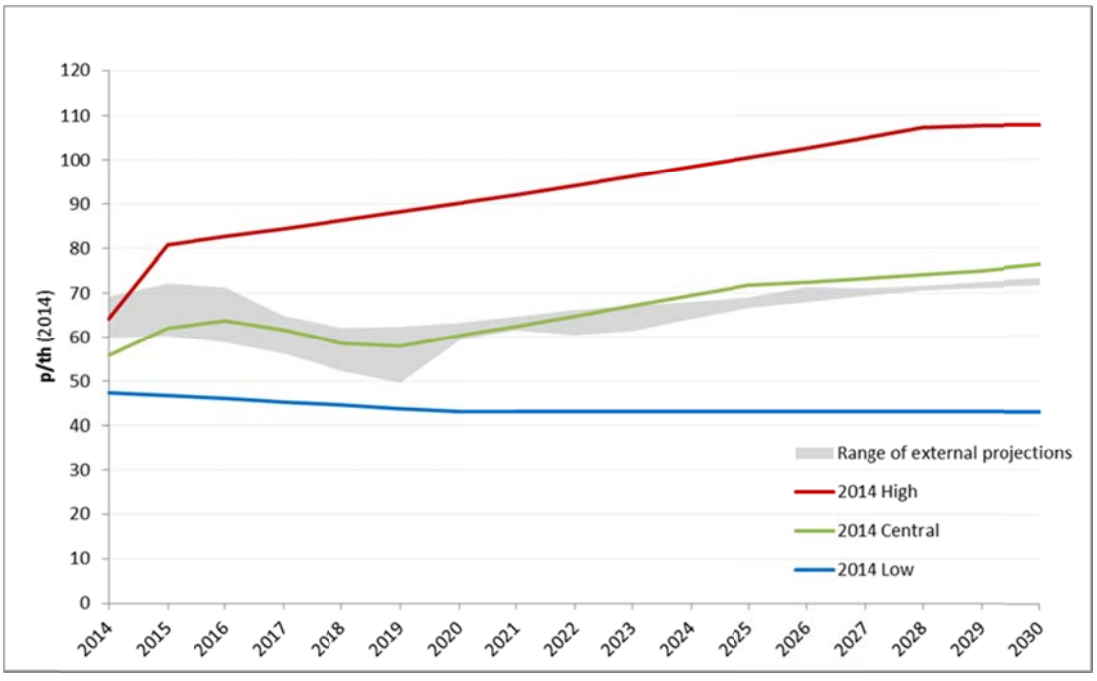
38. From 2015 onwards gas prices are linked to (high) oil prices until the mid-2020s; there is no easing of gas market fundamentals, unlike under the Central scenario. This could reflect a scenario in which Asian demand for LNG remains high whilst planned increases in LNG supply capacity for the second half of this decade are delayed. It could also reflect delays in the transition to liberalised markets in Europe.

39. Beyond this point, gas is assumed to be de-linked from (high) oil prices and plateaus at 106p/th in 2014 prices. This level is some way above the range of estimates of long-run marginal costs for gas to Europe so would need to reflect limited gas availability or competition among suppliers, for example as a result of rising production costs or very strong competing demand from Asia.

Comparison with external projections

All prices are in 2014 pence per therm.

Figure 2: Comparison with External Gas Price Projections



Source: organisations mentioned in footnote 3 above.

DECC 2014 Coal Price Projections

(in 2014 $/tonne)	Low	Central	High	Notes
2014	65.6	77.2	88.7	**Central scenario** 2014-2017 – based on forward curve 2018-2019 – linear interpolation 2020 – long run marginal cost of coal imports from Russia 2021-2035 – 1% real growth rate year on year **Low scenario** 2014-2015 – downward adjustment on forward prices 2016-2019 – linear interpolation 2020-2035 – long run marginal cost of coal imports from South Africa / Columbia **High scenario** 2014-215 – upward adjustment on forward prices 2016-2024 – linear interpolation 2025 – cost of coal imports from the US based on the EIA high coal cost scenario 2030-2035 – 2% real growth rate year on year
2015	66.2	80.9	97.6	
2016	67.6	84.6	100.5	
2017	69.1	87.5	103.4	
2018	70.5	89.5	106.3	
2019	71.9	91.5	109.3	
2020	73.3	93.5	112.2	
2021	73.3	94.5	115.1	
2022	73.3	95.4	118.0	
2023	73.3	96.4	120.9	
2024	73.2	97.3	123.8	
2025	73.2	98.3	126.7	
2026	73.2	99.3	129.3	
2027	73.2	100.3	131.9	
2028	73.2	101.3	134.5	
2029	73.1	102.3	137.2	
2030	73.1	103.3	139.9	
2031	73.1	104.3	142.7	
2032	73.1	105.4	145.6	
2033	73.0	106.4	148.5	
2034	73.0	107.5	151.5	
2035	73.0	108.6	154.5	

Methodology

40. The methodology for DECC's central coal price projection was revised from last year. The 2013 central projection was formulated using a regression of coal on gas prices. A historical time series for spot prices for the two fuels was used to determine regression coefficients.

41. However the relationship between coal and gas has weakened over time due to an oversupply in the coal market, in both the Atlantic and the Pacific basins. The increase in

coal exports in the Atlantic basin has primarily been because of a fall in gas prices in the US, which have fallen since 2009 resulting in fuel switching from coal to gas in the US power sector. Therefore US coal exports have found their way to Europe, resulting in an oversupply. The Pacific basin has also seen an increase in exports, especially from South Africa which tends to be a swing supplier between the two basins.

42. Therefore a revised methodology for the central projection was selected this year: prices are based on the long run marginal cost of coal.

43. The 2014 coal price projections are for coal imports to North West (NW) Europe over a given year. Projections are in $/tonne (2014 prices).

Central scenario

44. The price in 2014 is based on a weighted average of spot prices and forward prices. The prices in 2014-2017 are based on CIF ARA[5] forward prices as observed in 2014. Prices were linearly interpolated in 2018 and 2019.

45. A long run marginal cost (LRMC) approach was used to calculate the central estimate in 2020. The LRMC of coal imports into NW Europe from different coal-producing countries was calculated by adding the cash cost for FOB (free on board) coal exports from each country, freight rates from each country to NW Europe and an assumed margin covering capital costs[6]. A supply curve was generated using this data which was then compared to import demand for coal in the IEA New Policies Scenario[7]. This comparison showed that in order to satisfy import demand into Europe, the marginal unit of coal would be imported from Russia. Therefore the central estimate in 2020 is calculated as the sum of the average cost of coal produced in Russia, freight rate from Russia to NW Europe and a margin covering capital cost. Data on cash costs for coal exports and coal import demand into Europe was taken from the IEA World Energy outlook (WEO) 2013.

46. A 1% real growth rate was applied on coal prices beyond 2020. The use of a non-zero growth rate beyond 2020 reflects the expectations of external forecasters such as IEA, EIA and Wood-Mackenzie. The three external sources assume upward sloping trajectories for coal prices beyond 2020 as the current oversupply in the market is expected to be absorbed over the next few years, with demand for coal increasing in the Pacific basin.

Low scenario

47. The low estimates for 2014 and 2015 were calculated by applying a downward adjustment on forward prices to reflect uncertainty. The adjustment factors used were close to the historic yearly variation in average coal prices. Prices were linearly interpolated from 2016 to 2019.

---

[5] Method of selling coal i.e. cost insurance freight basis to major coal importing ports in northwest Europe - Antwerp/Rotterdam/Amsterdam.

[6] This was calculated using investment cost of USD 50 per tonne of annual capacity addition in 2007 prices (Haftendorn et al, 2010); this was converted to a required margin by calculating the required annual revenue over a period of 10 years at a 10% cost of capital; a 90% capacity utilisation factor was applied to the resulting required annual revenue.

[7] The New Policies Scenario is the central scenario in the IEA WEO.

48. The low estimate for the price of coal in the long term was also based on the LRMC approach, similar to the methodology for the central estimate. Based on a comparison of import demand in the IEA 450 scenario[8] and projections for net coal exports, South Africa was found to set the price of coal in 2020 while Columbia set the price of coal in 2035. Prices are interpolated between the two time periods.

High scenario

49. The high estimates for 2014 and 2015 were calculated by applying an upward adjustment on forward prices. Prices were linearly interpolated from 2016 to 2024.

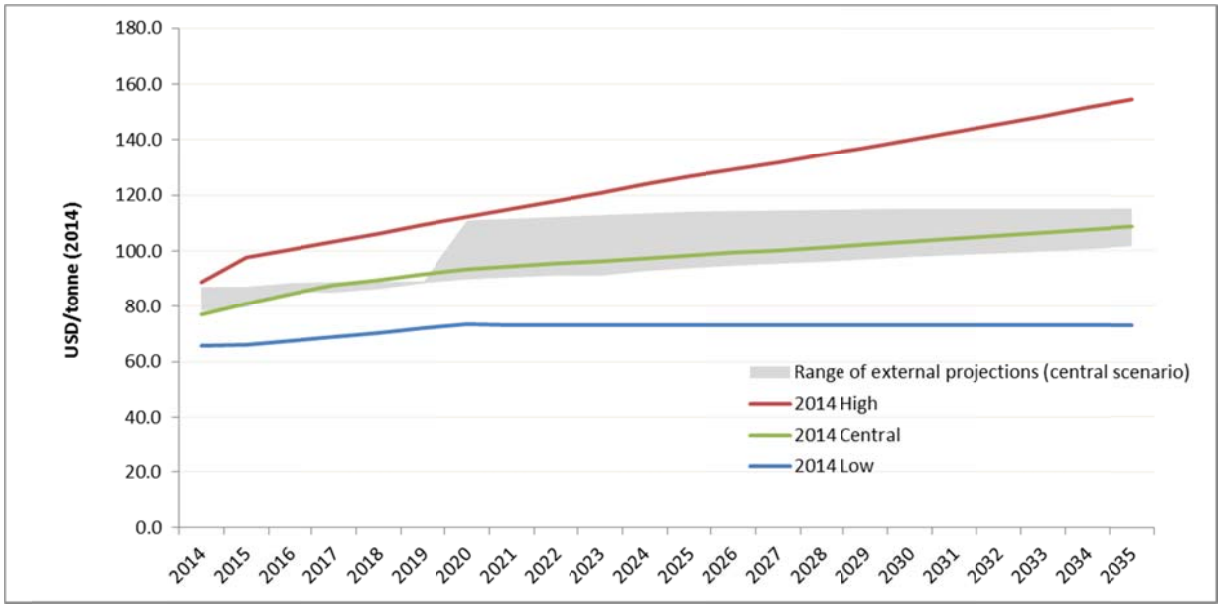
50. The high estimate for the price of coal in the long term makes use of the EIA high coal cost scenario based on the expectation that US sets the price of coal imports into NW Europe. This scenario assumes lower mine productivity in the US and higher costs for labour, mine equipment, and coal transportation to power plants. This is calculated as the sum of the cost of coal exports from the US (taken from the EIA Annual Energy Outlook 2013), assumed inland transportation costs to ports[9] and freight rates from US to NW Europe.

51. Beyond 2025, prices are assumed to increase at a real rate of 2% year on year i.e. using a slightly higher growth rate than the rate used in the central scenario.

Comparison with external projections

All prices are in $/tonne (2014 prices)

Figure 3: Comparison with External Coal Price Projections (sourced from Wood Mackenzie, the International Energy Agency and the US Energy Information Administration)[10]



[8] The IEA 450 scenario is the low energy demand scenario in the IEA WEO.

[9] Inland transportation costs were produced by DECC in 2005/06

[10] Note the kink in 2020 in the external projections is caused by one of those series only beginning in 2020.

Department of Energy & Climate Change
3 Whitehall Place
London SW1A 2AW
www.gov.uk/decc
URN 14D/351