Prospects for Oil and Gas from the UK Continental Shelf to 2030

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1. Introduction

The UK Continental Shelf (UKCS) is widely but loosely described as a mature petroleum province. This is generally interpreted to mean that production has passed its peak, the average size of new discoveries is on a falling long-term trend, and exploration interest is less than in earlier years of the life of the province with the result that additions to reserves are not replacing those being depleted. These statements can certainly be applied to the UKCS. Production peaked at 4.6 million barrels of oil equivalent per day (mmboe/d) in 1999 and fell to 3.8 mmboe/d in 2004. The average size of discovery is now just over 30 mmboe compared to 500-600 mmboe in the late 1960’s and the first half of the 1970’s. Additions to new reserves have been less than depletion since the mid-1990’s. Despite these trends the central proposition of this chapter is that the UKCS still has the potential for a long productive life.

This is not guaranteed, however. To ensure that the potential is realised much effort and imagination is required by the main stakeholders, particularly investors and the Government in its capacity as landlord, regulator, and tax authority. Maturity has brought with it a well-developed infrastructure of pipelines, terminals, and platforms which may be used to facilitate the development of new fields at substantially lower cost compared to stand-alone methods. But much of this infrastructure was installed some considerable time ago, and if it is going to support the development of projects extending to 2020 and beyond, substantial reinforcement will be required.

On present trends over the next 10-15 years the fields for which much of the present infrastructure was built will be economically depleted. If the life of this infrastructure is to be extended further business is required to sustain it. This means more new field developments and incremental recovery projects. Given their generally small average size large numbers of developments will be required to compensate in part for the depletion of the current generation of producing fields.

Several PILOT initiatives, principally those dealing with fallow blocks/discoveries, field stewardship and Infrastructure Code of Practice are currently under way. Their reasonable success is necessary if developments are to be enhanced and accelerated. In turn these can ensure that the economic life of the infrastructure can be extended and investment in reinforcements justified. A virtuous circle could be produced. The present chapter measures potential activity levels given reasonable success of the pursuit of the prospects by investors and the associated PILOT initiatives. The implications of less success are also indicated.
2. Methodology and Assumptions

The projections of production and expenditures have been made through the use of financial modelling, including the use of the Monte Carlo technique, informed by a large field database validated by the relevant operators. The field database incorporates best estimate information on production, and investment, operating and decommissioning expenditures. These refer to 274 sanctioned fields, 142 incremental projects relating to these fields, 40 probable fields, and 20 possible fields. The latter 3 categories are unsanctioned but are currently being examined for development. An additional database contains 216 fields defined as being in the category of technical reserves. Summary data on reserves (oil/gas) and block location are available. They are not currently being examined for development by licensees.

Monte Carlo modelling was employed to estimate the possible numbers of new discoveries in the period to 2030. The modelling incorporated assumptions based on recent trends relating to exploration effort, success rates, sizes, and types (oil, gas, condensate) of discovery. A moving average of the behaviour of these variables over the past 6 years was calculated separately for 6 areas of the UKCS (Southern North Sea, (SNS), Central North Sea (CNS), Moray Firth (MF), Northern North Sea (NNS), West of Scotland (WOS), and Irish Sea (IS)), and the results employed for use in the Monte Carlo analysis. Because of the very limited data for WOS and IS over the 6-year period judgemental assumptions on success rates and average sizes of discoveries were made for the modelling.

It is postulated that the exploration effort depends substantially on a combination of (a) the expected success rate, (b) the likely size of discovery, and (c) oil/gas prices. In the present study 3 future oil/gas price scenarios were employed as follows:

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Future Oil and Gas Price Scenarios</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Oil Price (real)</td>
</tr>
<tr>
<td></td>
<td>$/bbl</td>
</tr>
<tr>
<td>High</td>
<td>40</td>
</tr>
<tr>
<td>Medium</td>
<td>30</td>
</tr>
<tr>
<td>Low</td>
<td>20</td>
</tr>
</tbody>
</table>

The postulated numbers of annual exploration wells for the whole of the UKCS were modelled to decline in a linear fashion over the period to 2028 as follows:

<table>
<thead>
<tr>
<th>Table 2</th>
<th>Exploration Wells</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2004</td>
</tr>
<tr>
<td>High</td>
<td>50</td>
</tr>
<tr>
<td>Medium</td>
<td>38</td>
</tr>
<tr>
<td>Low</td>
<td>25</td>
</tr>
</tbody>
</table>

It is postulated that success rates depend substantially on a combination of (a) recent experience, and (b) size of the effort. It is further suggested that higher effort is associated with more discoveries but with lower success rates compared to reduced levels of effort. This reflects the view that low levels of effort will be concentrated on
the lowest risk prospects, and thus that higher effort involves the acceptance of higher risk. For the UKCS as a whole 3 success rates were postulated as follows:

<table>
<thead>
<tr>
<th>Success Rates</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Medium effort/Medium success rate</td>
<td>23%</td>
</tr>
<tr>
<td>High effort/Low success rate</td>
<td>19%</td>
</tr>
<tr>
<td>Low effort/High success rate</td>
<td>25%</td>
</tr>
</tbody>
</table>

It is assumed that technological progress will maintain these success rates.

The mean sizes of discoveries made in the period 1997-2003 inclusive for each of the 6 regions were calculated. It was then assumed that they would decrease in line with historic experience. Such decline rates are quite modest. For 2004 the average size of discovery for the whole of the UKCS is 34 million barrels of oil equivalent (mmboe). For purposes of the Monte Carlo modelling of new discoveries the Standard Deviation (SD) was set at 50% of the mean value. In line with historic experience the size distribution of discoveries was taken to be lognormal.

Using the above information the Monte Carlo technique was employed to project discoveries in the 6 regions to 2028. For the whole period the total numbers of discoveries for the whole of the UKCS were are follows:

<table>
<thead>
<tr>
<th>Total Number of Discoveries to 2028</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>High Effort/Low Success Rate ($40, 36 pence)</td>
<td>211</td>
</tr>
<tr>
<td>Medium Effort/Medium Success Rate($30, 28 pence)</td>
<td>181</td>
</tr>
<tr>
<td>Low Effort/High Success Rate ($20, 18 pence)</td>
<td>121</td>
</tr>
</tbody>
</table>

For each region the average development costs (per boe) of fields sanctioned since the later 1990’s and those in the probable and possible categories were calculated. Using these as the mean values the Monte Carlo technique was employed to calculate the development costs of new discoveries. A normal distribution with a SD = 20% of the mean value was employed. For the whole of the UKCS the average development costs on this basis were $4.33 boe. Annual operating costs were modelled as a percentage of accumulated development costs. This percentage was taken to increase as the size of the field was reduced reflecting the presence of economies of scale.

With respect to fields in the category of technical reserves it was recognised that many have remained undeveloped for a long time. Accordingly, it was assumed that their development costs would be $1/boe higher than for new discoveries for each of the regions. For purposes of Monte Carlo modelling a normal distribution of the recoverable reserves for each field with a SD = 50% of the mean was assumed. With respect to development costs the distribution was assumed to be normal with a SD = 20% of the mean value.

The annual numbers of new field developments were assumed to be constrained by the capacity of the industry. The ceilings were assumed to be linked to the oil/gas
scenarios with maxima of 32, 27, and 20 respectively under the High, Medium, and Low Price Cases. These constraints do not apply to incremental projects which are additional to new field developments.

A noteworthy feature of the 142 incremental projects in the database is the expectation that the great majority will be executed over the 3 years from 2005. It is virtually certain that in the medium and longer-term many further incremental projects will be designed and executed. They are just not yet at the serious planning stage. Such projects can be expected not only on currently sanctioned fields but also on those presently classified as in the categories of probable, possible, technical reserves, and future discoveries.

Accordingly, estimates were made of the potential extra incremental projects from all these sources. Examination of the numbers of such projects and their key characteristics (reserves and costs) being examined by operators over the past 4 years indicated a decline rate in the total volumes. On the basis of this, and from a base of the information of the key characteristics of the 142 projects in the 2004 database, it was felt that, with a decline rate reflecting historic experience, further portfolios of incremental projects could reasonably be expected. As noted above such future projects would be spread over all categories of host fields.

The financial modelling incorporates an investment threshold or hurdle rate, field economic cut-off, and the full details of the current petroleum tax system. The base case emphasised has a post-tax threshold rate of return of 10% in real terms. It is also important to note that it is assumed that investment decisions are made on the basis of the oil/gas prices indicated. For the $40, 36 pence case this does not represent current behaviour and the results should be seen accordingly.

3. Model Results

a. Number of Fields in Production

A basic indicator of the changing activity levels is the number of fields in production. These are shown in Charts 1 by the different categories of fields under the $30, 28 pence price scenario.

The number of producing fields rises from just over 250 in 2004 to exceed 300 in the period 2010-2018. Currently sanctioned fields constitute the majority until 2011. By 2020 technical reserves and new finds account for nearly 250 of the 300 fields in production. This dramatises the transformation in the prospects. The development of fields in the categories of technical reserves and new discoveries is obviously not guaranteed and depend in part on the success of the various PILOT initiatives.

Under the $40, 36 pence scenario the number of producing fields rises to a peak in excess of 350 in 2018. Under the $20, 18 pence scenario the peak number is around 270 in the period 2009-1020 and by 2020 is 213. The results indicate the substantial long-term price sensitivity of the numbers of field developments and the timing of their economic cut-off.
b. Production

Oil production (excluding NGLs) is shown under the $30, and 28 pence prices in Chart 2. Production holds up well in the short-term and could even increase slightly from present levels of 1.85 mmb/d. By 2010, however, it falls to 1.57 mmb/d, and to 1.3 mmb/d in 2020. The reduced pace of decline after 2010 is due to the development of substantial numbers of fields in the technical reserves category and from new discoveries. By 2020 these account for much of total production. Future incremental projects also make substantial contributions in that year. There is little short-term price sensitivity to production in the short-run but in the long-term there is more sensitivity. Thus under the $40, 36 pence scenario output is 1.6 mmb/d in 2010 and 1.3 mmb/d in 2020. Under the $20, 18 pence production is 1.5 mmb/d in 2010 and just under 1 mmb/d in 2020.

Potential gas production (excluding NGLs) under the $30, 28p case is shown in Chart 3. From 9.8 billion cubic feet per day (bcf/d) in 2004, it falls to 7.1 bcf/d in 2010 and to 5.8 bcf/d in 2020. As for oil, in the period beyond 2012 the total is very much dependent on large production from fields in the technical reserves and new discoveries categories, and in the development of many future incremental projects. Under the $40, 36 pence case production is 7.3 bcf/d in 2010 and 5.8 bcf/d in 2020. The corresponding values under the $20, 18 pence case are 6.9 bcf/d and 4.5 bcf/d for the two years. More developments in the categories of new discoveries and technical reserves under the high price mainly account for the difference.
In Chart 4 total hydrocarbon production (including NGLs) is shown under the $30, 28p scenario. From 3.8 mmboe/d in 2004 output is 2.93 mmboe/d in 2010 which is just below the PILOT aspirational target. By 2020 it is 2.3 mmboe/d. The moderation in the rate of decrease depends very clearly on the development of large numbers of fields in the categories of technical reserves and new discoveries. After 2020 the pace of decline becomes faster, largely because there are far fewer remaining opportunities for developing fields in the technical reserves category. In Chart 5 the regional breakdown of the potential production is shown. The share attributable to the CNS increases in the short-term. The share of WOS increases somewhat.

Chart 2

Potential Oil Production
$30/bbl and 28p/therm
Hurdle Rate : 10%
In Chart 6 total hydrocarbon production (including NGLs) is shown under the $40, 30 pence scenario. In this case the PILOT target of 3 mmb/d in 2010 is just attained. The moderation to the decline rate in the following few years depends overwhelmingly on the development of many fields in the technical reserves and new discoveries categories. By 2020 production has fallen to 2.4 mmb/d. By 2030 it is 1 mmb/d.

In Chart 7 prospective total hydrocarbon production (including NGLs) is shown under the $20, 18 pence scenario. Production is 2.79 mmb/d in 2010. It is noteworthy that, even under this low price case, output is still dependent on worthwhile contributions from future incremental projects and smaller contributions from both new discoveries and the development of some fields in the technical reserves category. By 2020 total production is around 1.83 mmb/d at which date technical reserves, new discoveries, and future incremental projects constitute most of the total.

The results indicate the substantial long-term price sensitivity of production. This sensitivity is not so dramatic as that relating to the numbers of fields. This is due to the small sizes of most of the future fields. A large number of new developments is necessary to make a moderate difference to aggregate production.
Chart 6

Potential Hydrocarbon Production
$40/bbl and 36p/therm
Hurdle Rate: 10%

Chart 7

Potential Hydrocarbon Production
$20/bbl and 18p/therm
Hurdle Rate: 10%
c. Consistency with Independent Estimates of Reserves

It was felt appropriate to test for consistency the projections made above against independent estimates of remaining reserves. Cumulative production from 2005 to 2030 under the 3 scenarios was calculated. In the $20, 18 pence case the grand total is 20.4 bn boe, in the $30, 28 pence case 22.6 bn boe, and under the $40, 36 pence case 23.6 bn boe. Total cumulative production to date is around 34 bn boe. Remaining discovered reserves are estimated by DTI/PILOT to be around 18-19 bn boe. The central estimate of undiscovered recoverable reserves also made by the DTI is around 9 bn boe and the high estimate is 13.6 bn boe. The total remaining potential as indicated by these figures is thus felt to be consistent with the projections made here.

d. Total Development Expenditures

Development expenditures under the $30, 28 pence cases are shown in Chart 8 (at 2005 prices). In the early part of the period the expenditures are dominated by the requirements for the sanctioned fields, current incremental projects, and probable fields. This produces around £4 billion in 2005. From 2006 the level of investment falls sharply with a rebound from 2009 onwards. The decline reflects the completion of some large developments such as Buzzard in the near future and the moderate investment requirements of fields in the probably and possible categories. In this context it should be noted that in recent years investment requirements per boe produced have been substantially underestimated. Such underestimates particularly apply to development drilling requirements. It is quite likely that such underestimates may apply to future investment requirements as well.

From Chart 8 it is seen that in the period beyond 2009 investment expenditures increase sharply based on the development of fields in the technical reserves category and on future incremental projects. The latter are very heavily dominated by drilling expenditures. It is quite likely that the pattern of expenditure through time on these categories of projects will be smoother than indicated in Chart 8. From around 2011 it is seen that field investment becomes overwhelmingly dependent on new discoveries, technical reserves, and future incremental projects.

Under the $40, 36 pence scenario the pattern of field investment in the next few years is not very different from the $30, 28 pence case. The rebound from 2009 onwards is stronger, however, and, on average, expenditures exceed £3 billion annually in the period 2009 – 2016. Thereafter there is a substantial fall reflecting the lack of remaining opportunities among fields in the technical reserves category. Under the $20, 18 pence case the rebound in investment from 2009 is more modest. The annual average exceeds £2 billion in the period 2009 – 2015.
e. **Operating Expenditures**

In Chart 9 prospective operating expenditures are shown under the $30, 28 pence price case. In 2004 they were nearly £5 billion. In the short-term they are projected to fall to £3.9 billion in 2010 and to £2.9 billion in 2020 (all at 2005 prices). The decline is at a more regular and moderate pace than was the case with the lumpy investment profile. From around 2015 onwards an increasingly large proportion of the expenditures depend on the development of technical reserves, new discoveries, and future incremental projects.

Under the $40, 36 pence scenario annual operating expenditures remain at least as high as £4 billion until 2015, and are well in excess of £3 billion (2005 prices) in 2020. The larger numbers of field developments from new discoveries and technical reserves account for the difference. Under the $20, 18 pence case they fall at a brisk rate reaching £3.8 billion in 2010 and £2.2 billion in 2020. The lower number of fields in the categories of technical reserves and new discoveries accounts for the difference.
f. **Decommissioning Expenditures**

Prospective cumulative decommissioning costs to 2030 are shown under the $30, 28 pence scenario in Chart 10. It should be stressed that the expenditures relate to field decommissioning and generally exclude main pipelines and terminals which may or may not remain operational by the end of the period. If they are decommissioned within the period the total would be considerably higher. It is seen that expenditures grow substantially in the period after 2012. This reflects the decommissioning of large, expensive platforms. Cumulative expenditures to 2030 amount to £10.8 billion (2005 prices). Under the $40, 36 pence scenario they reach nearly £11 billion by 2030, while under the $20, 18 pence case the cumulative total is £9.2 billion. More new fields are developed and decommissioned with higher prices in the period. But higher prices also prolong the economic lives of fields beyond 2030, particularly in the case of the $40, 36 pence scenario. A further key feature of the findings is the predominance of the currently sanctioned fields in the total. Many of the future fields are developed with subsea systems tied back to other installations. Their decommissioning costs are thus much less.
4. Conclusions

Using financial simulation modelling, including the Monte Carlo method for analysing risks, it has been demonstrated that, with realistic price assumptions, cumulative production in the range 20.5 – 24 billion boe could be produced from the UKCS from 2005 to 2030. In 2020 production could be 1.8 mmboe/d under a $20, 18 pence scenario, and as much as 2.4 mmboe/d under a $40, 36 pence case. There is a substantial price sensitivity to activity levels in the longer term, relating principally to the viability of continued exploration and the development of fields currently in the technical reserves category.

As was made clear in the Introduction the attainment of these output levels depends on the continued availability of substantial infrastructure and on reasonable success of the PILOT initiatives relating to fallow blocks/discoveries, stewardship, and Infrastructure Code of Practice. This relates particularly to the longer term situation. Thus, in 2015, under the $30, 28 pence scenario, nearly 60% of the total production comes from fields and projects in the technical reserves, new discoveries, and future incremental categories. By 2020 over 80% of total production comes from these categories. This is clearly challenging but attainable if the key stakeholders, namely investors and the Government, pursue present policies and initiatives with vigour. If this does not happen it is clear that aggregate production will fall at quite a steep rate with serious consequences for indigenous energy supplies, the UK balance of trade, tax revenues, and the supply/contracting sector.
The supply/contracting sector is a major employer in the UKCS (including onshore field investment – related work). Currently a high level of activity is being experienced. But the phasing of field development work has frequently been lumpy in the past. Looking ahead there is a prospect of a temporary downturn which could cause problems for the sector. There are clear advantages in the acceleration of field developments and further incremental projects to the period 2007 – 2009.

Developing the remaining reserves of the UKCS, estimated to be in the 26 - 32.6 billion boe range is challenging. But the potential returns to the UK energy sector and the economy generally are substantial. With imagination and much effort by the key stakeholders the potential can be realised.

Reference:

Kemp, A.G. and Stephen, L. “Prospects for Activity Levels in the UKCS to 2030: The 2005 Perspective,” University of Aberdeen, Business School, Department of Economics, North Sea Study Occasional Paper No. 98, pp. 52