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The Prospects for Activity in the UK Continental Shelf to 2040: the 2009 Perspective

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Research in North Sea Economics has been conducted in the Economics Department since 1973. The present and likely future effects of oil and gas developments on the Scottish economy formed the subject of a long term study undertaken for the Scottish Office. The final report of this study, The Economic Impact of North Sea Oil on Scotland, was published by HMSO in 1978. In more recent years further work has been done on the impact of oil on local economies and on the barriers to entry and characteristics of the supply companies in the offshore oil industry.

The second and longer lasting theme of research has been an analysis of licensing and fiscal regimes applied to petroleum exploitation. Work in this field was initially financed by a major firm of accountants, by British Petroleum, and subsequently by the Shell Grants Committee. Much of this work has involved analysis of fiscal systems in other oil producing countries including Australia, Canada, the United States, Indonesia, Egypt, Nigeria and Malaysia. Because of the continuing interest in the UK fiscal system many papers have been produced on the effects of this regime.

From 1985 to 1987 the Economic and Social Science Research Council financed research on the relationship between oil companies and Governments in the UK, Norway, Denmark and The Netherlands. A main part of this work involved the construction of Monte Carlo simulation models which have been employed to measure the extents to which fiscal systems share in exploration and development risks.

Over the last few years the research has examined the many evolving economic issues generally relating to petroleum investment and related fiscal and regulatory matters. Subjects researched include the economics of incremental investments in mature oil fields, economic aspects of the CRINE initiative, economics of gas developments and contracts in the new market situation, economic and tax aspects of tariffing, economics of infrastructure cost sharing, the effects of comparative petroleum fiscal systems on incentives to develop fields and undertake new exploration, the oil price responsiveness of the UK petroleum tax system, and the economics of decommissioning, mothballing and re-use of facilities. This work has been financed by a group of oil companies and Scottish Enterprise, Energy. The work on CO2 Capture, EOR and storage was financed by a grant from the Natural Environmental Research Council (NERC) in the period 2005 – 2008.

For 2009 the programme examines the following subjects:

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c) Comparative study of Petroleum Taxation in North West Europe/ North Atlantic (UK, Norway, Denmark, Netherlands, Ireland, Faroe Islands, Iceland and Greenland)
d) Economics of Decommissioning in the UKCS: Further Analysis
e) Economics of Gas Exploitation from West of Shetland

f) Prospective Activity levels in the UKCS to 2035
g) EOR from CO_2 Injection
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The Prospects for Activity in the UK Continental Shelf to 2040: the 2009 Perspective

Professor Alexander G. Kemp
And
Linda Stephen

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The Prospects for Activity in the UK Continental Shelf to 2040: the 2009 Perspective

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1. Introduction

The investment environment in the UK Continental Shelf (UKCS) is constantly changing. This reflects the effects of several factors including major changes in (1) oil and gas prices (and expectations regarding their future behavior), (2) exploration success rates, (3) investment and operating costs, and (4) costs and availability of finance. In addition Finance Act 2009 introduced tax reliefs for investment in some new fields[1]. The net result is that the longer-term outlook is perhaps more unclear than usual.

In this paper financial modelling is employed to produce long term projections of activity to 2040. The underlying assumptions reflect those which are likely to be employed in making long term investment decisions. They are not intended to reflect the behavior of market prices over the period. The outputs highlighted are production of oil and gas, field investment and operating costs, and decommissioning costs.

2. Methodology and Data

The projections of production and expenditures have been made through the use of financial simulation modelling, including the use of the Monte Carlo technique, informed by a large, recently-updated, field database validated by

[1] For a detailed discussion see Alex Kemp & Linda Stephen, North Sea Study Occasional Paper No. 113, The Budget 2009 Tax Proposals and Activity in the UK Continental Shelf (UKCS), University of Aberdeen, Department of Economics, June 2009.

the relevant operators. The field database incorporates key, best estimate information on production, and investment, operating and decommissioning expenditures. These refer to over 320 sanctioned fields, 159 incremental projects relating to these fields, 29 probable fields, and 28 possible fields. These are as yet unsanctioned but are currently being examined for development. An additional database contains 251 fields defined as being in the category of technical reserves. Summary data on reserves (oil/gas) and block locations are available for these. 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 2035. 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 5 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 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 1 Future Oil and Gas Price Scenarios		
	Oil Price (real) $/bbl	Gas Price (real) pence/therm
High	80	70
Medium	60	50
Low	45	30

The postulated numbers of annual exploration wells drilled for the whole of the UKCS are as follows for 2009, 2030, and 2035:

Table 2 Exploration Wells Drilled				
	2009	2010	2030	2035
High	18	38	30	28
Medium	18	32	25	23
Low	18	25	20	19

The annual numbers are modelled to decline in a broadly linear fashion over the period.

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 with the medium one reflecting the average over the past 5 years.

Table 3 **Success Rates for UKCS**	
Medium effort/Medium success rate	= 26%
High effort/Low success rate	= 24%
Low effort/High success rate	= 28%

It should be noted that success rates have varied considerably across sectors of the UKCS. Thus in the CNS and SNS the averages have exceeded 30% while in the other sectors they have been well below the average for the whole province. It is assumed that technological progress will maintain these success rates over the time period.

The mean sizes of discoveries made in the historic period for each of the 6 regions were calculated. They are shown in Table 4. It was then assumed that the mean size of discovery would decrease in line with recent historic experience. Such decline rates are quite modest.

Table 4 Mean Discovery Size MMboe	
SNS	**9**
CNS	**25**
NNS	**25**
MF	**20**
WoS	**81**
IS	**5**

For purposes of the Monte Carlo modelling of new discoveries the 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 2035. For the whole period the total numbers of discoveries for the whole of the UKCS were are follows:

Table 5 **Total Number of Discoveries to 2035**	
High effort/Low success rate	210
Medium Effort/Medium Success Rate	194
Low effort/High success rate	167

For each region the average development costs (per boe) of fields in the probable and possible categories were calculated. These reflect substantial cost inflation over the last few years. Investment costs per boe depend on several factors including not only the absolute costs in different operating conditions (such as water depth) but on the size of the fields. Thus in the SNS development costs were found to average nearly $14 per boe because of the small size of fields. In the CNS they averaged nearly $19/boe and in the NNS they averaged over $17/boe. Operating costs over the lifetime of the fields were also calculated. The averages were found to be $8.5/boe in the SNS, over $11/boe in the CNS and $12.4/boe in the NNS. Total lifetime field costs (including decommissioning but excluding E and A costs) were found to average over $23 per boe in the SNS, over $32 per boe in the CNS, and $31 per boe in the NNS.

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 new discoveries annual operating costs were modelled as a percentage of accumulated development costs. This percentage varied according to field size. It was taken to increase as the size of the field was reduced reflecting the presence of economies of scale in the exploitation costs. Thus the field lifetime costs in small fields could become very high on a per boe basis.

With respect to fields in the category of technical reserves it was recognised that many have remained undeveloped for a long time, and so the mean development costs in each of the basins was set at $5/boe higher than the mean for the new discoveries in that basin. Thus for the CNS the mean development costs are over $24/boe and in NNS over $22/boe. 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 physical and financial capacity of the industry. This subject is currently very pertinent in the UKCS. The ceilings were assumed to be linked to the oil/gas price scenarios with maxima of 20, 17, and 13 respectively under the High, Medium, and Low Price Cases. These constraints do <u>not</u> apply to incremental projects which are <u>additional</u> to new field developments.

A noteworthy feature of the 159 incremental projects in the database validated by operators is the expectation that the great majority will be executed over the next 3 or 4 years. 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 to be linked not only to currently sanctioned fields, but also to 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 5 years indicated a decline rate in the volumes. On the basis of this, and from a base of the information of the key characteristics of the projects in the 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. Their sizes and costs reflect recent trends.

With respect to investment decision making and project screening criteria oil companies (even medium-sized and smaller ones) currently assess their opportunities in the UKCS in comparison to those available in other parts of the world. Capital is allocated on this basis with the UKCS having to compete for funds against the opportunities in other provinces. A problem with the growing maturity of the UKCS is the relatively small average field size and the high unit costs. Recent mean discovery sizes are shown in Table 4 but, given the lognormal distribution, the most likely sizes are below these averages. It follows that the materiality of returns, expressed in terms of net present values (NPVs), is quite low in relation to those in prospect in other

provinces (such as offshore Angola, for example). Oil companies frequently rank investment projects according to the NPV/I ratio. Accordingly, this screening method has been adopted in the present study. Specifically, the numerator is the post-tax NPV at 10% discount rate in real terms and the denominator is pre-tax field investment at 10% discount rate in real terms. This differs from the textbook version which states that I should be in post-tax terms because the expenditures are tax deductible through allowances. Oil companies maintain that they allocate capital funds on a pre-tax basis, and this is employed here as the purpose is to reflect realistically the decision-making process. The development project goes ahead when the NPV/I ratio as defined above in real terms ≥ 0.3. The 10% real discount rate reflects the weighted average cost of capital to the investor. The modelling has been undertaken under the current tax system. This includes the field allowances introduced in the Finance Act 2009.

In the light of experience over the past few years some rephasing of the timing of the commencement dates of new field developments and incremental projects from those projected by operators was undertaken related to the probability that the project would go ahead. Where the operator indicated that a new field development had a probability $\geq 80\%$ of going ahead the date was left unchanged. Where the probability $\geq 60\% < 80\%$ the commencement date was slipped by 1 year. Where the probability $\geq 40\% < 60\%$ the date was slipped by 2 years. Where the probability was $\geq 20\% < 40\%$ the date was slipped by 3 years, and where the probability was $< 20\%$ it was slipped by 4 years. If an incremental project had a probability of proceeding $\geq 50\%$ the date was retained but where it was $< 50\%$ it was slipped by 1 year.

3. Results

A. Numbers of Fields in Production

The numbers of producing fields (excluding incremental projects) under the 3 oil/gas price scenarios are shown in Charts 1 – 3. Under the low scenario it is seen that the numbers fall very steeply from around 300 in 2008 to less than 50 in 2040. The sharp decrease reflects (1) the small numbers of new fields and incremental projects which are triggered under the investment hurdle specified, (2) the sharp production decline rates in sanctioned fields, thus hastening their COP dates, and (3) the (comparatively) small number of new discoveries under the low price case. Under the $60, 50 pence case (Chart 2) the numbers of producing fields remain well in excess of 250 until after 2018 after which there is a steady decline at a modest pace to just below 100 in 2040. It is seen that under this scenario the development of far more new discoveries is triggered compared to the low price case. Similarly, it is seen that substantial numbers of fields in the category of technical reserves are triggered. In Chart 3 it is seen that the numbers of fields in production actually increase to a peak in excess of 325 in the period 2015 – 2017. After that there is a gradual decrease but the total still exceeds 300 in 2022. Thereafter the decline is faster but there are still over 90 producing fields in 2040. Compared to the $60, 50 pence case there is a noteworthy increase in the numbers of high cost fields in the category of technical reserves.

Chart 1

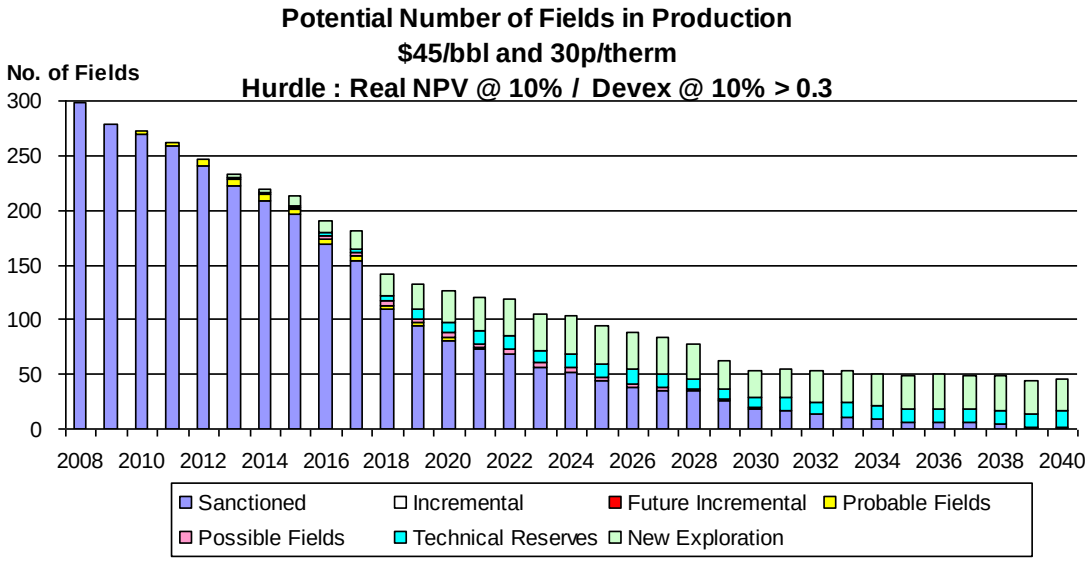


Chart 2

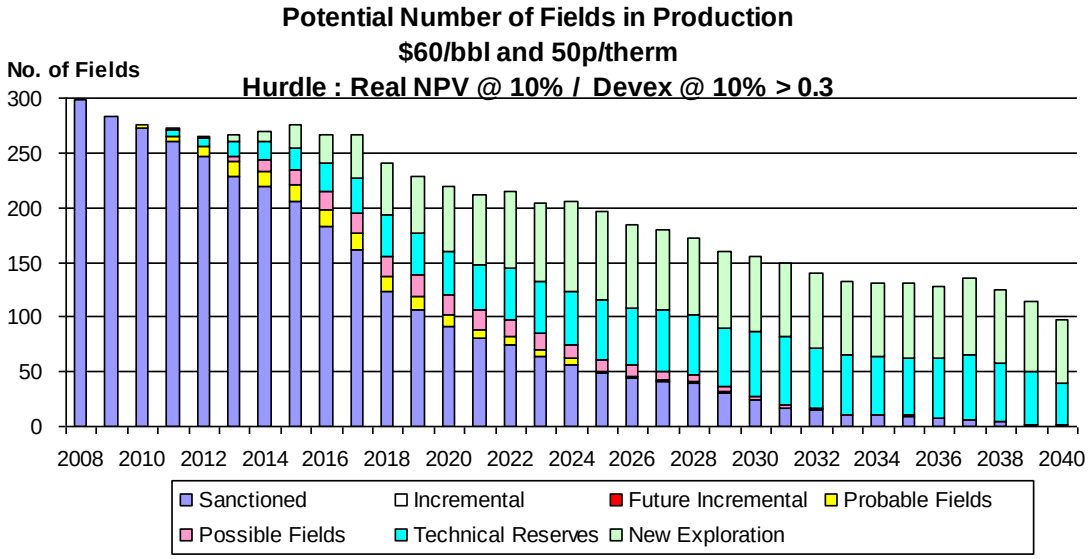
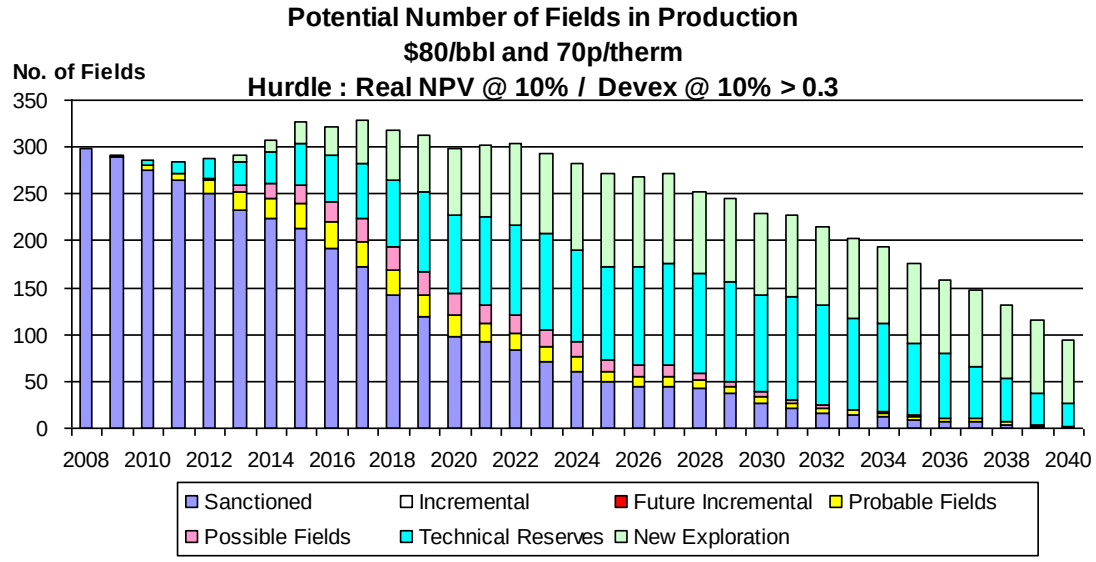


Chart 3



B. Production

(i) Oil

Prospective oil production under the 3 price cases is shown in Charts 4 – 6. In the low price case (Chart 4) it is seen that oil production falls at a fast pace over the period and, compared to 1.4 mm b/d in 2008, is around 0.22 mm b/d in 2040. Output from the sanctioned fields falls at a brisk pace. This is moderated somewhat in the longer terms by the development of incremental projects. A noticeable feature is the small contribution from fields in the probable and possible categories. In the long term there is a worthwhile contribution from future discoveries but little from the high cost fields in the category of technical reserves.

In Chart 5 the prospective oil production under the $60, 50 pence case is shown. The decline rate is much less steep in the period to 2028 after which it falls more briskly to around 0.46 mm b/d in 2040. It is seen that there is a very substantial contribution from fields in the categories of new discoveries and technical reserves in the longer term.

In Chart 6 the prospects under the $80, 70 pence case are shown. In this scenario the decline rate over the next decade is very modest indeed, though it accelerates in the period after 2024 to reach around 0.44 mm b/d in 2040. The remarkably low decline rate over the next decade is principally due to the development of very substantial numbers of fields in the category of technical reserves, as well as considerable output from new discoveries. The tax reliefs in the 2009 Budget play a worthwhile role in this high production case. It should be stressed that this scenario is highly optimistic. In particular an underlying assumption is that extensive capital rationing and consequentially tough investment hurdle rates do not hamper new developments to a marked extent[2]. In the current circumstances of capital markets it would not be surprising if higher costs of capital and tougher investment hurdles than are incorporated in this scenario did prevail in some cases, particularly in relation to high cost fields in the technical reserves category. Thus the results should be regarded as very optimistic.

[2] See section 3G below

Chart 4

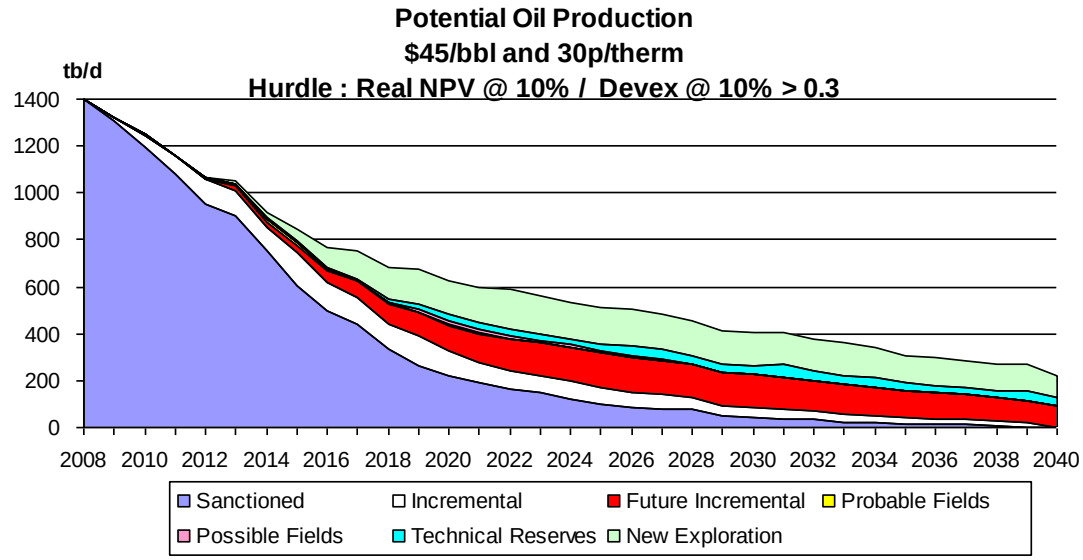


Chart 5

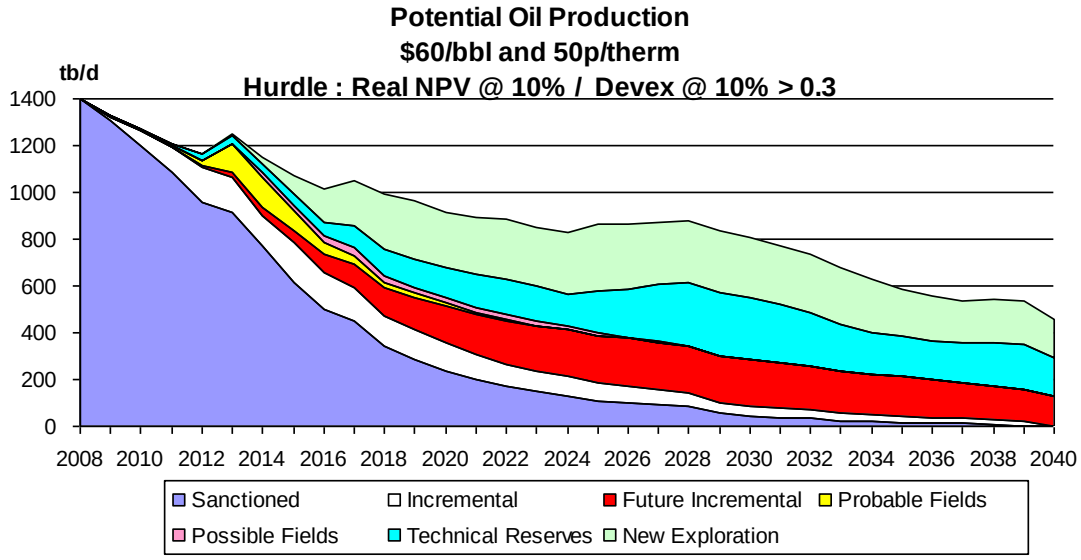
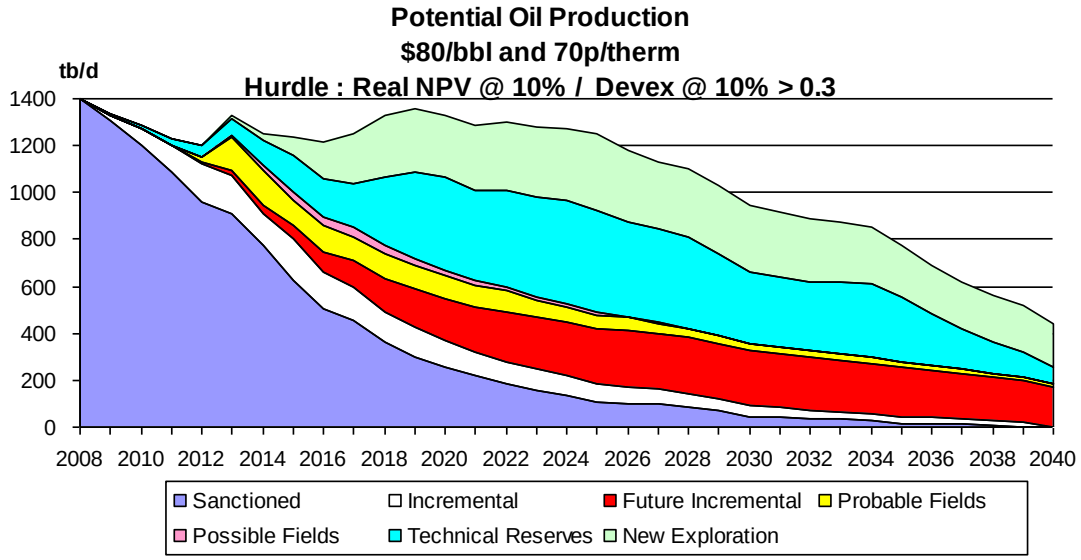


Chart 6


Potential Oil Production
$80/bbl and 70p/therm
Hurdle : Real NPV @ 10% / Devex @ 10% > 0.3
tb/d
1400
1200
1000
800
600
400
200
0
2008 2010 2012 2014 2016 2018 2020 2022 2024 2026 2028 2030 2032 2034 2036 2038 2040
Sanctioned
Incremental
Future Incremental
Probable Fields
Possible Fields
Technical Reserves
New Exploration

In Charts 7 – 9 prospective oil production under the 3 price cases are shown categorised according to 6 geographical areas of the UKCS. Under the $45, 30 pence case (Chart 7) it is seen that the CNS remains the most important area of production for many years. The W of S region becomes relatively more important in the later part of the period but cannot prevent the decline rate from being persistently steep.

Under the $60, 50 pence case (Chart 8) the CNS plays a major role in ensuring that the overall decline rate is much less steep than in the low price case. In the longer term the W of S region becomes increasingly important. Under the $80, 70 pence case (Chart 9) the major contribution from the CNS in producing the very modest rates of decline is noteworthy, but the most striking feature is the much larger contribution from the W of S region. At this price the high cost fields in this region including new discoveries become economic.

Chart 7

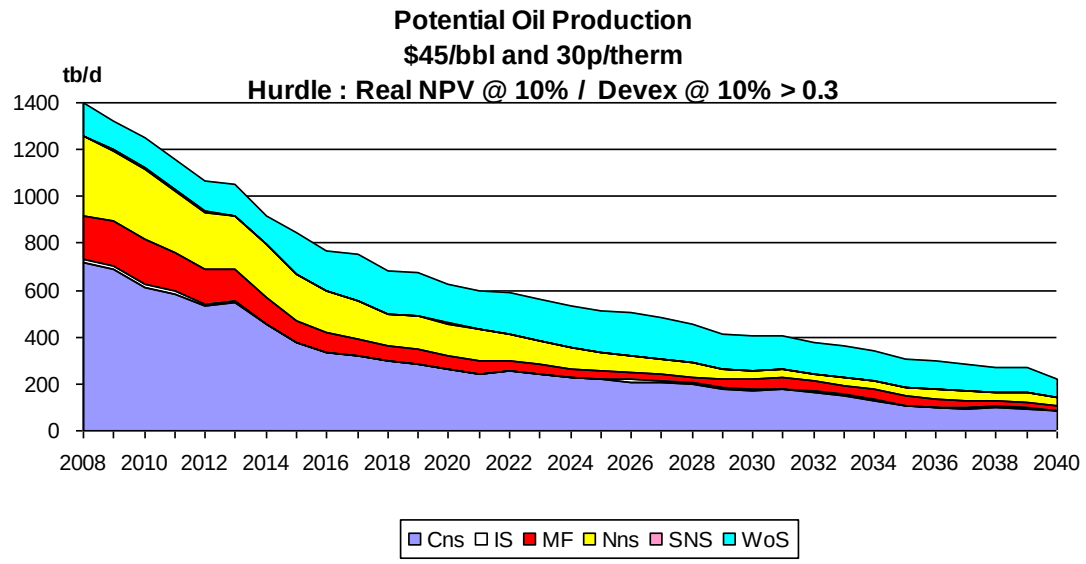


Chart 8

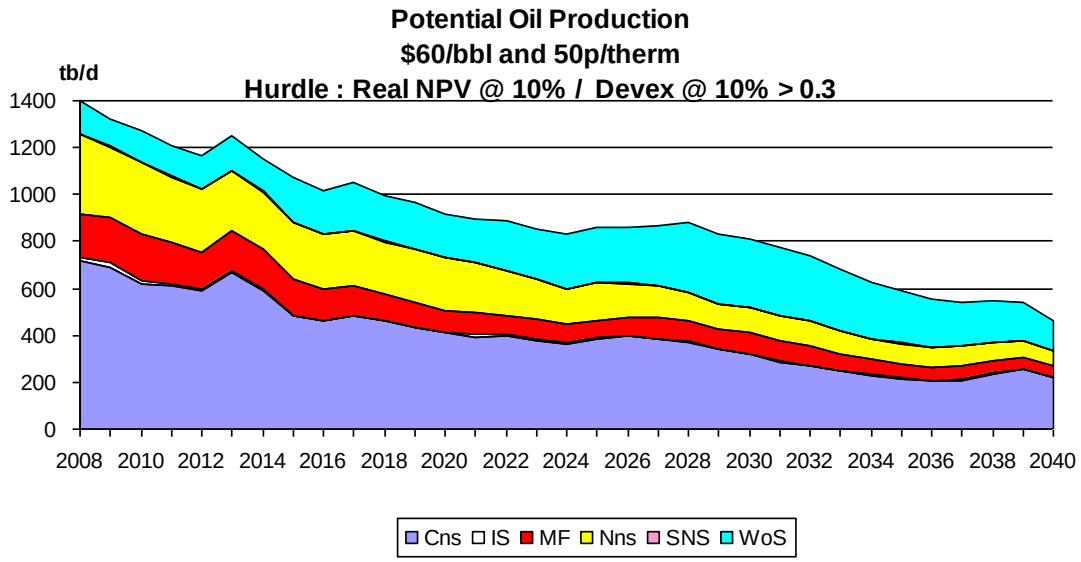
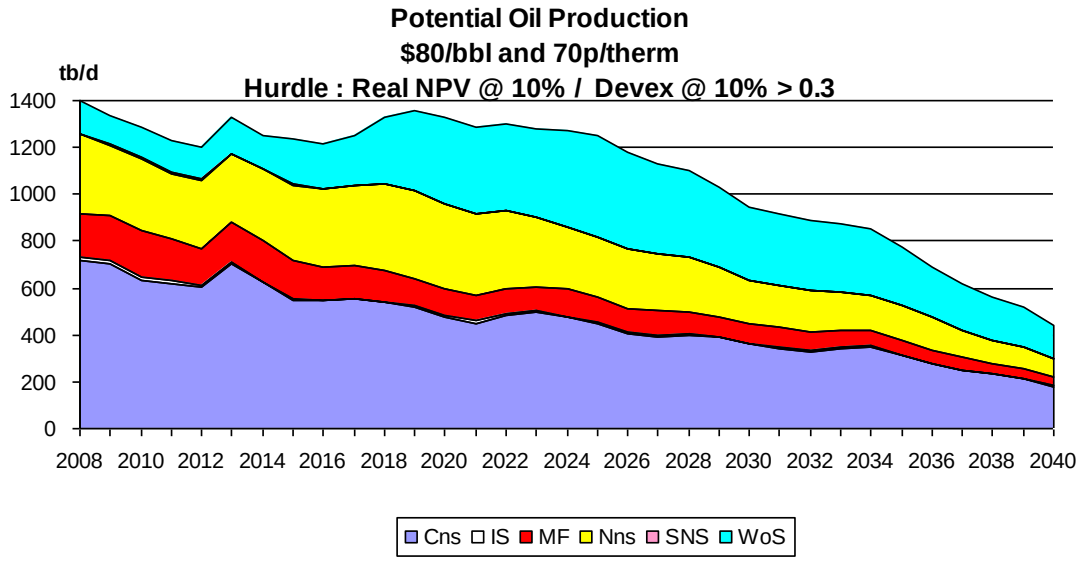


Chart 9



(ii) Natural Gas

Natural gas production prospects are shown under the various categories of fields and projects in Charts 10 – 12. Under the $45, 30 pence price case (Chart 10) it is seen that output falls at a very fast pace, especially over the next decade. It is very noticeable that very few new field developments are triggered over the whole period. Only incremental projects make a worthwhile contribution to output above that from the sanctioned fields. By 2040 production is only around 447 mm cf/d.

Under the $60, 50 pence case (Chart 11) the production decline rate is noticeably lower. Under this price scenario there is substantial output from new fields, including significant contributions from future discoveries and those in the category of technical reserves. By 2040 production is just under 1.4 b cf/d.

Under the $80, 70 pence case (Chart 12) the production decline rate is moderated still further. Compared to the lower price cases there is substantially greater output from probable/possible fields, technical reserves and new discoveries. In 2040 production is around 1.3 b cf/d.

Chart 10

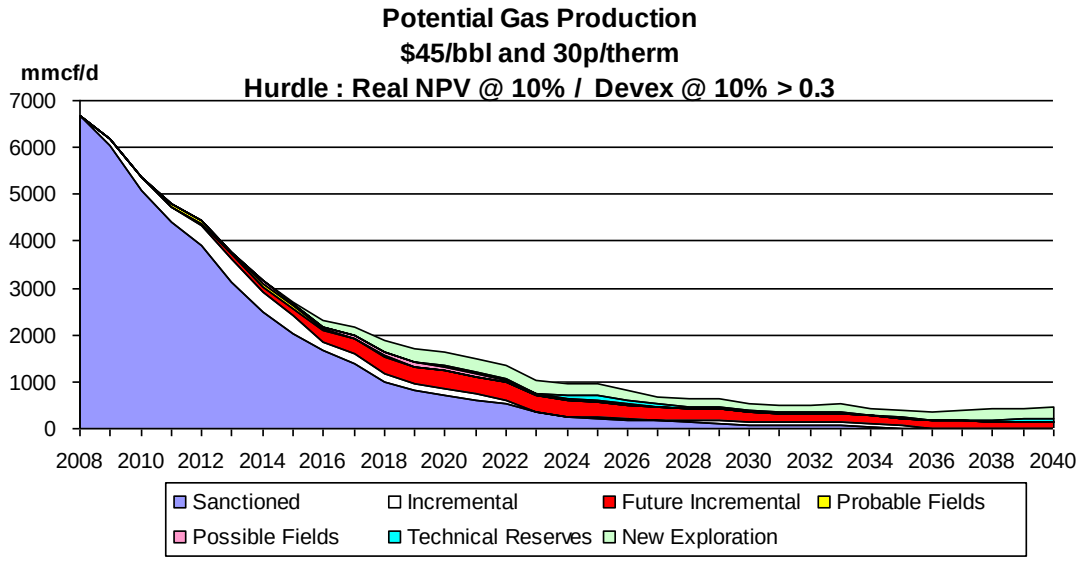


Chart 11

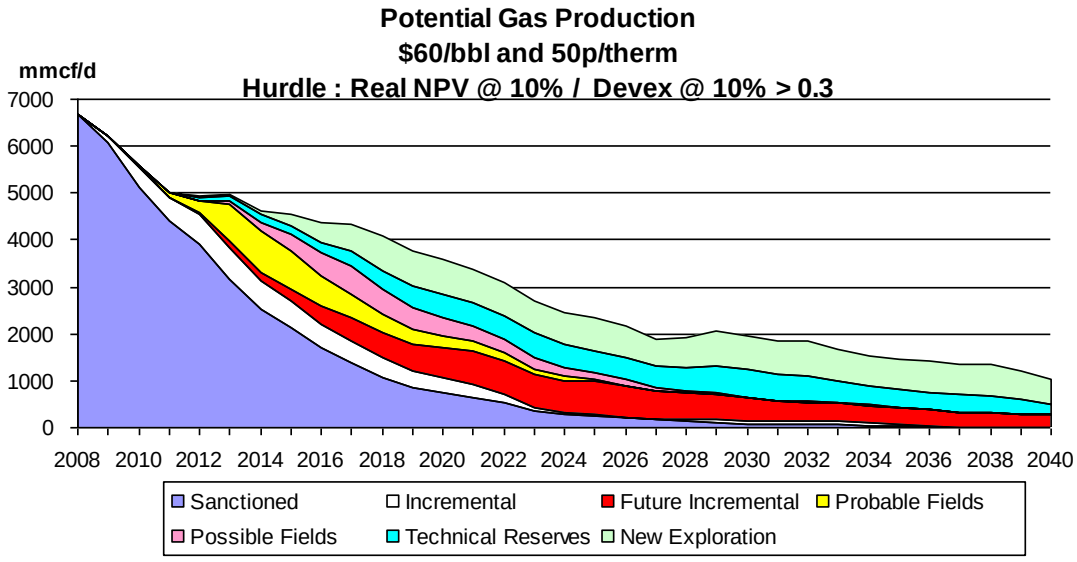
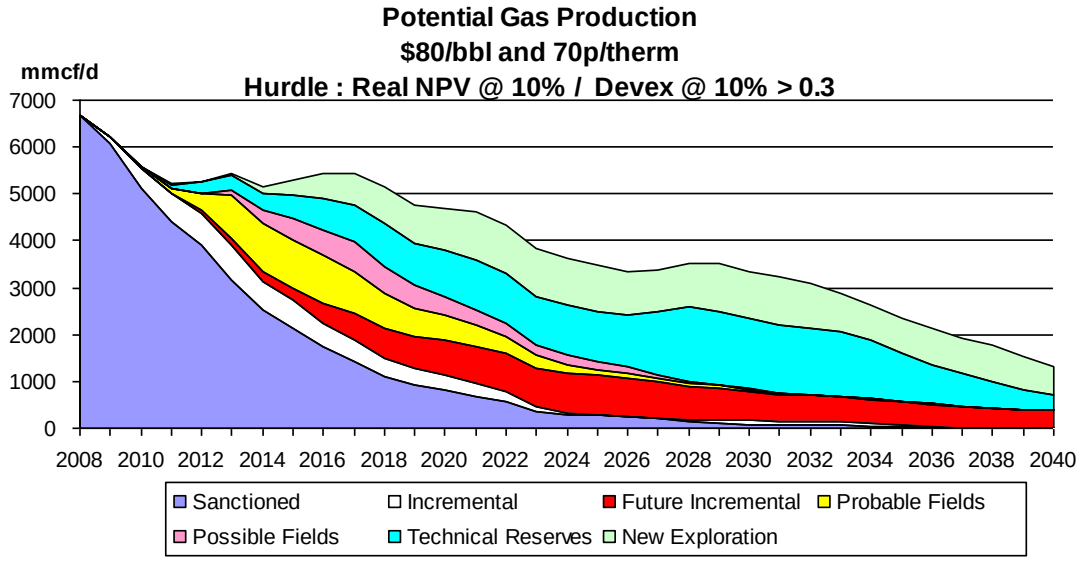


Chart 12


Potential Gas Production
$80/bbl and 70p/therm
Hurdle : Real NPV @ 10% / Devex @ 10% > 0.3
mmcf/d
7000
6000
5000
4000
3000
2000
1000
0
2008 2010 2012 2014 2016 2018 2020 2022 2024 2026 2028 2030 2032 2034 2036 2038 2040
Sanctioned
Incremental
Future Incremental
Probable Fields
Possible Fields
Technical Reserves
New Exploration

Prospective gas production from the 6 geographic areas of the UKCS is shown in Charts 13 – 15. Under the $45, 30 pence case (Chart 13) it is seen that the SNS continues to make a very substantial contribution to the total for many years ahead. It is also noticeable that there is only a tiny contribution from the W of S region. The new fields in this high cost area are uneconomic under this scenario.

The production prospects under the $60, 50 pence case (Chart 14) highlight substantially greater contributions from the CNS and SNS and more modest increases from W of S compared to the low price case. But the W of S share of the total remains quite low. Many projects remain uneconomic in this region. Under the $80, 70 pence case (Chart 15) the decline rate is noticeably more modest. In this scenario output from the SNS and CNS is considerably higher over the period. But the contribution from W of S remains fairly modest though it is clearly higher compared to the $60, 50 pence case.

Chart 13

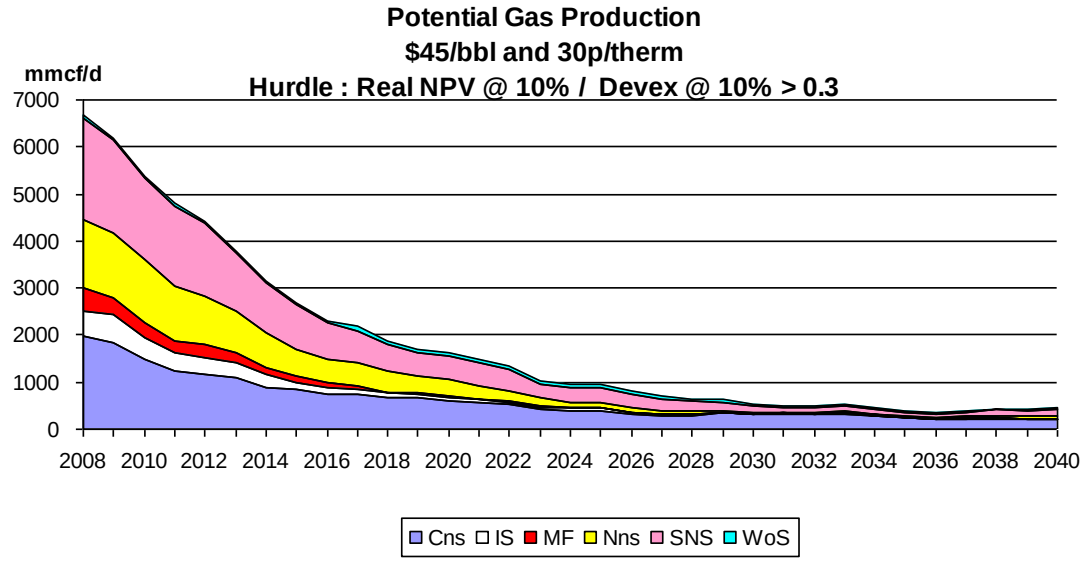


Chart 14

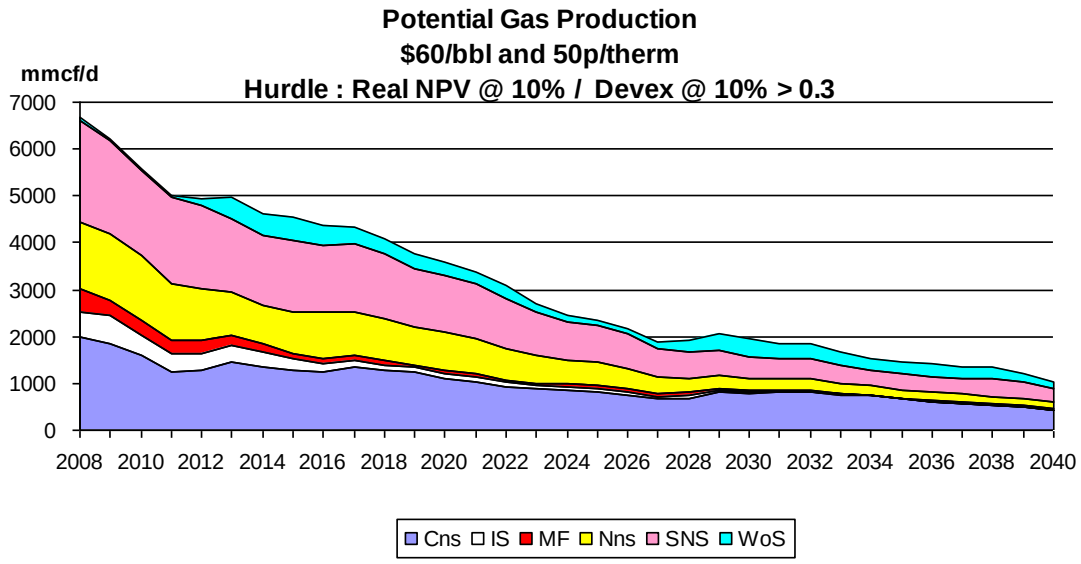
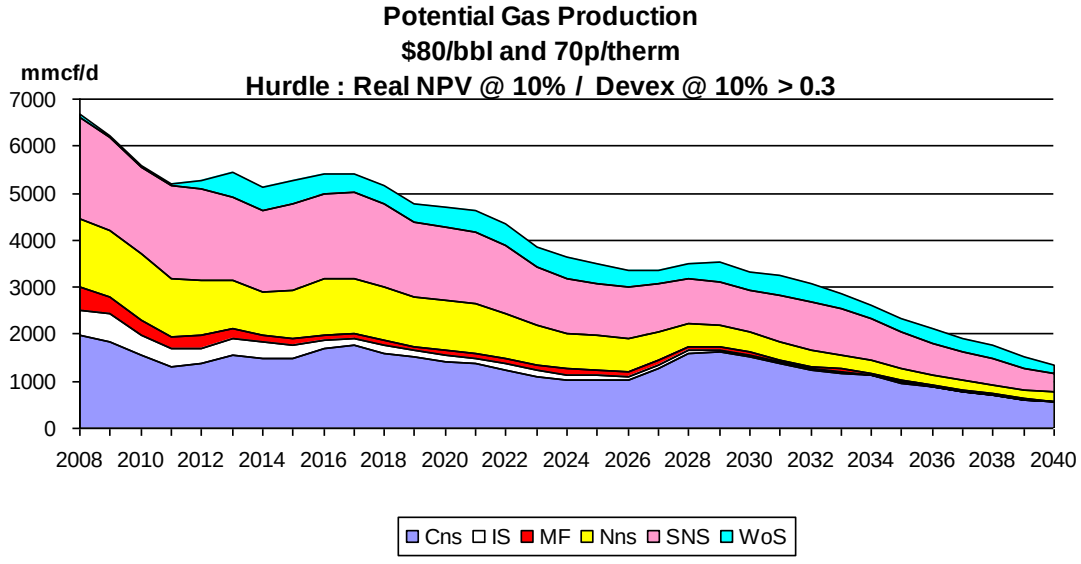


Chart 15



(iii) Total Hydrocarbons

Prospective total hydrocarbon production (including NGLs (not shown separately)) is shown in Charts 16 – 18 under the 3 price cases clarified by the different categories of investment project. In the $45, 30 pence case (Chart 16) the sharp rate of decline over the next decade is a noteworthy feature. In 2010 production is around 2.3 mm boe/d which is well below the PILOT aspirational target of 3 mm boe/d. By 2020 output is around 0.9 mm boe/d and in 2040 it is around 0.3 mm boe/d.

Under the $60, 50 pence case (Chart 17) the long term decline rate is much more gentle although in the near term it is still quite sharp with output in 2010 around 2.35 mm boe/d. In 2020, it is nearly 1.6 mm boe/d and in 2040 it is 0.65 mm boe/d. In the longer term it is seen that there are substantial contributions from fields in the categories of new discoveries, technical reserves, and incremental projects.

In the $80, 70 pence case (Chart 18) output still falls noticeably in the short term to 2.37 mm boe/d in 2010, but the decline rate thereafter is much more gentle such that output in 2020 is 2.2 mm boe/d. After 2030 the decline rate does accelerate and in 2040 production is around 0.7 mm boe/d. In this scenario in the longer term output from fields in the categories of technical reserves and new discoveries is very substantial.

Chart 16

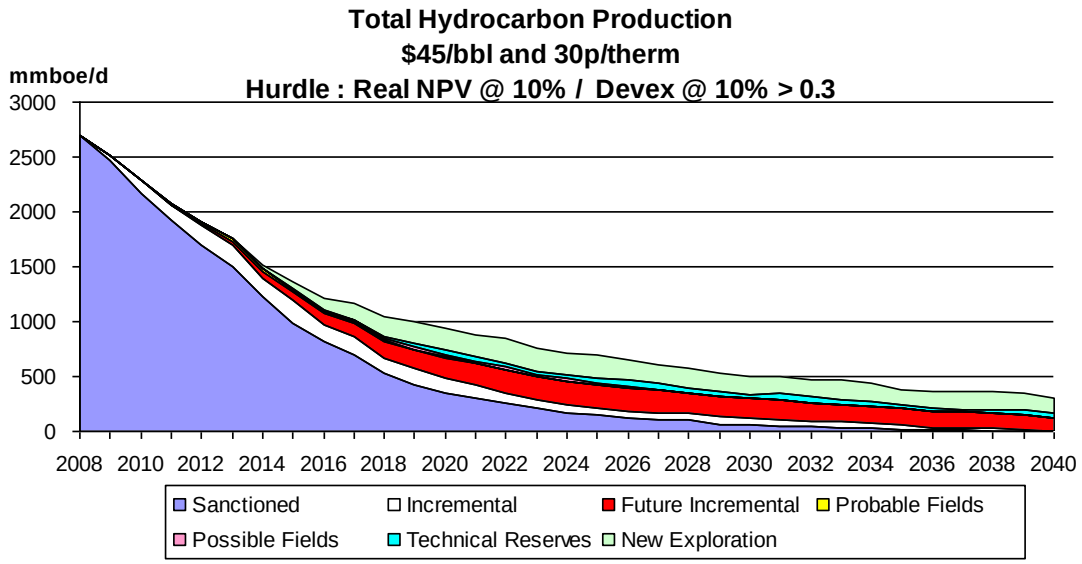


Chart 17

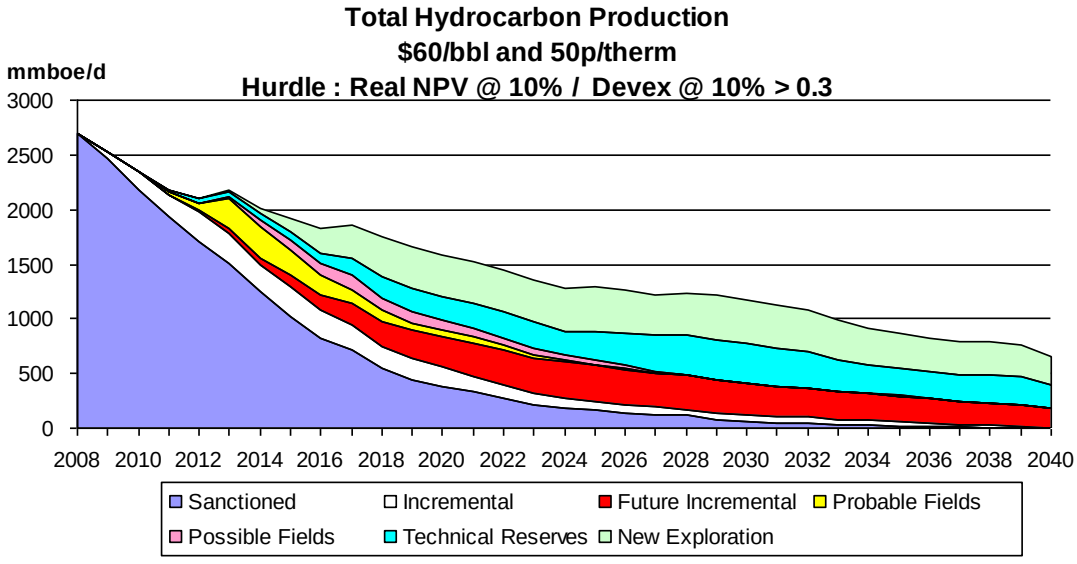
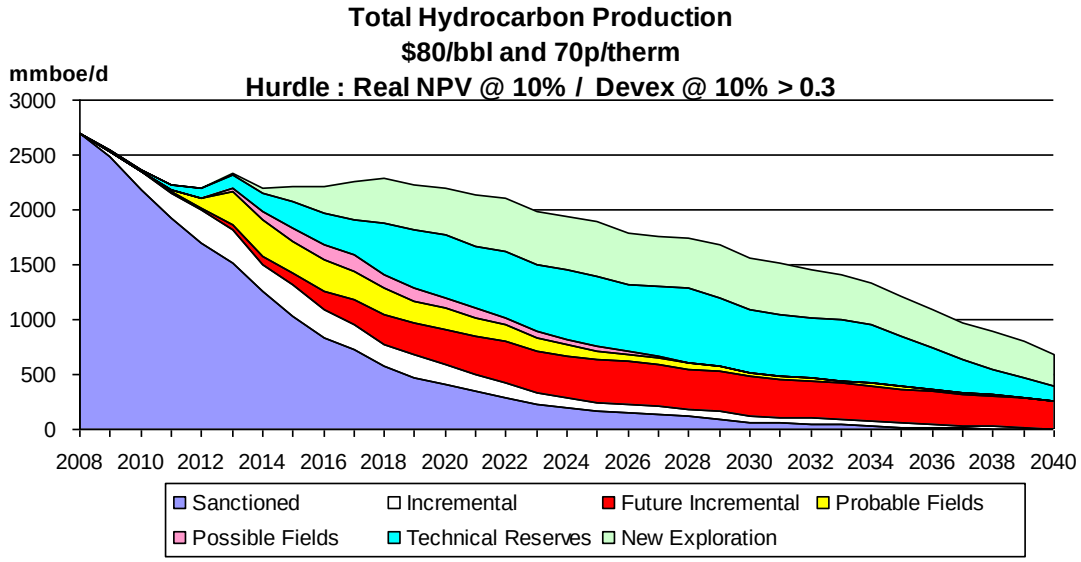


Chart 18


Total Hydrocarbon Production
$80/bbl and 70p/therm
Hurdle : Real NPV @ 10% / Devex @ 10% > 0.3
mmboe/d
3000
2500
2000
1500
1000
500
0
2008 2010 2012 2014 2016 2018 2020 2022 2024 2026 2028 2030 2032 2034 2036 2038 2040
Sanctioned
Incremental
Future Incremental
Probable Fields
Possible Fields
Technical Reserves
New Exploration

The prospects for total hydrocarbon production classified by the 6 regions of the UKCS are shown in Charts 19 – 21. Under the $45, 30 pence price scenario (Chart 19) the importance of the CNS throughout the period, and the NNS in the near and medium terms, are emphasised. The W of S region is seen to make a significant contribution in the longer term. In the $60, 50 pence case (Chart 20) the CNS remains the most important contributor to total production. The comparative share of the W of S region becomes greater. In the $80, 70 pence case (Chart 21) the CNS remains the largest contributor to aggregate output over the whole period, followed by the NNS. In the longer term the W of S region becomes the second largest contributor to the total.

Chart 19

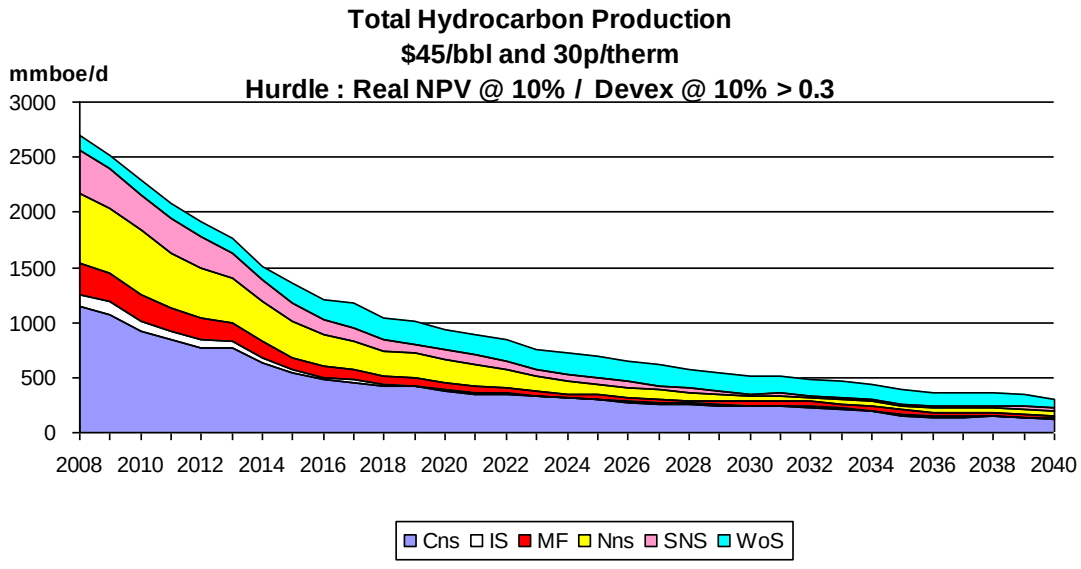


Chart 20

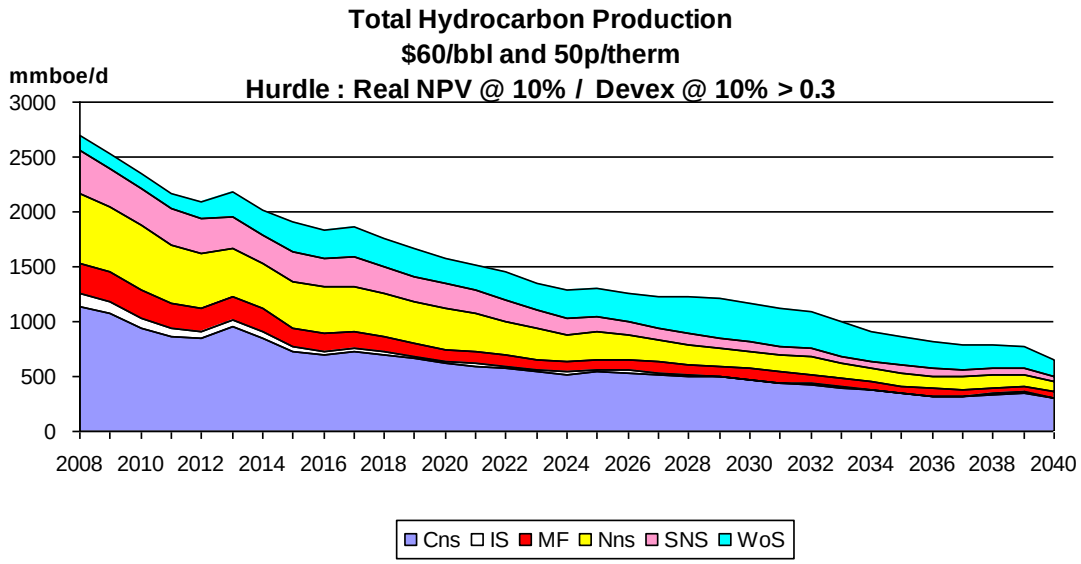
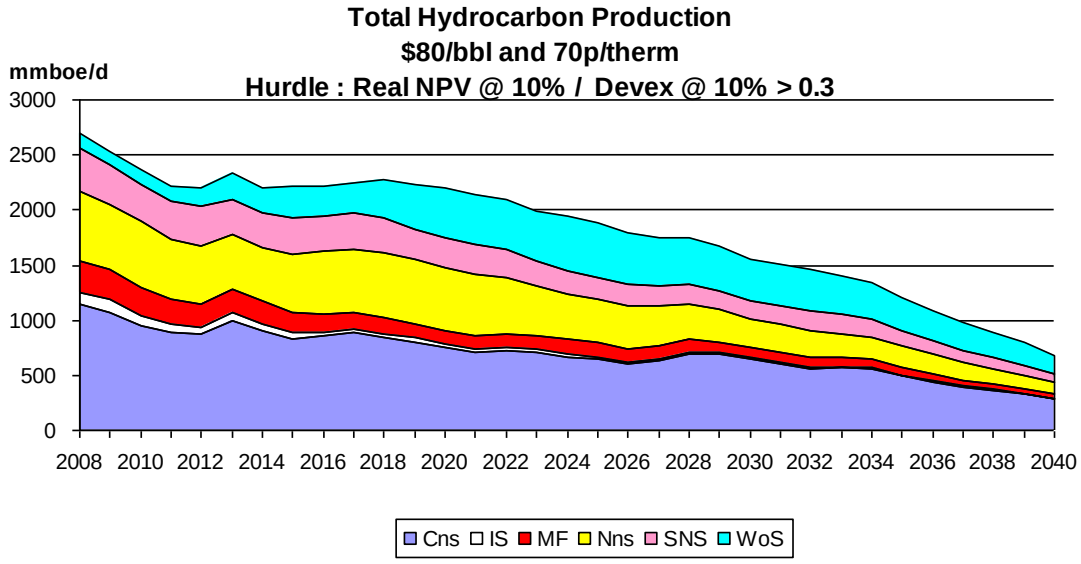


Chart 21



C. Development Expenditures

Field development expenditures classified according to types of fields and projects are shown in Charts 22 – 24. In the $45,30 pence case (Chart 22) it is seen that over the next few years they fall dramatically to £1.9 billion (at 2009 prices) in 2014. After that there is a modest recovery, but the downward trend continues from £2.1 billion in 2016 to £0.4 billion in 2040. In the $60, 50 pence case (Chart 23) investment exceeds £5 billion in the near term, but then falls sharply to below £3 billion in 2019. There is some recovery thereafter with the development of substantial numbers of new discoveries and technical reserves. After 2030 there is a downward movement to very low levels in 2040. In the $80, 70 pence case (Chart 24) development expenditures are seen to increase sharply over the next few years to 2014 reflecting the development of significant numbers of fields in the probable, possible and technical reserves categories. Investment remains at relatively high levels over the period to 2028, after which it falls terminally. This scenario should be regarded as very optimistic and not a likely outcome in the near term, given the problems in capital markets and the extent of capital rationing. (See Section G below).

Chart 22

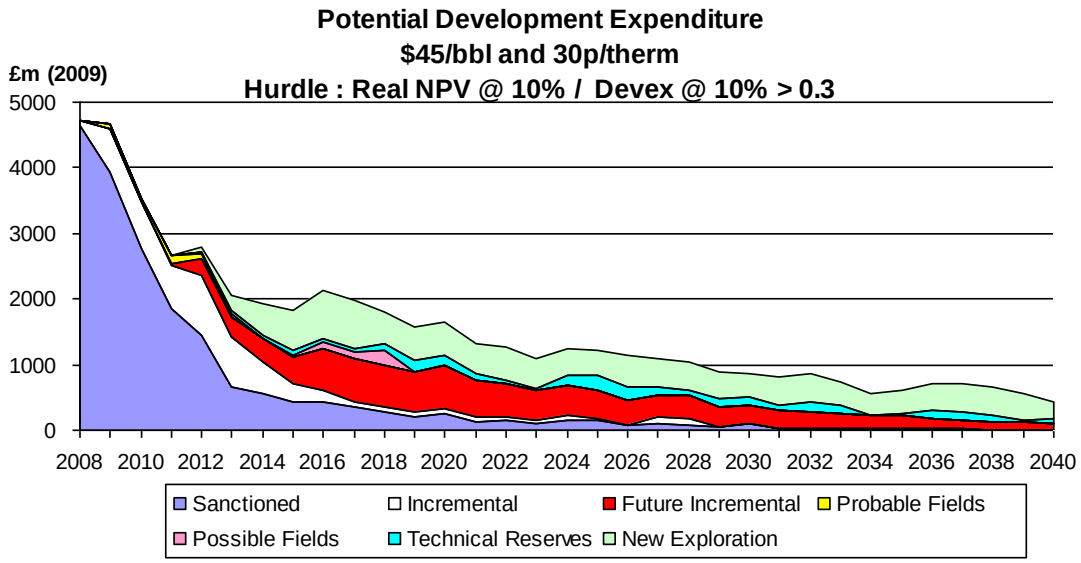


Chart 23

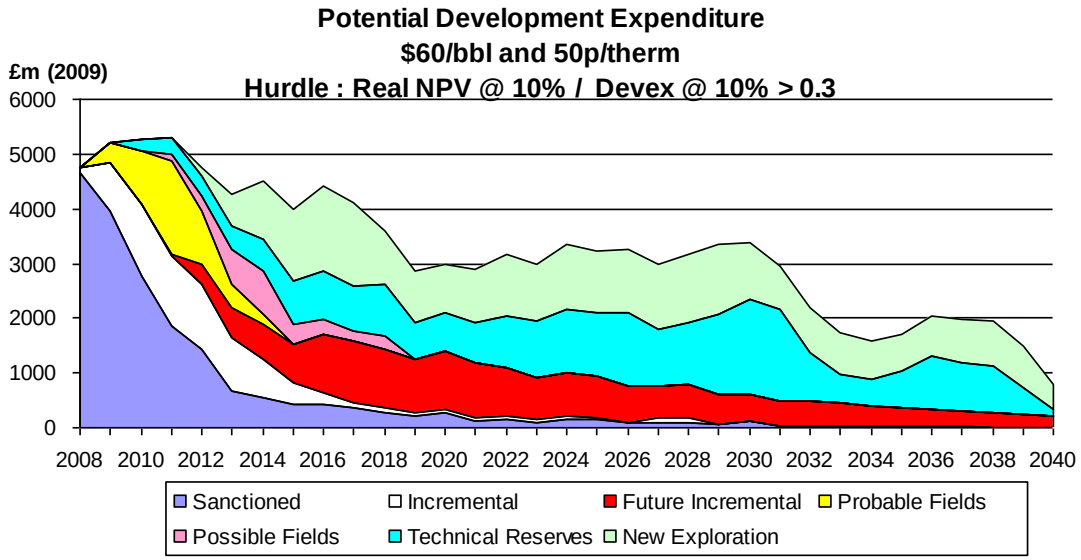
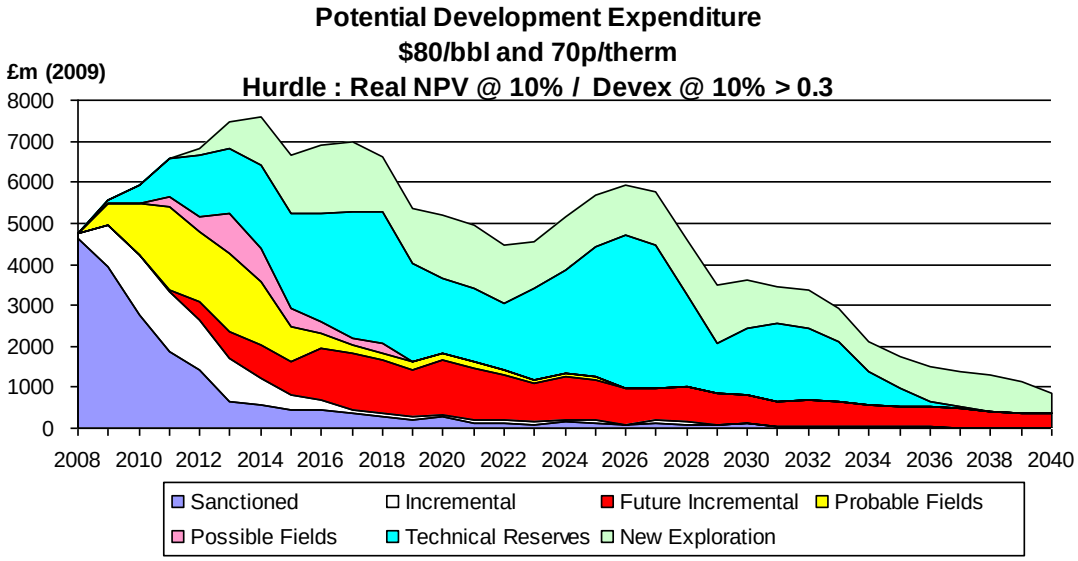


Chart 24


Potential Development Expenditure
$80/bbl and 70p/therm
Hurdle : Real NPV @ 10% / Devex @ 10% > 0.3
£m (2009)
8000
7000
6000
5000
4000
3000
2000
1000
0
2008 2010 2012 2014 2016 2018 2020 2022 2024 2026 2028 2030 2032 2034 2036 2038 2040
Sanctioned
Incremental
Future Incremental
Probable Fields
Possible Fields
Technical Reserves
New Exploration

D. Operating Expenditures

The behaviour of field operating expenditures in the 3 scenarios is shown in Charts 25 – 27. Under the $45,30 pence case (Chart 25) expenditures fall at a very fast pace reflecting (1) the decline in the number of producing sanctioned fields and their COP dates, and (2) the very small numbers of new field developments. Under the $60, 50 pence case (Chart 26) there is again a continued long term decline in expenditures but at much slower pace. Sanctioned fields take longer to reach their COP dates and in the longer medium term the substantial numbers of new field developments in the categories of new discoveries and technical reserves enhance the associated operating expenditures. Under the $80, 70 pence case (Chart 27) there is some decrease in the short term, but until 2025 the level of expenditure is always high, namely within the £6 – 7 billion range (at 2009 prices). The main reason in the longer term is the high expenditure on fields in the categories of new discoveries and technical reserves.

Chart 25

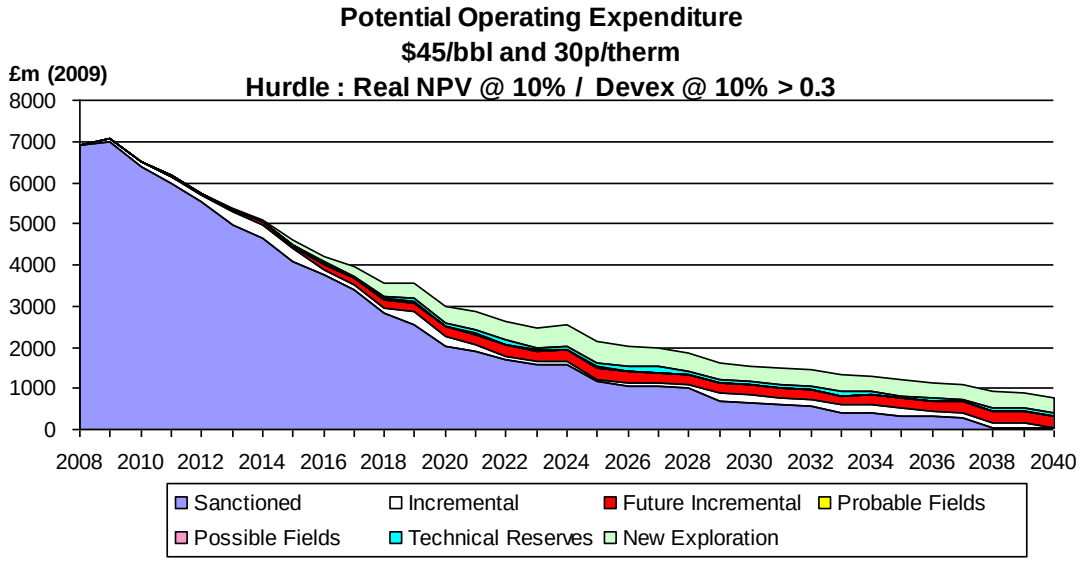


Chart 26

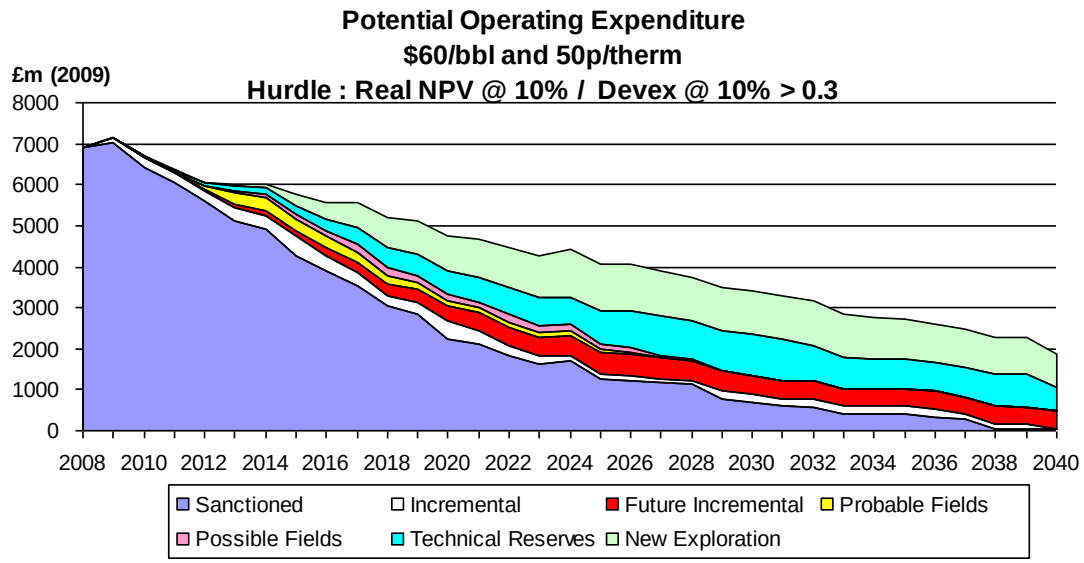
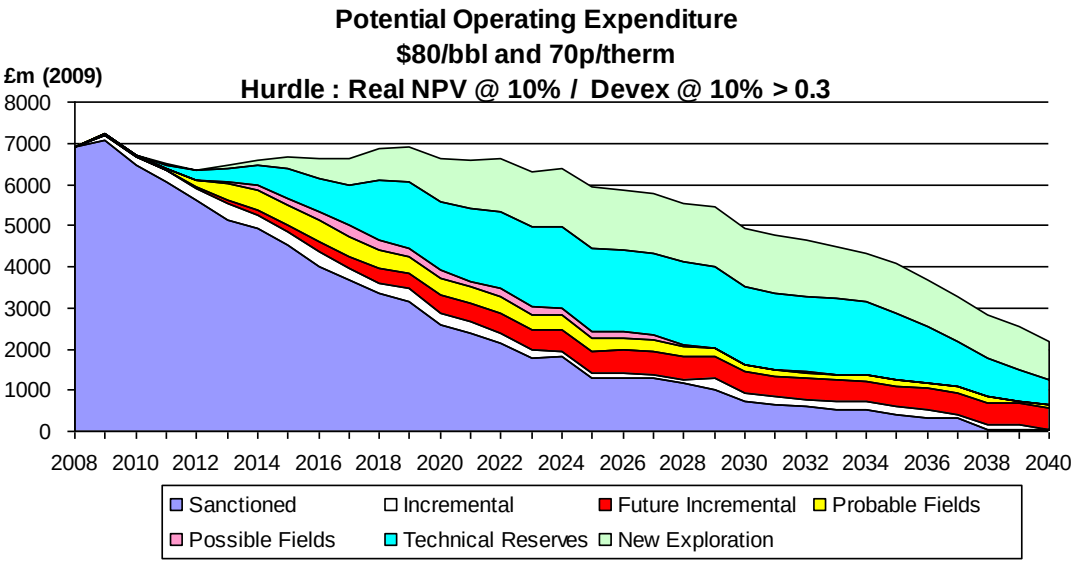


Chart 27



E. Decommissioning Expenditures

The behaviour of decommissioning expenditures under the $45, 30 pence scenario is shown in Charts 28 and 29. It is seen that expenditure increases dramatically from 2014 and remains at relatively high levels until 2024. Over the whole period to 2040 cumulative expenditures are around £23 billion (at 2009 prices). The overwhelming proportion of total expenditure is seen to be on already sanctioned fields. The expenditures under the $60, 50 pence scenario are shown in Charts 30 and 31. The broad pattern over the period is not very different from the low price case. But in this scenario there are more new field developments, and, given their small size, many of these reach their COP dates before 2040. The result is that the cumulative decommissioning costs to 2040 are around £27 billion (at 2009 prices).

Chart 28

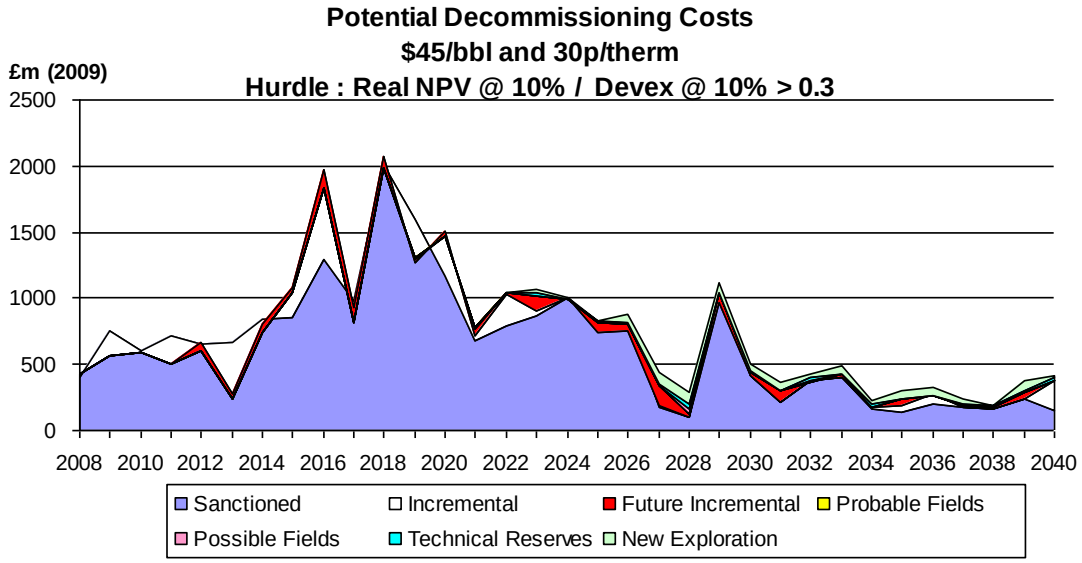


Chart 29

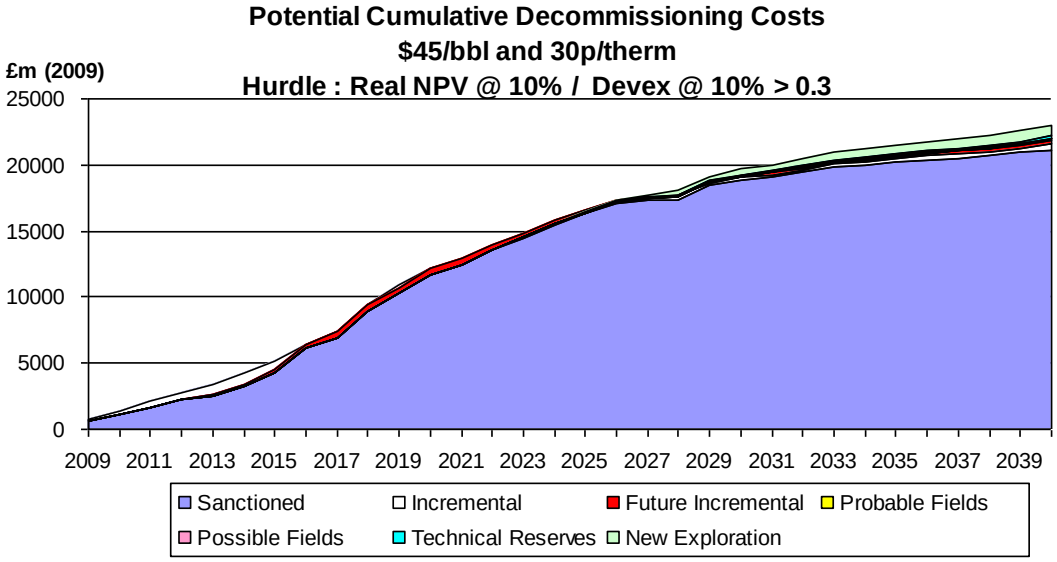


Chart 30

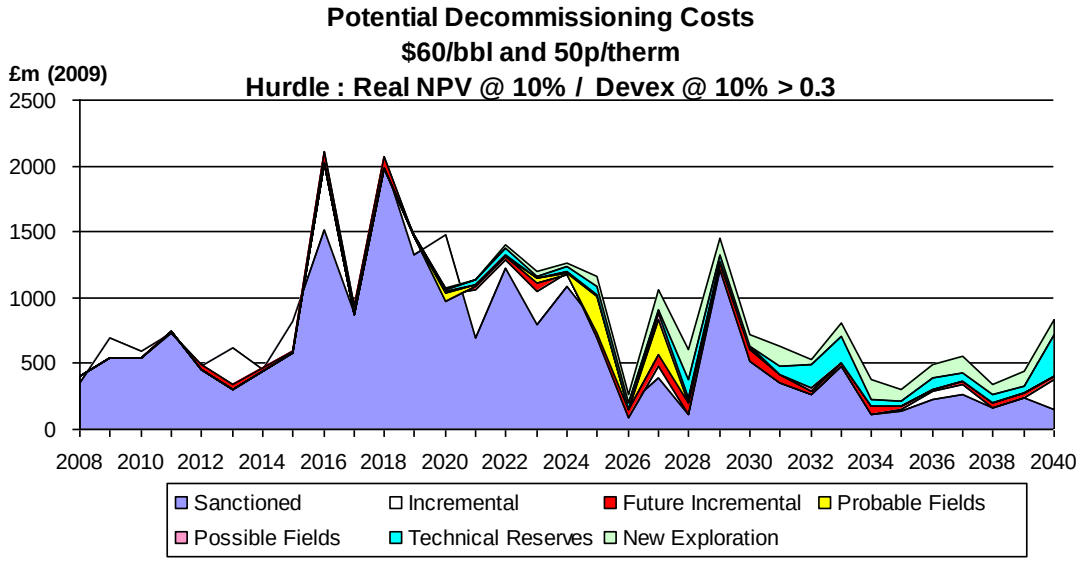
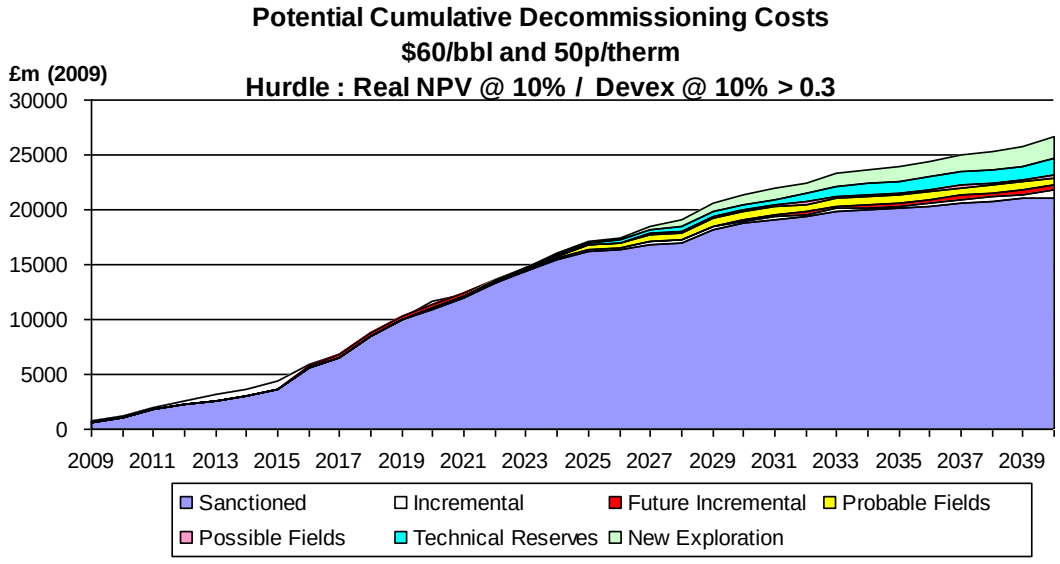


Chart 31



The expenditures under the $80, 70 pence case are shown in Charts 32 and 33. While the broad pattern remains the same as for the other scenarios there are far more new developments and many reach their COP dates by 2040. The result is that the cumulative expenditure by 2040 is £30 billion (at 2009 prices). It is seen that the high cost fields in the category of technical reserves make a significant contribution to the increase in the aggregate cost.

Chart 32

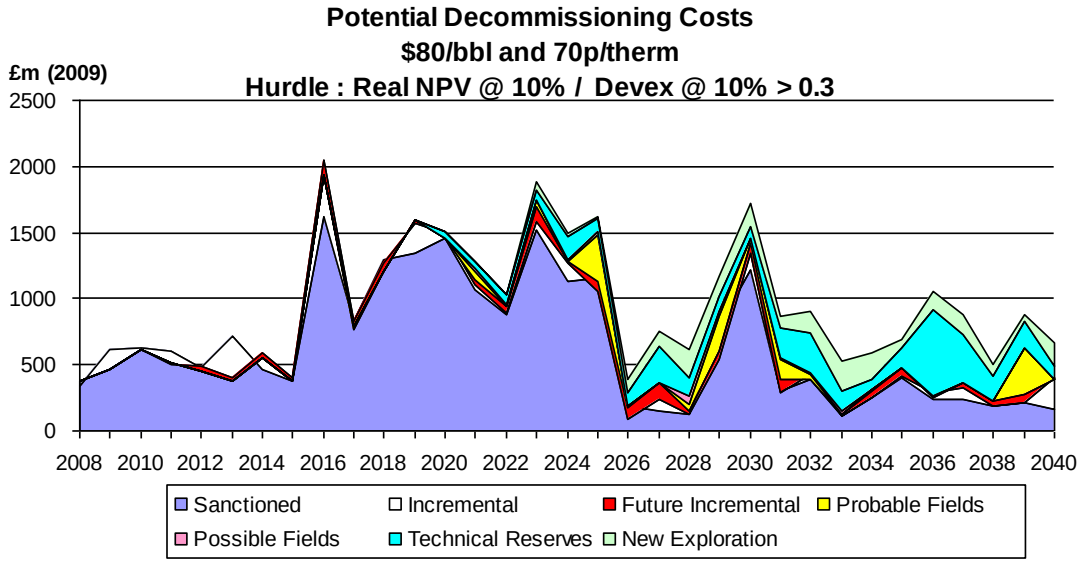
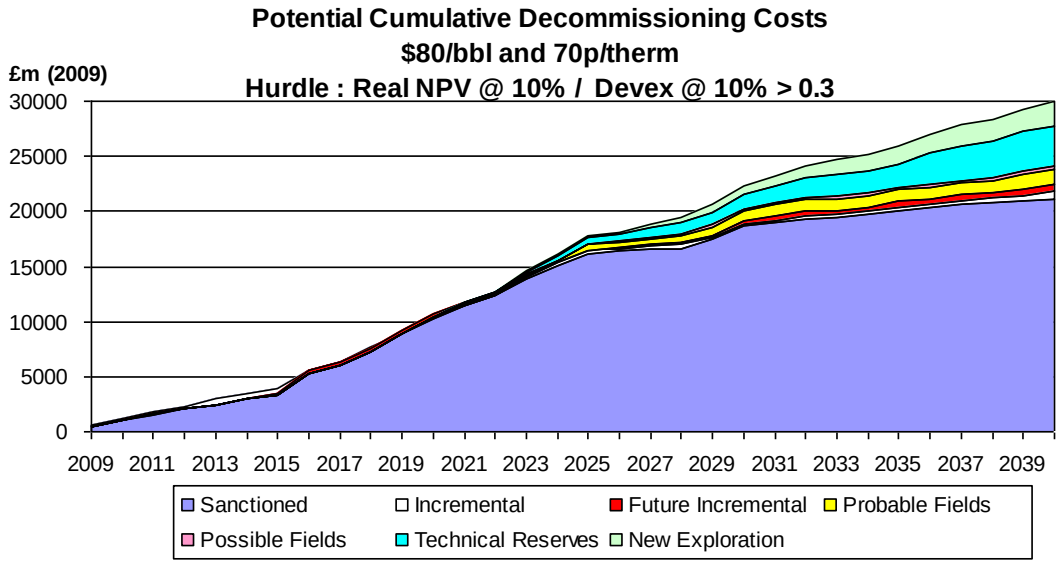


Chart 33



F. Consistency of Projections with Official Estimates of Remaining Potential

Estimates of the remaining potential from the UKCS are made every year by DECC. Their latest estimates[3] indicate a low estimate of 11 bn boe, a central estimate of 21 bn boe (the upper point of a considerable range depending on exploration success rates), and a high estimate of 37 bn boe.

The cumulative production 2009 – 2040 inclusive resulting from the modelling undertaken in this study are shown in Table 6. It is seen that under the low price scenario total depletion over the period 2009 – 2040 amounts to 10.8 bn boe. The greater element comes from currently sanctioned fields. It is noteworthy that the contribution from possible and probable fields is very small. Most do not pass the investment hurdle under this scenario. In the $60, 50 pence scenario total depletion over the period is 16.7 bn boe. There is a greatly enhanced contribution from new discoveries, technical reserves, and future incremental projects. Under the $80, 70 pence case total depletion over the period is 20.9 bn boe. Compared to the medium price case there is a substantially greater contribution from possible fields, and technical reserves. It is noteworthy that only under this scenario does a considerable proportion of the reserves in the probable category become economic.

[3] See https://www.og.decc.gov.uk/information/statistics.htm

Table 6

Cumulative Potential Production from 2009 to 2040
(Mmboe)
Hurdle : Real NPV @ 10% / Real Devex @ 10% > 0.3

	Sanctioned	Current Incremental	Future Incremental	Probable Fields	Possible Fields	Technical Reserves	New Exploration	**TOTAL**
$45/bbl and 30p/therm	6037	1066	1595	53	83	344	1623	**10802**
$60/bbl and 50p/therm	6159	1368	2475	563	394	2442	3295	**16695**
$80/bbl and 70p/therm	6251	1409	3017	1220	443	4708	3824	**20873**

The cumulative hydrocarbon production 2009 – 2040 under the same modelling assumptions is shown by the 6 geographic areas in Table 7.

Table 7

Cumulative Potential Production from 2009 to 2040 (Mmboe)
Hurdle : Real NPV @ 10% / Real Devex @ 10% > 0.3

	Cns	**Irish**	**MF**	**Nns**	**SNS**	**WoS**	**TOTAL**
$45/bbl and 30p/therm	4500	260	910	2170	1124	1838	**10802**
$60/bbl and 50p/therm	6779	314	1401	3327	1957	2917	**16695**
$80/bbl and 70p/therm	8035	357	1518	4528	2635	3800	**20873**

The general dominance of the CNS in the total is clearly apparent. Under the $80, 70 pence case the W of S region becomes increasingly significant. Perhaps surprisingly the NNS makes a very substantial contribution in this scenario as well.

There is broad consistency between the independent modelling conducted in this study and the official estimates of the remaining potential. The results of the present modelling have been terminated in 2040, but production continues after that date albeit at low levels. The input assumptions on exploration effort, prospectivity, success rates, and pace of new field developments in the modelling are relatively optimistic for the high price case, and the total depletion to 2040 under this scenario should be regarded as an indication of the maximum which could be achieved. As noted production will continue after 2040.

G. Effects of Higher Cost of Capital and Capital Rationing

Currently the capital rationing problem facing investors in the petroleum industry is more acute than it has been for some time. Investors, even small players, also increasingly examine opportunities on a worldwide basis, and thus the UKCS has to compete for capital with opportunities in other petroleum provinces. In recognition of this further substantial modelling was undertaken to estimate the effects of higher costs of capital and tougher hurdle rates on prospective activity in the UKCS. Rates of discount of 10%, 12.5%, and 15% and NPV/I ratios of 0.3 and 0.5 were chosen. All combinations were modelled. The results in terms of the numbers of new fields and projects (excluding future incremental projects) which pass the economic hurdle are shown in Table 8 under the 3 price scenarios. With the $45, 30 pence case over the period 2009 – 2040, 230 fields and projects (out of 634 discoveries) pass the hurdle used as the base case in the study. If the discount rate was kept at 10% but the minimum NPV/I ratio increased to 0.5 only 155 fields and projects would proceed. Increasing the discount rate to 12.5% while maintaining the minimum NPV/I ratio at 0.3 does not have such a serious

effect. Two hundred and seven fields pass the hurdle. Under the toughest hurdle (15% discount rate and minimum NPV/I of 0.5) only 138 fields and projects proceed.

Table 8

Number of Field Developments and Projects Passing
under Different Investment Hurdle Rates

Price	Discount rate	10%	10%	12.50%	12.50%	15%	15%
and	Min.NPV/I	0.3	0.5	0.3	0.5	0.3	0.5
Category							
$45,30 pence	Number of Fields /Projects						
Incremental Projects	**159**	**86**	**74**	**84**	**71**	**82**	**71**
Probable fields	**29**	**5**	**3**	**5**	**2**	**4**	**2**
Possible fields	**28**	**4**	**0**	**2**	**0**	**0**	**0**
New exploration finds	**251**	**52**	**30**	**45**	**29**	**40**	**26**
Technical reserves fields	**167**	**83**	**48**	**71**	**44**	**62**	**39**
Total	**634**	**230**	**155**	**207**	**146**	**188**	**138**

Table 8 (cont.)

Number of Field Developments and Projects Passing
under Different Investment Hurdle Rates

Price	Discount rate	10%	10%	12.50%	12.50%	15%	15%
and	Min.NPV/I	0.3	0.5	0.3	0.5	0.3	0.5
Category							
$60,50 pence	Number of Fields /Projects						
Incremental Projects	**159**	**112**	**100**	**110**	**93**	**108**	**90**
Probable fields	**29**	**15**	**10**	**14**	**8**	**12**	**8**
Possible fields	**28**	**19**	**10**	**19**	**8**	**16**	**7**
New exploration finds	**251**	**151**	**105**	**140**	**91**	**130**	**84**
Technical reserves fields	**194**	**182**	**158**	**176**	**149**	**171**	**140**
Total	**661**	**479**	**383**	**459**	**349**	**437**	**329**

Table 8 (cont.)

Number of Field Developments and Projects Passing
under Different Investment Hurdle Rates

Price	Discount rate	10%	10%	12.50%	12.50%	15%	15%
and	Min.NPV/I	0.3	0.5	0.3	0.5	0.3	0.5
Category							
$80,70 pence	Number of Fields /Projects						
Incremental Projects	**159**	**125**	**115**	**125**	**114**	**120**	**112**
Probable fields	**29**	**28**	**18**	**21**	**17**	**18**	**15**
Possible fields	**28**	**26**	**24**	**26**	**23**	**26**	**22**
New exploration finds	**251**	**227**	**199**	**224**	**188**	**218**	**177**
Technical reserves fields	**210**	**210**	**207**	**210**	**206**	**208**	**206**
Total	**677**	**616**	**563**	**606**	**548**	**590**	**532**

Under the $60, 50 pence case 479 fields and projects pass the base case hurdle of 10% discount rate and minimum NPV/I of 0.3. This falls dramatically to 383 when the minimum NPV/I is 0.5. The numbers of new discoveries and technical reserves which proceed are greatly reduced. Increasing the discount rate to 12.5% on its own does not have a major effect on activity, but this remains much more sensitive to a change in the NPV/I ratio.

Under the $80, 70 pence case there could be as many as 616 developments under the base case assumptions regarding hurdle rates. When the minimum NPV/I ratio is increased to 0.5 the numbers fall to 563 fields and projects.

Under the toughest combination of discount rates and NPV/I ratios examined there are 532 new fields and projects which proceed.

The results for cumulative production 2009 – 2040 under the costs of capital/ investment hurdles other than those in the base case are shown in Tables 9 – 13. With 12.5% discount rate and minimum NPV/I > 0.3 under the $45, 30 pence price case total depletion over the period is 10.3 bn boe. Under the $60, 50 pence case it is 15.8 bn boe and under the $80, 70 pence case it is 20.2 bn boe. The general conclusion is that raising the discount rate from 10% to 12.5% does not have a very significant effect on total depletion in the period.

Table 9

Cumulative Potential Production from 2009 to 2040 (Mmboe)
Hurdle : Real NPV @ 10% / Real Devex @ 10% > 0.5

	Sanctioned	Current Incremental	Future Incremental	Probable Fields	Possible Fields	Technical Reserves	New Exploration	**TOTAL**
$45/bbl and 30p/therm	6037	864	1287	31	0	215	827	**9261**
$60/bbl and 50p/therm	6159	1258	2256	314	187	1367	2820	**14360**
$80/bbl and 70p/therm	6251	1375	2935	615	434	3379	3655	**18644**

Table 10

Cumulative Potential Production from 2009 to 2040 (Mmboe)

Hurdle : Real NPV @ 12.5% / Real Devex @ 12.5% > 0.3

	Sanctioned	Incremental	Future Incremental	Probable Fields	Possible Fields	Technical Reserves	New Exploration	**TOTAL**
$45/bbl and 30p/therm	6037	1038	1545	53	21	328	1314	**10336**
$60/bbl and 50p/therm	6159	1319	2383	558	394	1869	3128	**15809**
$80/bbl and 70p/therm	6251	1409	3017	937	443	4336	3824	**20217**

Table 11

Cumulative Potential Production from 2009 to 2040 (Mmboe)

Hurdle : Real NPV @ 12.5% / Real Devex @ 12.5% > 0.5

	Sanctioned	Incremental	Future Incremental	Probable Fields	Possible Fields	Technical Reserves	New Exploration	**TOTAL**
$45/bbl and 30p/therm	6037	382	661	22	0	213	759	**8075**
$60/bbl and 50p/therm	6159	1212	2164	123	157	1157	2588	**13559**
$80/bbl and 70p/therm	6251	1354	2888	599	429	3078	3617	**18216**

Table 12

Cumulative Potential Production from 2009 to 2040 (Mmboe)

Hurdle : Real NPV @ 15% / Real Devex @ 15% > 0.3

	Sanctioned	Incremental	Future Incremental	Probable Fields	Possible Fields	Technical Reserves	New Exploration	**TOTAL**
$45/bbl and 30p/therm	6037	572	945	48	0	276	1100	**8978**
$60/bbl and 50p/therm	6159	1301	2346	330	263	1704	3047	**15150**
$80/bbl and 70p/therm	6251	1399	2991	615	443	3802	3663	**19165**

Table 13

Cumulative Potential Production from 2009 to 2040 (Mmboe)

Hurdle : Real NPV @ 15% / Real Devex @ 15% > 0.5

	Sanctioned	Incremental	Future Incremental	Probable Fields	Possible Fields	Technical Reserves	New Exploration	**TOTAL**
$45/bbl and 30p/therm	6037	382	661	22	0	164	626	**7892**
$60/bbl and 50p/therm	6159	1101	1945	123	141	1017	2441	**12927**
$80/bbl and 70p/therm	6251	1304	2773	568	409	2710	3617	**17633**

When the minimum NPV/I ratio is raised to 0.5 and the discount rate is 12.5% the effect is much more noticeable (Table 12). Total depletion over the period becomes 8.1 bn boe under the low price case, 13.6 bn boe under the medium case, and 18.2 bn boe under the high price case.

At 15% discount rate and minimum NPV/I of 0.3 (Table 13) cumulative production under the low price case becomes 9 bn boe, under the $60, 50 pence case it is 15.1 bn boe while under the high price it becomes 19.1 bn boe. A combination of 15% discount rate and minimum NPV/I of 0.5 produces a marked reduction in cumulative output compared to the base case. In the $45, 30 pence case it is 7.9 bn boe, 12.9 bn boe in the $60, 50 pence case, and 17.6 bn boe in the high price case.

4. Conclusions

In this study detailed modelling has been undertaken of the longer term prospects for activity in the UK Continental Shelf (UKCS). The cases modelled are designed to reflect the outcomes of 3 plausible long term investment scenarios which in turn reflect the likely cautious attitudes taken with regard to oil and gas prices for this purpose. The price scenarios are thus not indicators of likely market rice behaviour. The modelling also indicates the effects of variations in plausible costs of capital and capital rationing.

The results highlight a wide range of long term prospects for activity levels. The base case chosen employed discount rates of 10% in real terms and capital rationing measured by a minimum NPV/I ratio of 0.3 in real terms. In the low price case ($45, 30 pence in real terms) investment and production fall very sharply throughout the period. Less than 50 fields would remain in production in 2040 compared to over 300 in 2008. Production falls from 2.7 mm boe/d in

2008 to 0.3 mm boe/d in 2040. In the period 2009 – 2040 cumulative production is only 10.8 bn boe. Most new fields and incremental projects are uneconomic.

Under the $60, 50 pence case substantial numbers of new fields and incremental projects become viable. Investment holds up at current levels for a few years but still falls at a noticeable pace thereafter. Production falls to 0.65 mm boe/d in 2040. Over the period 2009 – 2040 cumulative production is 16.7 bn boe.

Under the $80, 70 pence price case investment is buoyant for some years ahead and many new fields and projects become viable. In 2040 production is 0.7 mm boe/d. Cumulative production over the period 2009 – 2040 inclusive is 20.9 bn boe.

But the effects of tougher capital rationing can have a major effect on the numbers of economically viable projects and thus on activity levels. Thus under the $45, 30 pence price scenario there could be 230 new field and incremental project developments in the period 2009 – 2040 (excluding future incremental projects) if the investment hurdle were minimum NPV/I of 0.3 with 10% discount rates. If the minimum NPV/I were 0.5 only 155 fields and projects would proceed. With 12.5% discount rate and minimum NPV/I of 0.5 only 146 fields and projects would go ahead. Tougher investment hurdles result in less cumulative production over the period to 2040. Increasing the discount rate to 12.5% on its own does not have a major effect but, if combined with a minimum NPV/I of 0.5, the result is that only 8.1 bn boe are produced over the period. With 15% discount rate and minimum NPV/I of 0.5 only 7.9 bn boe are recovered.

Under the $60, 0 pence case 479 fields and projects go ahead over the period with discount rate of 10% and minimum NPV/I ratios of 0.3. But at 12.5% discount rates and minimum NPV/I ratios of 0.5 only 349 fields and projects are viable. In this scenario only 14.4 bn boe are recovered. With 15% discount rate and minimum NPV/I of 0.5 only 12.9 bn boe are recovered.

Under the $80, 70 pence case no less than 616 fields and projects proceed with discount rates of 10% and minimum NPV/I ratios of 0.3. But, at 12.5% discount rates and minimum NPV/I ratio of 0.5, only 548 fields and projects go ahead. With 12.5% discount rate and minimum NPV/I of 0.5 18.2 bn boe are recovered over the period. If 15% discount rate and minimum NPV/I were employed only 17.6 bn boe would be recovered. The range of outcomes is thus very wide, and there is considerable sensitivity to the required NPV/I ratio but less to the discount rate.

It should be stressed that the prospects indicated in the modelling depend on the various DECC and PILOT initiatives continuing to bear fruit over the period. Those initiatives refer to fallow field/blocks, stewardship of mature fields, infrastructure Code of Practice, and the continued availability and integrity of that infrastructure. All this cannot be taken for granted. The need for tax incentives to stimulate investment in mature PRT-paying fields remains valid, and amendments to the field allowance for the Supplementary Charge could further enhance investment[4].

[4] See Alex Kemp and Linda Stephen, North Sea Study Occasional Paper No. 110, The Economics of PRT Redetermination for Incremental Projects in the UKCS, University of Aberdeen Department of Economics, November 2008, and North Sea Study Occasional Paper No. 113, The Budget 2009 Tax Proposals and Activity in the UK Continental Shelf (UKCS), University of Aberdeen, Department of Economics, June 2009.

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