Monetary Valuation of UK Continental Shelf Oil & Gas Reserves

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Abstract

The monetary value of UK Continental Shelf oil & gas reserves at 31 December 2011 is estimated to be £120 billion. This is £11 billion lower than the estimated value of the reserves at 31 December 2010. Using the Net Present Value method, applying the HM Treasury social discount rate and taking different asset lives of the reserves into account, this paper presents the monetary asset account (balance sheet) for the UK Continental Shelf oil & gas reserves for 2011. This paper also provides the methodology and the assumptions used to estimate the value of UK oil & gas reserves and compare the previous estimates to those published by the Office for National Statistics in 2012.

Introduction

In June 2012, the Office for National Statistics (ONS) announced in the UK Environmental Accounts that the methodology for valuation of UK Continental Shelf oil & gas reserves would be reviewed to provide best possible estimates of the reserves. A full review was carried out in 2012-13 and as a result this paper provides a revised methodology to value UK Continental Shelf oil & gas reserves.

This paper provides a monetary valuation of UK Continental Shelf oil & gas reserves for 2011 and presents them in an accounting structure by considering the beginning of 2011 as the opening balance and the end of 2011 as the closing balance. The monetary valuation of UK Continental Shelf oil & gas reserves will feed into the total natural capital estimates that ONS is developing. As part of the roadmap “Accounting for the value of nature in the UK”, ONS also set out a timetable to fast-track work to improve the valuations of the natural capital element of the estimates of national wealth published by the World Bank and the Inclusive Wealth Report¹ – the so-called “top-down approach”. This update is provided in a paper “Towards Wealth Accounting – Natural Capital Estimates within Comprehensive Wealth” that ONS has published alongside this paper.

As discussed in the paper “Towards a sustainable environment – UK Natural Capital and Ecosystem Accounting”, the conceptual model adopted by the UK and the international statistical community for environmental accounts is the United Nations’ System of Economic and Environmental Accounts (SEEA), a satellite system of the System of National Accounts (SNA). The accounts produced under this standard bring environmental and economic information together within a common framework.

A multi-year process of revision to SEEA was initiated by the United Nations Statistical Commission (UNSC). The revised SEEA consists of three parts:

- The Central Framework of agreed concepts, definitions, classifications, accounting rules and tables which, following a period of global consultation, has been adopted as the international statistical standard for environmental-economic accounts by the UNSC in February 2012

¹ The Inclusive Wealth Report, published in June 2012, is a joint collaboration between the United Nation University International Human Dimensions Programme and the United Nations Environment Programme
• **Experimental Ecosystem Accounting**, which following a global consultation was endorsed by the UNSC as international guidance in February 2013

• **Extensions and Applications**, which outlines applications of environmental economic accounting.

ONS aim is to develop monetary asset account for UK Continental Shelf oil & gas reserves in accordance with SEEA Central Framework; however, ONS has taken a flexible approach in implementing SEEA as it acknowledges that countries could show flexibility in implementing the standards depending on their specific needs. Therefore, this paper implements SEEA whenever possible and adopts a flexible approach on developing a monetary asset account for UK oil & gas reserves.

This paper starts with a brief discussion on the approaches to the valuation of assets. It then provides the methodology used to value UK Continental Shelf oil & gas reserves and applies the NPV approach to value oil & gas reserves for 2011. The next two sections discuss the results and provide sensitivity analysis respectively. It then presents a monetary asset account for UK Continental Shelf oil & gas reserves for 2011 and provides an analysis on the changes in reserve values between the beginning and the end of 2011. The final section provides a comparison with the previous methodology and discusses the reasons for the differences in the previous and new methodology used to value oil & gas reserves.

**Valuation of environmental assets**

Environmental assets provide a series of benefits to individuals and to society and, in principle, all of the benefits delivered by the environmental assets should be valued. However, to be consistent with the System of National Accounts, the scope of valuation is limited to valuing the benefits that accrue to economic owners. SEEA defines an economic owner as the institutional unit entitled to claim the benefits associated with the use of an asset in the course of an economic activity by virtue of accepting the associated risks. In the case of the environmental assets, the government has a high degree of ownership or influence over the extraction of environmental assets. The valuation of these assets in monetary terms provides useful information for assessing future streams of income for government, for example, in the estimation of future government revenue from the extraction of oil and natural gas.

**Approaches to the valuation of assets**

Ideally, observable market prices should be used to value all assets and the ideal sources of market price observations are values observed in markets in which each asset traded is completely homogeneous. This allows a comparison against other assets in order to assess relative returns, national wealth and similar types of analysis.

Where market prices do not exist, an attempt should be made to estimate what the prices would be if a regular market existed and the assets were to be traded on the date to which the estimate of the stock relates. SEEA suggests two approaches that estimate the prices of the assets in the absence of any regular markets:
1) **Written down replacement cost**

The value of an asset declines over time from when it was purchased, commonly known as depreciation. Theoretically, the value of an asset at any given point in time in its life is equal to the current purchase price of an equivalent new asset less the cumulative depreciation over its life. When reliable market prices are not available, this approach gives a reasonable approximation of what the market price would be if the asset was offered for sale.

2) **Discounted value of future returns**

This approach, commonly known as Net Present Value (NPV), uses projections of the future returns of an asset and discounts them in today’s money to reflect the value an investor would be prepared to pay for the asset in the current period. This approach provides reasonable proxies for observable market prices and is consistent with the System of National Accounts.

SEEA Central Framework describes that an important principle to value environmental assets is to value it in situ – as far as subsoil assets are concerned, the asset itself as it is in the ground – rather than after its removal. For environmental assets, which are extracted, the price of the output from extraction can normally be found in the market, but the market price of environmental asset in situ is not common.

Since environmental assets in situ are not traded in the market, there are generally no observable prices for the value of the opening and closing stock for the capital and for the flows between these two time periods. Therefore, an attempt should be made to estimate the observable market price.

The written down replacement cost method does not appear to estimate the prices for environmental assets due to two reasons. First, there is no current purchase price of an equivalent environmental asset and, secondly, the value of subsoil assets, such as oil & gas, do not depreciate.

The NPV method provides reasonable estimates for observable market prices for environmental assets which are extracted, as it uses projections of the future rate of extraction of the asset together with projections of its price to generate a time series of expected returns. These streams of expected returns are discounted to reflect the value an investor would be prepared to pay for the asset in the current period. Though this method provides market prices for the environmental asset, a choice of social discount rate used to calculate the NPV takes into account the societal aspect as well. This is because the use of social discount rate is generally lower than the market discount rate and a lower rate places higher relative importance on income earned by future generations. The NPV approach is recommended by SEEA and is used to value the UK’s oil & gas reserves.

**Methodology to value UK Continental Shelf oil & gas reserves**

SEEA categorises known oil & gas reserves into three classes – Class A: Commercially Recoverable Resources, Class B: Potentially Commercially Recoverable Resources and Class C: Non-Commercial and Other Known Deposits. The scope of the monetary asset account for oil & gas reserves is limited to Commercially Recoverable Reserves (Class A). According to the System of National Accounts, the market value is assumed to be zero if the extraction and sale have not yet been confirmed to be economic. Since Class B and Class C have a certain degree of uncertainty regarding

2 A complete categorisation is given in Appendix A.
the expected extraction profiles and incomes, they are not included in the monetary asset valuation. However, SEEA suggests if Class B and Class C need to be valued, the values of each class should be clearly distinguished.

In the UK, the discovered oil & gas reserves are categorised as proven, probable and possible depending upon their commercial viability to be extracted. In addition to these three classes, there are estimates of undiscovered reserves which have not been discovered but are potentially recoverable in the map lead. The UK Continental Shelf’s reserves categorisation is different to SEEA Central Framework; however, Class A reserves could broadly be categorised as proven and probable reserves. Therefore, this paper values only the estimates of proven and probable reserves within the UK Continental Shelf.

Joint Account Structure

Ideally, oil & gas reserves should be valued separately; however, oil & gas reserves are often extracted jointly and it is therefore not possible to identify the extraction cost of each resource. Therefore, these reserves are valued together in this paper. The price in situ is not available for UK Continental Shelf oil & gas reserves; however, it is possible to estimate the value in the ground by subtracting all the extraction costs from the total output of oil & gas reserves. This is known as resource rent. The NPV method is then used to discount the expected pattern of resource rents to value the total oil & gas reserves in the present accounting period.

Net Present Value (NPV)

This section discusses in detail the NPV method that is used to value the oil & gas reserves. There are four main aspects of the NPV that require explanation:

1. The measurement of returns on environmental assets
   - Resource rent
     i. Rate of return on produced assets
     ii. Decommissioning costs
2. Pattern of expected resource rent
3. Asset life

1. The measurement of returns on environmental assets

Resource rent

In SEEA, the return on environmental assets is defined using the concept of economic rent. Economic rent is best considered as the surplus value, referred as resource rent, accruing to the extractor after all costs and normal returns have been taken into account.

The most common way to estimate the resource rent is the residual value method. The resource rent is derived from the total income after adjusting it for operating expenditure, decommissioning costs and user costs of produced assets. Table 1 shows the resource rent for 2010 and 2011 for UK Continental Shelf oil & gas reserves.
The following equation is used to estimate the resource rent:

\[ \text{Resource Rent} = \text{Total income} - \text{Operating expenditure} - \text{Decommissioning cost} - \text{User cost of produced assets} \]

Where:

User cost of produced assets = Consumption of fixed capital\(^3\) + Normal returns on produced assets

The data for total income and operating expenditures are taken from the Office for Budget Responsibility (OBR).\(^4\) The projected decommissioning cost is taken from the OBR forecast; however, it has been adjusted in our calculations (discussed below). The user cost of produced assets is not provided by these data sources and is therefore calculated separately. The net capital stock and the consumption of fixed capital are derived from the OBR projection of capital expenditure using the Perpetual Inventory Method (PIM)\(^5,6\); whereas, the rate of return on produced assets is discussed below.

### i. Rate of return on produced assets

The rate of return on produced assets is required to estimate the user cost of the produced assets used in the extraction of the environmental assets. If this cost is not deducted the resulting estimates of resource rent will be overstated. SEEA Central Framework provides two approaches – endogenous and exogenous – to calculate the rate of return.

The endogenous approach derives the rate of return by taking the net operating surplus and dividing it by the value of the stock of the produced asset. This approach is commonly used for produced assets; however, it is not recommended by SEEA because it implicitly assumes that non-produced assets, including environmental assets, have no value. Hence, this approach is not appropriate for oil & gas reserves.

The exogenous approach, recommended by SEEA, assumes that the expected rate of return on produced assets is equal to an external rate of return. Ideally, an industry specific rate of return should be used, for example, the interest rate on bonds issued by UK resource companies can be a proxy for estimating returns on capital. However, the issue of bonds by the private sector (oil & gas companies or other extraction industries) is not common in the UK. SEEA suggests that a realistic approach could be to use an economy wide rate of return based on government bond rates. The government bond rates may not include an adequate risk premium for specific industries, but it provides a reasonable reflection of a normal return. To incorporate the risk specific to the oil & gas industry is an area for future consideration.

This paper follows the exogenous approach and uses a ten year moving average of government bond rates (of 4.5% and 4.3 % for 2010 and 2011 respectively) to estimate the return on produced assets by multiplying the rate with the net capital stock invested in the oil & gas sector.

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\(^3\) Also known as depreciation of fixed asset

\(^4\) See Appendix B for detailed data

\(^5\) The PIM is a method of constructing estimates of capital stock and consumption of fixed capital from time series of gross fixed capital formation in National Accounts (OECD)

\(^6\) Data are in Appendix B (Row O and Q)
\[ \text{Return on produced assets} = \text{net capital stock} \times \text{rate of return} \]

\[ \text{Return on produced assets 2010} = \£48.5 \text{ billion} \times 0.045 = \£2.2 \text{ billion} \]

\[ \text{Return on produced assets 2011} = \£53.0 \text{ billion} \times 0.043 = \£2.3 \text{ billion} \]

ii) Decommissioning Costs

An important component of the costs of extracting oil & gas reserves is the eventual decommissioning costs associated with the dismantling of the production facilities. There are three main approaches to dealing with decommissioning costs in an accounting framework:

- First, the total remaining decommissioning cost could be divided by the remaining years of projected production. However, this method is not appropriate, as the decommissioning cost is accumulated towards the end of the production period, which results in an increasingly large decommissioning cost in the future.
- Secondly, allocating the decommissioning cost paid in a year to that specific year. However, this will overstate the cost of that specific year because the cost realised in any given year is predominantly related to past production.
- Thirdly, the projected decommissioning cost in a year could be apportioned appropriately to past production. This method is then applied to every subsequent year while assuming that all decommissioning costs allocated to previous years are considered as a sunk cost.

This paper uses the third approach to allocate the decommissioning cost to UK Continental Shelf oil & gas production. The decommissioning cost for each year is related to the past production. For example, the 2010 decommissioning cost is related to 1966\(^8\) to 2009 production and 2011 decommissioning cost is related to 1966 to 2010 production and so on. Therefore, the decommissioning expenditure for one year, for example 2010, should be spread in proportion to the past production from the start of the production (1966) until 2009. This could be done by calculating a decommissioning cost per unit of production for every year of forecasted decommissioning cost and then multiplying these costs to all previous years’ extraction.

By following this method the decommissioning cost attributed to production in 2010 and 2011 is £0.6 billion and £0.5 billion respectively (shown in Table 2). The decommissioning cost is based on the OBR forecasts and the cost for all other years is given in Appendix B.

2. Pattern of expected resource rents

The critical factor in the valuation of oil & gas reserves is determining the expected pattern of the resource rent. Expected patterns are not observed and hence assumptions concerning the flows must be made. The pattern of the expected extraction of oil & gas reserves determines its asset life.

A simplified way to determine the expected resource rent is to assume that the current extraction rate is constant over the asset life, but this might not be the case. Another way to determine the expected extraction is to project the rate of future extraction. Based on the projection the resource rent for each future year can be calculated. This method is preferable because it takes into account forecasted prices, costs and extraction rates.

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7 Source: See Appendix B (Row Q)
8 The start of significant [offshore] production of oil & gas in the UK
This paper uses the projection method to determine the pattern of expected resource rent. This is possible due to an oil & gas projection of extraction, extraction cost and commodity price forecasted by OBR in nominal terms. This forecast is given in Appendix B.

3. Estimate of the asset life

The asset life is the expected time over which the extraction from a natural resource can take place. It is important to estimate the asset life in the NPV model because it determines the expected time over which an asset should be discounted. In this paper, the projection profile discussed in the previous section is used to determine the point at which the reserves are depleted.

The asset life is determined as the time it takes for the projected cumulative production to equal the reserves. The asset life for a particular year depends upon the reserves in that year; therefore, it is assumed that the extraction stops exactly at the point when the cumulative production equals the reserves of that year.

The asset life for UK Continental oil & gas reserves at 31 December 2010 and 31 December 2011 is estimated as follows:

2011 opening balance\(^9\) asset life

Reserves as at 31 December 2010 = 1,314 million tonnes of oil equivalent (mtoe)

The cumulative production reaches the reserves (1,314 mtoe) in 2025. This gives an asset life of 16 years\(^10\).

2011 closing balance asset life

Reserves as at 31 December 2011 = 1,328 million tonnes of oil equivalent

The cumulative production reaches the reserves (1,328 mtoe) in 2028. This gives an asset life of approximately 18 years\(^11\).

4. Choice of discount rate

The discount rate is required to convert the expected stream of resource rents into a current period. A discount rate expresses a time preference - the preference for the owner of an asset to receive income now rather than in the future. It also reflects the owner’s attitude to risk. The use of discount rates in NPV calculations can be interpreted as an expected rate of return on the environmental assets. There are two broad types of discount rates – market (individual) discount rate and social discount rate.

\(^{9}\) 31 December 2010 is also the opening stock of oil & gas reserves on 1 January 2011.

\(^{10}\) This figure is Inclusive of 2010.

\(^{11}\) The OBR projection forecasts the production until 2040. However, only proven and probable reserves are valued in this paper. Therefore, the resource rent in the last year (the 16\(^{th}\) year and 18\(^{th}\) year for 2010 and 2011 respectively) is adjusted to ensure that the extraction stops exactly when the sum of the future production reaches the estimated reserves. This figure is also inclusive of 2011.
The market discount rate is higher than the social discount rate as individuals or enterprises tend to demand a quicker return from ownership of an asset. The use of a market discount rate provides a stronger comparison across different types of assets and the trade off between assets can be considered. On the other hand, the social discount rate places a higher relative importance on income earned by future generations.

Since environmental assets are of long term value to society, they should be captured from a societal perspective. Therefore, this paper uses the social discount rate shown in Table 1 to value UK Continental Shelf oil & gas reserves.

### Table 1: Green Book Social Discount Rates

<table>
<thead>
<tr>
<th>Period of years</th>
<th>0-30</th>
<th>31-75</th>
<th>76-125</th>
<th>126-200</th>
<th>201-300</th>
<th>301+</th>
</tr>
</thead>
<tbody>
<tr>
<td>Discount rate</td>
<td>3.5%</td>
<td>3%</td>
<td>2.5%</td>
<td>2%</td>
<td>1.5%</td>
<td>1%</td>
</tr>
</tbody>
</table>

*Source: HM Treasury’s Green Book*

Since the asset lives for oil & gas reserves for 2010 and 2011 are 16 years and 18 years respectively, they both fall under the 0-30 years’ social discount rate (Table 1). Therefore, a social discount rate of 3.5% is used in this paper to estimate the UK Continental Shelf oil & gas reserves.

### Application

This section applies the above methodology to estimate the UK Continental Shelf oil & gas reserves at the end of 2010 and 2011. The following NPV formula is used:

\[
\text{Total Value of UK Continental Shelf oil & gas resources} = \sum resource\ rent\ in\ year\ T^{12} \frac{1}{(1 + r)^t}
\]

**Resource rent**

The resource rent for 2011 is shown in Table 2 and, as discussed above, is estimated by using the following equation:

Resource Rent = Total income – Operating expenditure – Decommissioning cost – User cost of produced assets

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12 “T” is the accounting period
Table 2: 2010 and 2011 oil & gas resource rent, £ billion

<table>
<thead>
<tr>
<th>Year to 31 December</th>
<th>Total Income</th>
<th>Operating expenditure</th>
<th>Decommissioning cost - apportioned</th>
<th>Capital Consumption</th>
<th>Return on produced assets</th>
<th>Resource rent</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td>33.7</td>
<td>7.2</td>
<td>0.6</td>
<td>5.3</td>
<td>2.2</td>
<td>18.4</td>
</tr>
<tr>
<td>2011</td>
<td>36.9</td>
<td>7.2</td>
<td>0.5</td>
<td>5.5</td>
<td>2.3</td>
<td>21.4</td>
</tr>
</tbody>
</table>

Resource rents for future years are provided in Appendix B.

Asset life (t)
- As at 31 December 2010 – 16 years
- As at 31 December 2011 – 18 years

Social discount rate (r)
- 3.5%

The total value of UK Continental Shelf oil & gas reserves is the sum of the resource rent calculated for each year and discounted appropriately into today’s money.

At the end of 2010 (2011 opening balance):

\[
£132 \text{ billion} = \frac{£18.4 \text{ bn}}{(1 + 1.035)^0} + \frac{£21.3 \text{ bn}}{(1 + 1.035)^1} + \frac{£20.9 \text{ bn}}{(1 + 1.035)^2} + \frac{RR \text{ in year } T}{(1 + 1.035)^t} \ldots
\]

At the end of 2011 (2011 closing balance):

\[
£120 \text{ billion} = \frac{£21.4 \text{ bn}}{(1 + 1.035)^0} + \frac{£21.0 \text{ bn}}{(1 + 1.035)^1} + \frac{£18.7 \text{ bn}}{(1 + 1.035)^2} + \frac{RR \text{ in year } T}{(1 + 1.035)^t} \ldots
\]

Results

By applying the NPV under the following assumptions:

- Proven and probable reserves are always extracted first
- Social discount rate of 3.5%
- Rate of return of long term government bonds

The monetary valuation of UK Continental Shelf oil & gas reserves at the end of 2010 and 2011 is estimated to have been £132 billion and £120 billion, respectively. The values for oil & gas reserves derived in this paper are based on SNA principles and are consistent with SEEA and could be incorporated into the UK Environmental Accounts and, subsequently, into the UK National Accounts.
Sensitivity Analysis

Table 3 shows how the valuation estimates change with a change in the discount rate. By holding everything else constant and using a 4% social discount rate, the value of reserves decreases by £2 billion in 2011. On the other hand, using a 3% social discount rate increases the value of reserves by £3 billion in 2011.

Table 3: Impact of social discount rate on the 2011 value of oil & gas reserves

<table>
<thead>
<tr>
<th>Social discount rate percentage</th>
<th>Value of oil &amp; gas reserves £ billion</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>118</td>
</tr>
<tr>
<td>3.5</td>
<td>120</td>
</tr>
<tr>
<td>3</td>
<td>123</td>
</tr>
</tbody>
</table>

Similar analysis is carried out in Table 4 for a change in the rate of return. By holding everything else constant and using an 8% rate of return (as used in the previous methodology), the value of reserves decreased by £41 billion in 2011. On the other hand, using a 3% rate of return, the value of reserves increased by £15 billion in 2011.

Table 4: Impact of rate of return on produced assets on the 2011 value of oil & gas reserves

<table>
<thead>
<tr>
<th>Rate of Return percentage</th>
<th>Value of oil &amp; gas reserves £ billion</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>79</td>
</tr>
<tr>
<td>5</td>
<td>113</td>
</tr>
<tr>
<td>4.3</td>
<td>120</td>
</tr>
<tr>
<td>3</td>
<td>135</td>
</tr>
</tbody>
</table>

Monetary asset account for UK Continental Shelf oil & gas reserves

This section presents the monetary asset account for oil & gas reserves for 2011. The monetary asset account is shown in Table 5 and the methodology to construct this table is given in Appendix D.

A brief description of price in situ is discussed below as this relates to the valuation of the flows within the account structure.

Prices used to value flows

SEEA suggests that the valuation of all changes in the stock of a natural resource (including extraction, discoveries and catastrophic losses) must be carried out using average in situ resource prices underlying the valuation of the opening and closing stock. Using this price permits a
balanced and complete accounting of changes in the value of natural resources over an accounting period.

Therefore, this paper uses an average discounted price of oil & gas reserves, known as the average price in situ, to value the flows of oil & gas reserves in 2011.

This price in situ is derived by dividing the discounted total value of oil & gas reserves by physical oil & gas reserves.

At the end of 2010

Price in situ = £132 billion/1,314 mtoe = £100 per tonne of oil equivalent.

At the end of 2011

Price in situ = £120 billion/1,328 mtoe = £91 per tonne of oil equivalent

Average price in situ

Average price in situ = (£100 + £91)/2 = £96 per tonne of oil equivalent

This average discounted price is applied to each of the categories of additions and reductions in stock in Table 5.

Table 5: Monetary asset accounts for UK Continental Shelf oil & gas reserves 2011

<table>
<thead>
<tr>
<th></th>
<th>Total (£ billion)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Opening stock of oil &amp; gas reserves at 1 January 2011</td>
<td>132</td>
</tr>
<tr>
<td><strong>Additions to stock</strong></td>
<td></td>
</tr>
<tr>
<td>Discoveries</td>
<td>Not available(^\text{13})</td>
</tr>
<tr>
<td><strong>Total additions to stock</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Reductions in stock</strong></td>
<td></td>
</tr>
<tr>
<td>Extraction</td>
<td>-9</td>
</tr>
<tr>
<td><strong>Total reduction in stocks</strong></td>
<td>-9</td>
</tr>
<tr>
<td>Revaluation</td>
<td>-13</td>
</tr>
<tr>
<td>Other volume changes</td>
<td>11</td>
</tr>
<tr>
<td><strong>Closing stock of oil &amp; gas reserves at 31 December 2011</strong></td>
<td><strong>120</strong></td>
</tr>
</tbody>
</table>

Note: All figures are rounded up

\(^{13}\) Currently, physical data are not available of the UK Continental Shelf oil & gas discoveries. The other volume changes category captures any increases (or decreases) in reserves. Hence, discoveries will be accounted for in this category instead.
Analysis

Table 5 shows that the value of the UK Continental Shelf oil & gas reserves fell by £11 billion between 1 January 2011 and 31 December 2011. However, the physical reserves increased by 15mtoe\textsuperscript{14}. The fall in monetary value was due to a downward revaluation of £13 billion combined with a fall of £9 billion due to extraction of reserves, partly offset by an increase of £11 billion in the value of other volume changes. The reserves were re-valued due to a change in the price in situ between 1 January 2011 and 31 December 2011. The price in situ decreased (£100 to £91) due to a fall in the total value of oil & gas reserves (£132 billion to £120 billion) combined with an increase in physical reserves at the end of the year. The fall in value of oil & gas reserves while physical reserves increased can be explained with the help of Chart 1.

**Chart 1: The components of resource rent between 2011 and 2039**

The fall in value of oil & gas reserves is largely related to the resource rent projection. As shown in Chart 1, the resource rent is the area between the line (total income) and the bars (total expenditure). The projected trend shows that the resource rent becomes smaller in the future due to two factors:

- First, total income decreases due to a fall in projected production, only partly offset by an increase in the projected price (Appendix B)

\textsuperscript{14} Million tonnes of oil equivalent
Secondly, the total cost (total bars in the chart) increases at the beginning of the forecast, though it remains stable in the medium term before it starts declining.

From Chart 1, it can be seen that operating expenditures are falling slightly, which is in line with the production forecast (Appendix B). This makes sense because operating expenditures should decline when production falls; however, the consumption of fixed capital (depreciation) does not follow a similar trend. Chart 1 show that the consumption of fixed capital remains high. This could be because consumption of fixed capital depends on the investment made in the past. If investment is large in a certain time period, it will increase the consumption of fixed assets in future years. The future production depends on the investment made now and although the projected production is lower than the past, the investment does not necessarily have to be lower. This is because oil & gas are non-renewable resources and the development cost per unit will generally become higher in the future as the resources become more difficult to discover and extract.

The trend of the resource rent explains why the value of reserves at 31 December 2011 decreased although the physical reserves increased. As the reserves increased in physical terms, it results in a longer asset life. However, the gain in the resource rent from a longer asset life is not enough to offset the loss of resource rent in one year (1 January 2011).

**Comparison with previous methodology**

*Table 6: ONS oil & gas reserve valuation methodology comparison*

<table>
<thead>
<tr>
<th>At the end of 2010</th>
<th>Previous Methodology</th>
<th>£140 billion</th>
<th>New Methodology</th>
<th>£132 billion</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Scope of valuation</strong></td>
<td>Proven + Probable + Lower range of undiscovered reserves</td>
<td>Proven + Probable reserves</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Future extraction profile/Asset life</strong></td>
<td>Constant for 4 years then decreasing rate</td>
<td>Projection</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Resource rent</strong></td>
<td>Weighted average unit resource rent hold constant over asset life</td>
<td>Resource rent varies with the projection of price and cost</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Method to calculate decommissioning cost</strong></td>
<td>Time period approach = total decommissioning cost/remaining life span</td>
<td>Unit production approach</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Discount rate</strong></td>
<td>Eurostat - 4%</td>
<td>Social discount rate – 3.5%</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Rate of return on produced asset</strong></td>
<td>Eurostat – 8%</td>
<td>Long term government bond rate – 10 year moving average</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

As mentioned in the introduction section, the methodology to value oil & gas reserves was reviewed in 2012. The NPV is used to value the oil & gas reserves in both methodologies. However, there are a number of differences. As a result of the review the following changes have been implemented:

1. The new methodology is developed based on SEEA Central Framework

2. The scope of the oil & gas reserves is redefined. The previous methodology included the lower range of undiscovered reserves in addition to the proven and probable reserves, which is not consistent with the international standards. The review redefined that the scope of the oil & gas reserves for valuation should be limited to only proven and probable reserves. This paper includes only proven and probable oil & gas reserves in its valuation.
3. The old methodology used a constant rate of extraction for four years and then a constant declining rate until the reserves are depleted to estimate asset life. Whereas, the review showed that data are available to project the future extraction profile and the resource rent to estimate asset life. Therefore, the new asset life is calculated based on the new methodology.

4. The decommissioning cost is treated differently in the two methods. In the old methodology, decommissioning costs were accumulated towards the end of the asset life resulting in a large sum. The review concluded that the decommissioning cost was apportioned incorrectly to future extraction. This presents a risk because the resource rent might be negative when the resources are close to the end of their asset life. The new methodology addresses this issue by adopting the unit of production approach instead of the time period approach.

Table 7 and Chart 2 show the differences in monetary valuation of UK Continental Shelf oil & gas reserves between 2001 and 2010 by using the old and new methodologies. The difference in the oil & gas values using both methodologies is due to a combination of reasons given above.

**Table 7: Oil & gas reserves value at the end of year, £ billion**

<table>
<thead>
<tr>
<th>Methodology</th>
<th>2001</th>
<th>2002</th>
<th>2003</th>
<th>2004</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
</tr>
</thead>
<tbody>
<tr>
<td>Old</td>
<td>105</td>
<td>99</td>
<td>99</td>
<td>130</td>
<td>162</td>
<td>180</td>
<td>225</td>
<td>186</td>
<td>183</td>
<td>140</td>
</tr>
<tr>
<td>New</td>
<td>174</td>
<td>177</td>
<td>174</td>
<td>179</td>
<td>180</td>
<td>175</td>
<td>167</td>
<td>157</td>
<td>138</td>
<td>132</td>
</tr>
</tbody>
</table>

*Note: Asset life of time series data is rounded up to the nearest year.*

**Chart 2: Comparison of oil & gas reserves values (2001 – 2010)**
### Appendices

**Appendix A**

**Categorisation of mineral and energy resources**

<table>
<thead>
<tr>
<th>SEEA Classes</th>
<th>Corresponding UNFC-2009 project categories</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Economic and social viability</td>
</tr>
<tr>
<td>Class A: Commercially Recoverable Resources¹</td>
<td>E1. Extraction and sale has been confirmed to be economically viable</td>
</tr>
<tr>
<td>Class B: Potentially Commercially Recoverable Resources²</td>
<td>E2. Extraction and sale is expected to become economically viable in the foreseeable future³</td>
</tr>
<tr>
<td>Class C: Non-Commercial and Other Known Deposits⁴</td>
<td>E3. Extraction and sale is not expected to become economically viable in the foreseeable future or evaluation is at too early a stage to determine economic viability</td>
</tr>
<tr>
<td>Exploration Projects Additional quantities in place</td>
<td>E3. Extraction and sale is not expected to become economically viable in the foreseeable future or evaluation is at too early a stage to determine economic viability</td>
</tr>
</tbody>
</table>

**Notes:**

1. *Includes on-production projects, projects approved for development and projects justified for development*
2. *Includes economic and marginal development projects pending and development projects on hold*
3. *Potential Commercial Projects may also satisfy the requirements for E1.*
4. *Includes unclarified development projects, non-viable development projects, and additional quantities in place*
### Appendix B

#### Table 1: Office for Budget Responsibility Projection (nominal term)

<table>
<thead>
<tr>
<th>Year</th>
<th>Oil price (nominal)</th>
<th>Gas price (nominal)</th>
<th>Oil production (millions of tonnes)</th>
<th>Gas production (billion therms)</th>
<th>Capital expenditure (£ billion)</th>
<th>Operating expenditure (£ billion)</th>
<th>Decommissioning expenditure (£ billion)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010-11</td>
<td>$80.3</td>
<td>$4.5</td>
<td>112.2</td>
<td>51.9</td>
<td>6.1</td>
<td>7.2</td>
<td>0.3</td>
</tr>
<tr>
<td>2011-12</td>
<td>111.0</td>
<td>5.5</td>
<td>122.2</td>
<td>68.6</td>
<td>8.0</td>
<td>7.7</td>
<td>0.4</td>
</tr>
<tr>
<td>2012-13</td>
<td>117.9</td>
<td>6.5</td>
<td>125.2</td>
<td>70.3</td>
<td>9.5</td>
<td>8.1</td>
<td>0.6</td>
</tr>
<tr>
<td>2013-14</td>
<td>111.8</td>
<td>7.5</td>
<td>128.3</td>
<td>72.1</td>
<td>10.1</td>
<td>8.8</td>
<td>0.8</td>
</tr>
<tr>
<td>2014-15</td>
<td>105.0</td>
<td>8.5</td>
<td>131.5</td>
<td>73.9</td>
<td>9.7</td>
<td>8.8</td>
<td>0.9</td>
</tr>
<tr>
<td>2015-16</td>
<td>99.5</td>
<td>9.5</td>
<td>134.8</td>
<td>75.7</td>
<td>9.4</td>
<td>8.4</td>
<td>1.0</td>
</tr>
<tr>
<td>2016-17</td>
<td>95.4</td>
<td>10.5</td>
<td>138.2</td>
<td>77.6</td>
<td>9.1</td>
<td>8.1</td>
<td>1.1</td>
</tr>
<tr>
<td>2017-18</td>
<td>97.8</td>
<td>11.5</td>
<td>141.7</td>
<td>79.6</td>
<td>9.1</td>
<td>7.8</td>
<td>1.2</td>
</tr>
<tr>
<td>2018-19</td>
<td>100.3</td>
<td>12.5</td>
<td>145.2</td>
<td>81.6</td>
<td>9.1</td>
<td>7.6</td>
<td>1.3</td>
</tr>
<tr>
<td>2019-20</td>
<td>102.8</td>
<td>13.5</td>
<td>148.8</td>
<td>83.6</td>
<td>9.1</td>
<td>7.4</td>
<td>1.4</td>
</tr>
<tr>
<td>2020-21</td>
<td>105.3</td>
<td>14.5</td>
<td>152.5</td>
<td>85.7</td>
<td>9.1</td>
<td>7.2</td>
<td>1.5</td>
</tr>
<tr>
<td>2021-22</td>
<td>108.0</td>
<td>15.5</td>
<td>156.4</td>
<td>87.8</td>
<td>9.1</td>
<td>7.0</td>
<td>1.6</td>
</tr>
<tr>
<td>2022-23</td>
<td>110.7</td>
<td>16.5</td>
<td>160.3</td>
<td>90.0</td>
<td>9.1</td>
<td>6.8</td>
<td>1.7</td>
</tr>
<tr>
<td>2023-24</td>
<td>113.4</td>
<td>17.5</td>
<td>164.3</td>
<td>92.7</td>
<td>9.1</td>
<td>6.6</td>
<td>1.8</td>
</tr>
<tr>
<td>2024-25</td>
<td>116.3</td>
<td>18.5</td>
<td>168.4</td>
<td>95.4</td>
<td>9.1</td>
<td>6.4</td>
<td>2.0</td>
</tr>
</tbody>
</table>

#### Table 2: Resource Rent Calculation for 2011 (nominal term)

<table>
<thead>
<tr>
<th>Resource</th>
<th>Income</th>
<th>Cost</th>
<th>LT Total</th>
<th>Income Cost</th>
<th>Resource Rent (L×M×N×O×P)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oil</td>
<td>£154.3</td>
<td>£89.9</td>
<td>£64.4</td>
<td>£16.7</td>
<td>£6.7</td>
</tr>
<tr>
<td>Gas</td>
<td>£14.3</td>
<td>£8.9</td>
<td>£5.4</td>
<td>£0.4</td>
<td>£0.4</td>
</tr>
</tbody>
</table>

#### Notes:
1. The projection is calculated based on financial year. For simplicity, this is assumed to be calendar year for example, 2010-11 refer to 2010.
2. The expected resource rent shown is related to the 2011 valuation. To calculate expected resource rent for 2010 valuation, applies similar approach but with different rate of return (10 year average government bond rate).
3. Consumption of fixed capital and net capital stock is estimated from the projection of capital expenditure (F) using Perpetual Inventory Model.
Appendix C

Oil & gas reserves Physical Account

<table>
<thead>
<tr>
<th>Proven and Probable reserves</th>
<th>2010</th>
<th>2011</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Tonnes of oil equivalent</td>
<td></td>
</tr>
<tr>
<td>Opening stocks</td>
<td>1,374,407,979</td>
<td>1,313,572,773</td>
</tr>
<tr>
<td>Extraction</td>
<td>-120,936,185</td>
<td>-97,433,125</td>
</tr>
<tr>
<td>Other volume changes</td>
<td>60,100,978</td>
<td>112,025,977</td>
</tr>
<tr>
<td>Closing stocks</td>
<td>1,313,572,773</td>
<td>1,328,165,625</td>
</tr>
</tbody>
</table>

Note: “Other volume changes” is calculated as a residual of the change between the closing and opening stocks less extraction.

Appendix D:

Opening stock

The monetary value of the UK Continental Shelf oil & gas reserves at the end of 2010 (as at 31 December 2010) is the opening stock of 2011 (as at 1 January 2011), which is £132 billion.

Additions to stock

Due to physical data not being available on discoveries, this category is unavailable. Any changes (other than extraction) will be accounted for in the other volume changes category.

Reductions in stock

The reduction in stock category consists of extraction. The physical data for oil & gas extraction that took place in 2011 is taken from the Department of Energy and Climate Change Energy Statistics. This is then multiplied by the average price in situ (£96 per toe).

Value of extraction = -97 mtoe * £96 per toe = -£9 billion

Other volume changes

The physical data on other volume changes is calculated as the residual change of the 2010 to 2011 oil & gas reserves less extraction (see Appendix C). This figure is then multiplied by the average price in situ (£91 per tonne of oil equivalent).

Value of other volume changes = 112 mtoe * £96 per toe = £11 billion

Revaluation

This category attempts to capture the effect of price changes over the year on the account. This is hoped to reduce the difference between the residual closing balance and the calculated closing balance (the one presented below). This revaluation figure is calculated as the average level of reserves (as at 31 December 2010 and 2011) multiplied by the difference in the price in situ in 2010 and 2011.

Average level of reserves = \( \frac{1,314 \text{ mtoe} + 1,328 \text{ mtoe}}{2} \) = 1,321 mtoe

Difference in price in situ = £100 (2010) - £91 (2011) = -£10

Value of revaluation = -£10 * 1,321 mtoe = -£13 billion
**Closing stock**

The closing stock is calculated under the same approach as the opening stock, but with 2011 reserves and resource rent.

The closing stock value of 2011 (as at 31 December 2011) oil & gas reserves is £120 billion.
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