



Department
of Energy &
Climate Change

DECC Fossil Fuel Price Projections

July 2013

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Introduction

1. This note presents an update to DECC's long-term price projections for oil, gas and coal. These projections are required for long term economic appraisal, therefore reflect long-term trends and do not capture short-term fluctuations in prices.
2. 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, such as future economic growth rates across the world, development of new technologies, global climate change policies, strategies of resource holders, and so on. 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.
3. These new projections will feed into work across Whitehall on appraising economic impacts of policies. Estimates of public finances will still be 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.
4. The projections for each fuel give a separate starting price (year 2013) for each of the low, central and high scenarios. This reflects the fact that these projections are estimated by DECC in February to allow their use in other DECC analysis to be ready before publication.

DECC 2013 Oil Price Projections

All Prices are in 2013 US dollars per barrel			
	Low	Central	High
2012	113.9	113.9	113.9
2013	95.0	110.0	125.0
2014	93.7	111.3	128.3
2015	92.4	112.7	131.7
2016	91.1	114.0	135.2
2017	89.9	115.4	138.8
2018	88.6	116.8	142.5
2019	87.4	118.2	146.2
2020	86.2	119.7	150.1
2021	85.0	121.1	154.1
2022	83.8	122.6	158.2
2023	82.7	124.1	162.4
2024	81.5	125.6	166.7
2025	80.4	127.1	171.1
2026	79.3	128.6	175.6
2027	78.2	130.2	180.3
2028	77.1	131.8	185.1
2029	76.1	133.4	190.0
2030	75.0	135.0	195.0

Methodology

5. The methodology used to create DECC's oil price projections remains largely unchanged from last year and consists of reviewing: (a) predictions from a supply and demand model; (b) long-run external forecasts; and (c) for the low case, reviewing new information on the long run marginal costs of oil production. This year we have refined the supply and demand model to: include a degree of regional disaggregation for both consumption and production; make allowance for on-going depletion; include a degree of price sensitivity for production; and to use in-house econometric estimates throughout rather than relying on third-party estimates. A description of the new supply and demand model is provided in Annex A.
6. The starting price is based on the futures curve for 2013. The range around this price is 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 2013. All starting and end values are rounded to multiples of US\$5.

Central Scenario

7. The supply and demand model described in Annex A has been used to generate long-term forecasts based on using the central parameters in the model, starting from a 2013 price derived from the futures curve. The projections are then sense-checked against external forecasts such as those made by the International Energy Agency (IEA) and the Energy Information Administration (EIA).

High Scenario

8. The high scenario now starts from a price \$15 above the central 2013 price, in-line with the description above.
9. To derive the 2030 high scenario price, the supply and demand model is adjusted to incorporate zero global supply growth in oil over the period to 2030 and the results are then sense-checked against external high oil price scenario estimates. Having established an estimate for the 2030 price, we then link the 2013 and 2030 prices with a constant compound annual growth rate.

Low Scenario

10. The low scenario now starts from a price \$15 below the central price estimated for 2013, in-line with the description above.
11. The low scenario 2030 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 unconventional oil will remain economic. To sense check this projection, we compare to low oil price scenario estimates from the IEA and EIA as well as looking at comparability with the supply and demand model under the assumption that the emerging economy income elasticity of demand falls to the level of advanced economies between 2020 and 2030.

Comparison with external and previous DECC projections

All prices are in 2013 US dollars per barrel.

Figure 1: Comparison of 2013 DECC oil projections with those from 2012

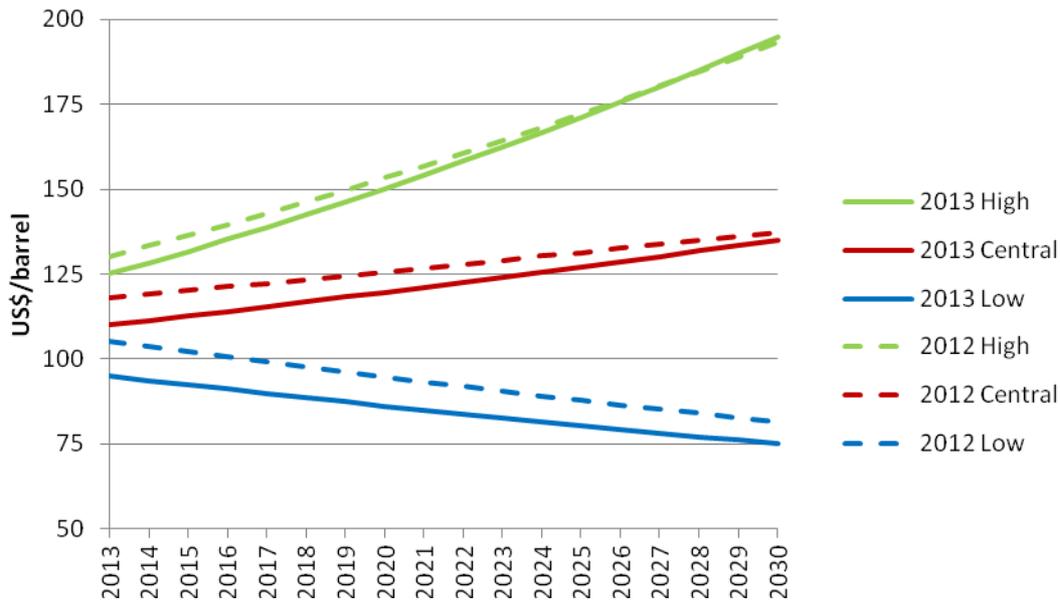
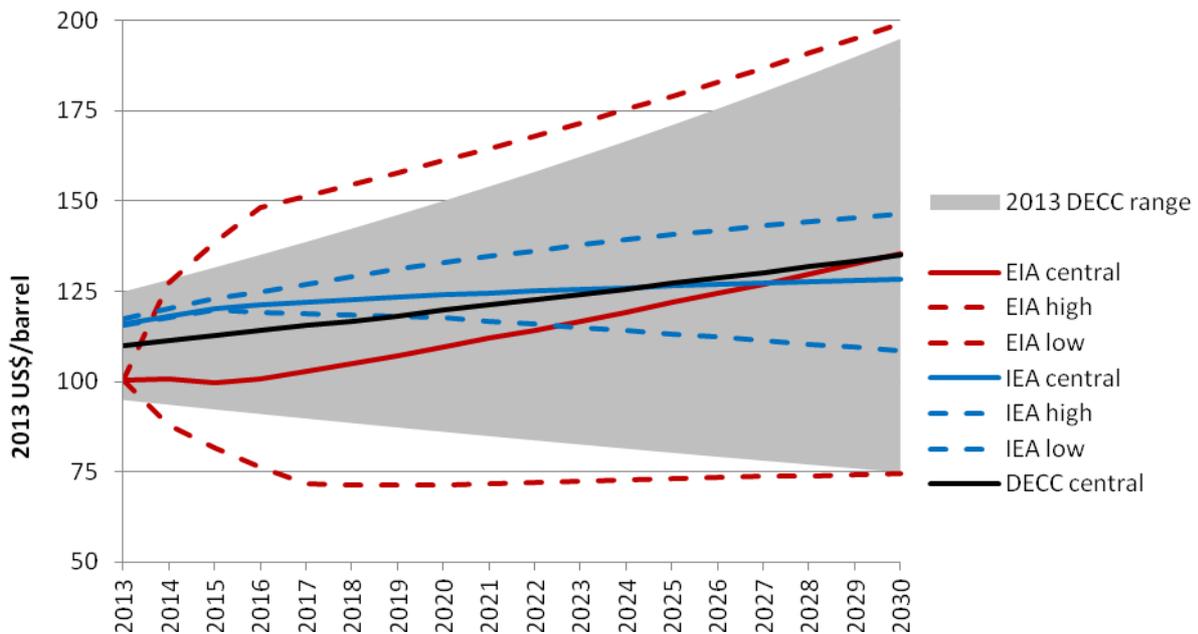


Figure 2: Comparison of external and DECC 2013 oil projections



DECC 2013 Gas Price Projections

All Prices are in 2013 pence per therm			
	Low	Central	High
2012	61.4	61.4	61.4
2013	54.1	63.6	73.2
2014	51.7	66.7	88.2
2015	49.3	69.7	90.6
2016	46.9	70.6	93.0
2017	44.6	72.2	95.4
2018	42.2	73.8	97.9
2019	42.2	73.8	100.5
2020	42.2	73.8	103.2
2021	42.2	73.8	105.4
2022	42.2	73.8	105.4
2023	42.2	73.8	105.4
2024	42.2	73.8	105.4
2025	42.2	73.8	105.4
2026	42.2	73.8	105.4
2027	42.2	73.8	105.4
2028	42.2	73.8	105.4
2029	42.2	73.8	105.4
2030	42.2	73.8	105.4

Central

12. The 2013 central price projection follows a similar approach to the 2012 projection with some minor adjustments made.
13. 2013 prices are based on forward prices. Beyond 2013, the projection assumes the 'gas glut' observed in Europe at the end of the last decade continues to erode in the short to medium term. Although European demand growth is expected to be moderate at best, supply is expected to tighten as a result of less LNG availability. The main reason is continued growth in Asian LNG demand and limited increases in global LNG supply capacity until the second half of this decade.
14. As a result of tightening gas market conditions, UK and European hub prices are projected to partly re-link with gas-to-oil prices from 2014. The re-linked price assumes an '11% rule' for gas-to-oil pricing¹ with oil prices based on DECC's new central oil price projection. As with last year's projection a discount on the has been applied to the re-link period to reflect the fact that continental European gas buyers have, in recent years, re-negotiated contract terms with suppliers in many cases the maintaining an element of gas-to-oil pricing (although the proportion of natural gas sales in contracts linked to oil prices has fallen in recent years). The gas price over this oil-linked period is somewhat below the level seen in last year's projections. This is due to a lower central projection in the 2013 oil price assumptions and a slightly larger discount applied to the oil linked price to reflect the reporting of additional re-negotiations since those projections were produced.
15. Efforts to liberalise European gas markets (EU 'Third Package' measures) and growth in global LNG supply capacity are assumed to undermine gas-to-oil pricing and loosen gas market fundamentals in the second half of the decade. As a result, hub prices decouple from oil-linked gas prices over 2017-2018 (as previously)².
16. From 2018 onwards, prices are assumed to be 74p/therm in real terms³, based upon the range of long-run marginal costs of supplying gas to the UK. 74p/therm is toward the upper end of this range implying there remains some tightness in European and global gas markets.

High

17. As with last year's projections, the high and low scenarios start from a price 15% above the central price estimated for 2013. This is based on the average historical deviations between the forward price and outturn price.
18. Otherwise the 2013 high projection assumes a re-linking with gas-to-oil pricing with full re-linking in 2014 based on DECC's high oil price projection, which has been revised down this year. Gas remains linked to oil-prices until the early 2020s i.e. there is no easing of gas market fundamentals, unlike the central projection. This could reflect a scenario in which Asian demand for LNG remains high whilst planned increases in LNG supply capacity for

¹ The '11% rule' is a rule of thumb for gas-to-oil pricing based on empirics – the price of gas in \$/mmbtu is approximately 11% of the lagged price of Brent crude oil in \$/bbl. The typical lag used is 6-9 months.

² For example, Australia plans to increase its LNG supply by three to fourfold by the end of this decade.

³ This is a re-inflation of the long-run price of 70p/therm assumed in the 2011 central projection.

the second half of this decade are delayed. It could also reflect delays in the transition to liberalised markets in Europe.

19. Beyond this point, gas is assumed to be de-linked from (high) oil prices and plateaus at 105p/therm in 2013 prices⁴. 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.

Low

20. As with the high price scenario, the 2013 low price uses a range around the forward price based on historical deviations between forward prices and outturn prices.
21. The low price projection assumes gas prices gradually fall from their current levels to a long run price of 42p/therm⁵ in 2018. This could reflect a scenario in which global LNG supplies are plentiful (as capacity 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.

⁴ A re-flation of the long-run figure of 100p/therm assumed under the 2011 projections.

⁵ A re-flation of the long-run figure of 41p/therm assumed under the 2012 projections.

Comparison with external and previous DECC projections

All prices are in 2013 pence per therm

Figure 3: Comparison of 2013 DECC gas projections with those from 2012

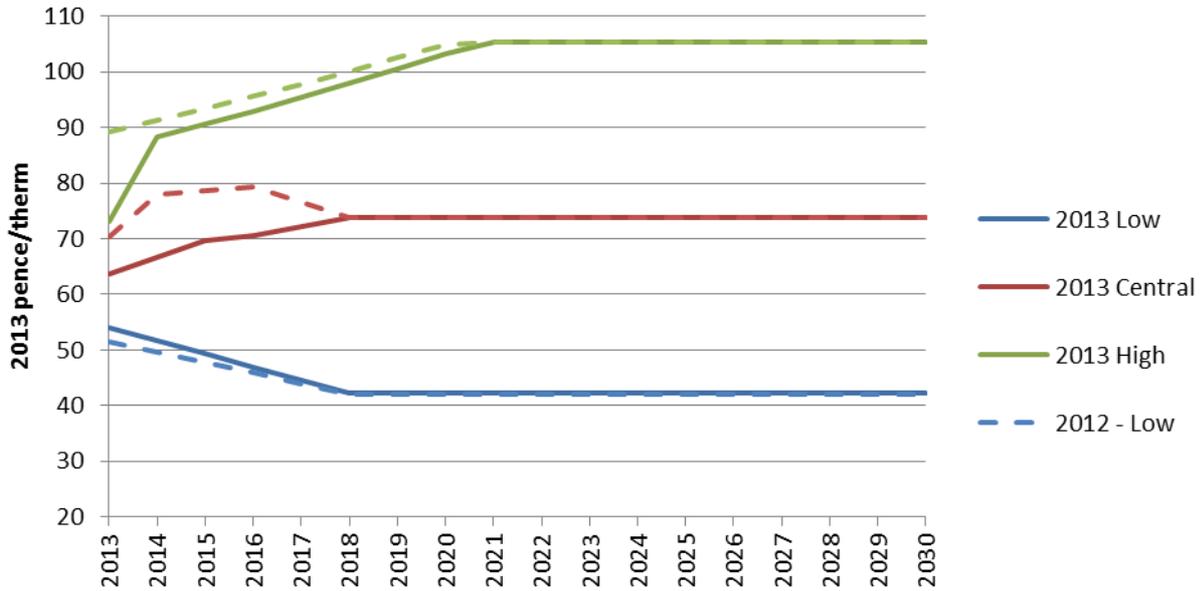
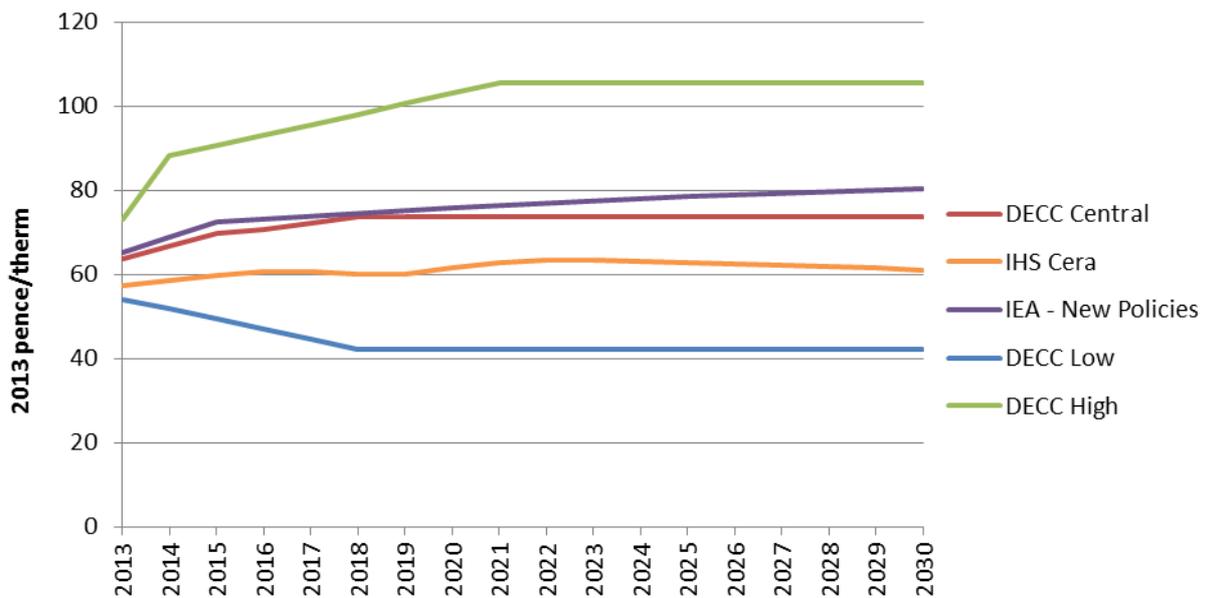


Figure 4: Comparison of external and DECC 2013 gas projections



DECC 2013 Coal Price Projections

All Prices are in 2013 US dollars per tonne			
	Low	Central	High
2012	94.2	94.2	94.2
2013	86.8	91.4	96.0
2014	87.7	97.6	107.4
2015	88.5	103.9	112.7
2016	89.4	107.7	118.0
2017	90.2	111.5	123.3
2018	91.1	115.3	128.6
2019	91.9	119.1	133.9
2020	92.8	122.9	139.2
2021	92.8	122.9	144.6
2022	92.8	122.9	149.9
2023	92.8	122.9	155.2
2024	92.8	122.9	160.5
2025	92.8	122.9	165.8
2026	92.8	122.9	165.8
2027	92.8	122.9	165.8
2028	92.8	122.9	165.8
2029	92.8	122.9	165.8
2030	92.8	122.9	165.8

Methodology

22. The methodology used in formulating DECC's 2013 coal price projections is largely unchanged from that used last year. The central projection is based on forwards prices, analysis of market fundamentals and regression analysis. Projections have also been sense-checked against those carried out by external organisations. The high and low scenarios consider evidence on the likely costs of different sources of possible marginal imports for the UK based on estimates of long run marginal costs and EIA estimates for US export prices.
23. Forwards prices are used up to 2015 (2013 in the low scenario and 2014 in the high scenario). We then interpolate from 2016 (2014 in the low scenario and 2015 in the high scenario) to the projected 2020 value (2025 for the high scenario). In the central scenario, price projections from 2020 are calculated using regression analysis and informed by long-term price forecasts.

Central Scenario

24. Prices to 2015 are based on forward prices, and then linear interpolation is used to 2020. From 2020, prices are formulated using regression analysis of the relationship between coal and gas prices. This methodology results in a coal price in 2030 of \$123/tonne.
25. The projections have also been informed by the EIA 2012 'reference case' long-term steam coal price forecasts, inland transportation and updated freight costs. The 'reference case' results in a projected CIF⁶ ARA7 price of \$120/tonne in 2030. The EIA reference case is based on a model assuming baseline US economic growth of 2.5% a year from 2010 to 2035, and light sweet crude oil rising to around \$145/bbl (2010 prices) in 2035.
26. Price projections have been revised to account for updated historical data on the relationship between coal and gas prices and this year's central scenario gas projections. Together with the analysis of the coal market fundamentals a rationale for analysing the link between coal and gas prices was considered. This is due to the fact that current energy and EUA markets appear to hedge fossil generation (from both gas and coal) quite well.

High Scenario

27. In the period 2013-2014, projections are based on forward prices, adjusted upwards by 5% and 10% respectively. This reflects increasing uncertainty further out along the forward curve. For the period 2015-2024 linear interpolation is used. From 2025 the coal price is based on long-term cost estimates. The interpolation did not take place from 2020, as the methodology would have suggested a price of \$111/tonne, a lower projection than that of the central scenario and was deemed to be unrealistic.
28. In 2013, projections have been revised to reflect EIA's 2012 long-term steam coal price forecasts, as well as estimated inland transportation costs⁸ and updated freight costs⁹. In a

⁶ Cost, Insurance and Freight: A trade term requiring the seller to arrange for the carriage of goods by sea to a port of destination, and provide the buyer with the documents necessary to obtain the goods from the carrier.

⁷ i.e. as delivered to the Amsterdam, Rotterdam and Antwerp region.

⁸ DECC Updated Emissions Projections Model.

supply constrained world with high demand for coal, European imports may come from high-cost, less productive mines elsewhere in the world (for example, the USA). Hence we use the EIA 'high coal cost' scenario, which is based on lower productivity growth rates, higher mining wages, higher transportation costs and higher mine equipment costs, to derive a reasonable high case for European import prices. Taking the EIA 'high coal cost' projections, and adding inland transportation and freight costs, results in a price of \$166/tonne in 2030.

Low Scenario

29. The projection for 2013 is based on forward prices, with a downwards adjustment of 5% to reflect uncertainty. For the period 2014-2020 linear interpolation is used. Initially a downwards adjustment of 10% for 2015 was considered, to reflect uncertainty. However the 10% level was finally rejected, in favour of the smoothing interpolation to avoid an anomaly of an increasing and decreasing low price projection that was not based on economic rationale but as a result of modelling selection.
30. Historically, coal markets have tended to be international in nature and prices determined by the cost of supplying the marginal unit of coal. In the low scenario, projections from 2020 have been formulated based on an assumption about future SRMC that has been informed by lower-end IEA WEO 2012 short run production costs, and updated freight costs. A margin covering capital costs has now been assumed¹⁰ to reflect a world where investment in coal plants remains sustainable in the long-term.
31. The marginal cost of coal supply to the European market is assumed to be equal to the cost of producing and exporting from South Africa. Major steam coal-exporting regions that could serve European coal markets include Colombia, South Africa, New South Wales, Russia and the US (ordered by increasing current short-run production costs - see paragraph 14 above). A low coal price scenario might be characterised by low future coal demand, both globally and in Europe, for example as reflected by the IEA WEO 2012 450 Scenario. There may be limited increase, or even decline, in global production capacity.
32. A simple comparison of European coal demand in the IEA WEO 2012 450 scenario with the IEA's forecasted coal exports by region in the World Energy Outlook 2012 New Policies Scenario (no data for exports was available for the 450 scenario), suggests that South Africa could be the cheapest supplier of coal required to meet European coal demand in 2020. As such, South African production costs provide the basis of our low scenario LRMC estimate.
33. This methodology results in a coal price in the period 2020-2030 of \$93/tonne. This projection is below the majority of other forecasters but similar by 2030 to the IEA 450 scenario.

⁹ Coal shipping rates sourced from Bloomberg. An average was taken of shipping rates between January 2002 and January 2013 in real 2013 prices.

¹⁰ 'COALMOD-World: A Model to Assess International Coal Markets until 2030', Haftendorn et al (2010)

Comparison with external and previous DECC projections

All prices are in 2013 US dollars per tonne

Figure 5: Comparison of 2013 DECC coal projections with those from 2012

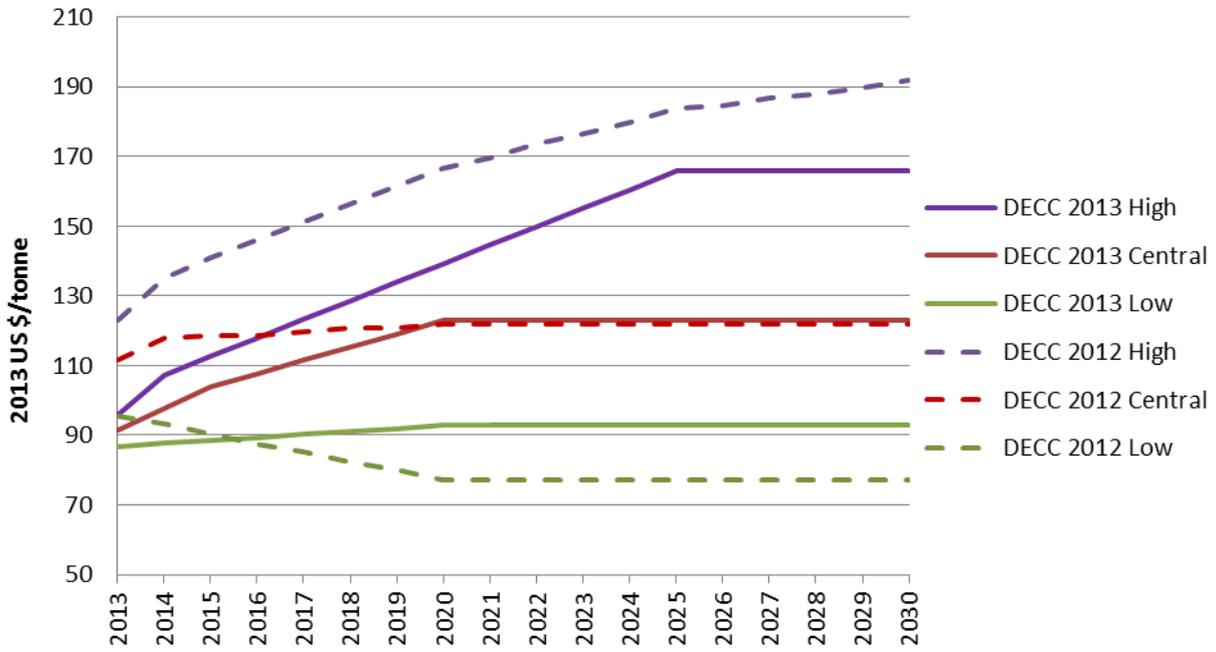
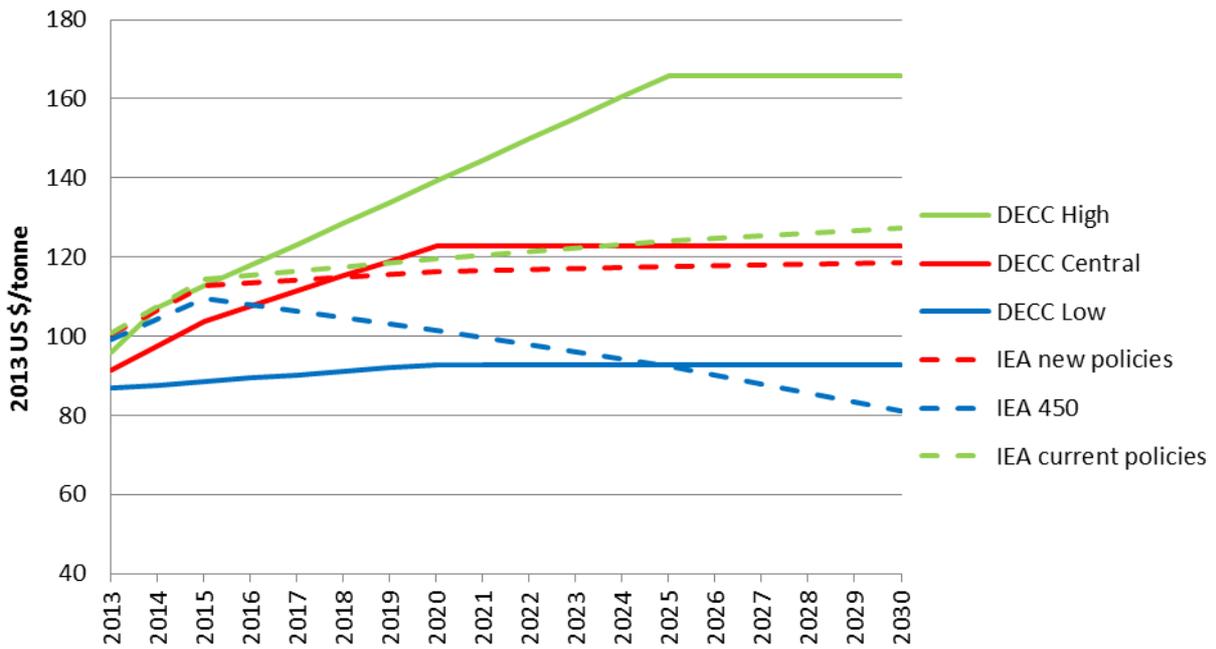


Figure 6: Comparison of external and DECC 2013 coal projections



Annex A – Revised Oil Supply and Demand Model

Introduction

This Annex outlines a modification to the supply and demand modelling that forms one strand of the overall oil methodology. The general approach for improving the supply and demand model is to build on the existing model used in 2011 and 2012.

Starting with the previous methodology, this has been refined to: (a) revisit the price formation equation by adding regional disaggregation as well as replacing parameters chosen from academic literature with in-house econometric estimates; (b) incorporate features from the 2012 IMF paper, “The Future of Oil: Geology versus Technology”¹¹, which includes endogenous supply modelling and incorporates feedbacks from oil prices to GDP growth; and (c) simplify the longer form of the model into a small structural VAR to provide an alternative approach.

Outline of Previous Supply and Demand Model

World demand was previously modelled with a constant elasticity and with the level of global GDP as the main determinant of the level of demand at time t :

$$\ln q_t^d = \gamma \ln y_t - \beta \ln p_t \quad (\text{A.1})$$

Where β is the average global price elasticity of demand and γ is the average global income elasticity of demand. Supply was assumed to be exogenous with zero short-run price elasticity of demand:

$$\ln q_t^s = q_t \quad (\text{A.2})$$

Combining (A.1) and (A.2) gives a determinant for price growth:

$$\Delta \ln p_t = \frac{1}{\beta} (\gamma \Delta \ln y_t - \Delta \ln q_t) \quad (\text{A.3})$$

Based on Hamilton(2009)¹², long-run PED was set equal to 0.6 and IED was set equal to 0.4 based on DECC estimates. GDP and production were assumed to be exogenous and relied on forecasts from the IMF and IEA respectively.

¹¹ Benes, J., Chauvet, M., Kamenik, O., Kumhof, M., Laxton, D., Mursula, S., Selody, J., 2012, “The Future of Oil: Geology versus Technology”, IMF Working Paper, <http://www.imf.org/external/pubs/ft/wp/2012/wp12109.pdf>

¹² Hamilton, James D., 2009, "Understanding Crude Oil Prices", The Energy Journal, International Association for Energy Economics, Vol. 0 (Number 2), pages 179-206.

New Model 1

Revisiting Price Formation

To add regional disaggregation, (A.1) is divided into two regions, Advanced and Emerging¹³, each with a separate IED and PED. This changes (A.3) to:

$$\Delta \ln p_t = \frac{1}{\beta} (\gamma^{Adv} \Delta \ln y_t^{Adv} + \gamma^{Eme} \Delta \ln y_t^{Eme} - \Delta \ln q_t) \quad (\text{A.4})$$

To adapt (A.4) into a model that can be estimated econometrically, this becomes:

$$\Delta \ln p_t = \alpha_0 + \alpha_1 \Delta \ln y_t^{Adv} + \alpha_2 \Delta \ln y_t^{Eme} - \alpha_3 \Delta \ln q_t + u_t \quad (\text{A.5})$$

We use a sample period of 1980 to 2010 throughout, using IMF data for economic growth and BP data for production and prices. The estimated relationship for (A.5) is¹⁴:

$$\Delta \ln p_t = -0.4653 + 4.920 \Delta \ln y_t^{Adv} + 7.962 \Delta \ln y_t^{Eme} - 3.180 \Delta \ln q_t \quad (\text{B.1})$$

Incorporating Innovations from IMF(2012)

IMF(2012) is an innovative paper that produces a supply curve that incorporates features of geology with features of standard economics. They start with Hubbert's famous result that annual production can be modelled by the logistic curve:

$$q_t = \alpha_s Q_t \left(\frac{\bar{Q} - Q_t}{\bar{Q}} \right) \quad (\text{IMF1})$$

Where q_t is production at time t (as above), Q_t is cumulative production at time t and \bar{Q} is Ultimately Recoverable Reserves (URR). Noting that Ultimately Recoverable Reserves are unobserved, the Hubbert linearisation can be estimated as:

$$\frac{q_t}{Q_t} = \alpha_4 + \alpha_5 Q_t \quad (\text{A.6})$$

The coefficient on Q_t is expected to be of negative sign. To (A.6), the IMF add the average price 4 to 6 years prior to t as well as contemporaneous prices. Following the IMF we add the former, but due to concerns of potential bias for estimation by OLS due to endogeneity and following the FFPA methodology from previous years, we continue to assume a short-run PES of zero. This leads to (A.7):

$$\frac{q_t}{Q_t} = \alpha_4 + \alpha_5 Q_t + \alpha_6 \frac{1}{3} \sum_{k=4}^6 p_{t-k} + v_t \quad (\text{A.7})$$

¹³ Based on IMF classifications.

¹⁴ Note that all variables in (B.1) are statistically significantly different from zero at the 90% level of significance.

The IMF also endogenise GDP growth in their model by including the knock-on impacts of oil prices on GDP growth. We include a simplified version of this approach by estimating for each region:

$$\Delta \ln y_t = \alpha_7 + \alpha_8 \Delta \ln y_{t-1} + \alpha_9 \Delta \ln p_{t-1} + w_t \quad (\text{A.8})$$

Estimating (A.8) once for advanced and once for emerging economies as well as estimating (A.7) separately for OPEC and non-OPEC production gives the following relationships after omitting variables statistically significantly different from zero at the 95% level of significance¹⁵:

Advanced countries GDP:

$$\Delta \ln y_t^{Adv} = 0.01477 + 0.4269 \Delta \ln y_{t-1}^{Adv} - 0.02464 \Delta \ln p_{t-1} \quad (\text{B.2})$$

Emerging countries GDP:

$$\Delta \ln y_t^{Eme} = 0.01797 + 0.6203 \Delta \ln y_{t-1}^{Eme} \quad (\text{B.3})$$

Non-OPEC Supply:

$$\frac{q_t^{NonOPEC}}{Q_t^{NonOPEC}} = 0.04640 - 0.0000581 Q_t^{NonOPEC} + 0.004608 \frac{1}{3} \sum_{k=4}^6 p_{t-k} \quad (\text{B.4})$$

OPEC Supply¹⁶:

$$\frac{q_t^{OPEC}}{Q_t^{OPEC}} = 0.02986 \quad (\text{B.5})$$

New Model 2

Adapting Model 1 into a VAR

Starting with Model 1 described by (B.1), (B.2), (B.3), (B.4) and (B.5) above, it is possible to simplify this into a small structural VAR by adapting the supply modelling. This is potentially desirable for the gains in transparency and parsimony (because less parameters are used), both of which are desirable features for forecasting models.

Starting with (A.7), it is straightforward to adapt this to make Δq_t the dependent variable while removing the lagged price variable. However, estimates of the resultant specification performed very poorly with the differenced data very noisy, especially due to the ΔQ_t^2 term introduced as an explanatory variable.

¹⁵ Note that constants have been included throughout whether statistically significant or not.

¹⁶ OPEC supply uses a quasi-linear specification because the oil peaking term and price terms were found to not be robustly statistically significant.

Instead, we propose introducing an ad hoc term for Δq_t capable of capturing some of the trend towards lower growth in global oil production in which changes in production are a function only of a constant and a time trend, plus a dummy, D_t , to address the declines in production from 1980-82.

The resultant model is¹⁷:

$$Az_t = b + Cz_{t-1} + dt + eD_t:$$

$$\begin{bmatrix} 1 & a_{12} & a_{13} & a_{14} \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} \Delta \ln p_t \\ \Delta \ln y_t^{Adv} \\ \Delta \ln y_t^{Eme} \\ \Delta \ln q_t \end{bmatrix} = \begin{bmatrix} b_1 \\ b_2 \\ b_3 \\ b_4 \end{bmatrix} + \begin{bmatrix} 0 & 0 & 0 & 0 \\ c_{21} & c_{22} & 0 & 0 \\ 0 & 0 & c_{33} & 0 \\ 0 & 0 & 0 & 0 \end{bmatrix} \begin{bmatrix} \Delta \ln p_{t-1} \\ \Delta \ln y_{t-1}^{Adv} \\ \Delta \ln y_{t-1}^{Eme} \\ \Delta \ln q_{t-1} \end{bmatrix} + \begin{bmatrix} 0 \\ 0 \\ 0 \\ d_4 \end{bmatrix} t + \begin{bmatrix} 0 \\ 0 \\ 0 \\ e_4 \end{bmatrix} D_t$$

¹⁷ The coefficient d_4 was estimated as -0.00020, with other relevant coefficients the same as for Model 1.

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