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The Implications of Different Acceptable Prospective Returns to Investment for Activity in the UKCS

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NORTH SEA ECONOMICS

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.

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The Implications of Different Acceptable Prospective Returns to Investment for Activity in the UKCS

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The Implications of Different Acceptable Prospective Returns to Investment for Activity in the UKCS

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1. Introduction and Context

As an element in the strategy to promote maximum economic recovery from the UKCS the Oil and Gas Authority (OGA) has indicated that licensees can anticipate an appropriate expected return on their investments. A key question is what constitutes such an expected return. There is no simple answer. Different investors will have different investment hurdles. In turn these will depend on factors such as their weighted average cost of capital (WACC), extent of capital rationing, assessment of, and attitude to, risk-taking, numbers of available investment opportunities, and expected materiality from projects. Most investors in the UKCS will be examining projects in other jurisdictions. A diversified portpolio is a common objective. It is likely that large companies will have different views on what is an adequate expected materiality from a project. Thus an expected net present value (NPV) from a small field may offer adequate materiality to a small company but be inadequate to a large one. The effect on earnings and earnings per share from a small field could be substantial to a small company but insignificant to a large one. The precise location of a possible development may also influence investment decisions. Thus a field located close to a hub platform belonging to the same licensee may appear more attractive than one linked to a hub owned by a competitor. Even with good will and collaboration this could involve extra costs and delays.

The purpose of the present study is to examine the consequences for activity levels in the UKCS of the adoption of different investment hurdles. This will highlight the effects of lower and higher hurdles on numbers of new field developments, investment, operating, and decommissioning expenditures, and production. The specific investment hurdles which are modelled are (1) post-tax IRR @ 10% real discount rate (i.e. non negative NPV @ 10% real discount rate), (2) post-tax IRR @ 15% real discount rate (i.e. non-negative NPV @ 15% real discount rate), (3) minimum post-tax NPV of £10 million in real terms @ 10% discount rate, (4) post-tax NPV @ 10% in real terms / pre-tax I @ 10% in real terms > 0.3, and (5) post-tax NPV @ 10% in real terms / pre-tax I @ 10% in real terms > 0.5. A post-tax real IRR of 10% is the lowest hurdle included in the study and is unlikely to be regarded as adequate by investors in current circumstances where there are capital constraints and the need for worthwhile net cash flows from projects. The minimum NPV of £10 million hurdle was designed to discover the extent of the sensitivity of returns on small fields to a minimum capital constraint. The NPV/I hurdle of 0.3 more generally captures the effect of capital rationing. The NPV/I hurdle of 0.5 is designed to capture the effects of very serious capital rationing.

2. Methodology and data

The projections of production and expenditures have been made using financial simulation modelling, including the use of the Monte Carlo technique, informed by a large field database of undeveloped fields, some validated by the relevant operators. Other field data are a combination of public and private domain information and estimates made by the authors. The overall field database incorporates key, best estimate information on production, and investment, operating and decommissioning expenditures. These relate to 14 probable fields, and 14 possible unsanctioned fields which are currently being examined for development. In addition, there are 249 fields defined as being in the category of technical reserves. Only summary data on reserves (oil/gas/condensate) and block locations are available for these and estimates of production and cost profiles were made by the authors. These fields 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 2047. The modelling incorporated assumptions based on recent trends relating to exploration effort, success rates, sizes, and types of discovery (oil, gas, condensate). A moving average of the behavior of these variables over the past 5 years was calculated separately for 5 areas of the UKCS (Southern North Sea (SNS), Central North Sea/Moray Firth (CNS/MF), Northern North Sea (NNS), West of Shetlands (WoS), and Irish Sea (IS)). The results were employed for use in the Monte Carlo analysis. Because of the very limited data for the WoS and IS over the period judgmental 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 2 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
Medium	60	50
Low	50	40

These price scenarios are designed to reflect investment screening prices, not market values. In this context, it should be noted that, when oil prices were $100 or more banks typically employed oil prices in the $65-$75 range to assess loan applications. With market prices of c. $50 banks may use prices in the $35 - $45 range to assess loan applications. In MOD terms the price scenario starting with $60 in 2017 becomes $115 in 2050, and the scenario starting with $50 in 2017 becomes over $96 in 2050. The exchange rate employed was £1 = $1.267 which was the rate when the modelling commenced. The structure of costs between dollars and sterling in the modelling reflects the up-to-date position.

The postulated numbers of annual exploration wells drilled for the whole of the UKCS are as follows for 2017, 2030, 2040, and 2045:

Table 2

Exploration Wells Drilled

	2017	2030	2040	2045
Medium effort	15	12	10	9
Low effort	12	9	7	6

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 higher effort involves the acceptance of higher risk. For the UKCS as a whole 2 success rates were postulated as follows with the medium one reflecting the average over the past 5 years.

Table 3 Success Rates for UKCS	
Low effort/Medium success rate	33%
Medium effort/Lower success rate	30%

It should be noted that success rates have varied considerably across the 5 sectors of the UKCS. The annual number of discoveries has been low since 2010 which is not surprising, given the large decline in the number of exploration wells since 2008. It is assumed that technological progress will maintain historic success rates over the time period.

The mean sizes of discoveries made in the historic periods for each of the 5 regions were calculated. It was then assumed that the mean size of discovery would decrease in line with recent historic experience. They are shown in Table 4.

Table 4

Mean Discovery Size MMboe

Year	**2017**	**2045**
SNS	**20**	**15**
CNS/MF	**17**	**12**
NNS	**38**	**6**
WoS	**59**	**28**
IS	**9**	**4**

For purposes of the Monte Carlo modelling of the size 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 5 regions to 2047. For the period to 2050 the total numbers of discoveries for the whole of the UKCS were as follows:

Table 5 **Total Number of Discoveries to 2050**	
Medium effort/Lower success rate	117
Lower Effort/Medium Success Rate	97

For each region the average development costs (per boe) of fields in the probable and possible categories were calculated. These reflect the cost reductions over the last two 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. For all of the UKCS the average development cost was calculated to be $16.66 per boe with the highest being $21.72. In the SNS development costs were found to average $11.44 per boe. In the CNS/MF, they averaged $18.5 per boe, in the WoS average development costs were $15.78 per boe (reflecting the relative large size of fields), and in the NNS they averaged $21.6 per boe.

Operating costs over the lifetime of the fields were also calculated. The average has fallen from $19 per boe to $11.5 for all of the UKCS. They are now estimated at $6 per boe in the SNS, $13 per boe in the CNS/MF, $12.5 per boe in the WoS, and $14.6 per boe in the NNS. Total lifetime field costs (including decommissioning but excluding E and A costs) were found to have fallen from an average of $38.9 per boe for all of the UKCS to $34.8 per boe, with $23 per boe in the SNS, $38 per boe in the CNS/MF, $30 per boe in the WoS (reflecting the relatively large size of fields), and $41 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. Annual operating costs were modelled as a percentage of accumulated development costs. This percentage varies according to field size. It was taken to increase as the size of the field was reduced reflecting the presence of economies of scale. The field lifetime costs in very small fields could become very high on a boe basis.

With respect to fields in the category of technical reserves it was recognised that there are many major challenges, and so the mean development costs in each of the basins was set at $5/boe higher than the mean for new discoveries in that basin. Thus for the CNS/MF the mean development costs are $23.5 per boe, and in NNS over $26 per boe. The distribution of these costs was assumed to be normal with a SD = 20% of the mean value. A binomial distribution was employed to find the order of new developments of fields in this category.

The annual numbers of new field developments were assumed to be constrained by the physical and financial capacity of the industry. The ceilings were assumed to be linked to the oil/gas price scenarios with maxima of 18 and 15 respectively for the Medium and Low price cases.

The modelling has been undertaken under the current tax system. It is assumed that probable and possible fields, technical reserves, and new discoveries have to generate taxable income form the new projects before they can use their tax allowances. Thus the Ring Fence Expenditure Supplement (RFES) is employed. The modelling is initially undertaken in MOD terms with an inflation rate of 2%. This incorporates the effects of any fiscal drag. The results are then converted to real terms.

In the light of experience over the past few years some rephrasing of the timing of the commencement dates of new field developments from those projects by operators was undertaken relating to the probability that the project would go ahead. Where the operator indicated that a new field development had a probability ≥ 80% of going ahead the date was left unchanged. Where the probability ≥ 70% <80% the commencement date was slipped by 1 year and where the probability ≥ 50% < 70% the commencement date was slipped by 2 years. Where the probability ≥ 40% < 50% the date was slipped by 3 years. Where the probability was ≥ 30% < 40% the date was slipped by 4 years, and where the probability was ≥ 20% < 30% it was slipped by 5 years. Where the probability was < 20% it was slipped by 6 years.

3. Results

a) $50, 40 pence price case

The numbers of fields passing/failing the various hurdles are shown in Table 6 under the $50, 40 pence price scenario. It is seen that, of the total of 374 fields only 270 have positive real but undiscounted net cash flows. A significant number (91) of the technical reserves do not have positive real net cash flows. Some of the fields in the probable and possible categories also fail to achieve positive net cash flows. The least demanding hurdle examined which takes account of discounting and the tax system is IRR ≥ 10%. In this case 210 fields pass. But only 50% of these in the probable/possible categories pass and only 118 (47.4%) of fields in the category of technical reserves pass. Interestingly, the numbers passing/failing this hurdle are the same before and after tax, though the RFES does not fully compensate for the lack of early tax relief.

Table 6

Numbers of Fields Passing/Failing Specified Hurdles

$50, 40 pence	NPV/I > 0.3		NPV/I > 0.5		IRR ≥ 10%		IRR ≥ 15%	
	Pass	Fail	Pass	Fail	Pass	Fail	Pass	Fail
Probable	4	10	3	11	7	7	7	7
Possible	3	11	2	12	7	7	3	11
Technical Reserves	51	198	18	231	118	131	96	153
New Exploration	45	52	22	75	78	19	75	22
	103	**271**	**45**	**329**	**210**	**164**	**181**	**193**

$50, 40 pence	Pre-tax Cashflow > £0		Pre-tax NPV @ 10% ≥ £0		Post-tax NPV > £10m.	
	Pass	Fail	Pass	Fail	Pass	Fail
Probable	11	3	7	7	7	7
Possible	11	3	7	7	6	8
Technical Reserves	158	91	118	131	81	168
New Exploration	90	7	78	19	77	20
	270	**104**	**210**	**164**	**171**	**203**

If a minimum post-tax NPV@10% of £10 million were the required hurdle it was found that a total of 171 fields passed and 203 failed, compared to 118 passes and 131 fails with the simple hurdle of IRR ≥ 10%. It is very likely that there will be materiality requirements of investors even on very small fields. This hurdle is not very demanding particularly for medium and larger fields where the substantial capital costs are likely to require correspondingly larger expected materiality.

Accordingly, the results with the hurdle of NPV/I > 0.3 are likely to be applicable to a substantial number of projects. From Table 6 it can be seen that 103 fields, or only 27.5% of the total, pass this hurdle. It is also seen that this hurdle means that some fields which fail have an IRR > 15%. Thus 181 fields have an IRR > 15%. Small fields with a correspondingly short life may have a fairly attractive IRR because the higher rate of discounting does not have such a strong effect as happens with longer-lived fields.

Employment of the hurdle of NPV/I > 0.5 results in only 45 fields passing and 329 failing. As indicated above this hurdle may be regarded as extremely demanding reflecting severe capital rationing.

Table 7

Numbers of Fields Passing Hurdles by Geographic Area

Pass	NPV/I > 0.3	NPV/I > 0.5	IRR 10%	IRR 15%	Real Pre-tax Cashflow > £0	Real Pre-tax NPV@10% > £0	Real Post-tax NPV@10% > £10m.
NNS	17	10	34	31	50	34	30
SNS	34	13	68	60	86	68	49
WoS	13	7	28	25	37	28	23
IS	1	0	2	2	3	2	2
CNS/MF	38	15	78	63	94	78	67
	103	**45**	**210**	**181**	**270**	**210**	**171**

In Table 7 the number of fields passing the various hurdles are shown according to main geographic areas of the UKCS. It is clear that the CNS/MF area is the one which exhibits the largest number of passes under all the hurdles. Perhaps surprisingly the SNS produces a substantial number of passes even when materiality is highlighted. The low investment costs are a main contributory factor here. It is seen that roughly 50% of the fields pass the hurdle of NPV/I > 0.3 compared to 10% IRR in all regions. In the SNS a large number of fields pass the hurdles of 10% IRR and 15% IRR but many fail to meet the hurdle of minimum NPV of £10m. This reflects the generally small size of fields in that region.

Chart 1

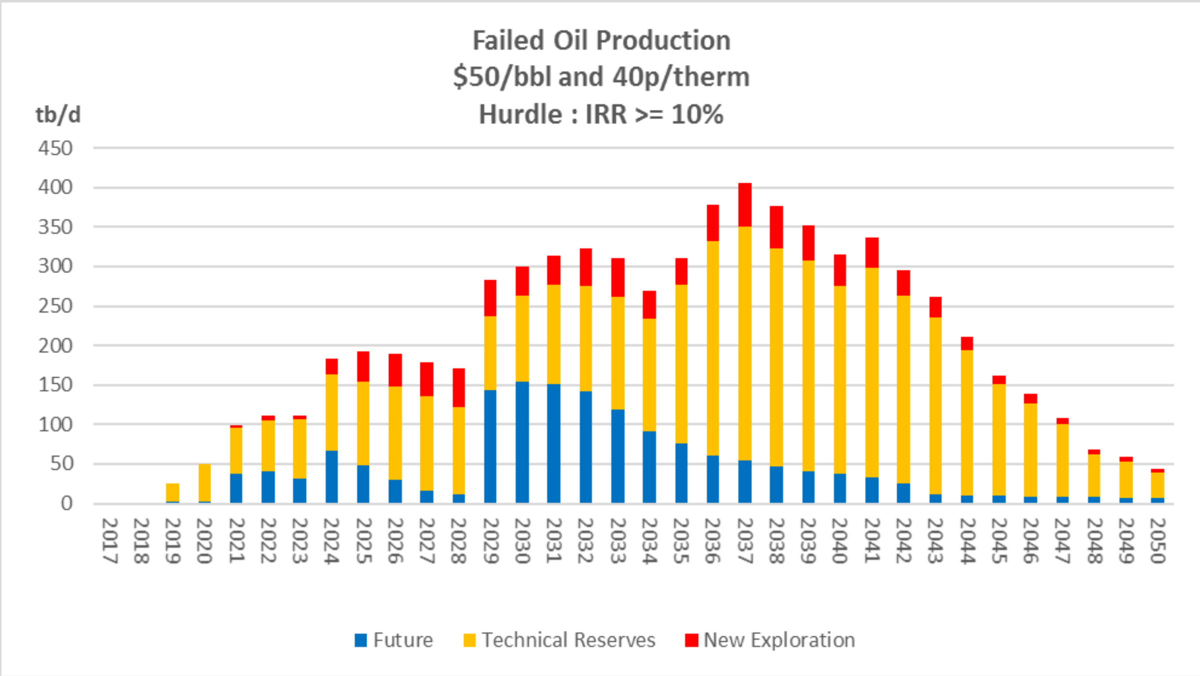


Chart 1 shows the oil production from fields which fail the 10% IRR hurdle. The aggregate loss of production in the period to 2050 is 2.5 bn boe.

Chart 2

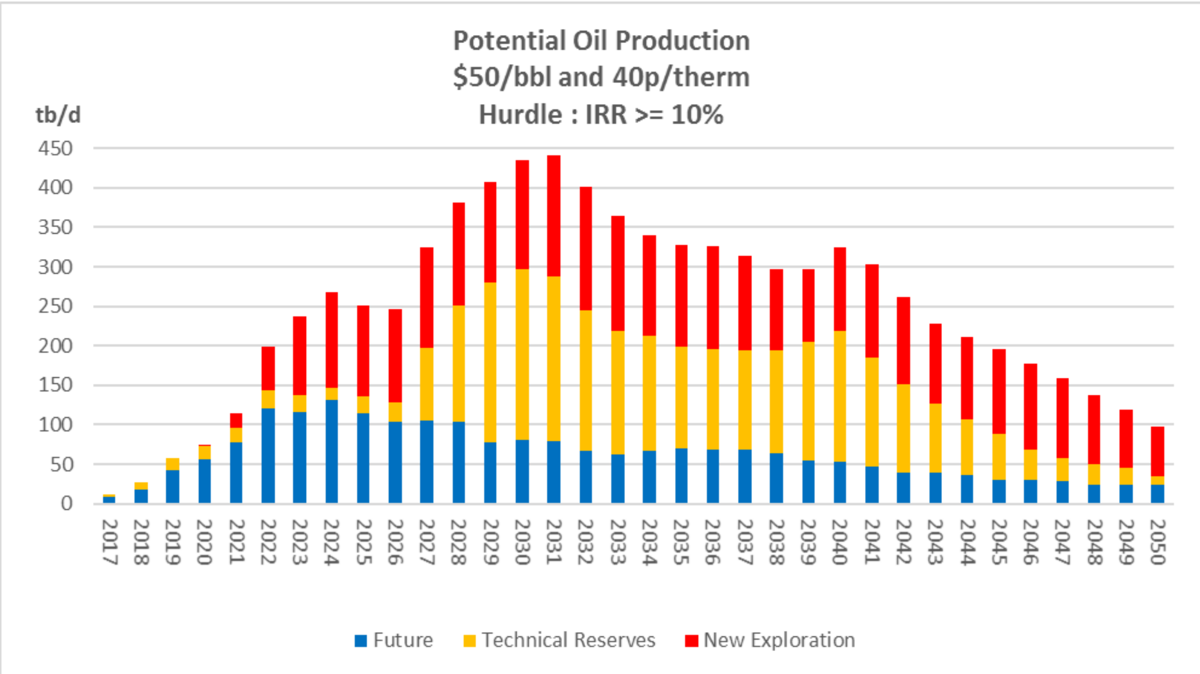
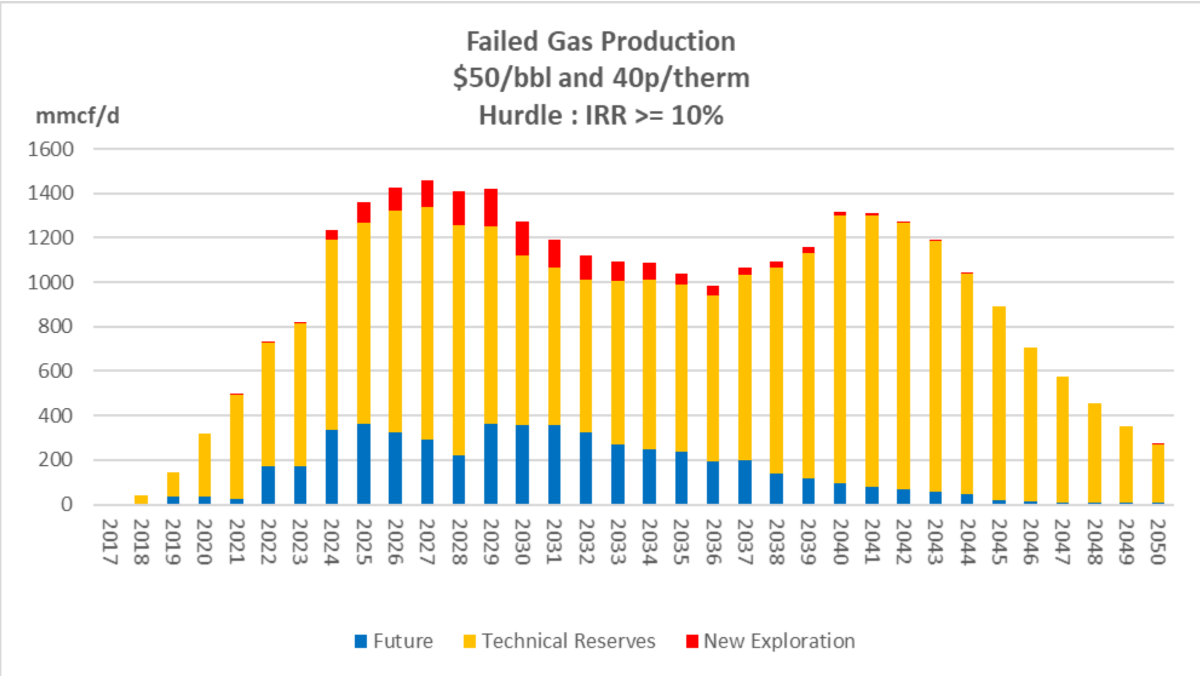


Chart 2 shows the oil production from the new fields which pass the 10% IRR hurdle. Over the period to 2050 3.1 bn bbls are produced. It is seen that a substantial proportion comes from future discoveries as well as fields in the category of technical reserves. The contribution of possible and probable fields over the whole period is fairly modest.

Chart 3



In Chart 3 the potential gas production from fields which fail the 10% IRR hurdle is shown. Over the period to 2050 the loss amounts to 2 bn boe. The great bulk comes from fields in the category of technical reserves.

Chart 4

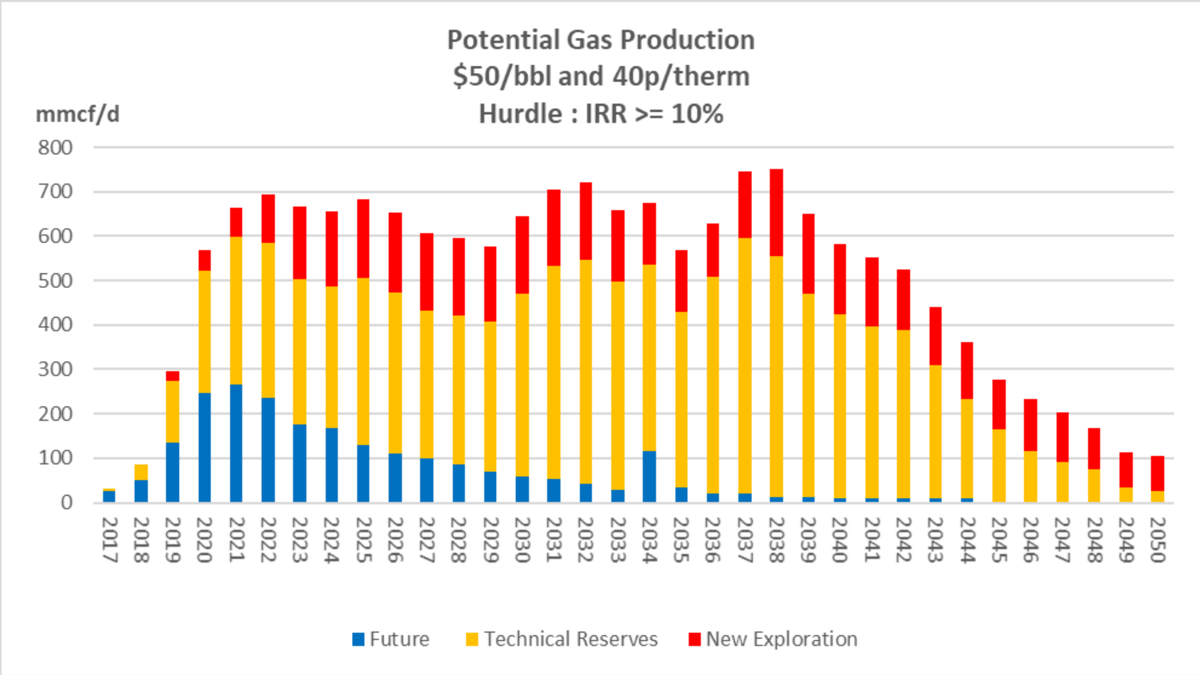


Chart 4 shows the potential gas production from fields which pass the 10% IRR hurdle. The total in the period to 2050 is 1.1 bn boe. The great bulk comes from fields in the category of technical reserves.

Chart 5

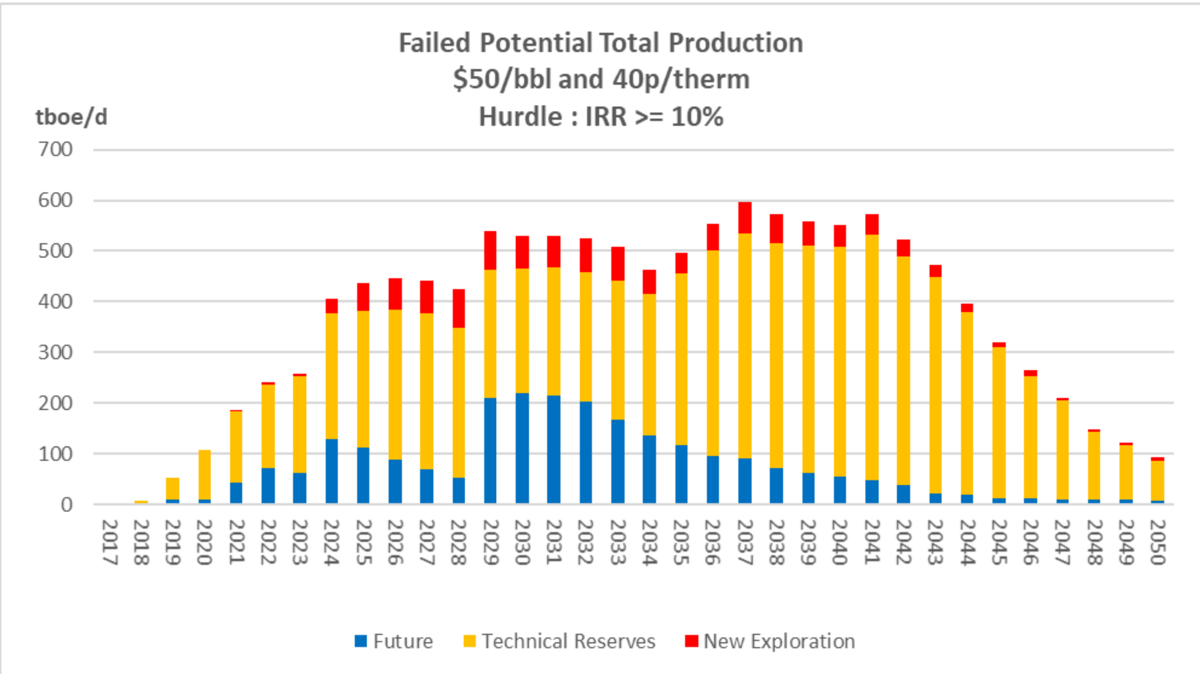


Chart 5 shows the total hydrocarbon production which could have been achieved from the fields which failed the 10% IRR hurdle. Over the period to 2050 the total is 4.6 bn boe with the great majority being in the category of technical reserves.

Chart 6

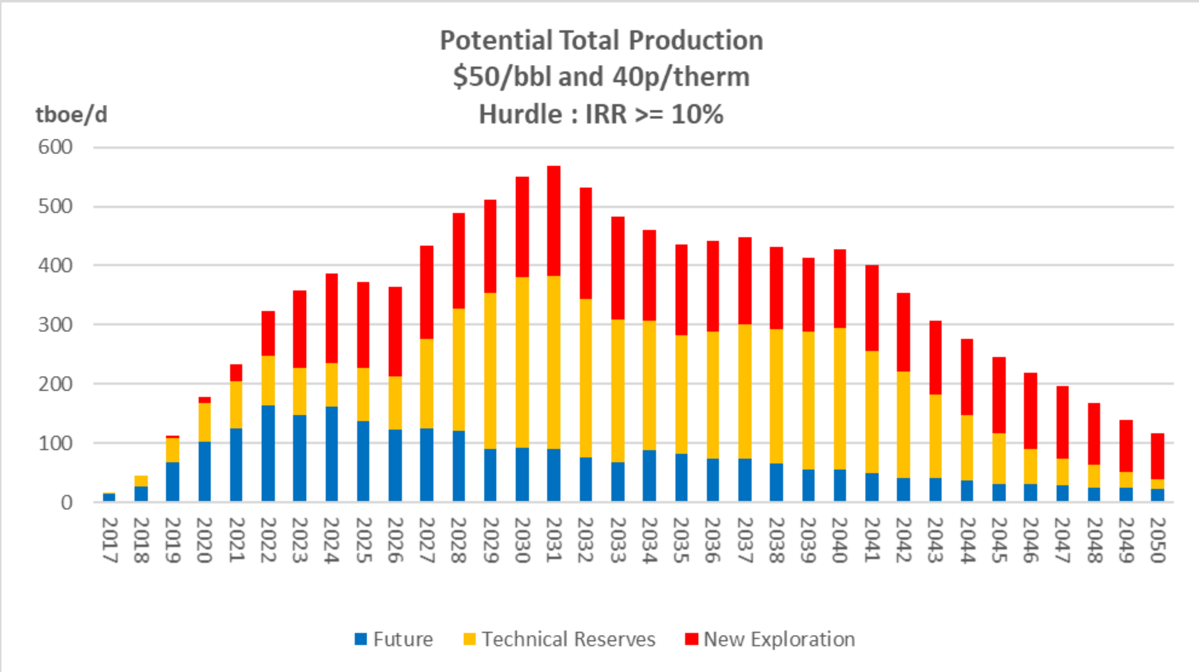


Chart 6 shows the potential total production from the fields which pass the IRR at 10% hurdle. Total production could amount to 4.2 bn barrels of oil equivalent for the period to 2050 with the bulk of this coming from technical reserve fields.

Chart 7

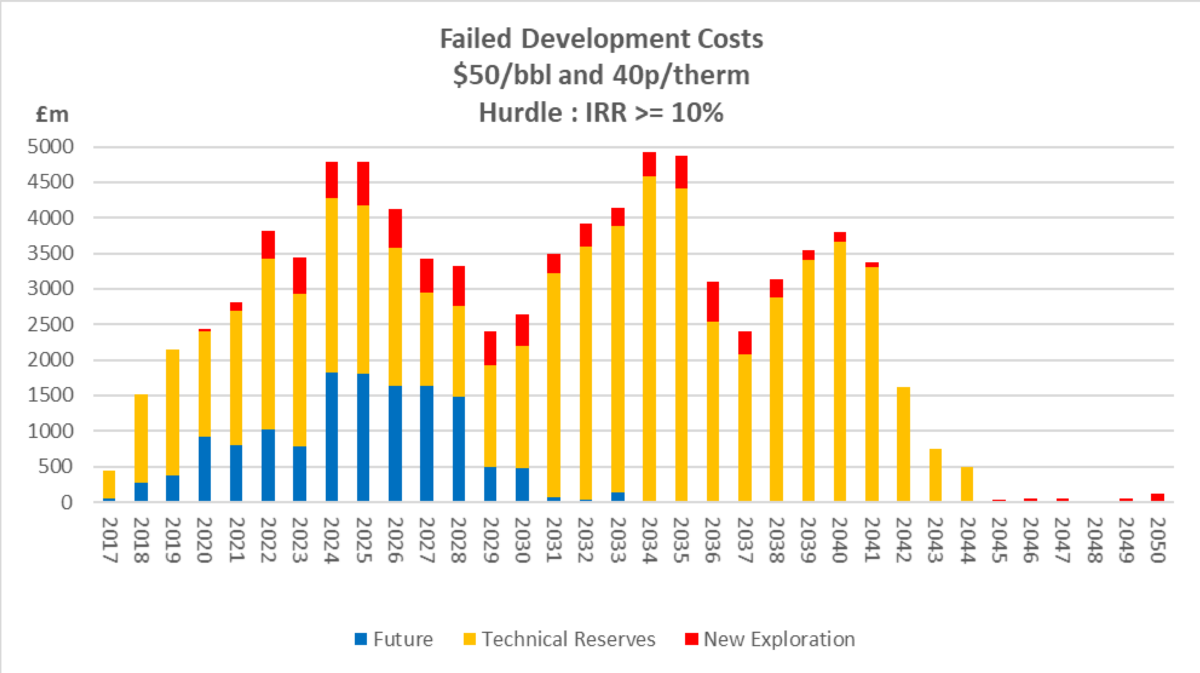


Chart 7 shows the potential development costs from the fields which fail the IRR at 10% hurdle. The loss of development costs could amount to £86 bn for the period to 2050, with the bulk of this coming from technical reserve fields.

Chart 8

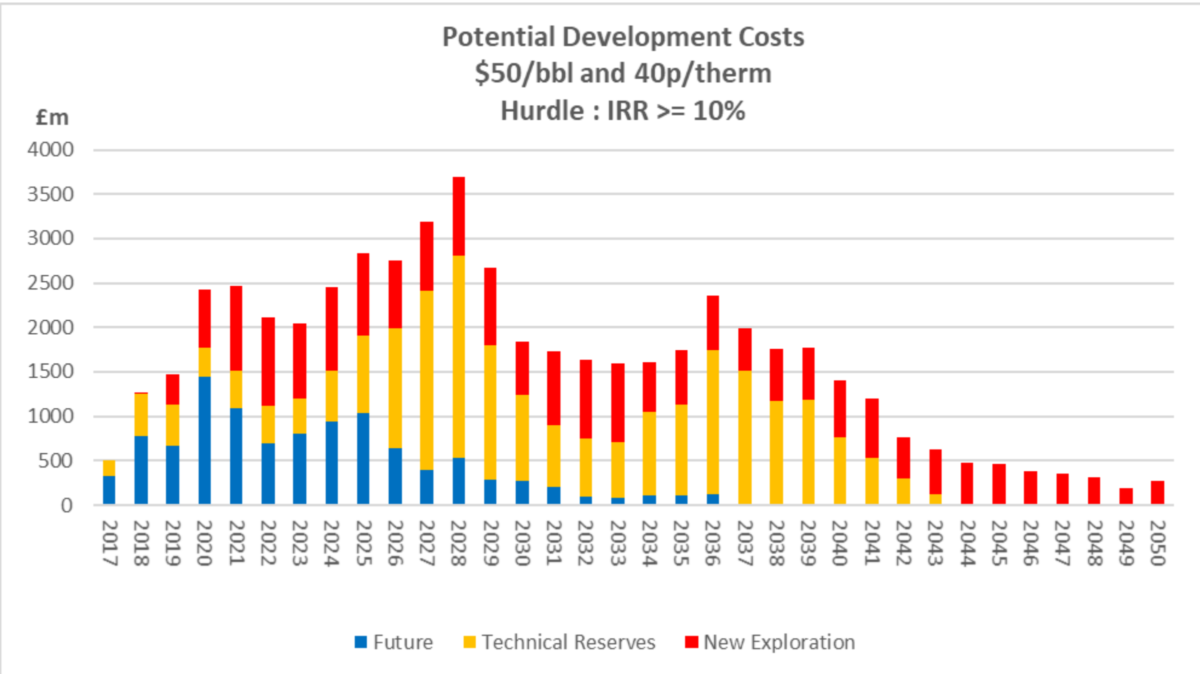


Chart 8 shows the potential development costs from the fields which pass the IRR at 10% hurdle. The potential development costs could amout to £54.3 bn with most coming from the technical reserve fields.

Chart 9

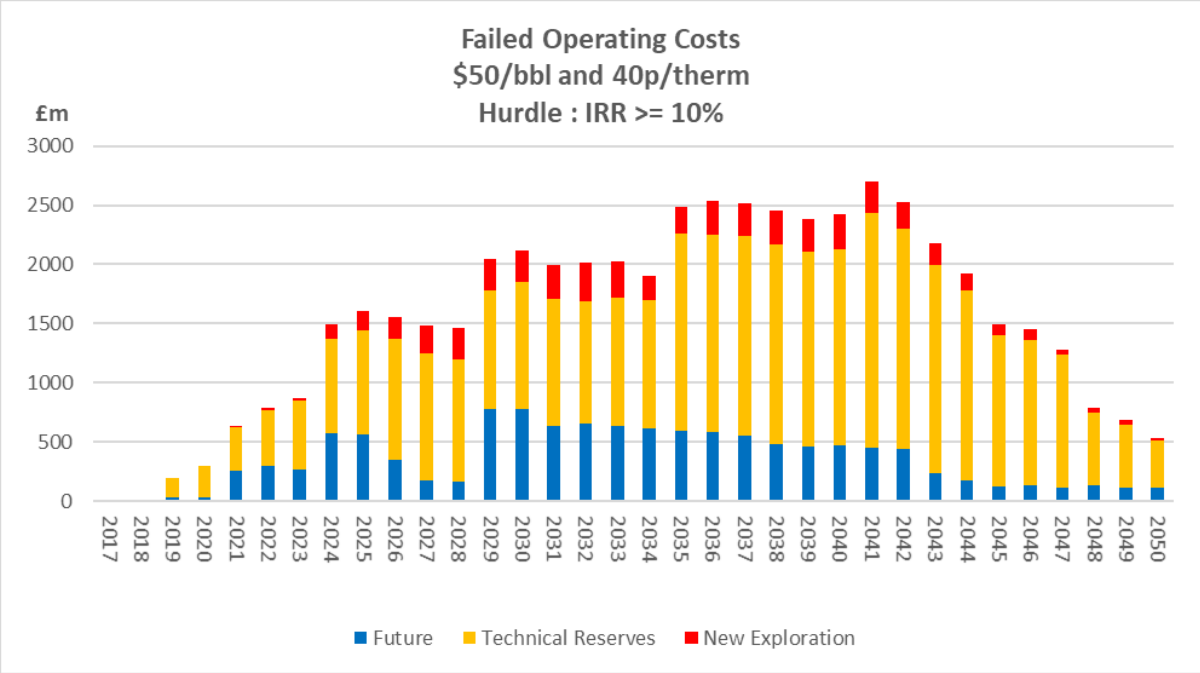


Chart 9 shows the potential operating costs from the fields which fail the IRR at 10% hurdle. The loss could amount to £52.9 bn for the period to 2050 with the bulk coming from technical reserve fields.

Chart 10

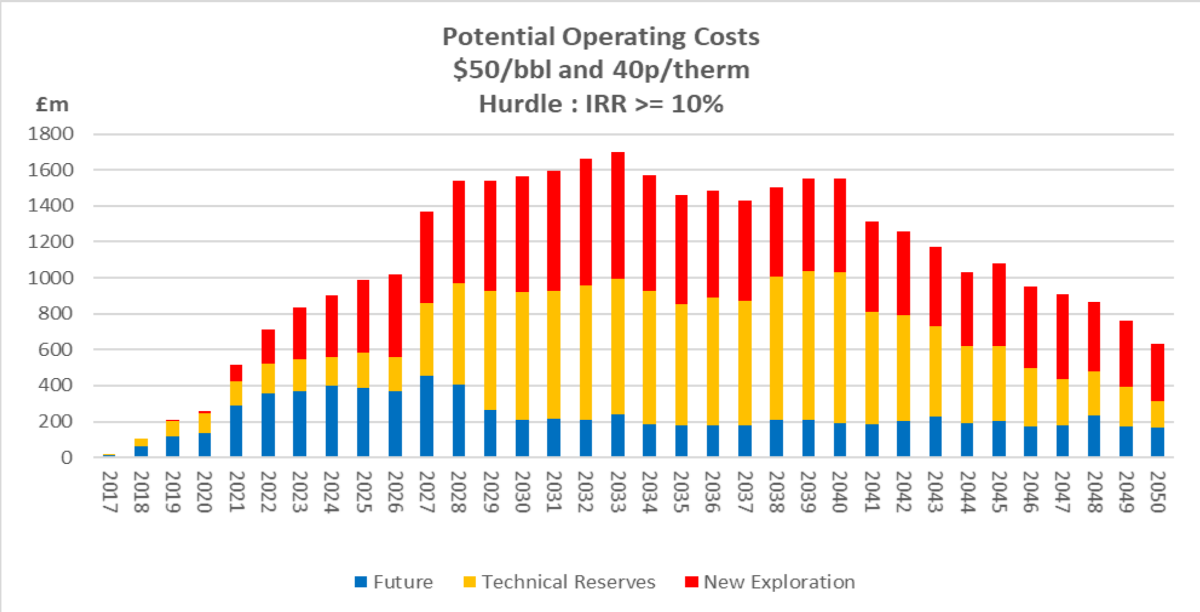


Chart 10 show the potential operating costs from the fields which pass the IRR at 10% hurdle. The potential operating costs could amount to £37.1 but with much coming from new exploration finds.

Chart 11

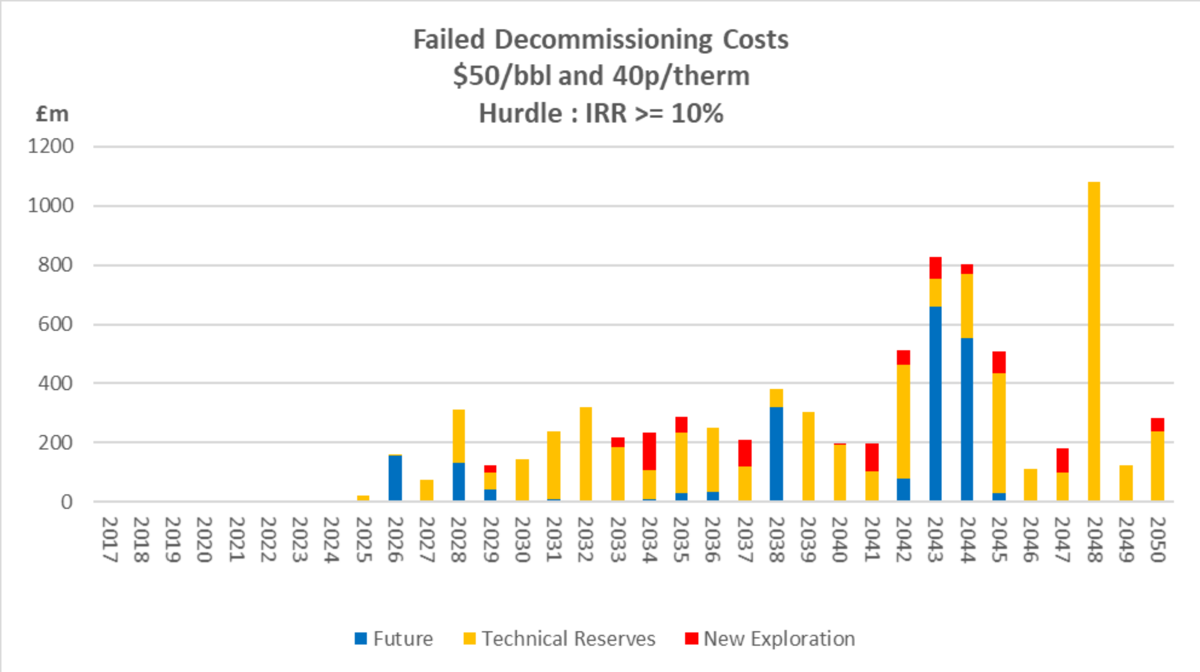


Chart 11 shows the potential decommissioning costs from the fields which fail the IRR at 10% hurdle. The loss of decommissioning costs could amount to £8.1 bn for the period to 2050, with the bulk coming from technical reserve fields.

Chart 12

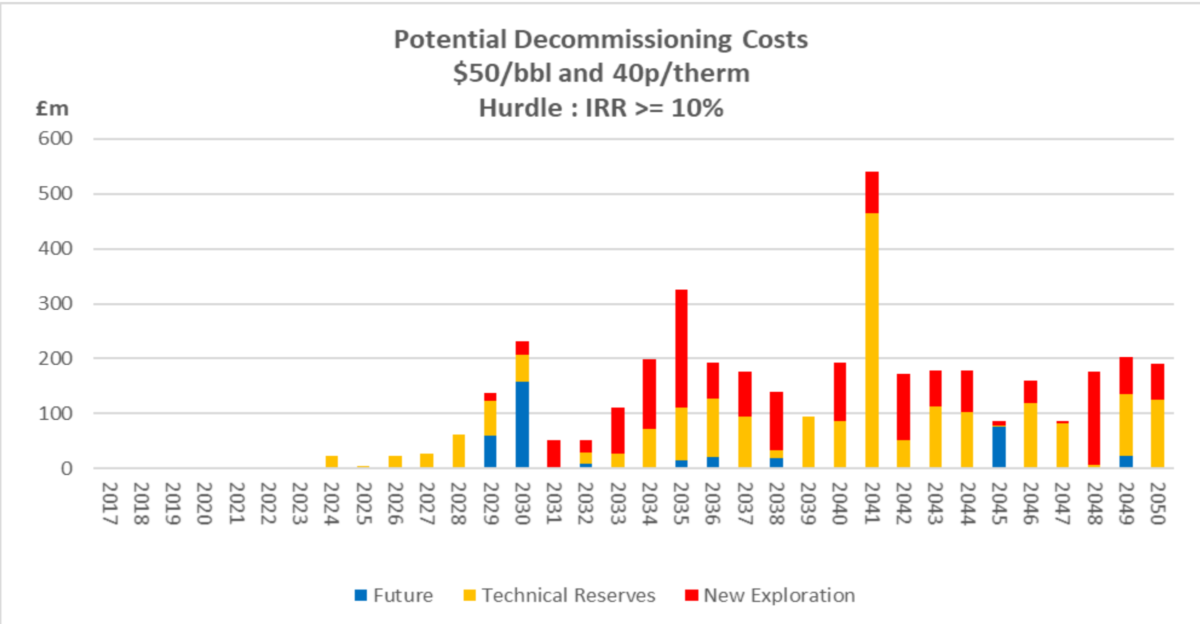


Chart 12 shows the potential decommissioning costs from the fields which pass the IRR at 10% hurdle. The potential decommissioning costs could amount to £4 billion with most coming from the technical reserve fields.

Chart 13

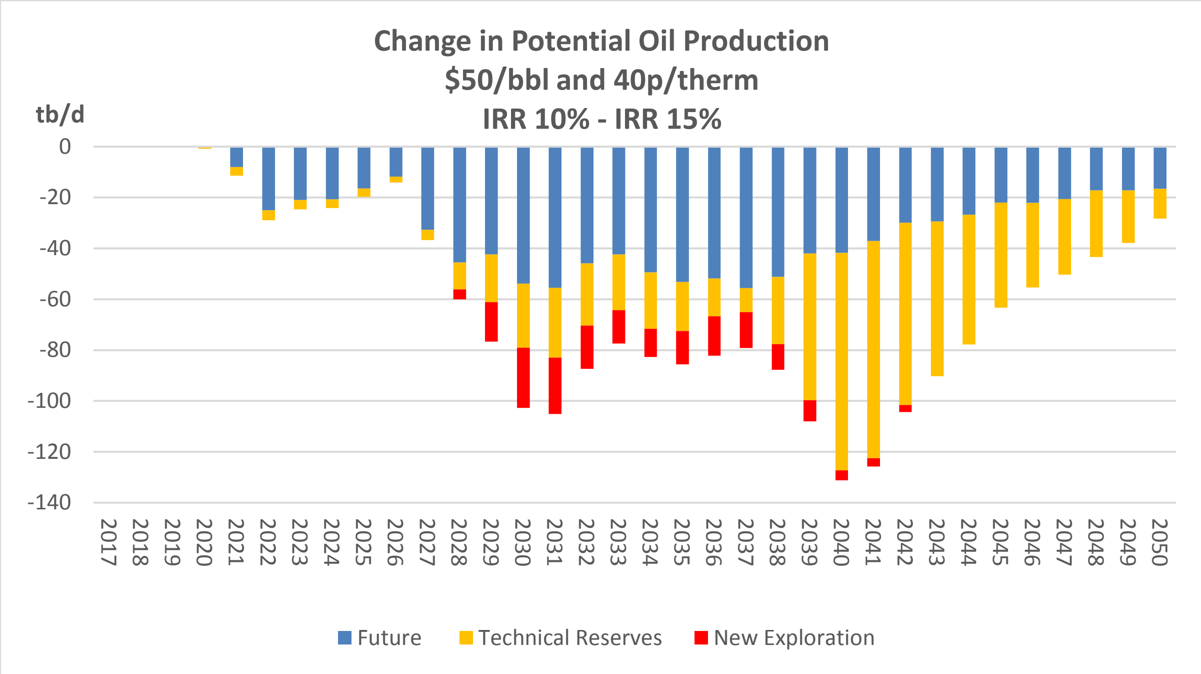


Chart 13 shows the change in oil production that occurs if the hurdle rate changes from IRR at 10% to IRR at 15%. The loss of oil production could amount to 731 million barrels of oil for the period to 2050 with the bulk of the loss coming from probable and possible fields.

Chart 14

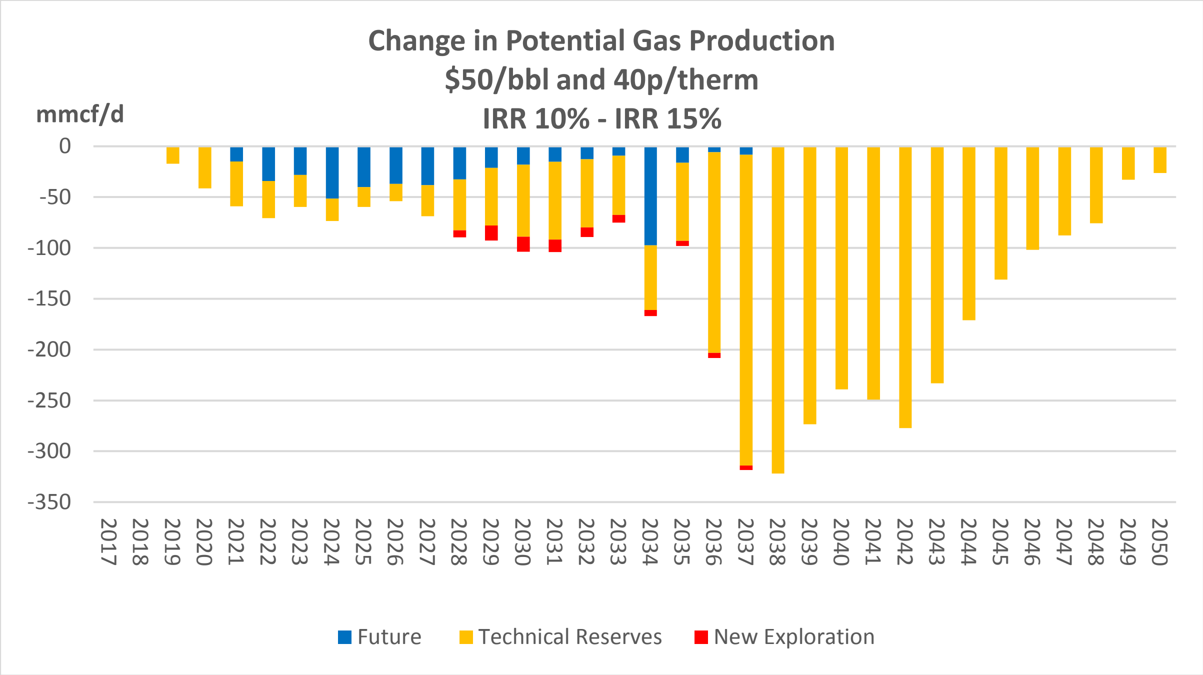


Chart 14 shows the change in gas production that occurs if the hurdle rate changes from IRR at 10% to IRR at 15%. The loss of gas production could amount to 261.5 million barrels of oil equivalent for the period to 2050 with the bulk of the loss coming from technical reserve fields.

Chart 15

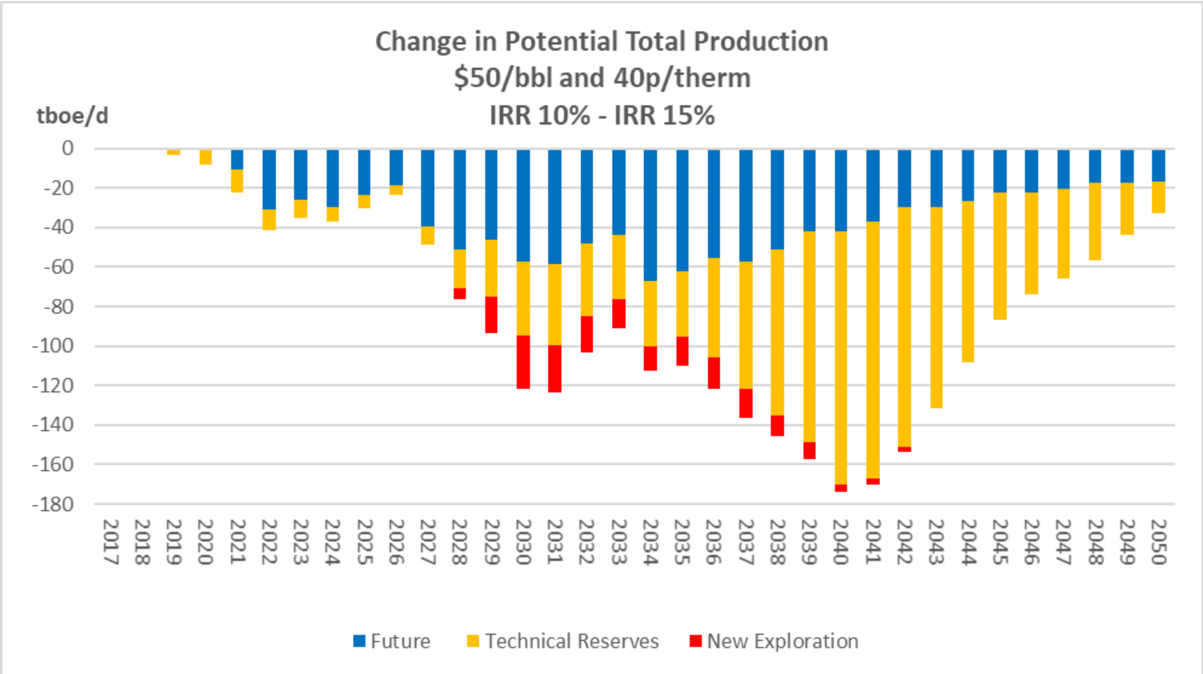


Chart 15 shows the change in total production that occurs if the hurdle rate changes from IRR at 10% to IRR at 15%. The loss of total production could amount to 1 bn boe for the period to 2050 with the bulk of the loss coming from technical reserve fields.

Chart 16

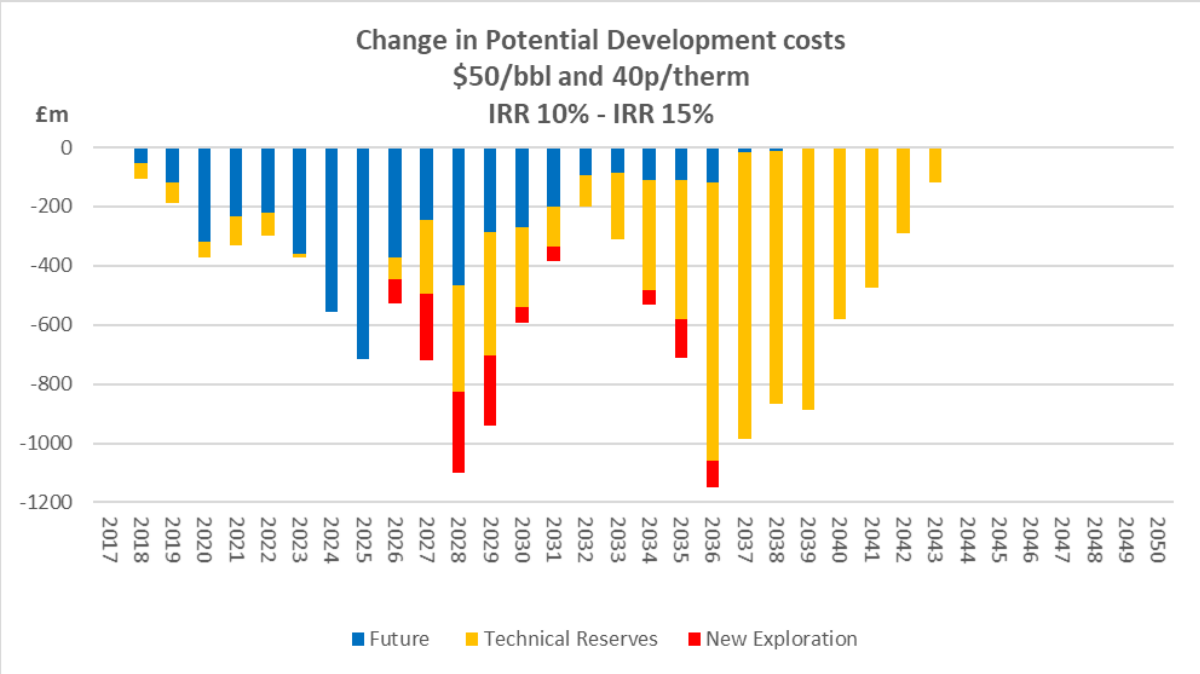


Chart 16 shows the change in development costs that occurs if the hurdle rate changes from IRR at 10% to IRR at 15%. The loss of development costs could amount to £14.3 bn for the period to 2050 with the bulk of the loss coming from technical reserve fields.

Chart 17

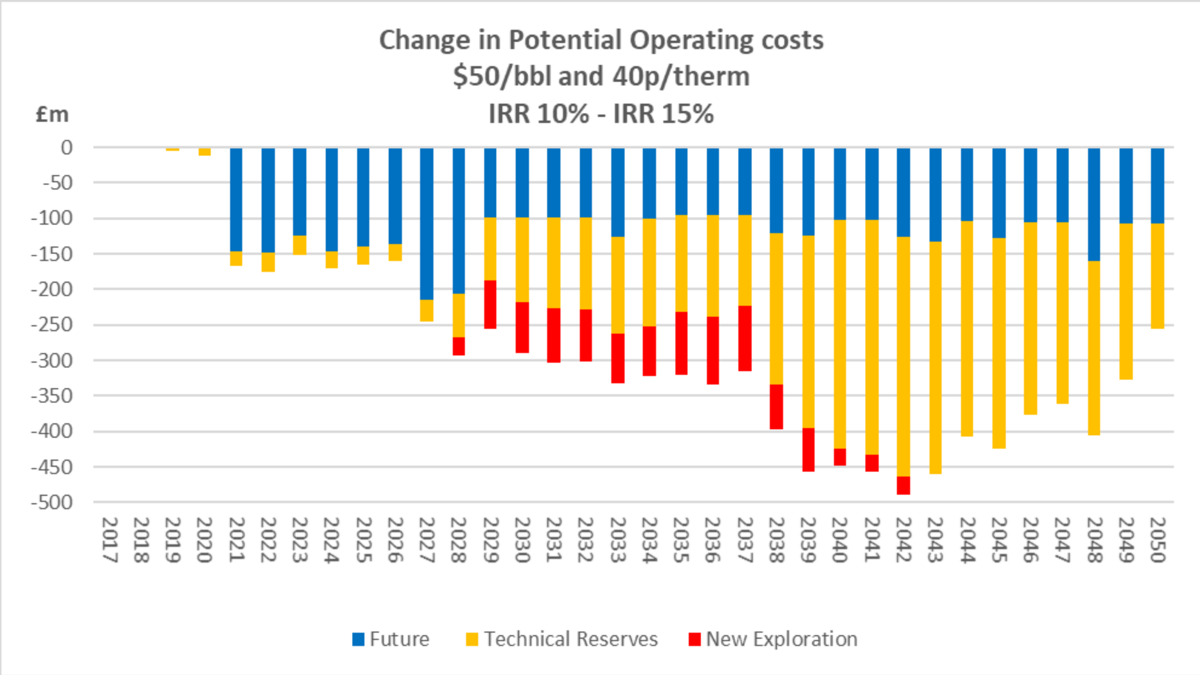


Chart 17 shows the change in operating costs that occurs if the hurdle rate changes from IRR at 10% to IRR at 15%. The loss of operating costs could amount to £9.6 bn for the period to 2050 with the bulk of the loss coming from technical reserve fields.

Chart 18

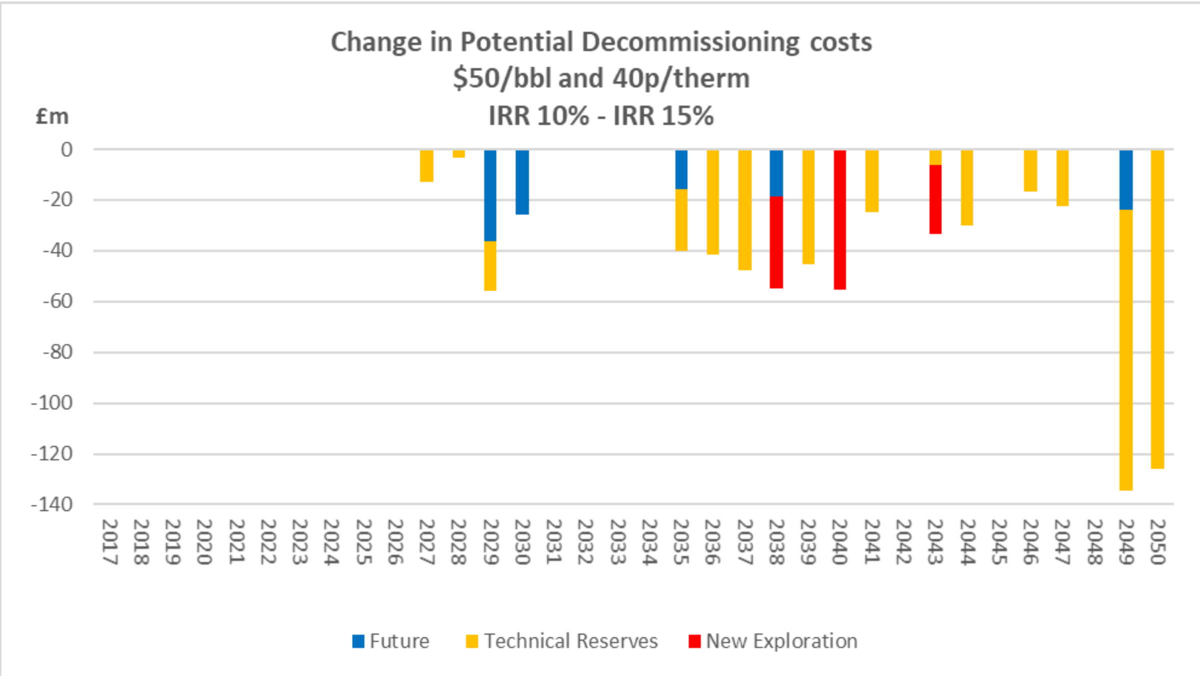


Chart 18 shows the change in decommissioning costs that occurs if the hurdle rate changes from IRR at 10% to IRR at 15%. The loss of decommissioning costs could amount to £770m. for the period to 2050 with the bulk of the loss coming from technical reserve fields.

Chart 19

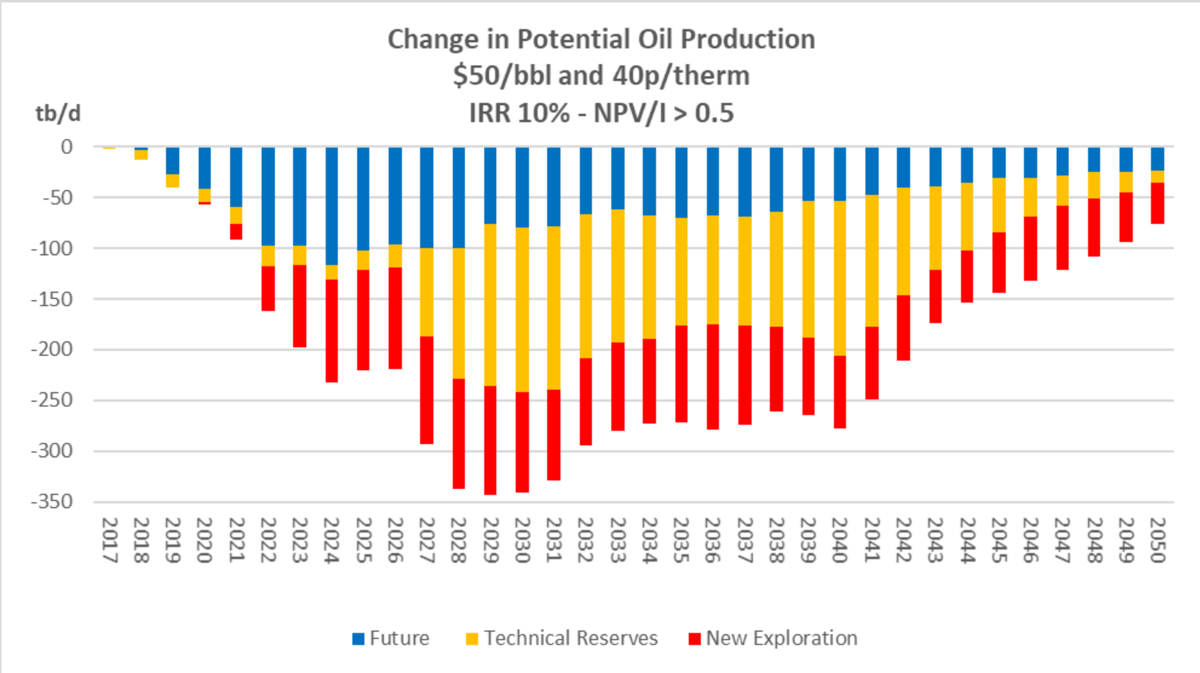


Chart 19 shows the change in oil production that occurs if the hurdle rate changes from IRR at 10% to NPV/I > 0.5. The loss of oil production could amount to 2.5 bn bbls for the period to 2050 with the bulk of the loss coming from new exploration finds.

Chart 20

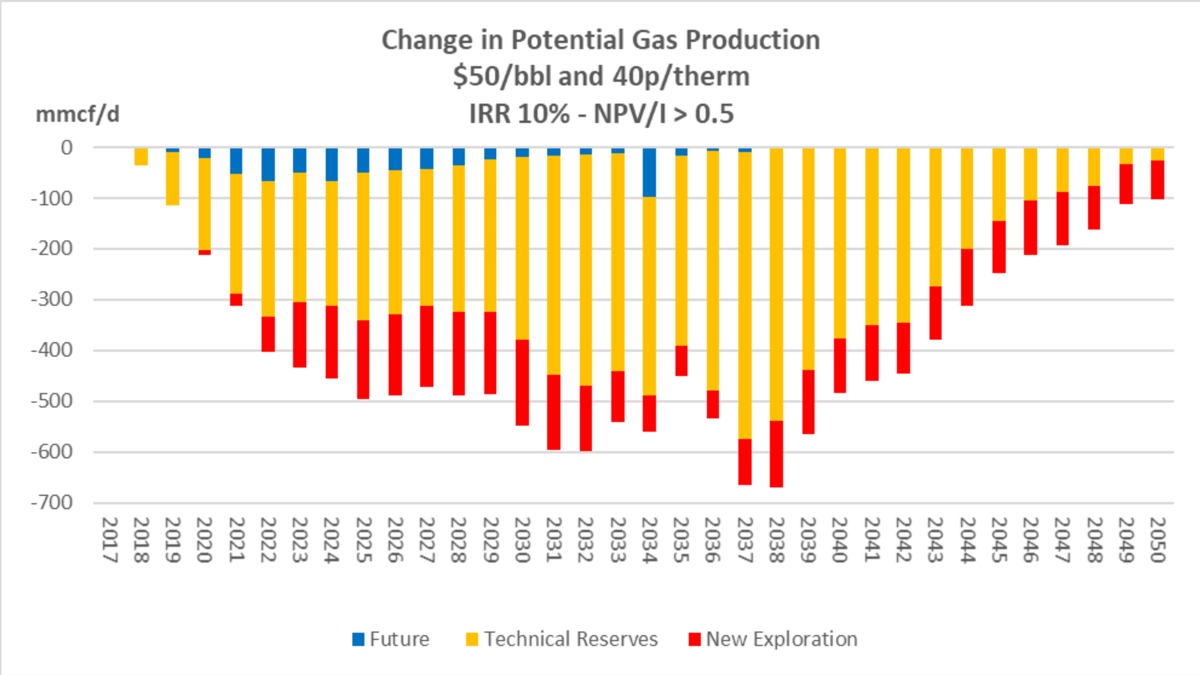


Chart 20 shows the change in gas production that occurs if the hurdle rate changes from IRR 10% to NPV/I > 0.5. The loss of gas production could amoun to 850.5 million barrels of oil equivalent for the period to 2050 with the bulk of the loss coming from technical reserve fields.

Char 21

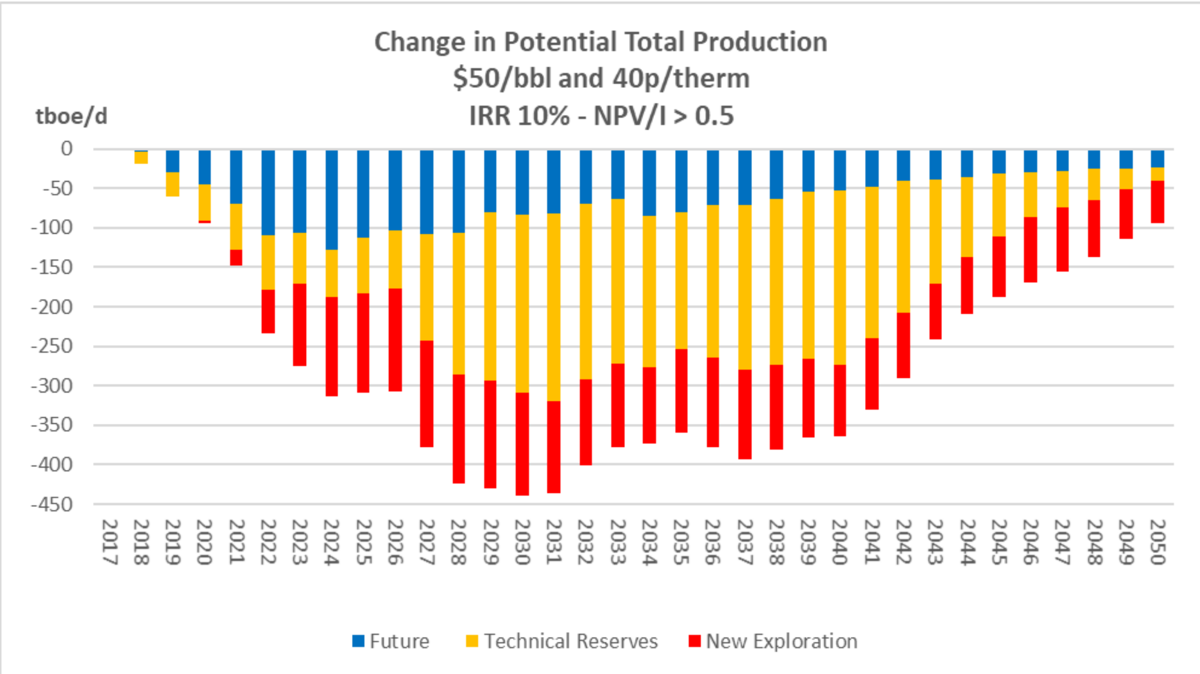


Chart 21 shows the change in total production that occurs if the hurdle rate changes from IRR at 10% to NPV/I > 0.5. The loss of total production could amount to an enoumous 3.35 bn boe for the period to 2050 with the bulk of the loss coming from technical reserve fields.

Chart 22

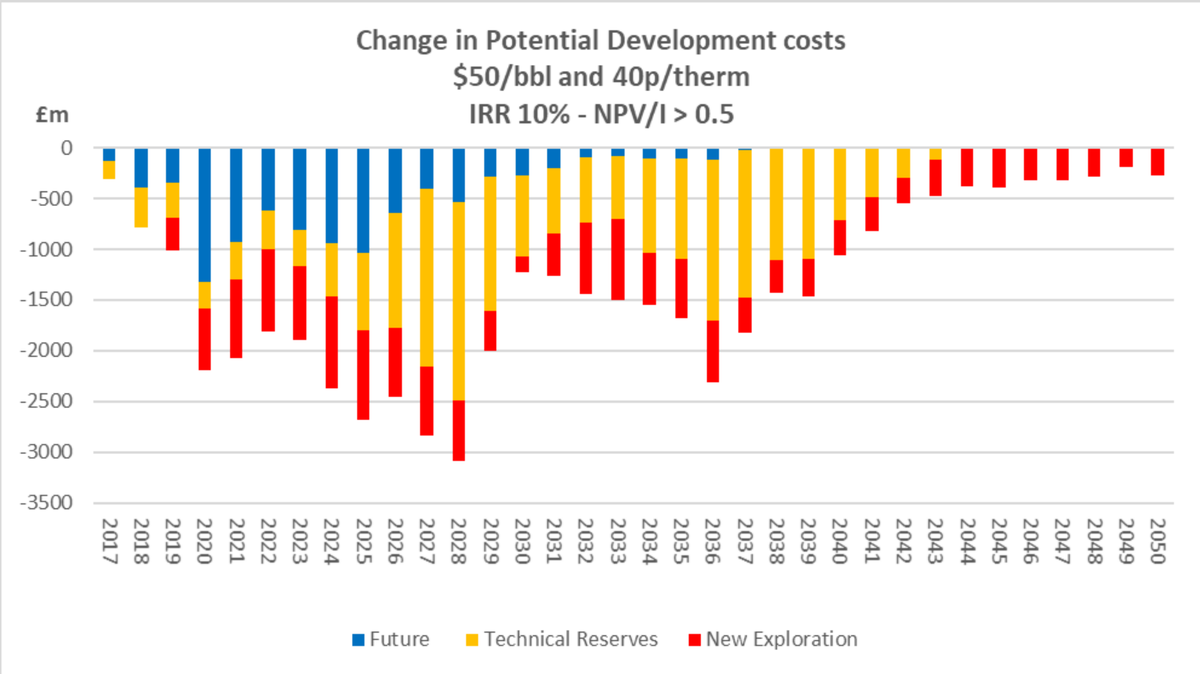


Chart 22 shows the change in development costs that occurs if the hurdle rate changes from IRR 10% to NPV/I > 0.5. The loss of development costs could amount to £46.3 bn for the period to 2050 with the bulk of the loss coming from technical reserve fields.

Chart 23

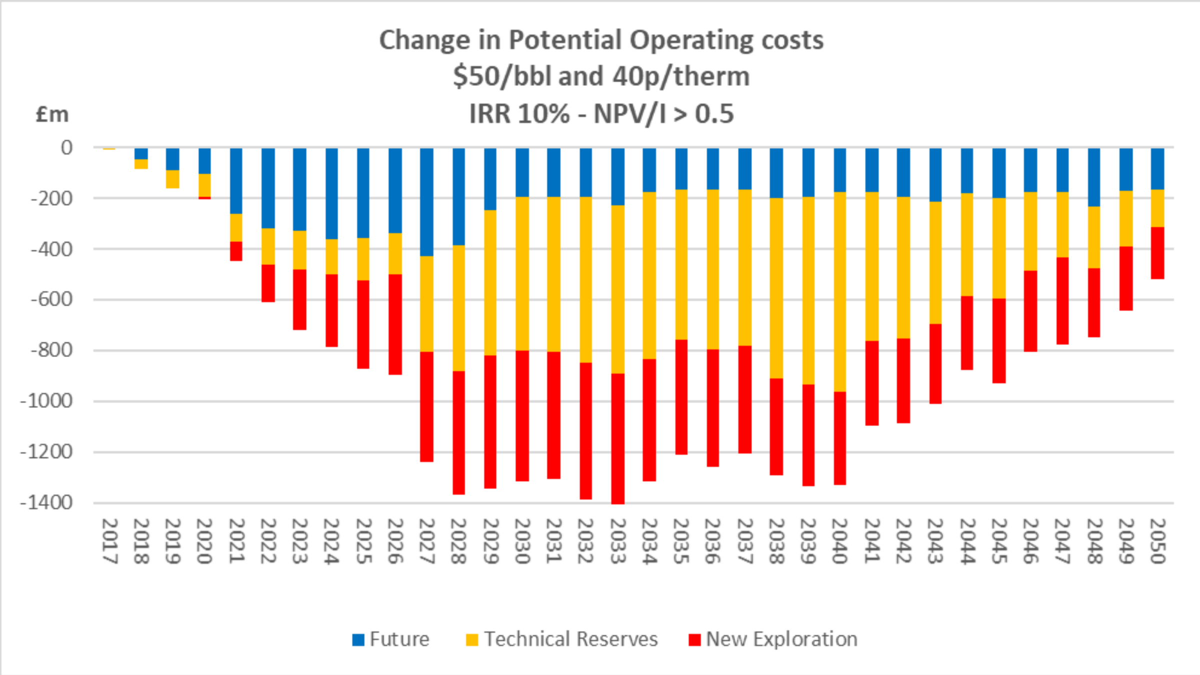


Chart 23 shows the change in operating costs that occurs if the hurdle rate changes from IRR at 10% to NPV/I > 0.5. The loss of operating costs could amount to £31.6 bn for the period to 2050 with the bulk of the loss coming from technical reserve fields closely followed by new exploration finds.

Chart 24

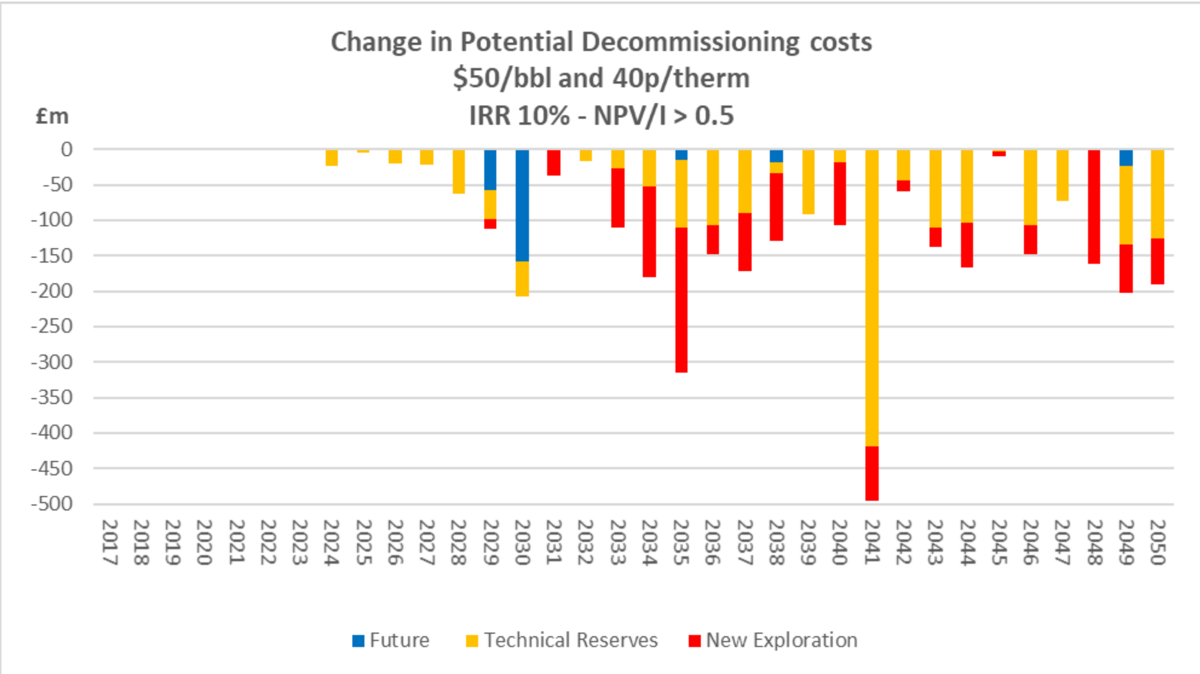


Chart 24 shows the change in decommissioning costs that occurs if the hurdle rate changes from IRR at 10% to NPV/I > 0.5. The loss of decommissioning costs could amount to £3.4 bn for the period to 2050 with the bulk of the loss coming from technical reserve fields.

Chart 25

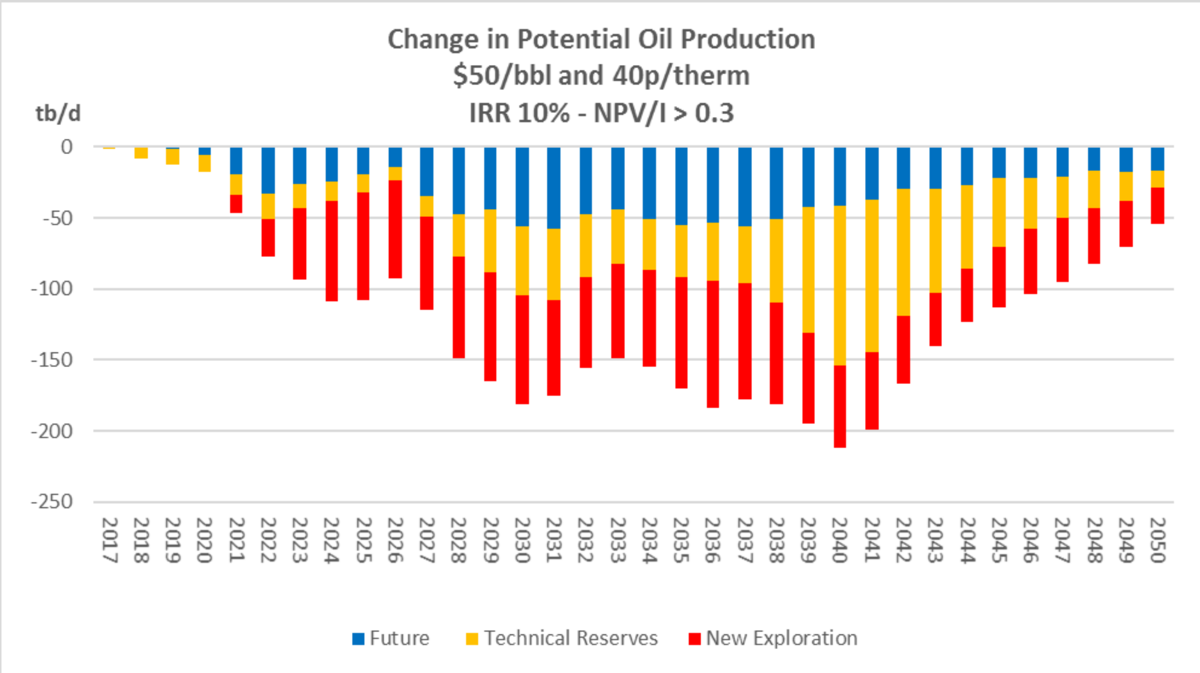


Chart 25 shows the change in oil production that occurs if the hurdle rate changes from IRR at 10% to NPV/I > 0.3. The loss of oil production could amount to 1.5 bn barrels of oil for the period to 2050 with the bulk of the loss coming from new exploration finds.

Chart 26

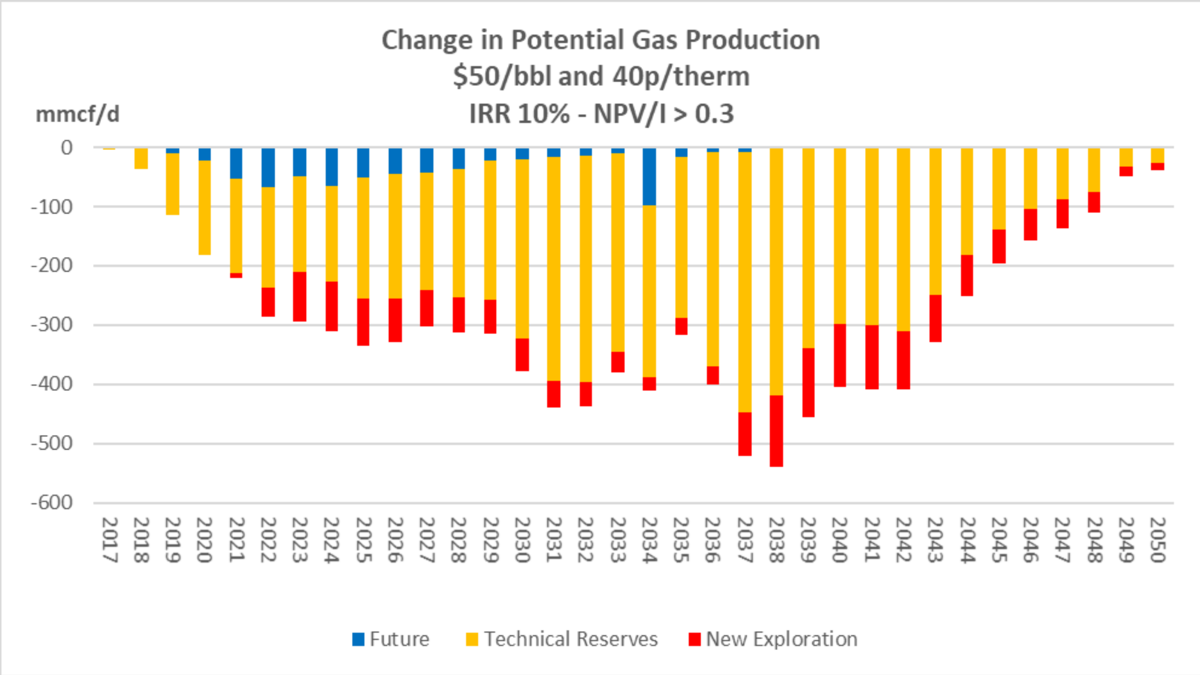


Chart 26 shows the change in gas production that occurs if the hurdle rate changes from IRR @ 10% to NPV/I > 0.3. The loss of gas production could amount to 630.6 million barrels of oil equivalent for the period to 2050 with the bulk of the loss coming from technical reserve fields.

Chart 27

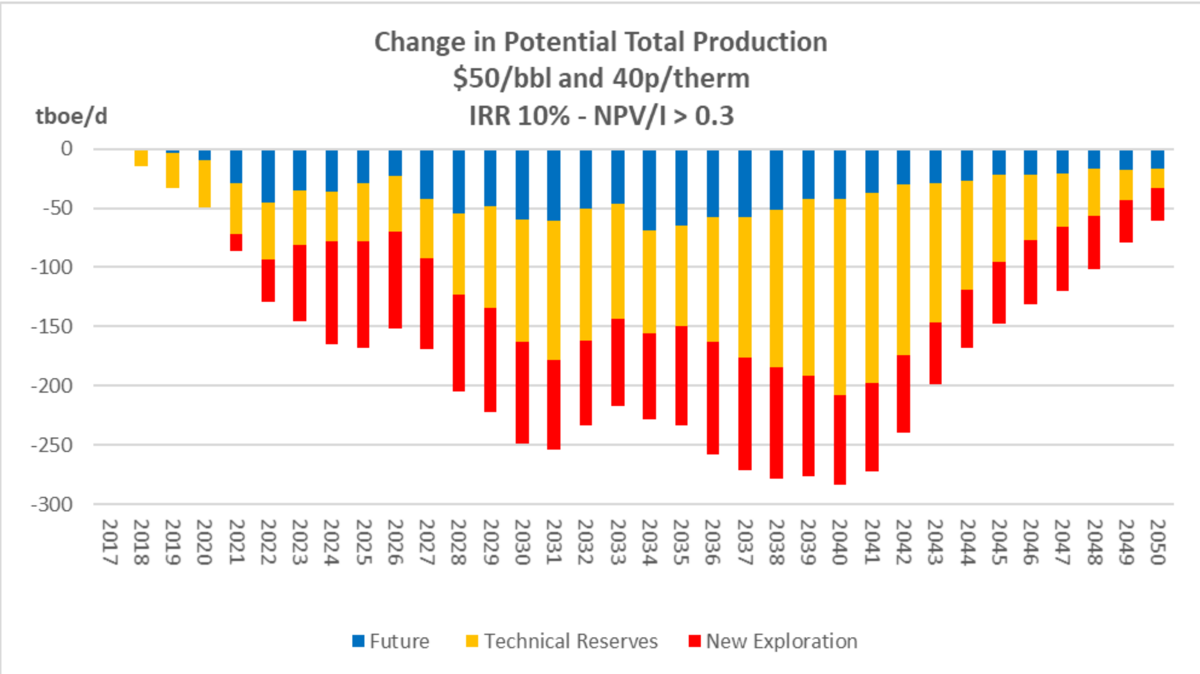


Chart 27 shows the change in total production that occurs if the hurdle rate changes from IRR at 10% to NPV/I > 0.3. The loss of total production could amount to 2.1 bn barrels of oil equivalent for the period to 2050 with the bulk of the loss coming from technical reserve fields.

Chart 28

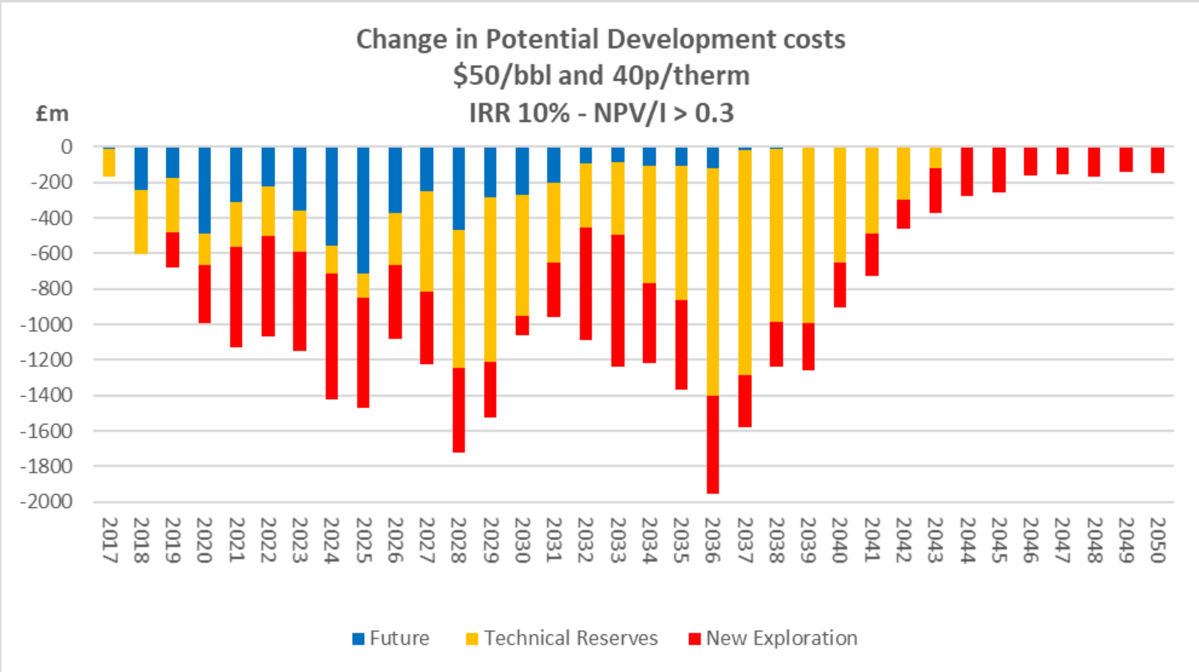


Chart 28 shows the change in development costs that occurs if the hurdle rate changes from IRR at 10% to NPV/I > 0.3. The loss of development costs could amount to £31 bn for the period to 2050 with the bulk of the loss coming from technical reserve fields.

Chart 29

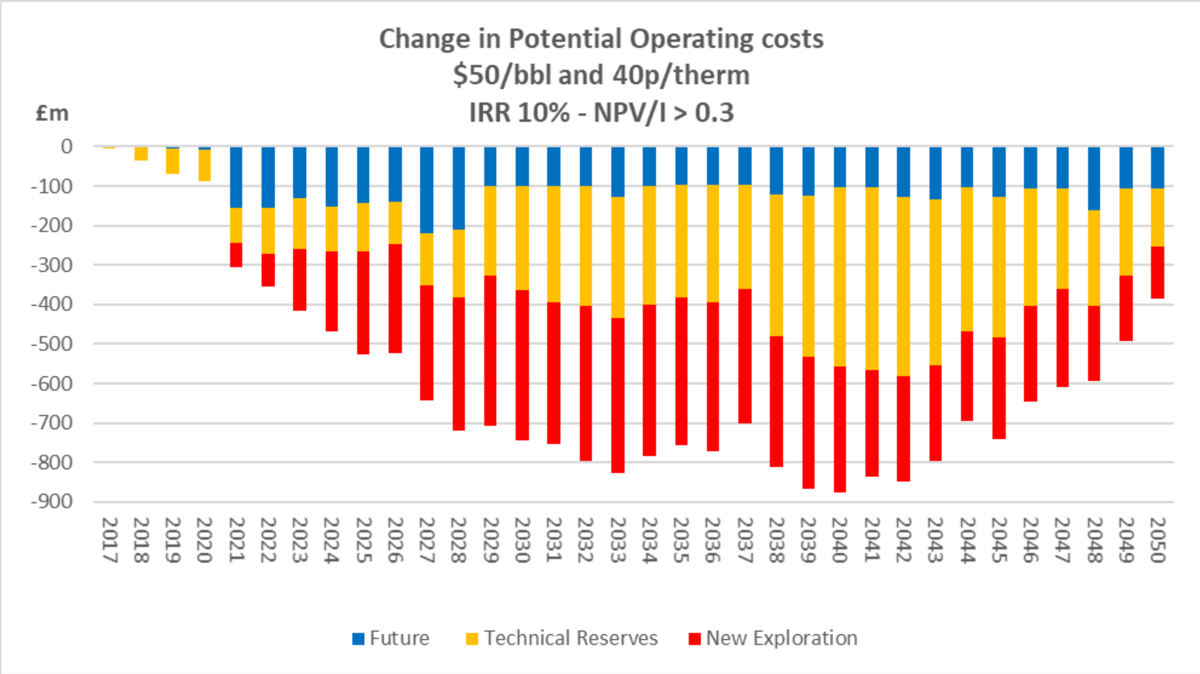


Chart 29 shows the change in operatig costs that occurs if the hurdle rate changes from IRR at 10% to NPV/I > 0.3. The loss of operating costs could amount to £20.2 bn for the period to 2050 with the bulk of the loss coming from new exploration finds.

Chart 30

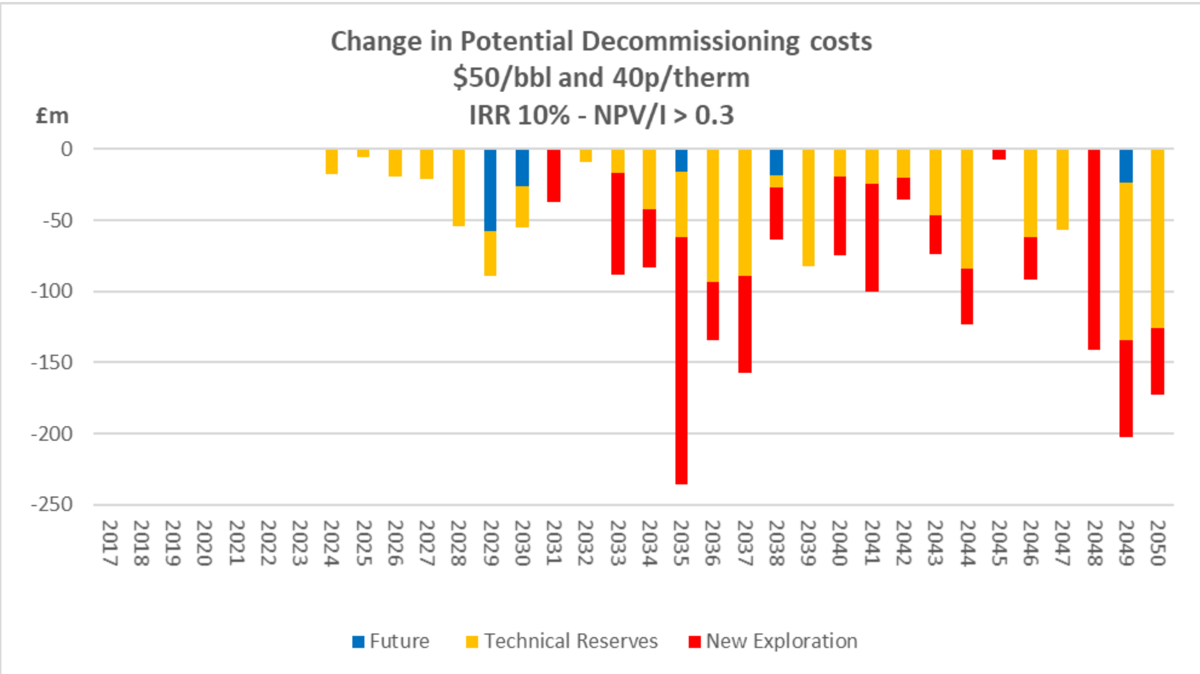


Chart 30 shows the change in decommissioning costs that occurs if the hurdle rate changes from IRR at 10% to NPV/I > 0.3. The loss of decommissioning costs could amount to £2.2 bn for the period to 2050 with the bulk of the loss coming from technical reserve fields.

Chart 31

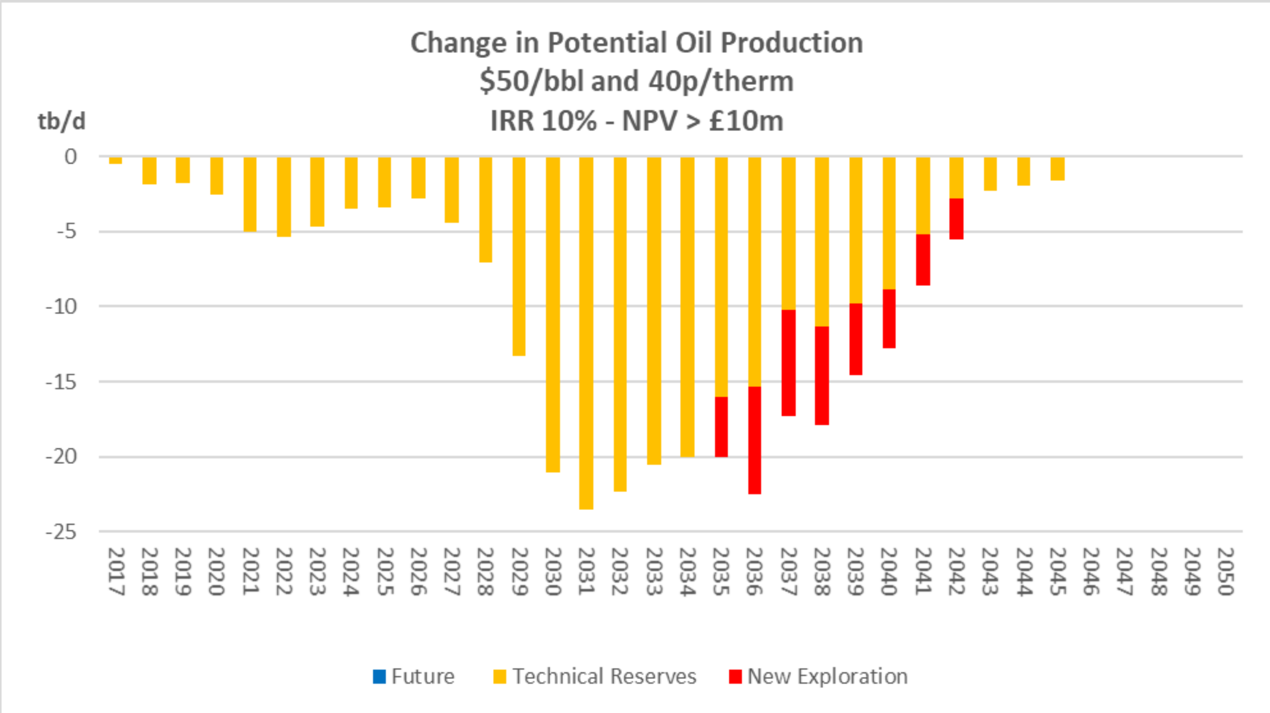


Chart 31 shows the change in oil production that occurs if the hurdle rate changes from IRR at 10% to NPV > £10m. The loss of oil production could amount to 105 million barrels of oil for the period to 2050 with the bulk of the loss coming from technical reserve fields.

Chart 32

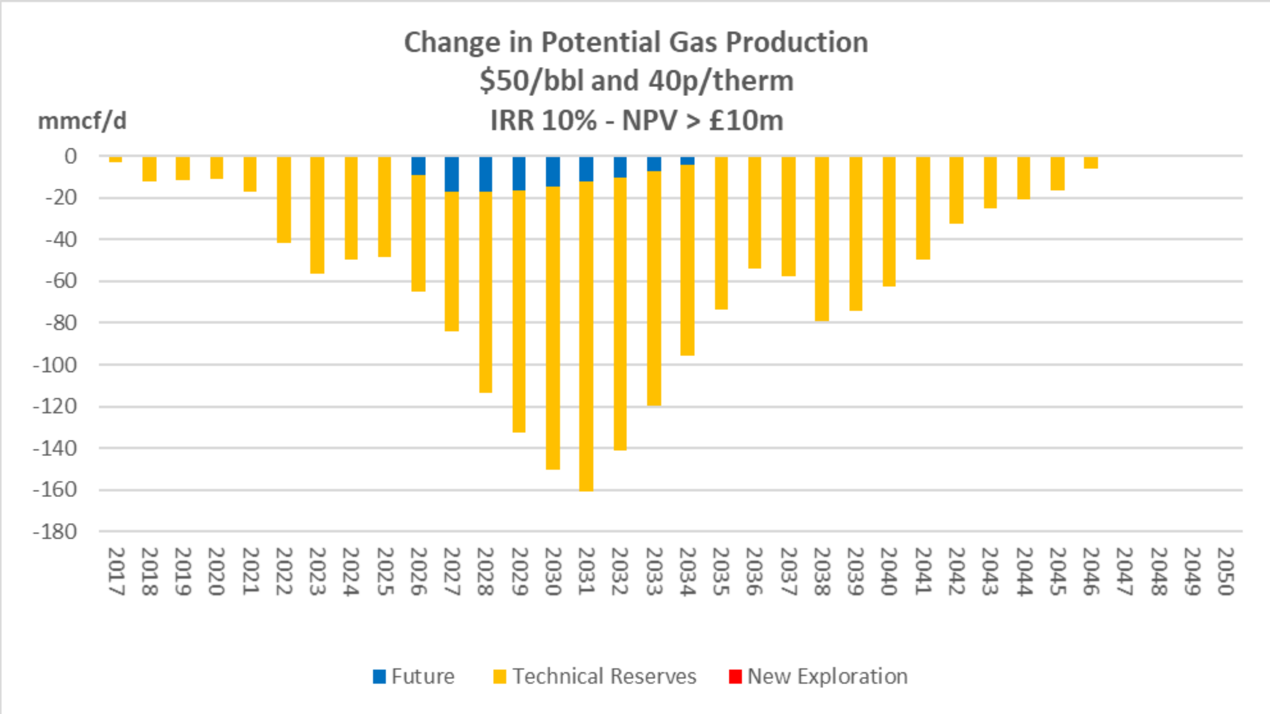


Chart 32 shows the change in gas production that occurs if the hurdle rate changes from IRR at 10% to NPV > £10m. The loss of gas production could amount to 120 million barrels of oil equivalent for the period to 2050 with the bulk of the loss coming from technical reserve fields.

Chart 33

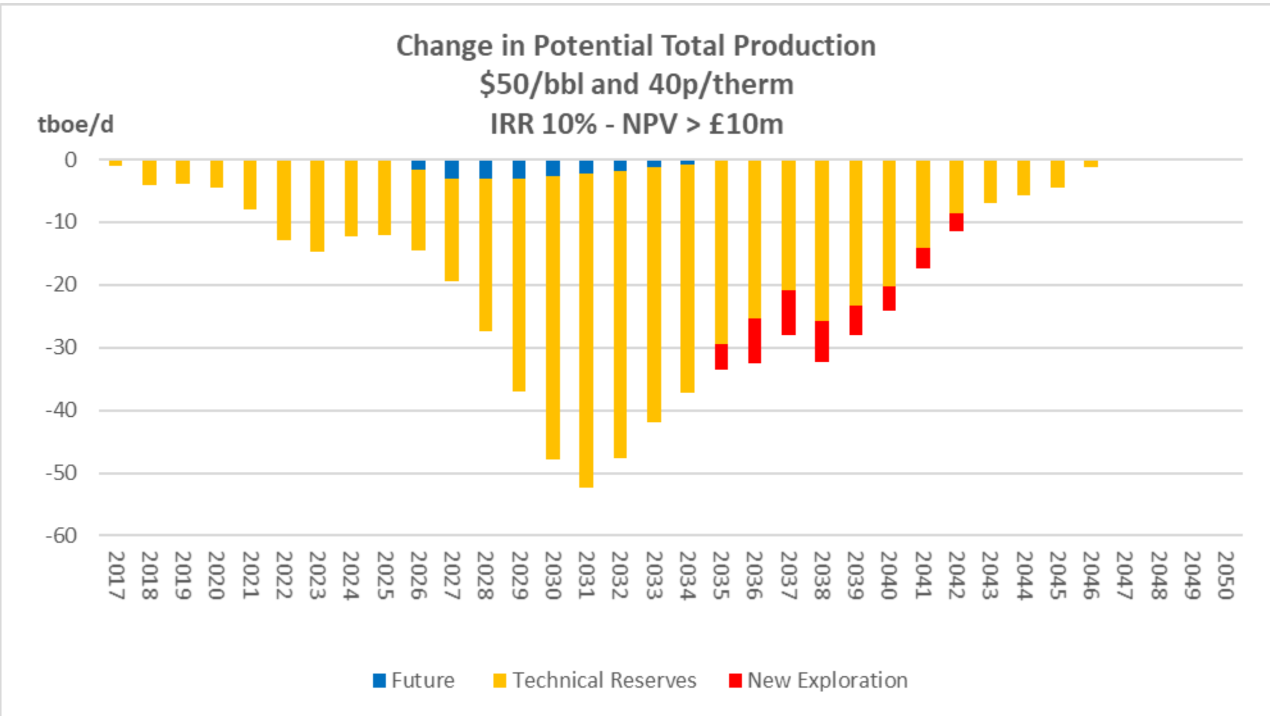


Chart 33 shows the change in total production that occurs if the hurdle rate changes from IRR at 10% to NPV > £10m. The loss of total production could amount to 228 million barrels of oil equivalent for the period to 2050 with the bulk of the loss coming from technical reserve fields.

Chart 34

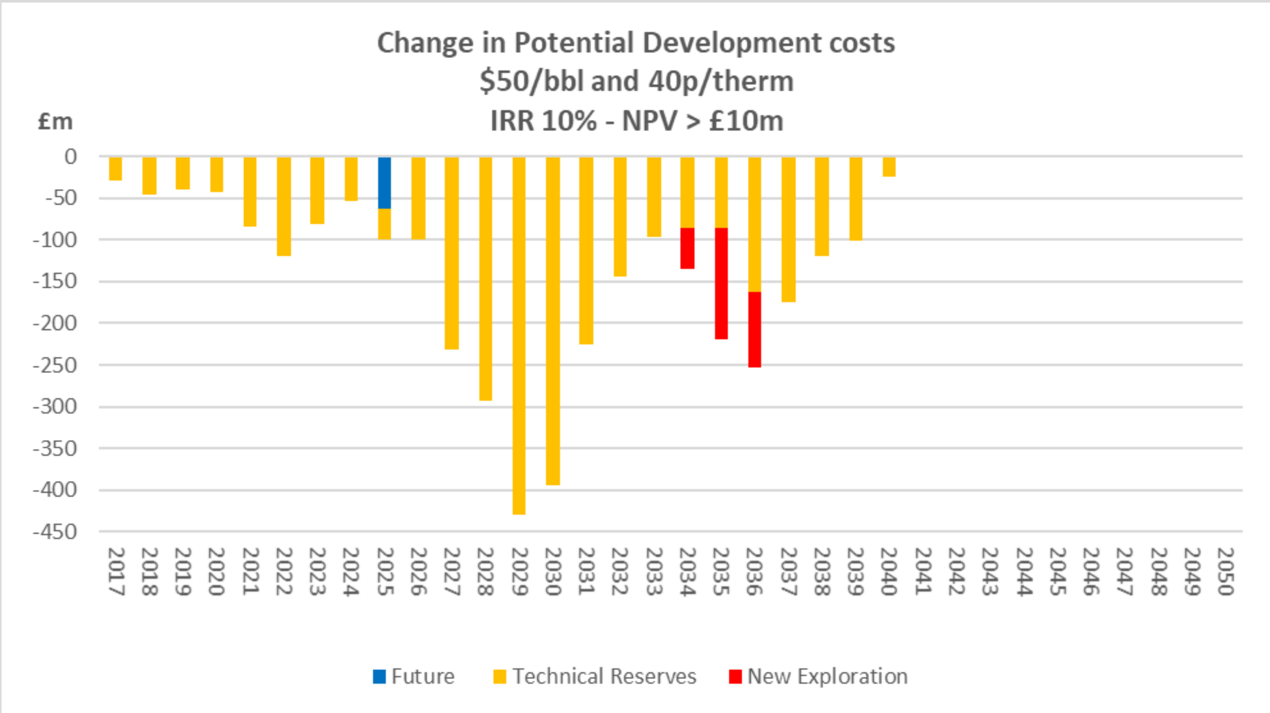


Chart 34 shows the change in development costs that occurs if the hurdle rate changes from IRR at 10% to NPV > £10m. The loss of development costs could amount to £3.5 bn for the period to 2050 with the bulk of the loss coming from technical reserve fields.

Chart 35

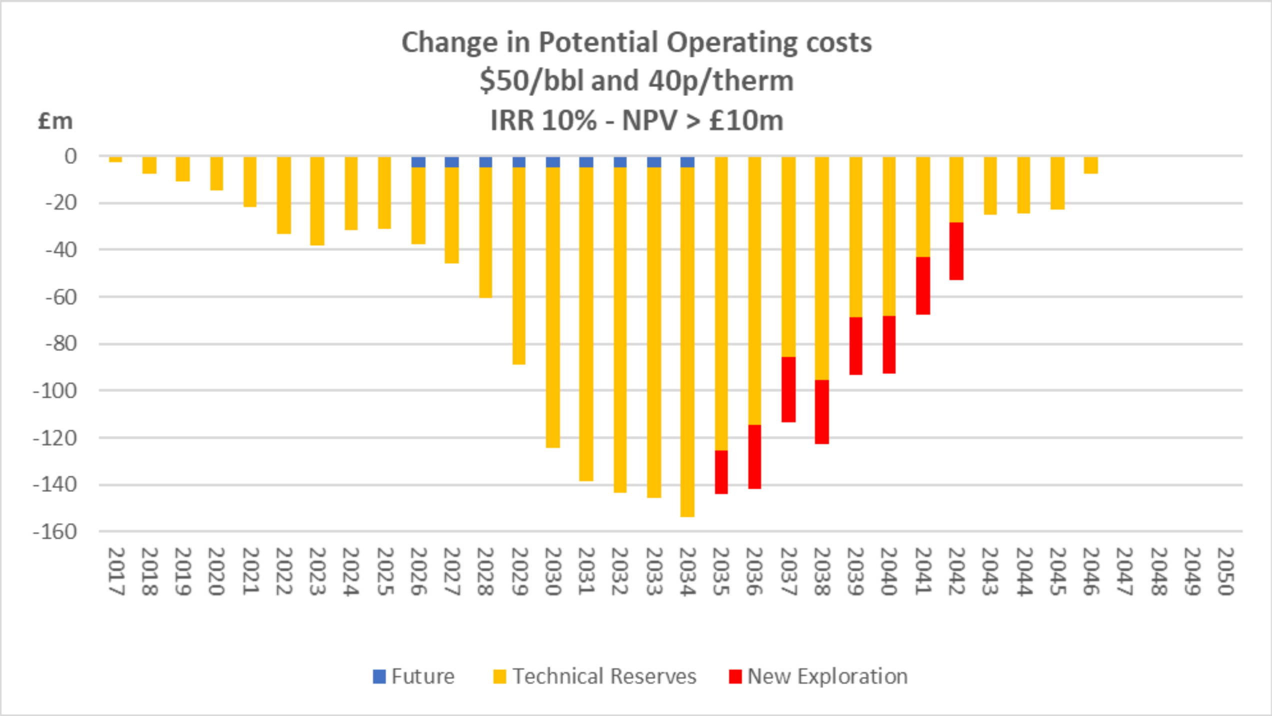


Chart 35 shows the change in operating costs that occurs if the hurdle rate changes from IRR at 10% to NPV > £10m. The loss of operating costs could amount to £2 bn for the period to 2050 with the bulk of the loss coming from technical reserve fields.

Chart 36

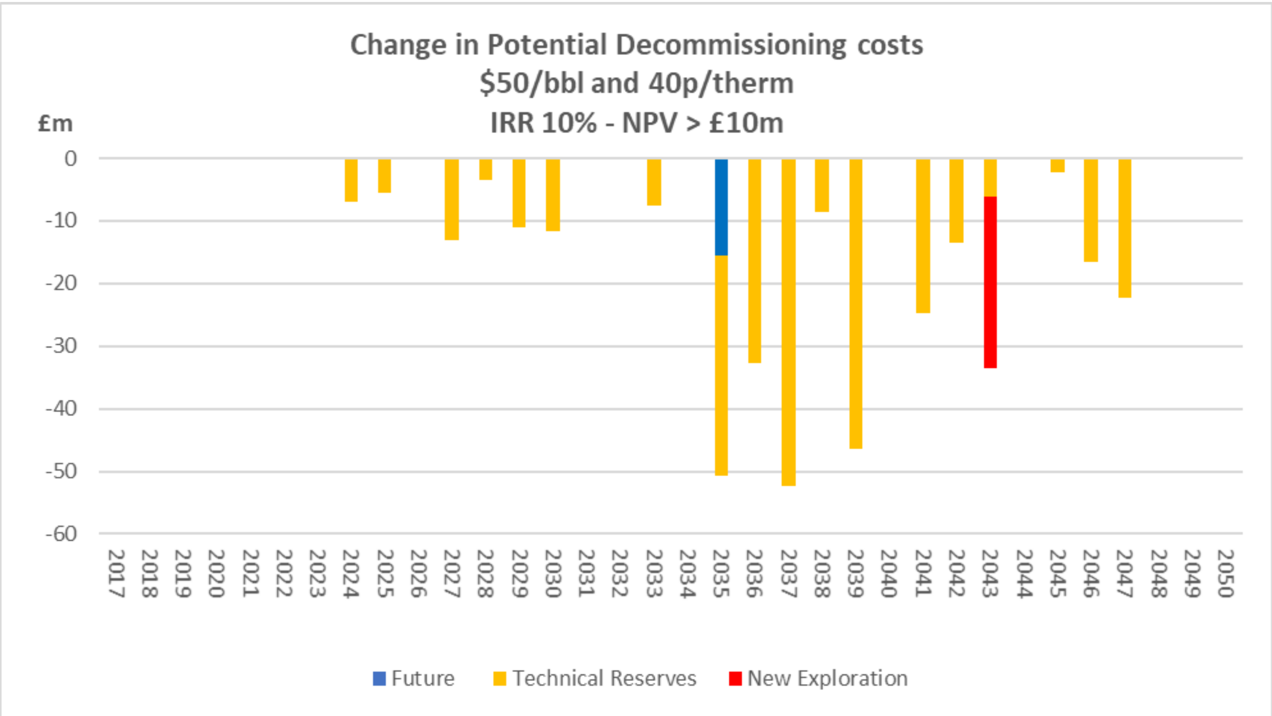


Chart 36 shows the change in decommissioning costs that occurs if the hurdle rate changes from IRR at 10% to NPV/I > £10m. The loss of decommissioning costs could amount to £363m for the period to 2050 with the bulk of the loss coming from technical reserve fields.

b) $60, 50 pence case

There are 14 Probable fields, 14 Possible fields, 249 Technical Reserves and 117 New Exploration finds.

Table 8

Numbers of Fields Passing/Failing Specified Hurdles

$60, 50 pence	NPV/I > 0.3		NPV/I > 0.5		IRR ≥ 10%		IRR ≥ 15%	
	Pass	Fail	Pass	Fail	Pass	Fail	Pass	Fail
Probable	7	7	4	10	13	1	11	3
Possible	7	7	5	9	12	2	10	4
Technical Reserves	104	145	60	189	184	65	161	88
New Exploration	93	24	69	48	115	2	109	8
	211	**183**	**138**	**256**	**324**	**70**	**291**	**103**

$60, 50 pence	Pre-tax Cashflow > £0		Pre-tax NPV @ 10% ≥ £0		Post-tax NPV > £10m.	
	Pass	Fail	Pass	Fail	Pass	Fail
Probable	14	0	13	1	13	1
Possible	13	1	12	2	11	3
Technical Reserves	229	20	184	65	160	89
New Exploration	117	0	115	2	114	3
	373	**21**	**324**	**70**	**298**	**96**

From Table 8 it is seen that with the 10% IRR hurdle 324 fields pass and 70 fail. Compared to the $50, 40 pence case (Table 6) there is a substantial increase in the number of passes in all categories of fields. The increase is particularly noticeable with the technical reserves where there are 184 passes at the $60, 50 pence price and 118 at the $50, 40 pence case. The proportion of passes for fields in the probable and possible categories increases dramatically, though the absolute numbers are quite small. The passes in the new discoveries category increase both absolutely and relatively. The absolute number of discoveries increases to 127 from 97 at the lower price reflecting the higher exploration effort at the $60 price.

With 15% IRR as investment hurdle the number of passes is still relatively high at 291 compared to 181 at the $50 price. The majority of the fields in the probable and possible categories pass this hurdle. In the category of technical reserves there is a dramatic increase in passes from 96 to 161 fields, and a major increase in passes from 75 to 109 fields in the category of future discoveries.

When materiality of returns was taken into account it was found that 298 fields obtained an NPV@10% exceeding £10m. This compares with 171 fields at the $50 price. In the technical reserves category there is a dramatic increase in the numbers of passes from 81 at the $50 price to 160 at the $60 price. The great majority of fields in the probable and possible categories pass this hurdle at the $60 price. Also, 104 fields in the category of future discoveries now pass this hurdle compared to 77 at the $50 price.

With the hurdle of NPV/I > 0.3 it is seen from Table 8 that 211 fields pass at the $60 price compared to 103 at the $50 price. It is seen that 104 fields in the category of technical reserves pass at the $60 price compared to 51 at the $50 price. It is also noticeable, however, that 145 fields in this category fail this hurdle at the $60 price. Also, 50% of the fields in the categories of probable and possible fields fail this hurdle at the $60 price. The great majority of fields in the future discoveries class do pass the hurdle at the $60 price.

With the extremely demanding investment hurdle of NPV/I > 0.5 138 fields pass and 256 fail. This is a significant improvement compared to the $50 price case, but in current circumstances it is clear that the great majority of fields in the category of technical reserves are unable to pass this extremely demanding hurdle.

Table 9

Numbers of Fields Passing Hurdles

Pass	NPV/I > 0.3	NPV/I > 0.5	IRR 10%	IRR 15%	Real Pre-tax Cashflow > £0	Real Pre-tax NPV@10% > £0	Real Post-tax NPV@10% > £10m.
NNS	37	23	67	60	84	67	58
SNS	68	44	98	91	107	98	90
WoS	29	18	41	35	45	41	39
IS	2	1	5	4	9	5	4
CNS/MF	75	52	113	101	128	113	107
	211	**138**	**324**	**291**	**373**	**324**	**298**

In Table 9 the numbers of fields passing with the $60, 50 pence price case are shown by main geographic areas of the UKCS. At the lowest hurdle of 10% IRR there are 113 passes in the CNS/MF region compared to 78 at the $50 price. In the NNS there are 67 passes compared to 34 at the $50 price. In the SNS there are 98 passes compared to 68 at the $50 price. In the W of S region there are 41 passes compared to 28 at the $50 price.

With a hurdle of 15% IRR there are 291 passes in total at the $60 price compared to 181 at $50. In the CNS/MF there are 101 passes compared to 63 at the $50 price. In the NNS the number of passes becomes 60 at the $60 price compared to 31 at the $50 case.

When materiality of returns is taken into account and the hurdle is minimum NPV of £10m. the total number of passes becomes 298 at the $60, 50 pence price compared to 171 at the $50, 40 pence price. In the SNS the number of passes becomes 90 compared to 49 at the $50, 40 pence case. Given that there are many small discoveries in the SNS this is an encouraging finding with gas prices at 50 pence.

With the hurdle at NPV/I > 0.3 there are 211 passes at the $60, 50 pence case compared to 103 at the $50, 40 pence scenario. There are 75 passes in the CNS/MF compared to 38 at the $50 price. In the NNS there are 37 passes at the $60 price compared to only 17 at the $50 case. Interestingly, 68 fields in the SNS pass this hurdle at the 50 pence price compared to only 34 at the 40 pence case. In the W of S region the number of passes more than doubles from 13 to 29 at the $60 price.

With the very demanding hurdle of NPV/I > 0.5 138 fields pass at the $60 price compared to only 45 at the $50 price. There is a major increase in the number of passes in all 4 main geographic areas. In the CNS/MF the number becomes 52 compared to 15 at the lower price. In the SNS the number of passes increase from 13 to 44. In the NNS the increase is from 10 to 23. In the W of S region the increase is from 7 to 18.

Chart 37

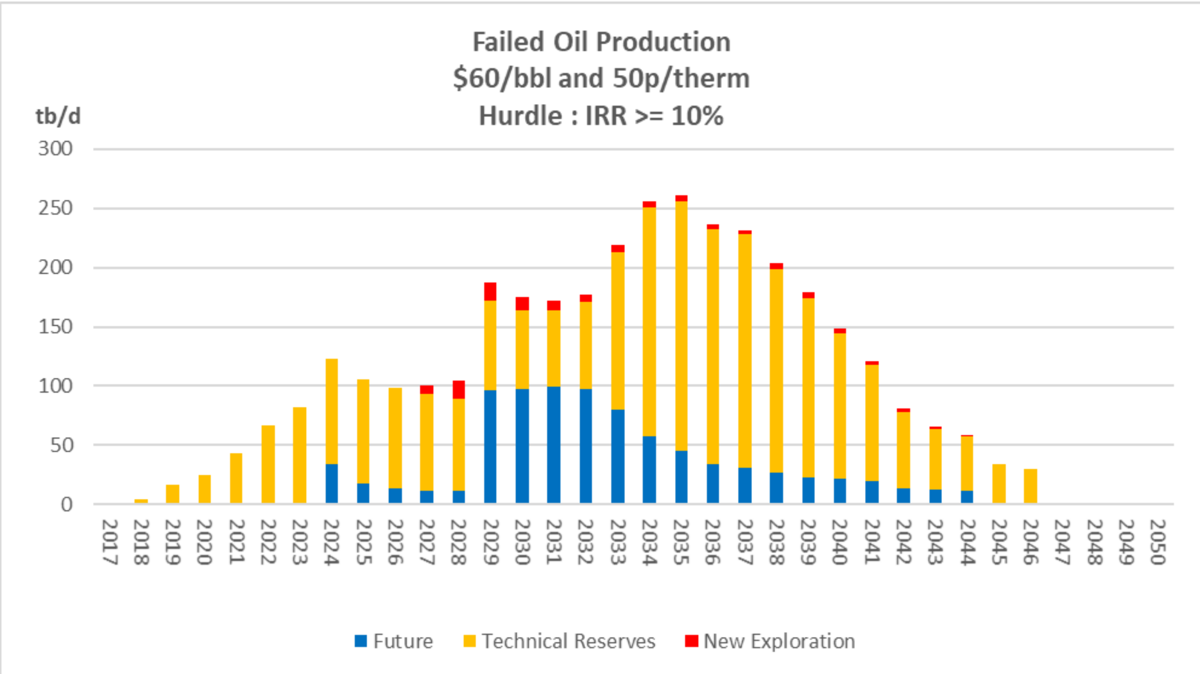


Chart 37 shows the oil production that could have been achieved from the fields which failed the IRR at 10% hurdle. For the period to 2050 the loss of oil production could amount to 1.3 bn barrels of oil.

Chart 38

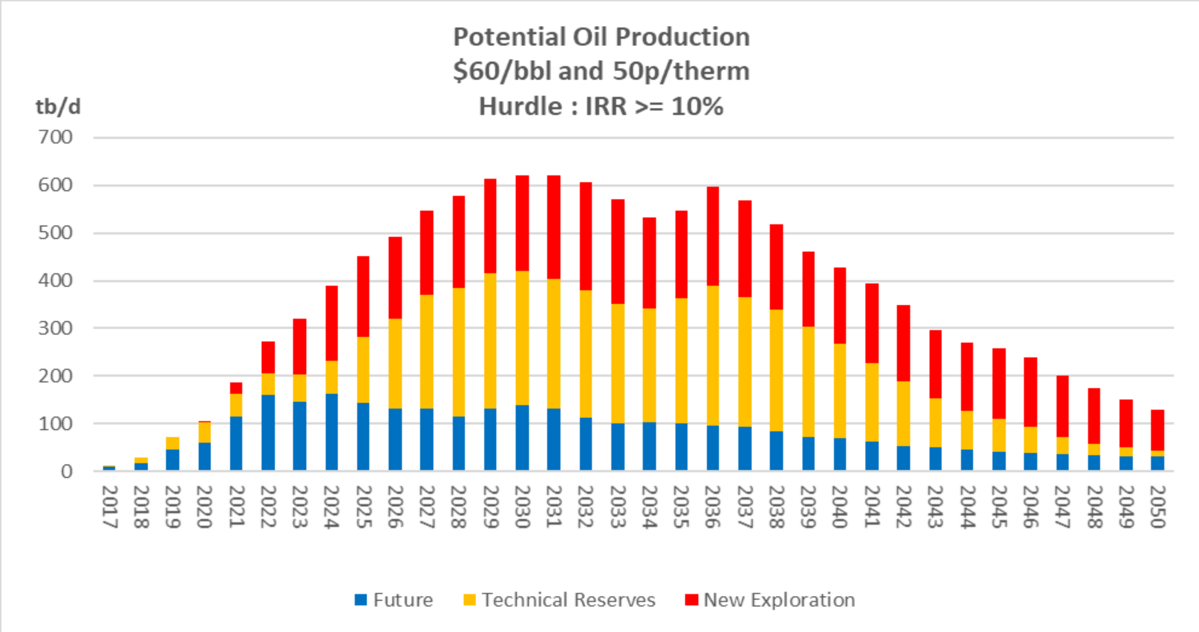


Chart 38 shows the potential oil production from the fields which pass the IRR at 10% hurdle. Oil production could amount to 4.6 bn barrels of oil for the period to 2050 with the bulk of this coming from new exploration finds closely followed by the technical reserve fields.

Chart 39

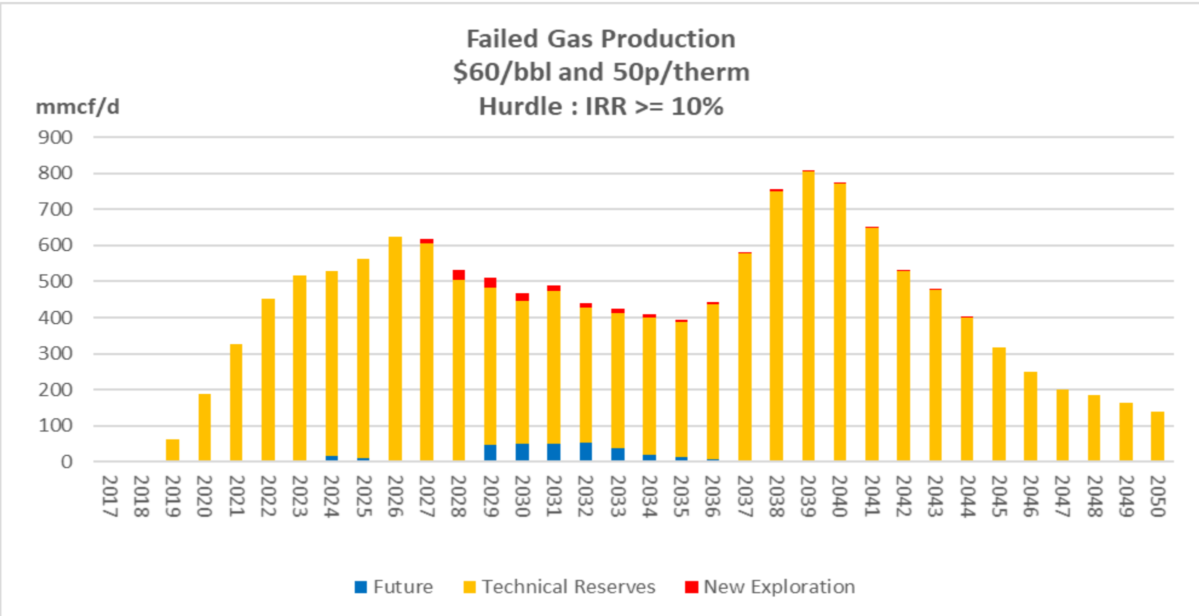


Chart 39 shows the gas production that could have been achieved from the fields which failed the IRR at 10% hurdle. For the period to 2050 the loss of gas production could amount to 913.5 million barrels of oil equivalent.

Chart 40

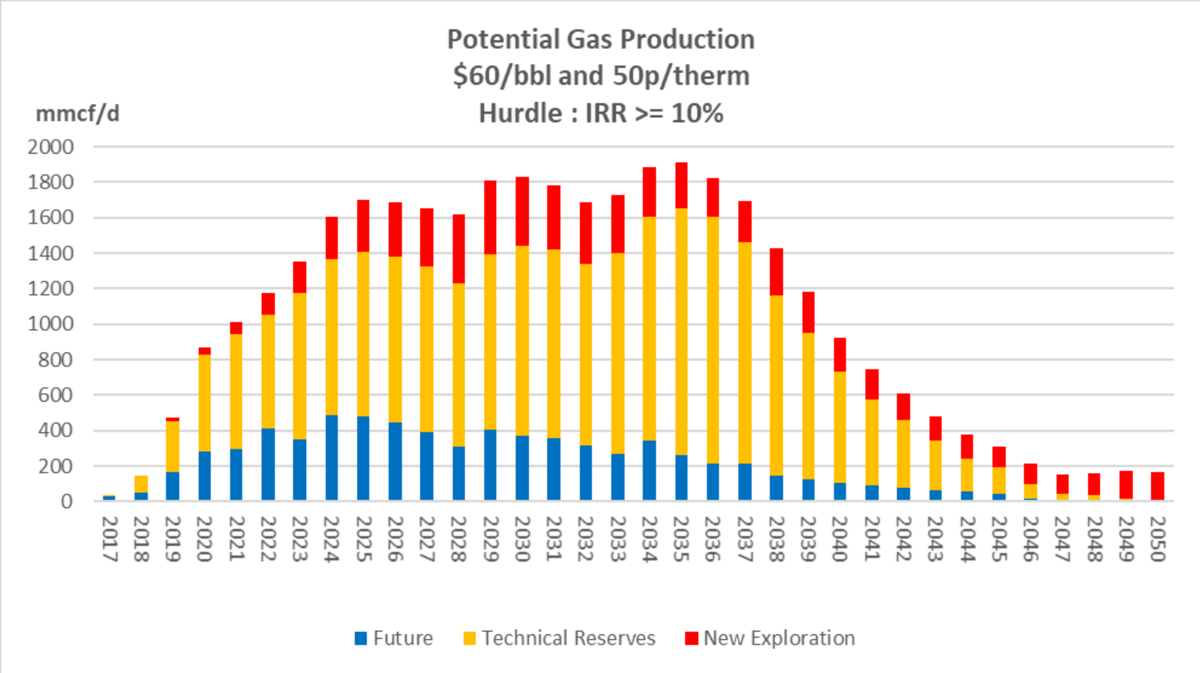


Chart 40 shows the potential gas production from the fields which pass the IRR at 10% hurdle. Gas production could amount to 2.3 bn barrels of oil equivalent for the period to 2050 with the bulk of this coming from technical reserve fields.

Chart 41

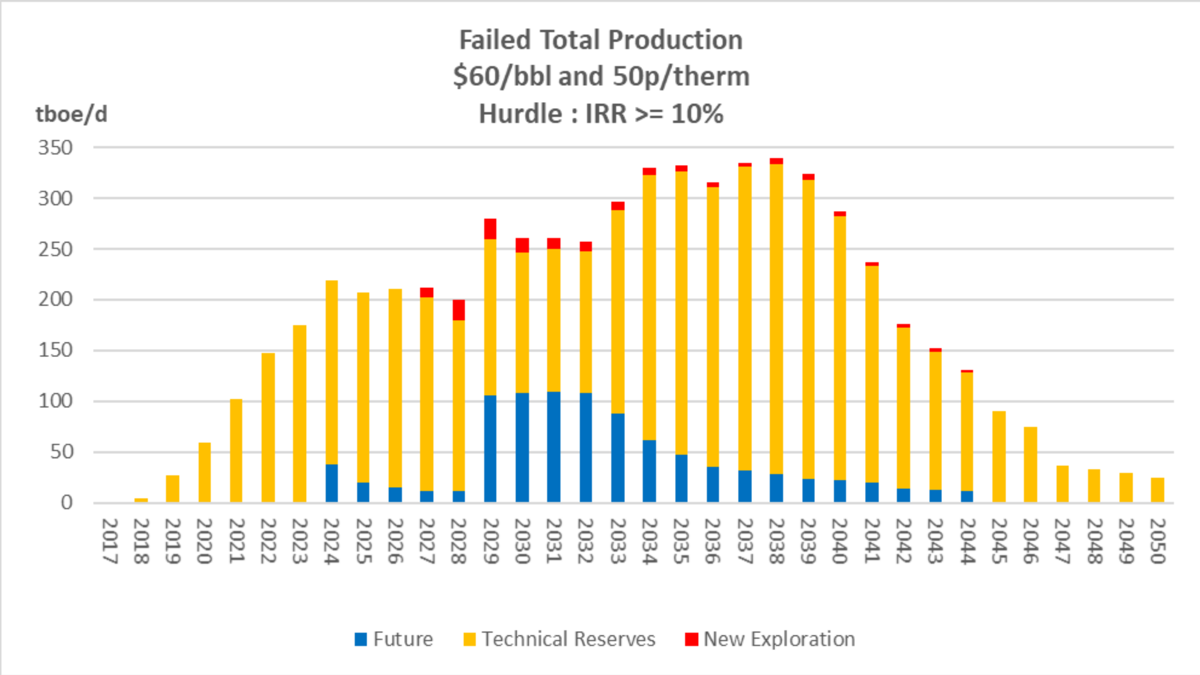


Chart 41 shows the total potential production that could have been achieved from the fields which failed the IRR at 10% hurdle. For the period to 2050 the loss of potential total production could amount to 2.25 bn barrels of oil equivalent.

Chart 42

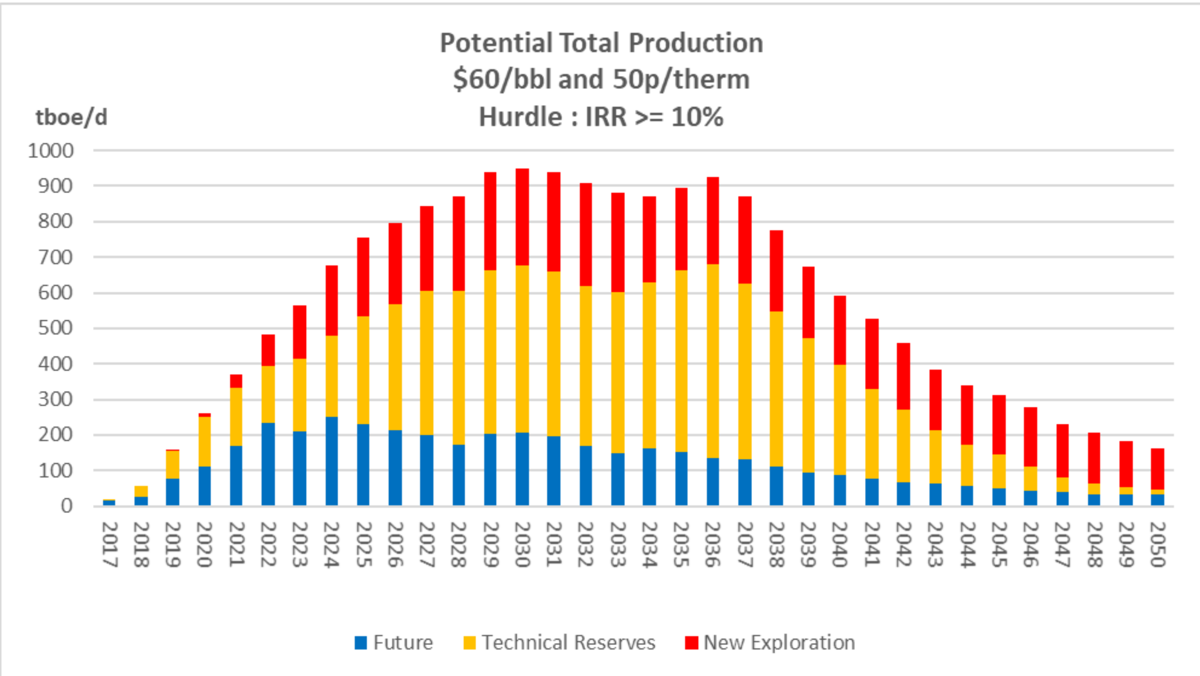


Chart 42 shows the potential total production from the fields which pass the IRR at 10% hurdle. Total production could amount to 7 bn barrels of oil equivalent for the period to 2050 with the bulk of this coming from technical reserve fields.

Chart 43

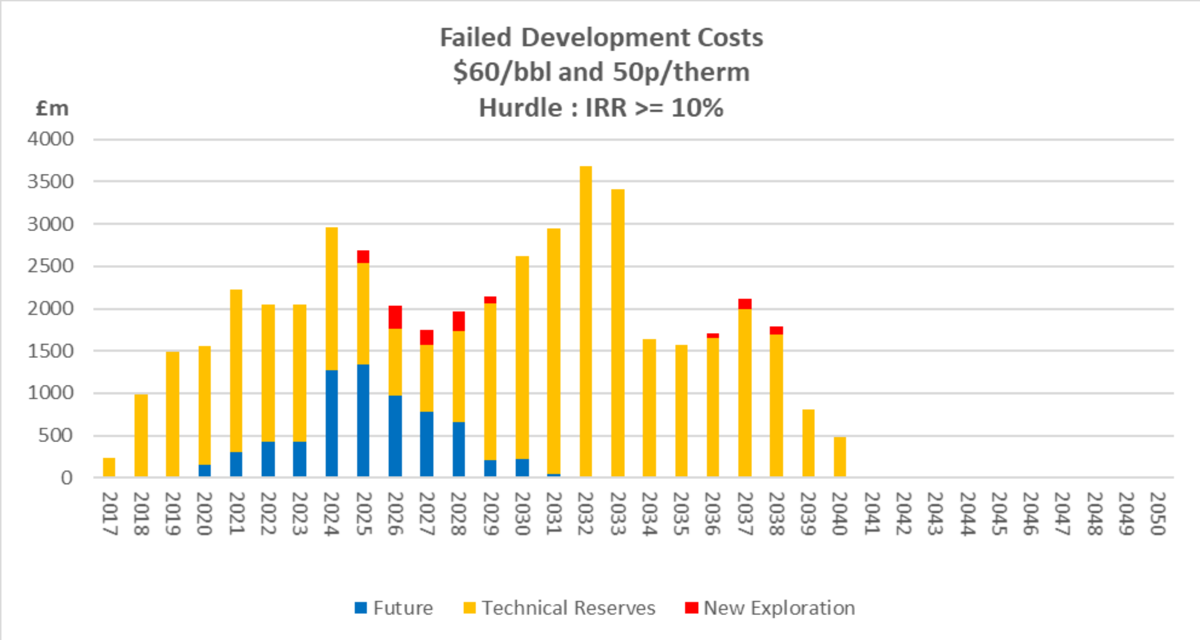


Chart 43 shows the potential development costs from the fields which fail the IRR at 10% hurdle. The loss of development costs could amount to £46.9 billion for the period to 2050 with the bulk coming from technical reserve fields.

Chart 44

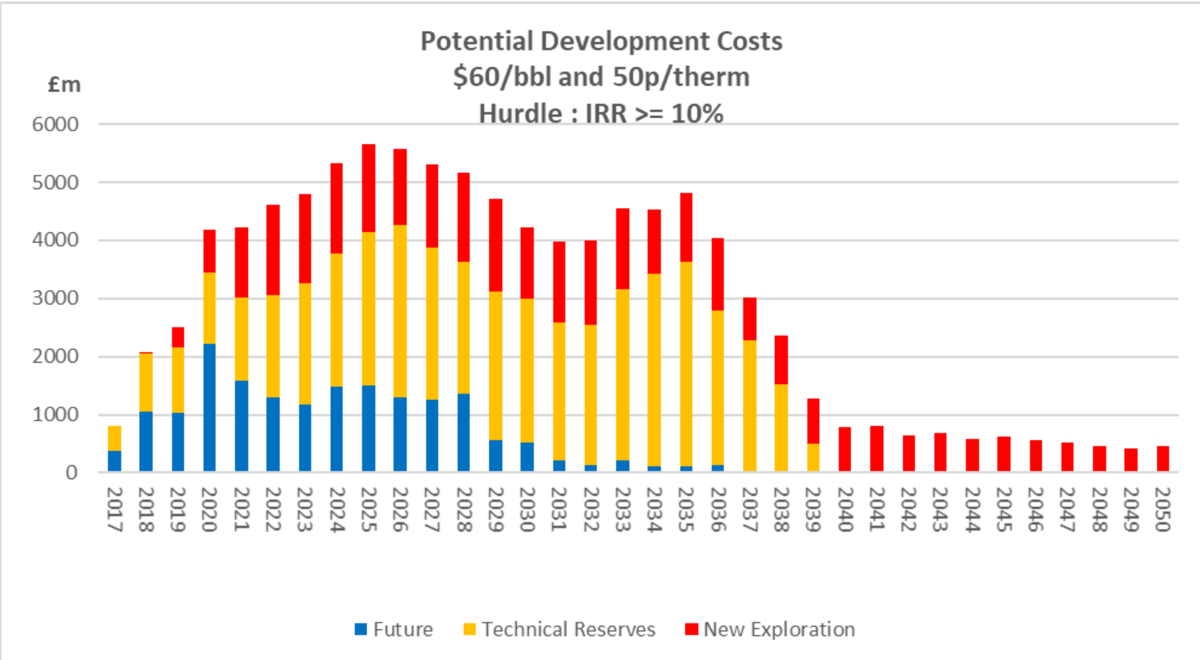


Chart 44 shows the potential development costs from the fields which pass the IRR at 10% hurdle. The potential development costs for fields passing the IRR 10% hurdle could amount to £98.207 billion with most coming from the technical reserve fields.

Chart 45

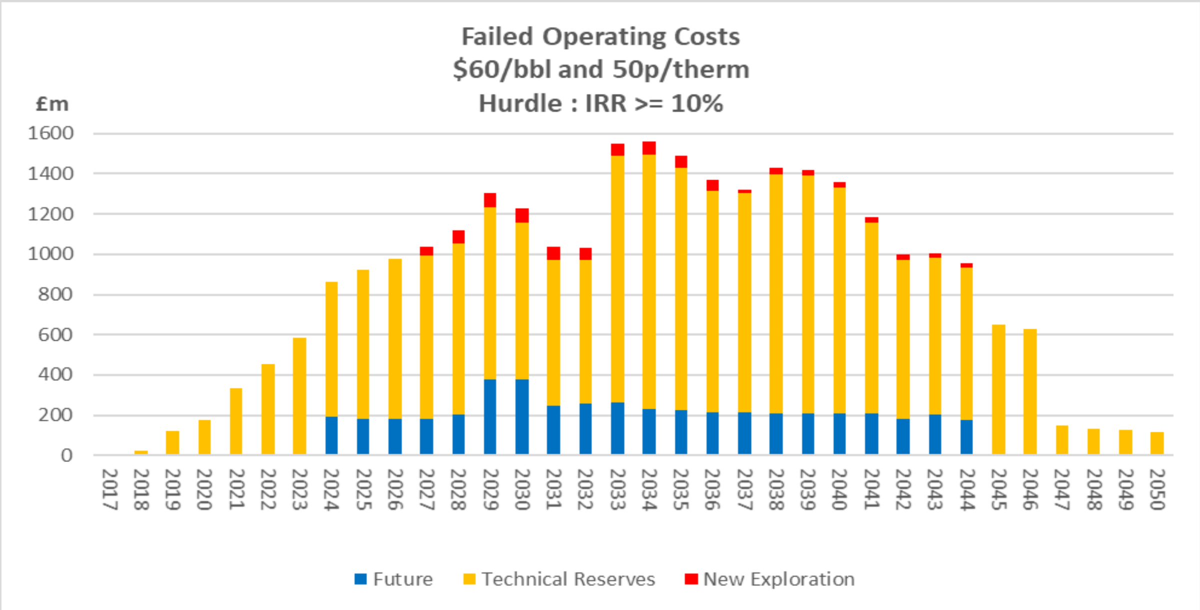


Chart 45 shows the potential operating costs from the fields which fail the IRR at 10% hurdle. The loss of operating costs could amount to £28.7 billion for the period to 2050 with the bulk coming from technical reserve fields.

Chart 46

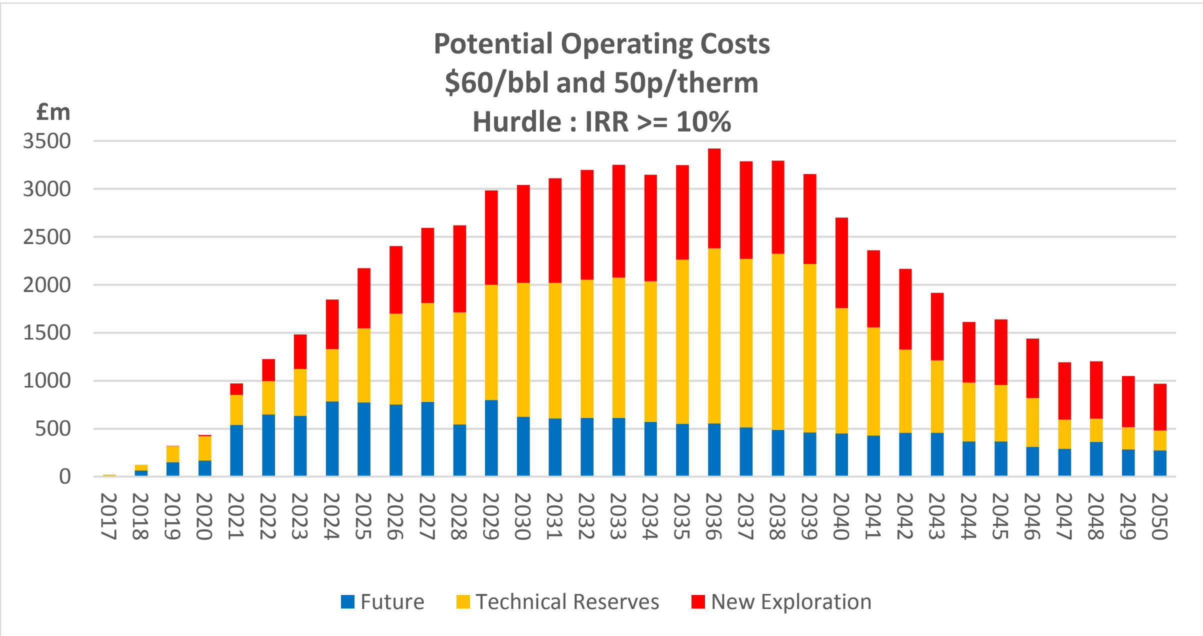


Chart 46 shows the potential operating costs from the fields which pass the IRR at 10% hurdle. The potential operating costs for fields passing the IRR 10% hurdle could amount to £69.6 billion with most of this coming from the technical reserve fields.

Chart 47

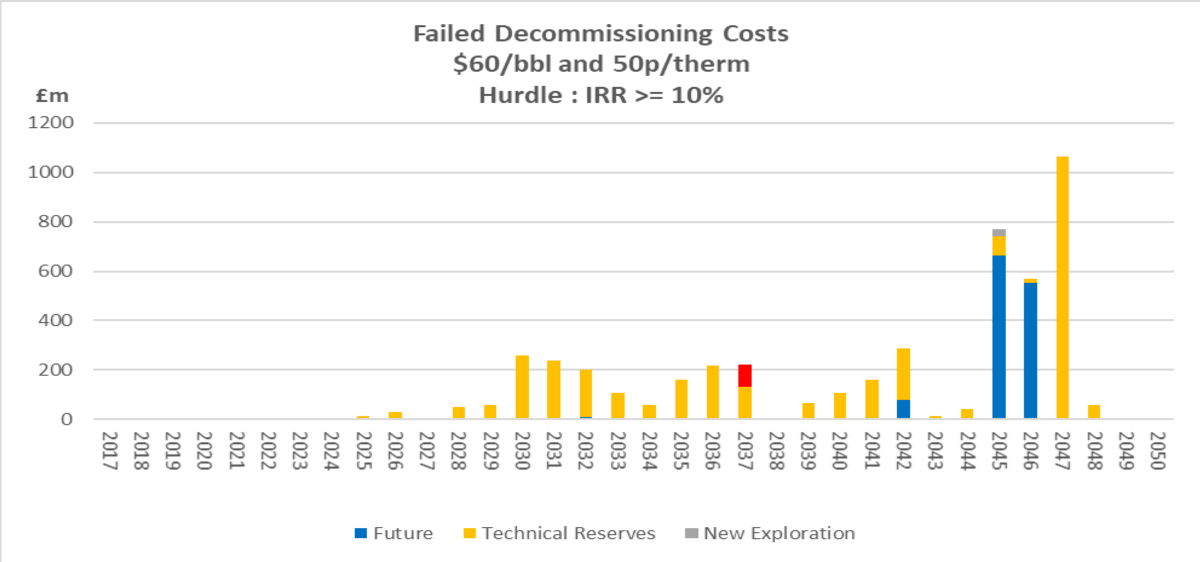


Chart 47 shows the potential decommissioning costs from the fields which fail the IRR at 10% hurdle. The loss of decommissioning costs could amount to £4.7 billion for the period to 2050 with the bulk of this coming from technical reserve fields.

Chart 48

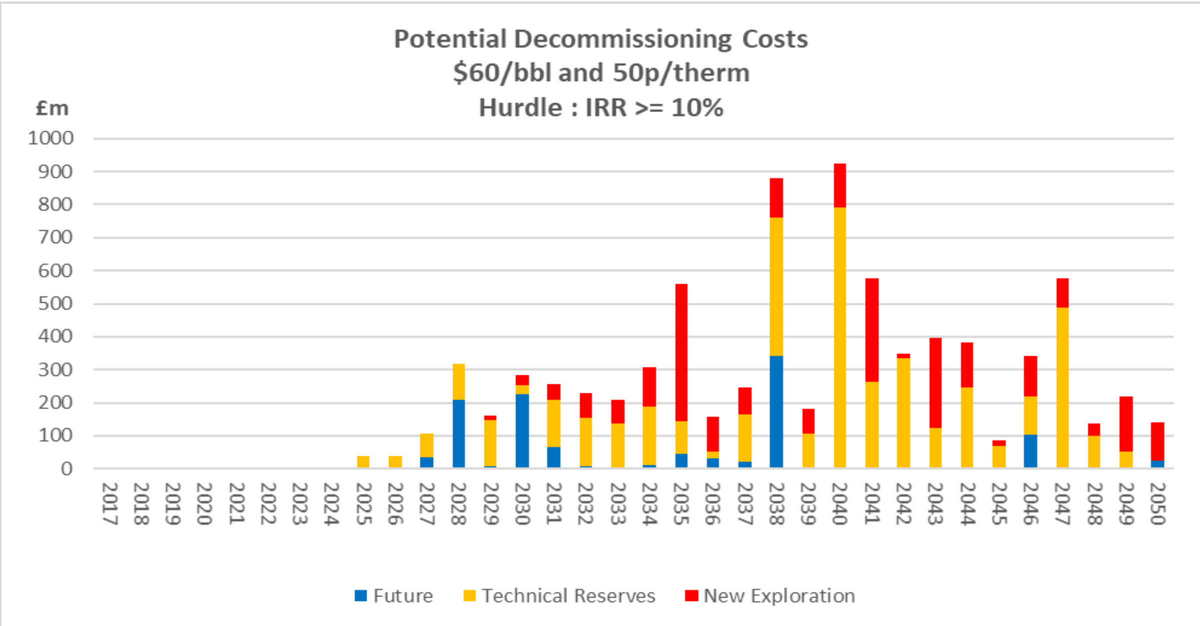


Chart 48 shows the potential decommissioning costs from the fields which pass the IRR at 10% hurdle. The potential decommissioning costs for fields passing the IRR 10% hurdle could amount to £8.1 billion with most coming from the technical reserve fields.

Chart 49

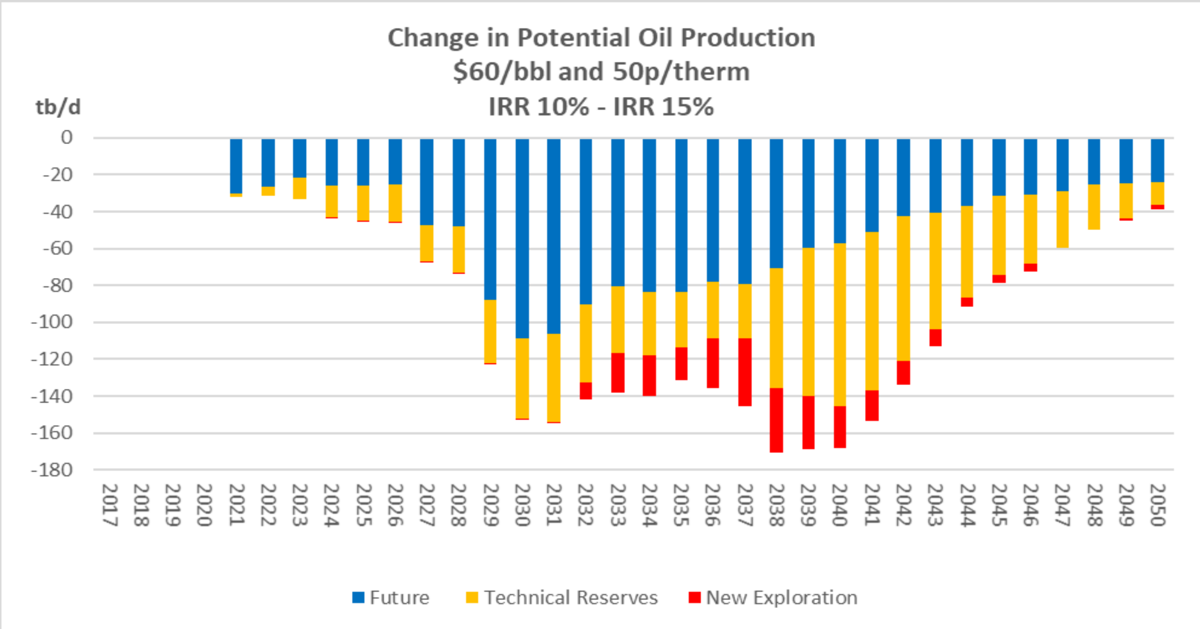


Chart 49 shows the change in oil production that occurs if the hurdle rate changes from IRR at 10% to IRR at 15%. The loss of oil production could amount to 1.1 billion barrels of oil for the period to 2050.

Chart 50

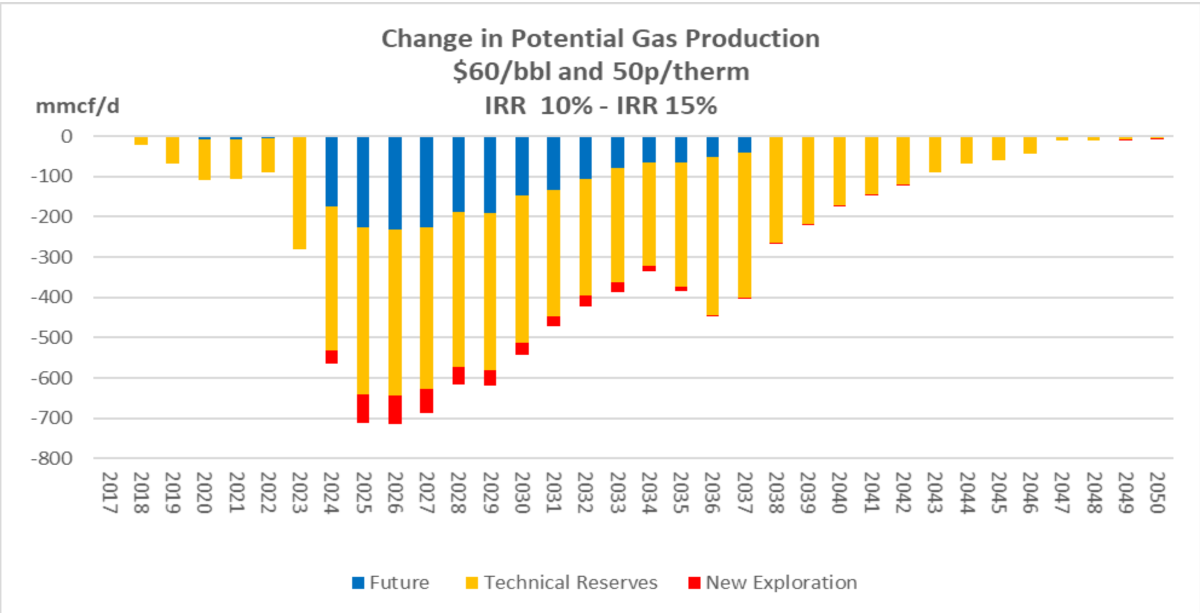


Chart 50 shows the change in gas production that occurs if the hurdle rate changes from IRR at 10% to IRR at 15%. The loss of gas production could amount to 591 million barrels of oil equivalent for the period to 2050 with the bulk of the loss coming from technical reserve fields.

Chart 51

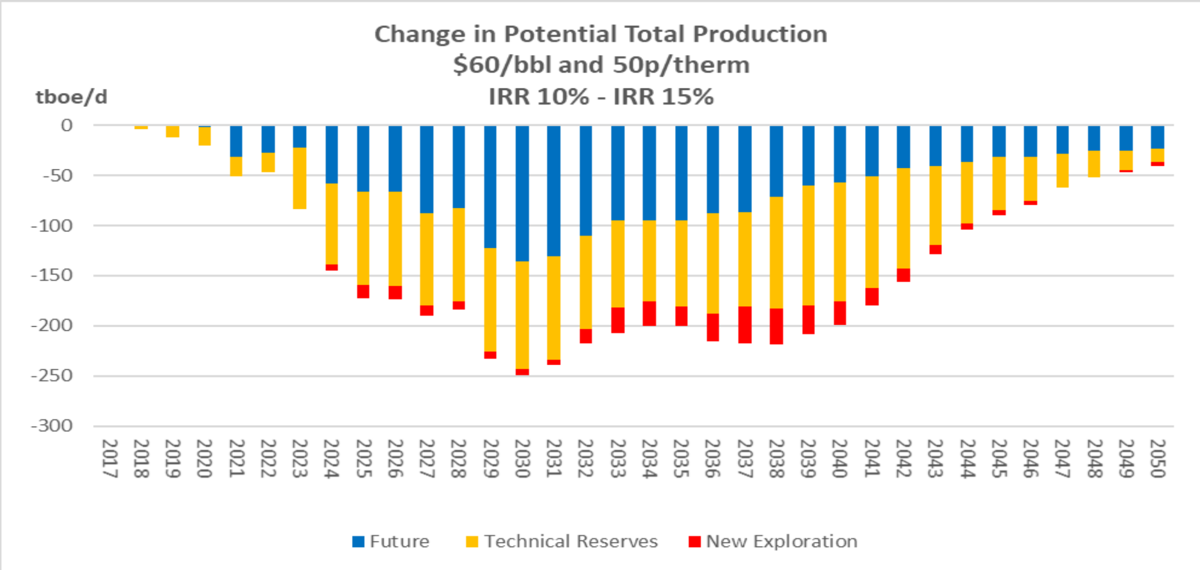


Chart 51 shows the change in total production that occurs if the hurdle rate changes from IRR at 10% to IRR at 15%. The loss of total production could amount to 1.7 billion barrels of oil equivalent for the period to 2050 with the bulk of the loss coming from technical reserve fields.

Chart 52

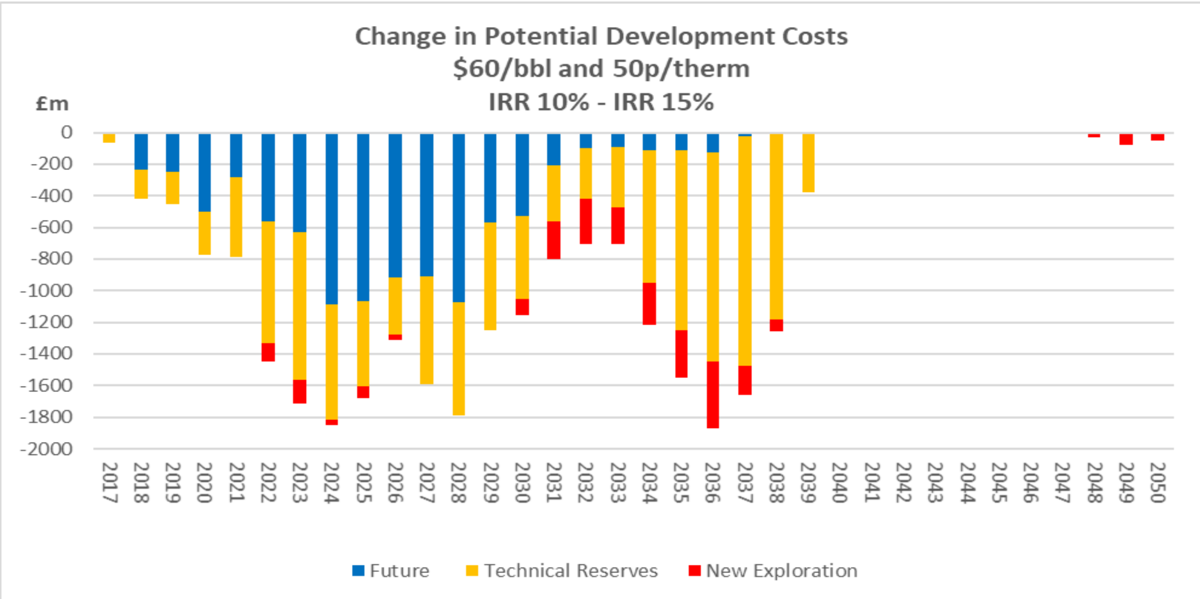


Chart 52 shows the change in development costs that occurs if the hurdle rate changes from IRR at 10% to IRR at 15%. The loss of development costs could amount to £26.6 billion for the period to 2050 with the bulk of the loss coming from technical reserve fields.

Chart 53

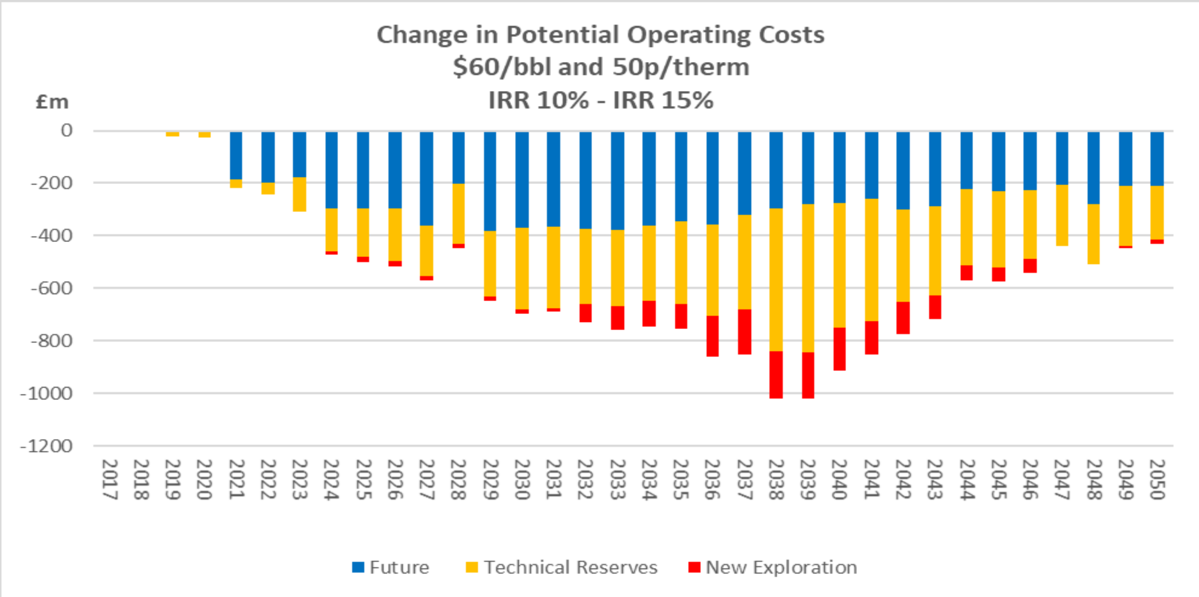


Chart 53 shows the change in operating costs that occurs if the hurdle rate changes from IRR at 10% to IRR at 15%. The loss of operating costs could amount to £18.9 billion for the period to 2050 with the bulk of the loss coming from probable and possible fields.

Chart 54

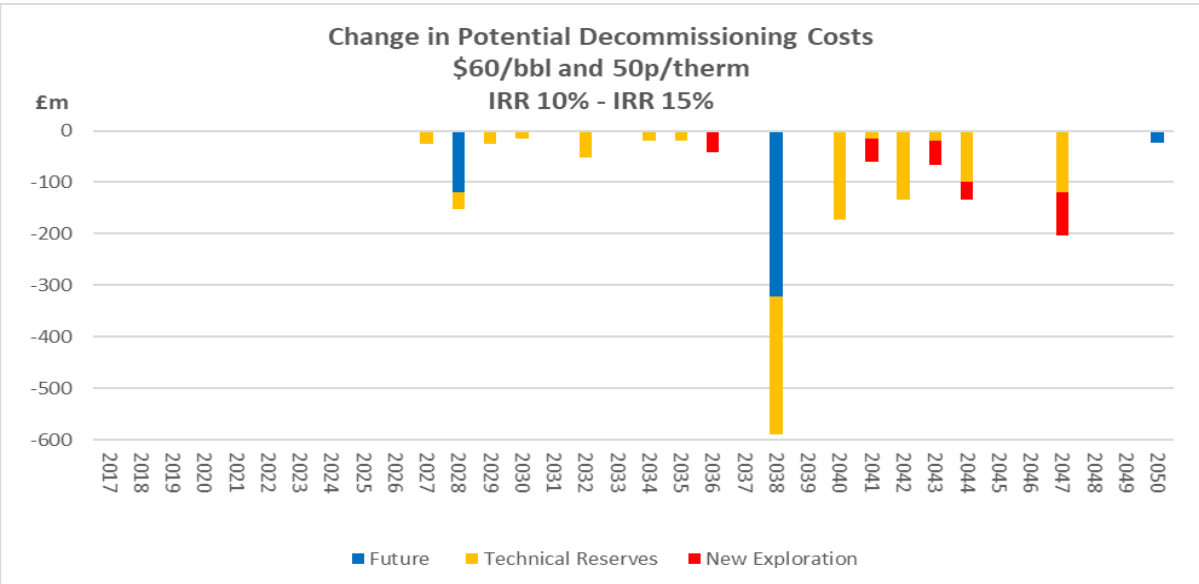


Chart 54 shows the change in decommissioning costs that occurs if the hurdle rate changes from IRR at 10% to IRR at 15%. The loss of decommissioning costs could amount to £1.7 billion for the period to 2050 with the bulk of the loss coming from technical reserve fields.

Chart 55

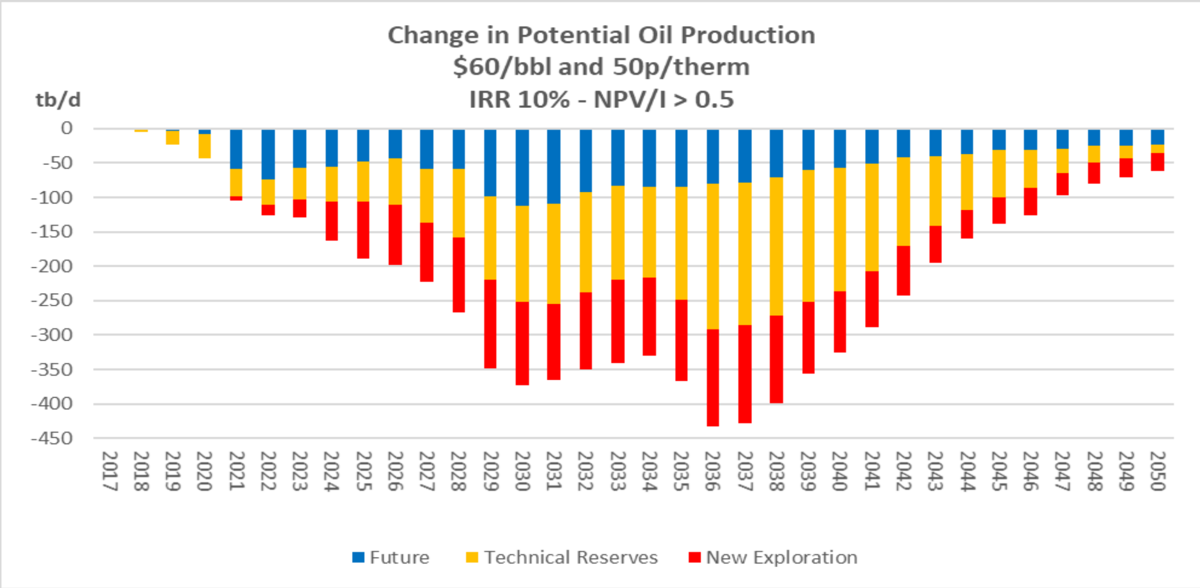


Chart 55 shows the change in oil production that occurs if the hurdle rate changes from IRR at 10% to NPV/I > 0.5. The loss of oil production could amount to 2.7 billion barrels of oil for the period to 2050 with the bulk of the loss coming from technical reserve fields.

Chart 56

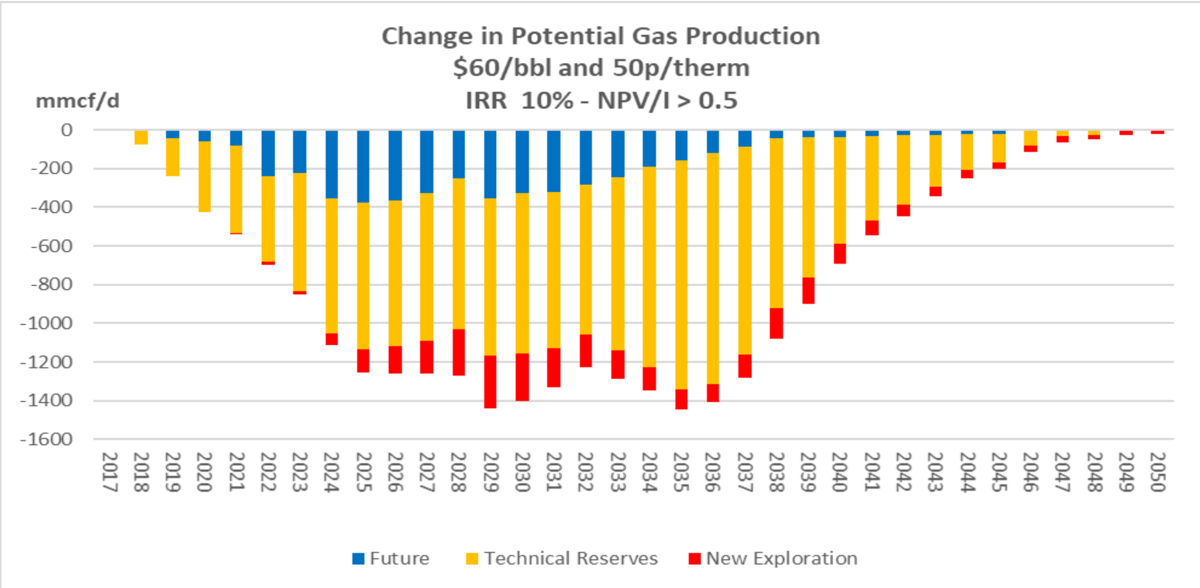


Chart 56 shows the change in gas production that occurs if the hurdle rate changes from IRR at 10% to NPV/I > 0.5. The loss of gas production could amount to 1.7 billion barrels of oil equivalent for the period to 2050 with the bulk of the loss coming from technical reserve fields.

Chart 57

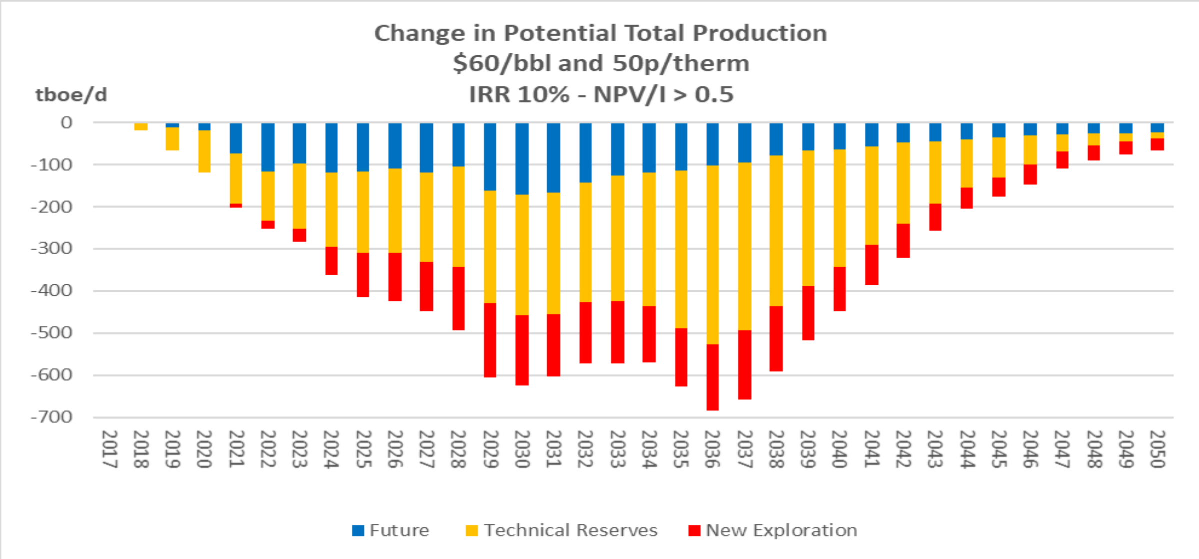


Chart 57 shows the change in total production that occurs if the hurdle rate changes from IRR at 10% to NPV/I > 0.5. The loss of total production could amount to 4.4 billion boe for the period to 2050 with the bulk of the loss coming from technical reserve fields.

Chart 58

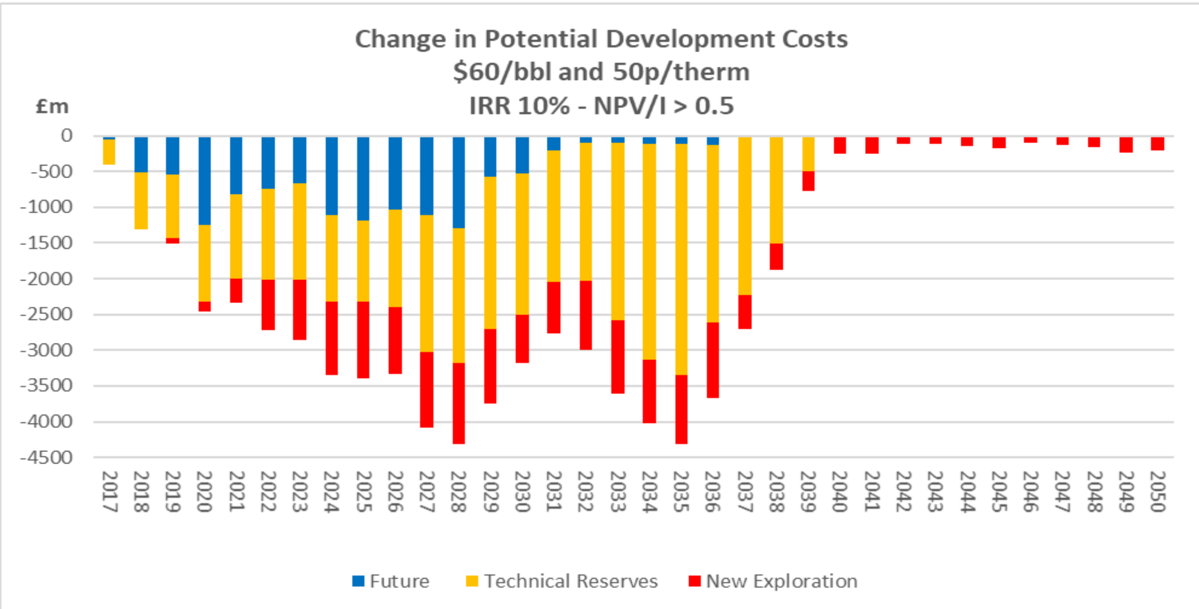


Chart 58 shows the change in development costs that occurs if the hurdle rate changes from IRR at 10% to NPV/I > 0.5. The loss of development costs could amount to £67.6 billion for the period to 2050 with the bulk of the loss coming from technical reserve fields.

Chart 59

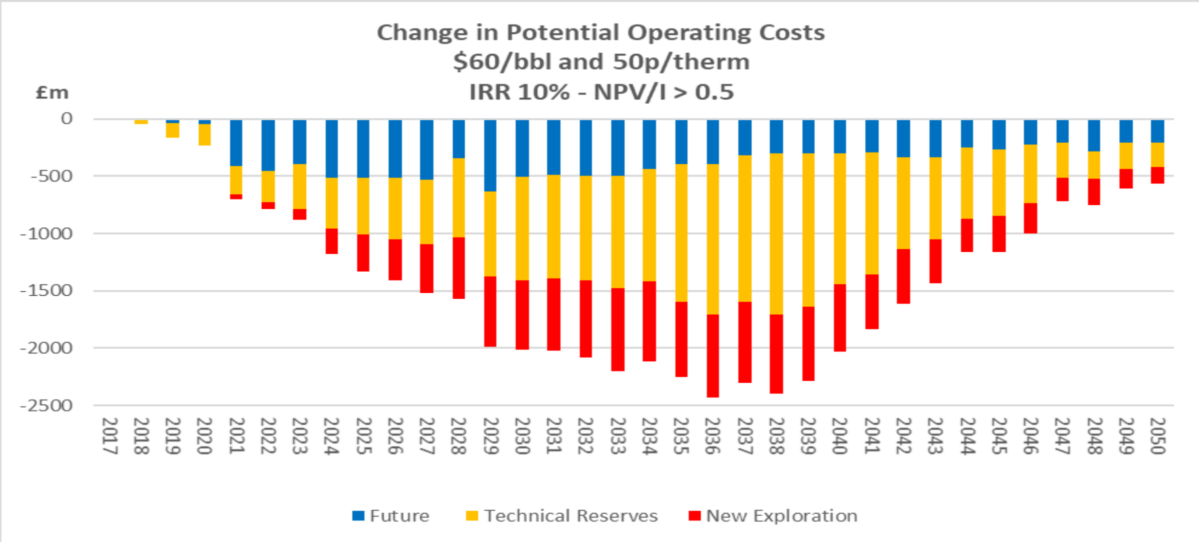


Chart 59 shows the change in operating costs that occurs if the hurdle rate changes from IRR at 10% to NPV/I > 0.5. The loss of operating costs could amount to £46.8 billion for the period to 2050 with the bulk of the loss coming from technical reserve fields.

Chart 60

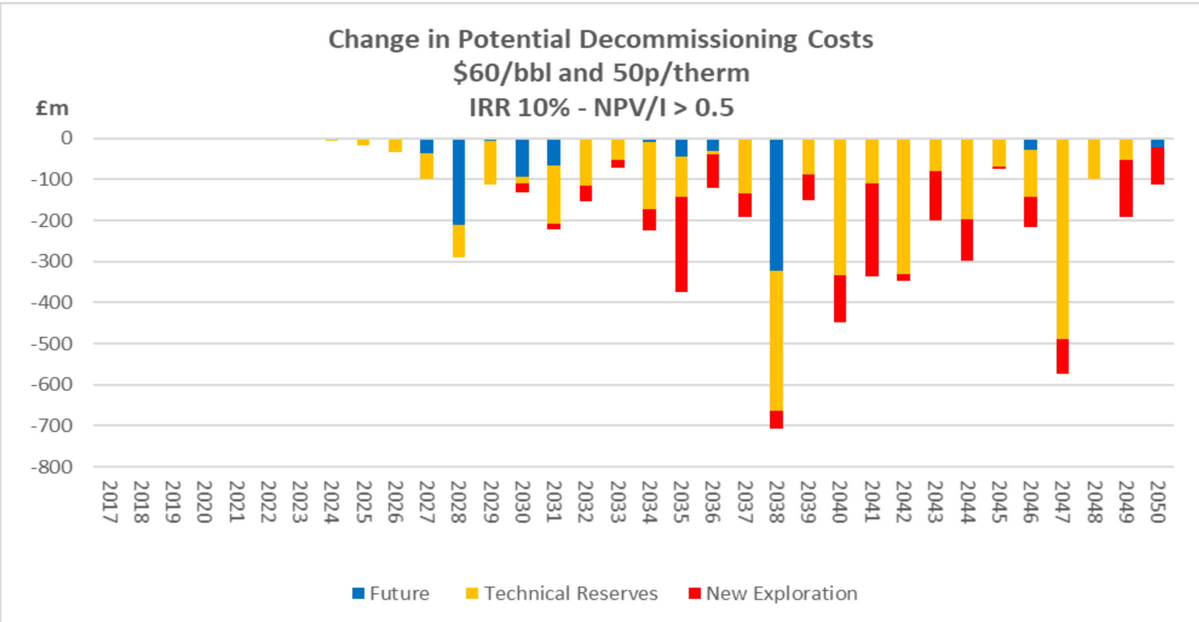


Chart 60 shows the change in decommissioning costs that occurs if the hurdle rate changes from IRR at 10% to NPV/I > 0.5. The loss of decommissioning costs could amount to £5.8 billion for the period to 2050 with the bulk of the loss coming from technical reserve fields.

Chart 61

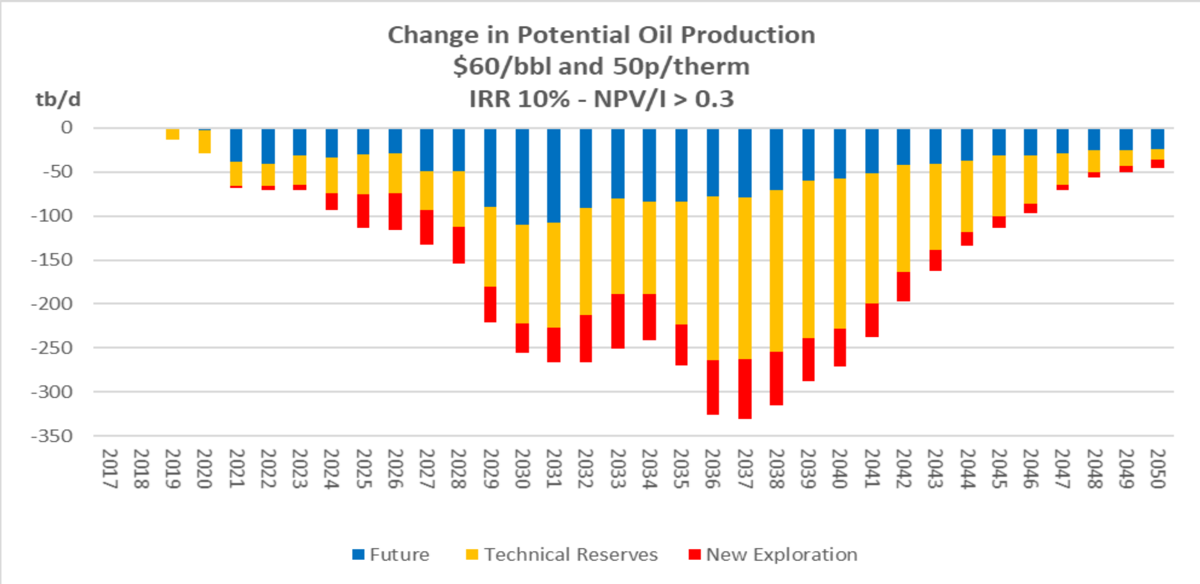


Chart 61 shows the change in oil production that occurs if the hurdle rate changes from IRR at 10% to NPV/I > 0.3. The loss of oil production could amount to 1.95 billion boe for the period to 2050 with the bulk of the loss coming from technical reserve fields.

Chart 62

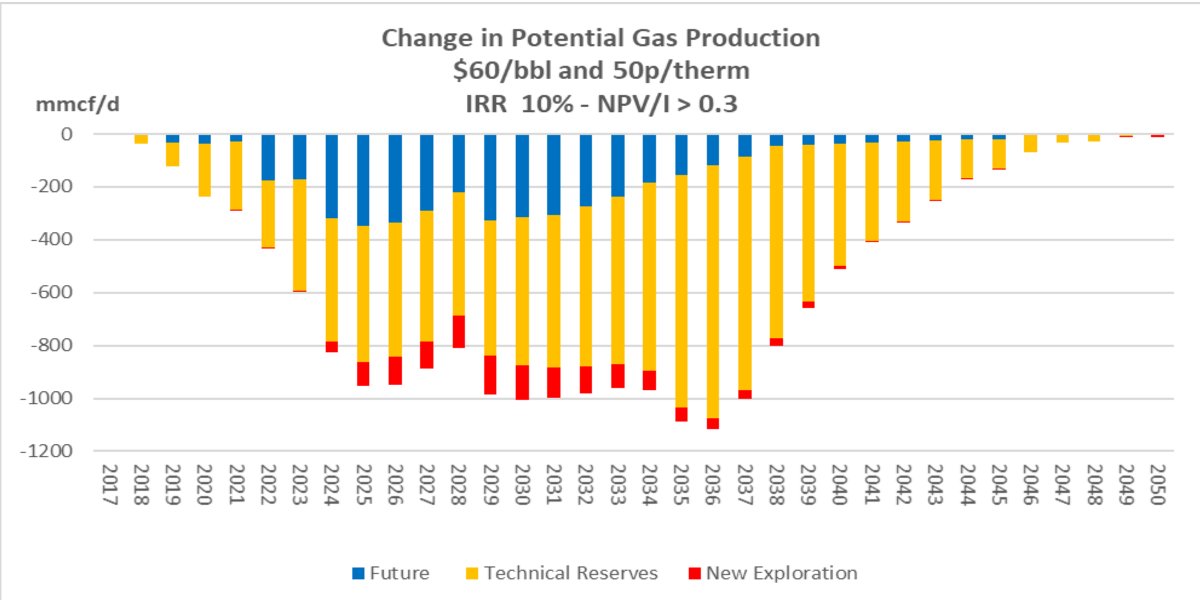


Chart 62 shows the change in gas production that occurs if the hurdle rate changes from IRR at 10% to NPV/I > 0.3. The loss of gas production could amount to 1.2 billion barrels of oil equivalent for the period to 2050 with the bulk of the loss coming from technical reserve fields.

Chart 63

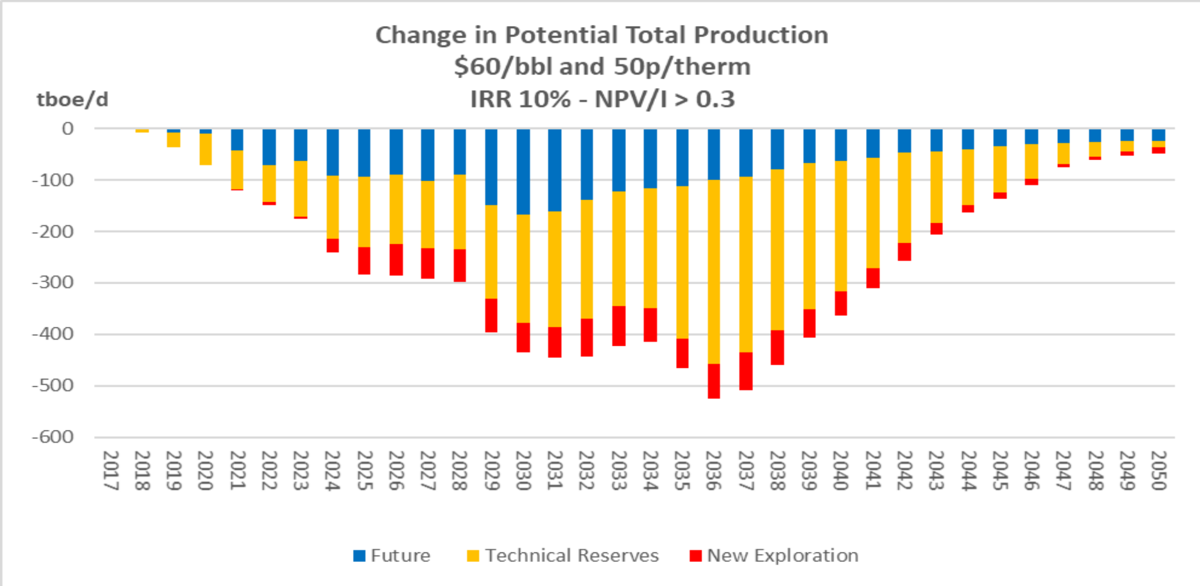


Chart 63 shows the change in total production that occurs if the hurdle rate changes from IRR at 10% to NPV/I > 0.3. The loss of total production could amount to 3.2 billion barrels of oil equivalent for the period to 2050 with the bulk of the loss coming from technical reserve fields.

Chart 64

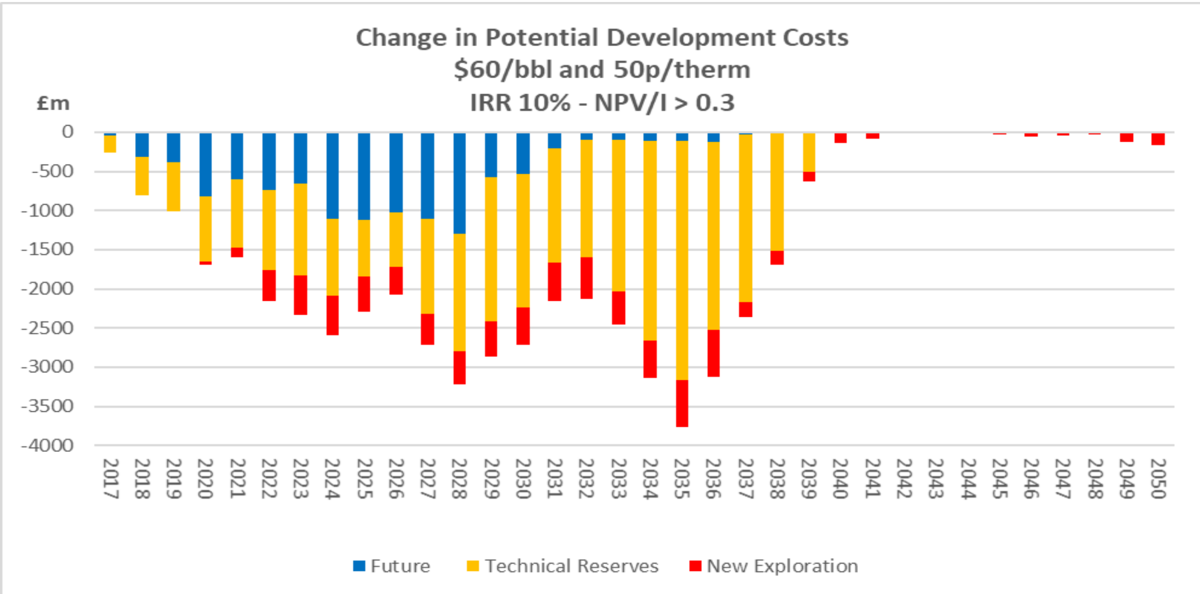


Chart 64 shows the change in development costs that occurs if the hurdle rate changes from IRR at 10% to NPV/I > 0.3. The loss of development costs could amount to £50.4 billion for the period to 2050 with the bulk of the loss coming from technical reserve fields.

Chart 65

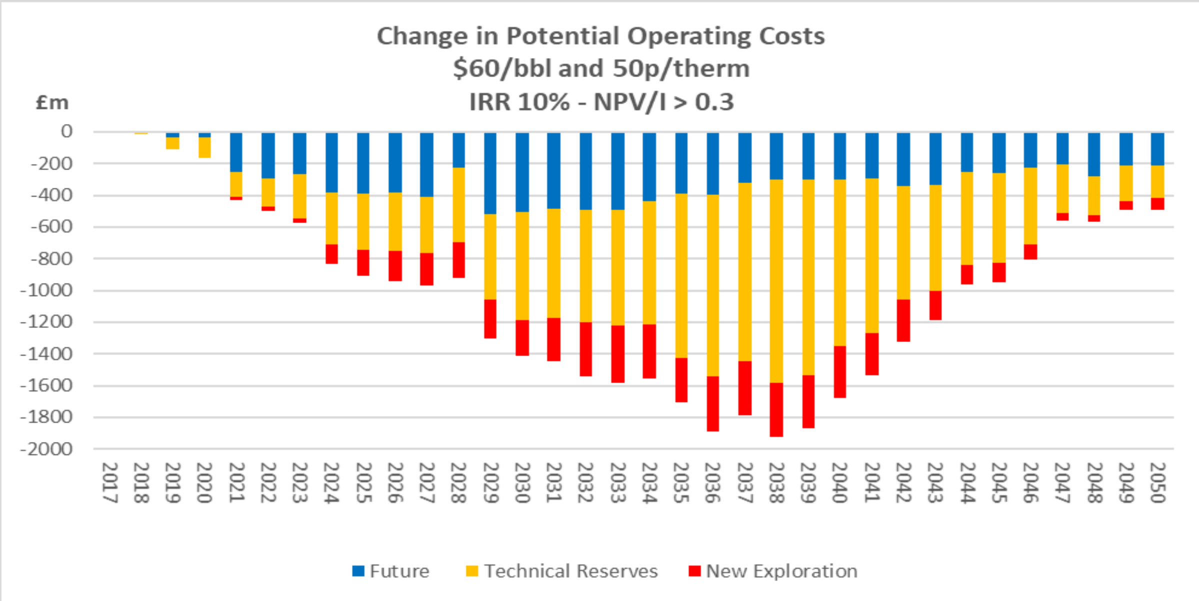


Chart 65 shows the change in operating costs that occurs if the hurdle rate changes from IRR at 10% to NPV/I > 0.3. The loss of operating costs could amount to £34.9 billion for the period to 2050 with the bulk of the loss coming from technical reserve fields.

Chart 66

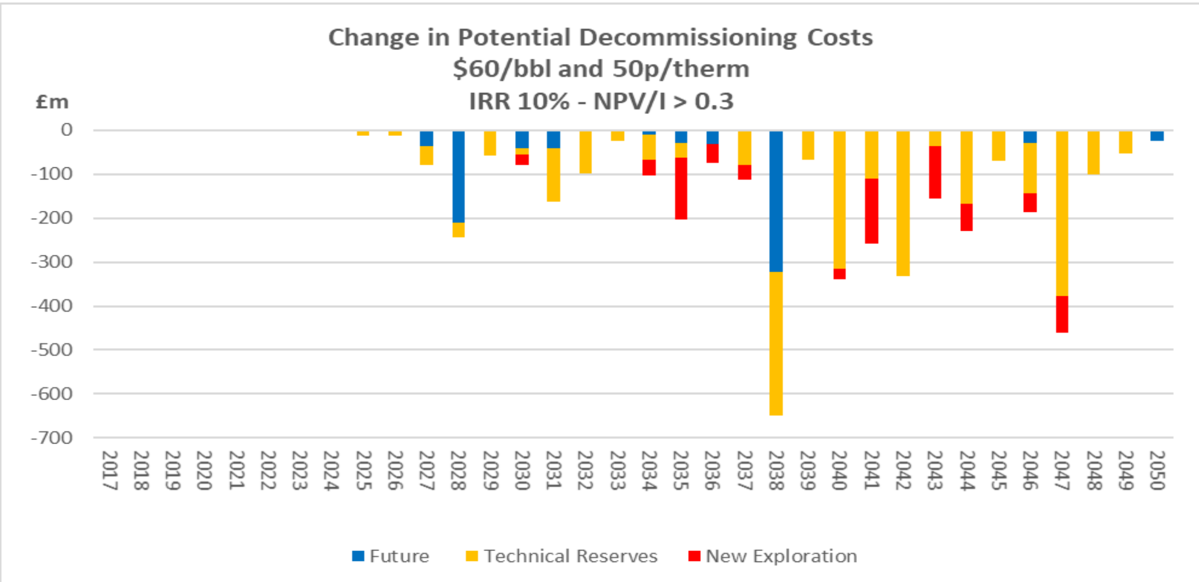


Chart 66 shows the change in decommissioning costs that occurs if the hurdle rate changes from IRR at 10% to I NPV/I > 0.3. The loss of decommissioning costs could amount to £4.2 billion for the period to 2050 with the bulk of the loss coming from technical reserve fields.

Chart 67

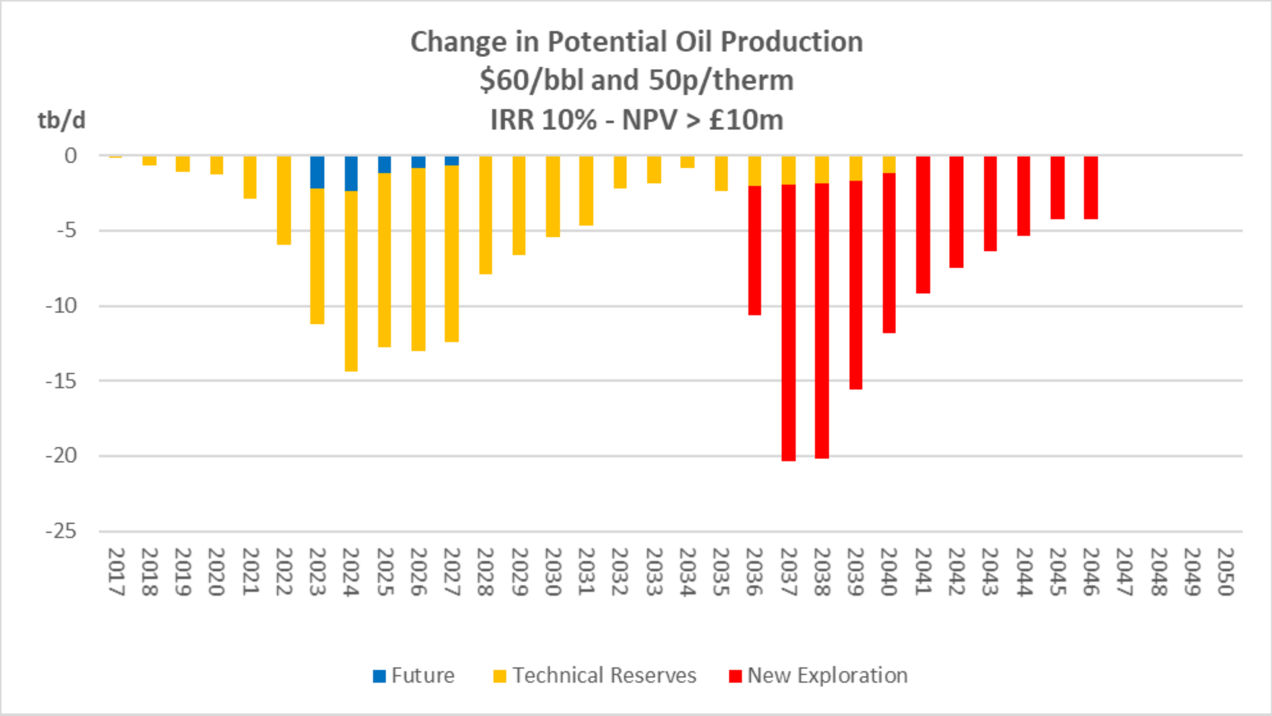


Chart 67 shows the change in oil production that occurs if the hurdle rate changes from IRR at 10% to NPV > 0.3. The loss of oil production could amount to 81 million barrels of oil for the period to 2050 with the bulk of the loss coming from the technical reserve fields very closely followed by the new exploration finds.

Chart 68

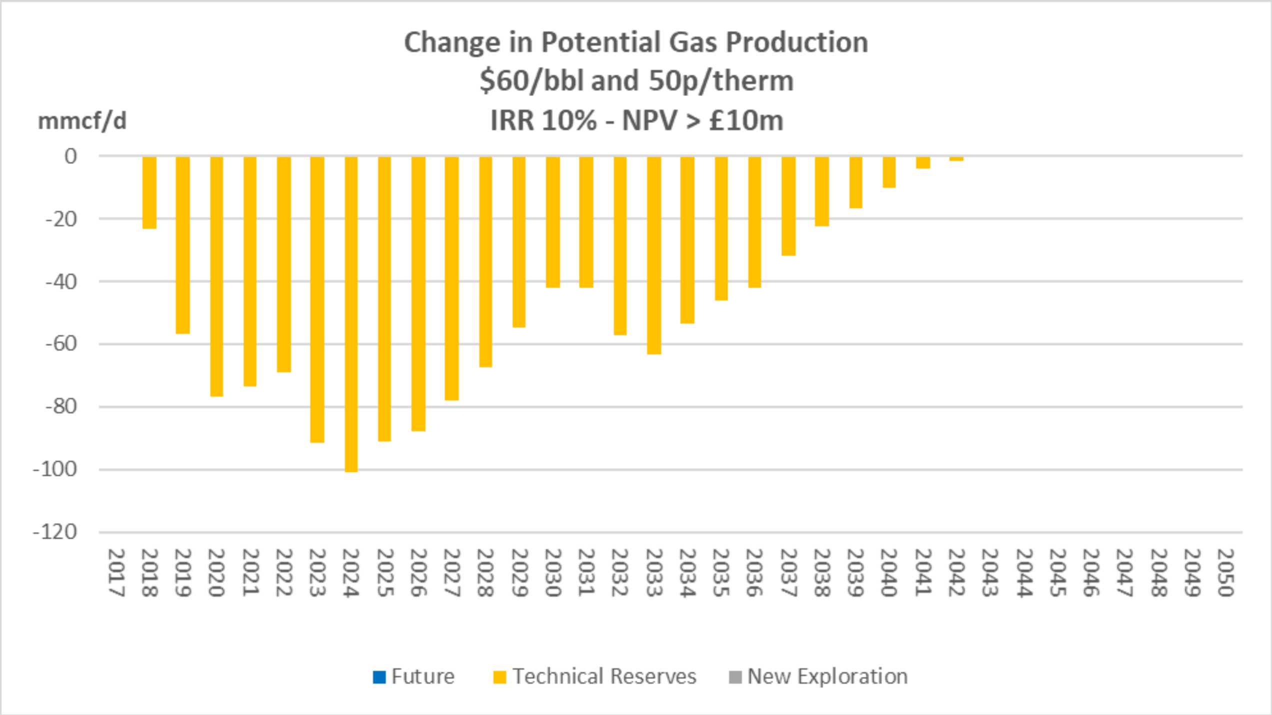


Chart 68 shows the change in gas production that occurs if the hurdle rate changes from IRR at 10% to NPV > £10m. The loss of gas production could amount to 84 million barrels of oil equivalent for the period to 2050 with the all of the loss coming from technical reserve fields.

Chart 69

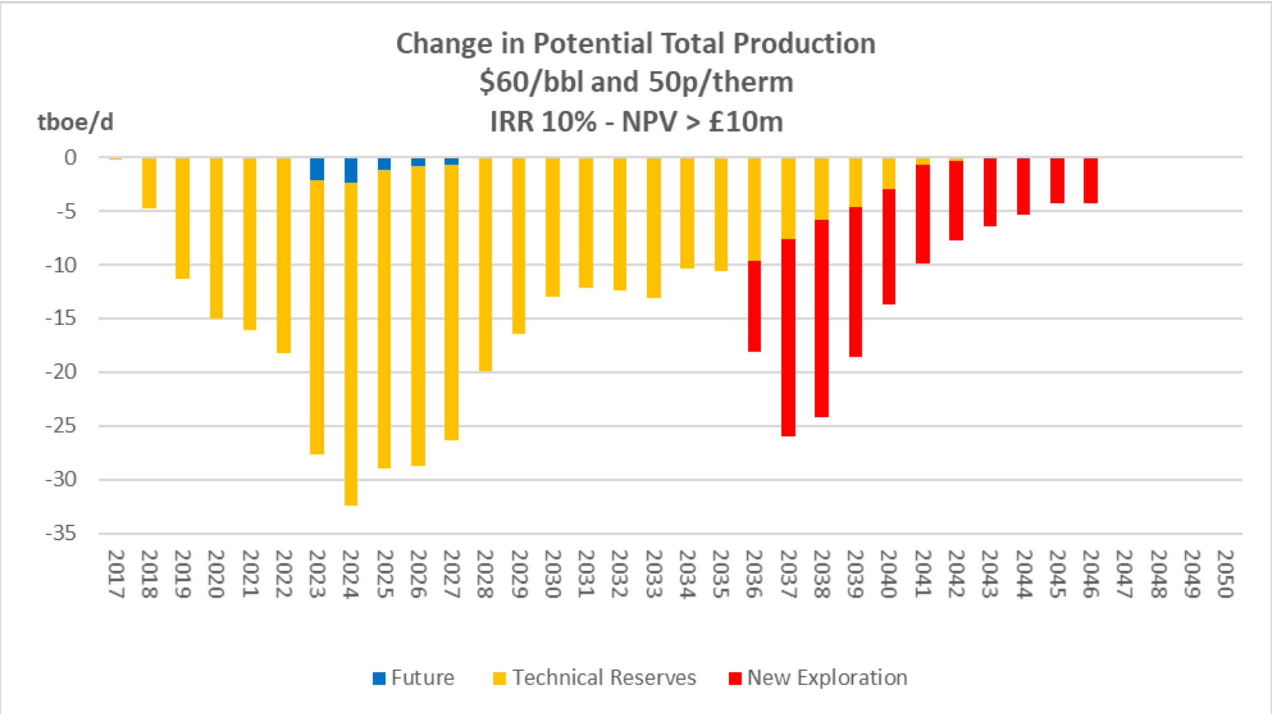


Chart 69 shows the change in total production that occurs if the hurdle rate changes from IRR at 10% to NPV > £10m. The loss of total production could amount to 166.5 million barrels of oil equivalent for the period to 2050 with the bulk of the loss coming from technical reserve fields.

Chart 70

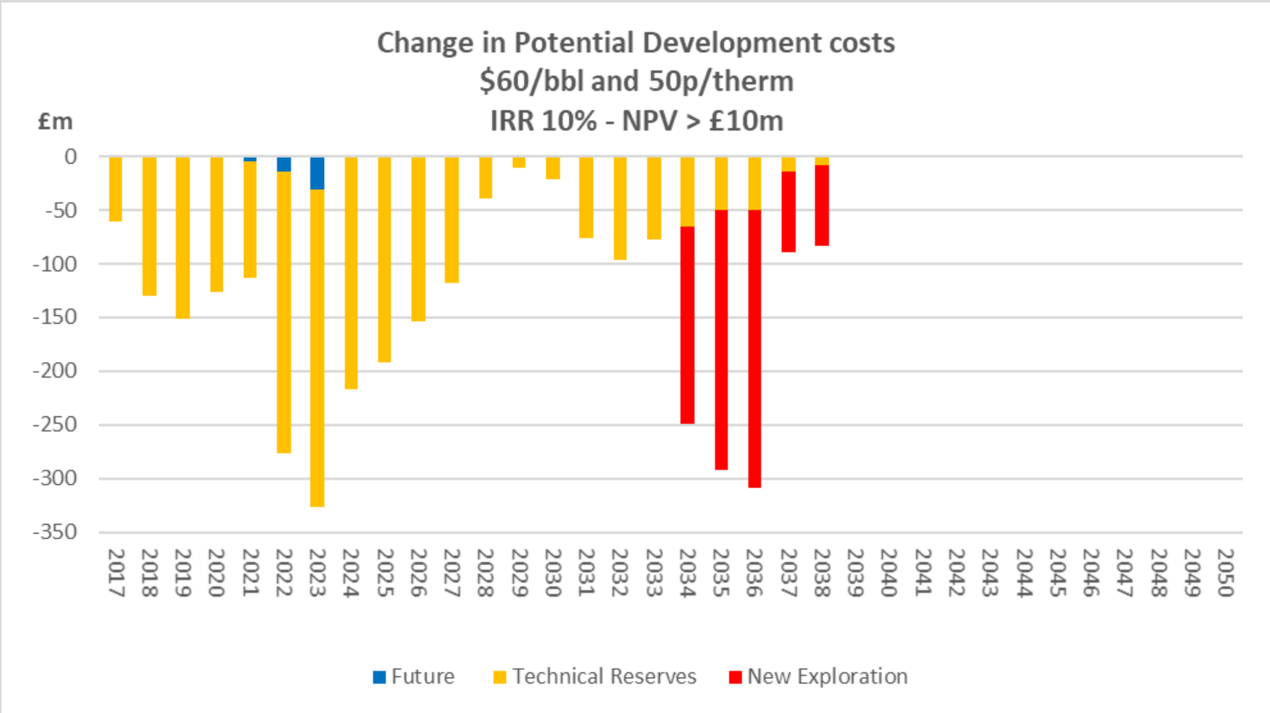


Chart 70 shows the change in development costs that occurs if the hurdle rate changes from IRR at 10% to NPV > £10m. The loss of development costs could amount to £3.2 billion for the period to 2050 with the bulk of the loss coming from technical reserve fields.

Chart 71

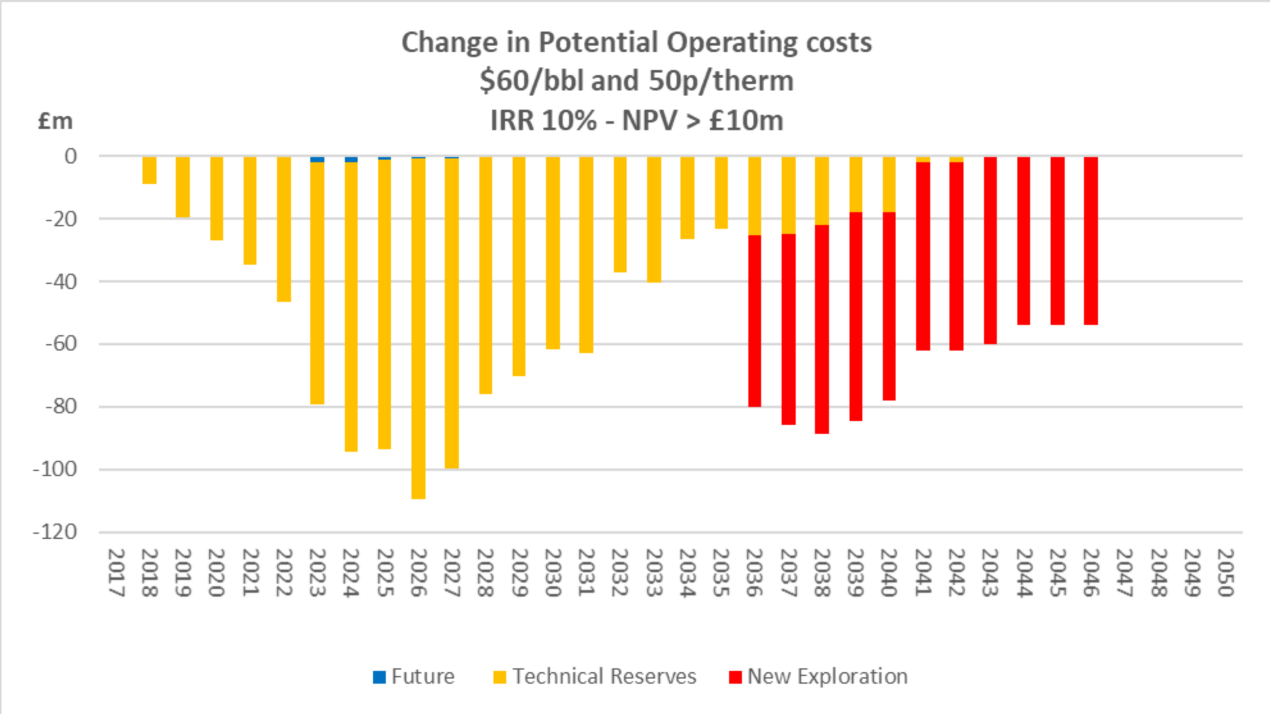


Chart 71 shows the change in operating costs that occurs if the hurdle rate changes from IRR at 10% to NPV > £10m. The loss of operating costs could amount to £1.8 billion for the period to 2050 with the bulk of the loss coming from technical reserve fields.

Chart 72

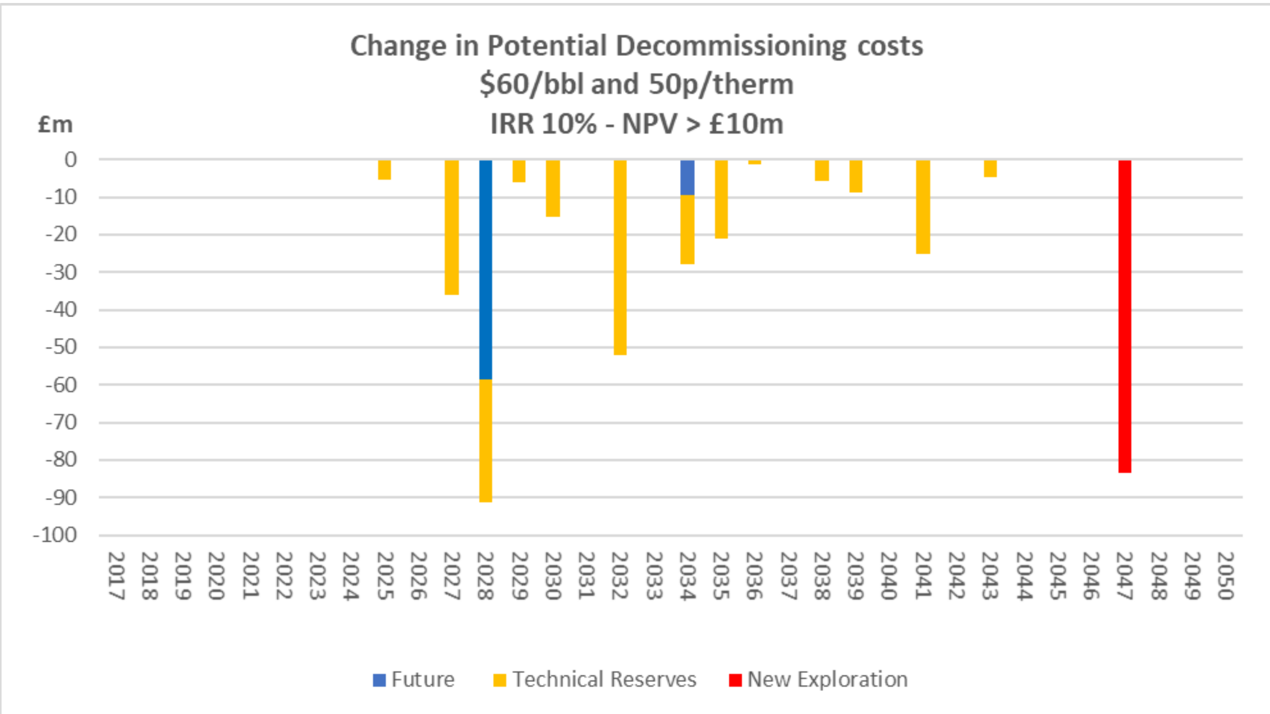


Chart 72 shows the change in decommissioning costs that occurs if the hurdle rate changes from IRR at 10% to NPV > £10m. The loss of decommissioning costs could amount to £384m for the period to 2050 with the bulk of the loss coming from technical reserve fields.

4. Summary and Conclusions

This study has examined the effects on activity levels in the UKCS emanating from the use of different investment hurdles for new field developments under 2 price scenarios, namely (a) $50 and 40 pence in real terms, and (b) $60 and 50 pence again in real terms. Hurdles are all post-tax and are (1) 10% real IRR, (2) 15% real IRR, (3) real NPV@10% > £10m. (4) real NPV/I > 0.3, and (5) real NPV/I > 0.5. There were 374 potential field development under the $50, 40 pence scenario and 394 fields under the $60, 50 pence case.

At both prices more fields pass the IRR at 10% than do with any of the other hurdles examined. At $50, 29 fewer fields pass when the hurdle changes from IRR at 10% to IRR at 15%, and at $60 33 fewer fields pass. The IRR does not give the investor any information on the materiality of the project under consideration. Thus although a field may pass the IRR hurdle the real NPV may be very low or very high. A hurdle which gives more information is real NPV at 10% ≥ £10m. When the hurdle changes from IRR ≥ 10% to NPV at 10% ≥ £10m. 39 fewer fields pass at $50, and 26 fewer at $60. The NPV at 10% / Devex at 10% ≥ 0.3 gives a measure of the productivity of the capital investment. When the hurdle changes from IRR at 10% to NPV at 10% / Devex at 10% ≥ 0.3, 107 fewer fields pass the hurdle at $50, and 113 fewer pass at $60. When the hurdle changes from NPV at 10% ≥ £10m. to NPV at 10% / Devex at 10% ≥ 0.3, 68 fewer fields pass at $50 and 87 fewer at $60. When the hurdle changes from IRR at 10% to NPV at 10% / Devex at 10% ≥ 0.5, 165 fewer fields pass at $50 and 186 fewer pass at $60. When the hurdle changes from NPV at 10% / Devex at

10% ≥ 0.3 to NPV at 10% / Devex at 10% ≥ 0.5, 58 fewer field pass at $50 and 73 fewer pass at $60.

In Table 10 the key effects of the different hurdle rates on new fields activity to 2050 are summarised with the $50, 40 pence case. For purposes of comparison the base case is the lowest hurdle rate, namely 10% real IRR.

Table 10

Variations in New Field Activity 2017-2050 with Different Investment Hurdles in $50, 40 pence case					
	10% IRR (base values)	15% IRR	NPV > £10m.	NPV/I > 0.3	NPV/I > 0.5
Oil Production	3.1 bn bbls	-731 mmbbls	-105 mmbbls	-1.5 bn bbls	-2.5 bn bbls
Gas Production	1.1 bn boe	-261 mmboe	-120 mmboe	-631 mmboe	-850 mmboe
Total Production	4.2 bn boe	-1 bn boe	-228 mmboe	-2.1bn boe	-3.4 bn boe
Development Costs	£54.3 bn	-£14.3 bn	-£3.5 bn	-£31 bn	-£46.3 bn
Operating Costs	£37.1 bn	-£9.6 bn	-£2 bn	-£20.2 bn	-£31.6 bn
Decommissioning Costs	£4 bn	-£770 m	-£363 m	-£2.2 bn	-£3.4 bn

It is seen from Table 10 that, with the 10% IRR hurdle, over the period to 2050 total oil production from new fields is 3.1 bn bbls and total gas production 1.1 bn boe. Total development expenditure is £54.3 bn, total operating costs £37.1 bn and total decommissioning costs £4 bn.

When the hurdle is rasied to 15% real IRR there is a reduction of oil production by 731 mmbbls and 261 mmboe of gas production. New field investment falls by £14.3 bn and operating costs by £9.6 bn. Overall this reduction may be regarded as signifncant especially in percentage terms.

When the hurdle is NPV@10% > £10m. the reduction in oil production from the base case of 10% IRR is 105 mmbbls and for gas 120 mmboe. In this case the reduction is greater for gas compared to oil whereas when the hurdle was raised from 10% IRR to 15% IRR the reduction was much greater for oil. The larger reduction for gas with the NPV > £10m. reflects the very small size of many of the fields in the SNS and thus their difficulty in meeting the materiality threshold.

When the hurdle is NPV/I > 0.3 it is seen that, compared to the base case threshold of 10% IRR, there is a very large reduction in activity. Oil production is reduced by 1.5 bn boe and gas production by 631 mmboe. Field investment is reduced by £31 bn and operating costs by £20.2 bn. If this hurdle is commonly employed then activity at the $50, 40 pence price case is very substantially reduced compared to the low hurdle of 10% IRR.

If the investment hurdle were NPV/I > 0.5 the reduction in activity is much greater. Compared to the 10% IRR case there is reduction in total oil production of 2.5 bn bbls and reduction in gas produciotn of 850 mmboe. New field investment is reduced by a massive £46.3 bn. and operating costs by £31.6 bn.

The comparative results of the same analysis with the $60, 50 pence price case are summarised in Table 11.

Table 11

Variations in New Field Activity 2017-2050 with Different Investment Hurdles in $60, 50 pence case					
	10% IRR (base values)	15% IRR	NPV > £10m.	NPV/I > 0.3	NPV/I > 0.5
Oil Production	4.6 bn bbls	-1.1 bn bbls	-81 mmbbls	-1.9 bn bbls	-2.7 bn bbls
Gas Production	2.3 bn boe	-591 mmboe	-84 mmboe	-1.2 bnboe	-1.7 bn boe
Total Production	7 bn boe	-1.7 bn boe	-166.5 mmboe	-3.2 bn boe	-4.4 bn boe
Development Costs	£98.2 bn	-£26.6 bn	-£3.2 bn	-£50.4 bn	-£67.6 bn
Operating Costs	£69.6 bn	-£18.9 bn	-£1.8 bn	-£34.9 bn	-£46.8 bn
Decommissioning Costs	£8.1 bn	-£1.7 bn	-£0.38 bn	-£4.2 bn	-£5.8 bn

From Table 11 it is seen that, with the 10% IRR hurdle, over the period to 2050 oil production from the new fields amounts to 4.6 bn bbls and gas production to 2.3 bn boe. Total development costs are £98.2 bn, total operating costs £69.6 bn, and total decommissioning costs of £8.1bn. When the hurdle is 15% IRR there is a reduction in oil production of 1.1 bn bbls and a reduction of 591 mmboe in gas production. New field investment falls by £26.6 bn. New field operating costs fall by £18.9 bn, and decommissioning costs by £1.7 bn. This may be regarded as a major reduction, particularly with regard to investment activity.

When the hurdle is NPV@10% > £10m. it is seen that new activity under all the headings falls by quite modest amounts compared to the 10% IRR threshold. The reduction in activity is very much less than in the case with the 15% IRR hurdle.

When the hurdle is NPV/I > 0.3 reflecting capital rationing it is seen from Table 11 that new activity under all headings is very substantially reduced not only in relation to the 10% IRR hurdle but to the 15% IRR hurdle as well. There is a 45% reduction in total production and a 51% reduction in investment expenditure compared to the 10% IRR case. Compared to the 15% IRR hurdle there is a reduction of 28% in total production and a reduction of 33% in total new field investment. This is a very major change. The NPV/I > 0.3 hurdle may reflect capital rationing to an extent which has been prevalent in recent years.

When a hurdle of NPV/I > 0.5 is used the reduction in new activity compared to <u>all</u> the other hurdles is dramatic. Thus, compared to the NPV/I > 0.3 hurdle total production is 31.6% lower with the tougher NPV/I > 0.5 threshold. Similarly, new field investment is 36% less with the NPV/I > 0.5 hurdle compared to the NPV/I > 0.3 case.

This study thus highlights the major difference in future investment and production activities which emanate from the choice of hurdle rates in assessing new projects. While several indicators will be employed by investors, in current circumstances it is likely that, given the existence of much capital rationing, much attention will be given to the NPV/I ratio. In current conditions a threshould of NPV/I > 0.3 using the weighted average cost of capital for discounting purposes may be common.