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Prospects for Activity in the UK Continental Shelf: the late 2019 Perspective

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and
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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 CO_2 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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Prospects for Activity in the UK Continental Shelf:

The Late 2019 Perspective

Professor Alexander G. Kemp and Linda Stephen

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Prospects for Activity in the UK Continental Shelf:

the Late 2019 Perspective

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1. Context

Activity in the UK Continental Shelf (UKCS) has been subject to much turbulence for several years. Following the major oil price collapse in the second half of 2014 investment in new field developments has fallen from around £12 billion in 2015 to around £5 - £5.5 billion in 2019 according to OGUK. But production has increased from around 1.43 million barrels of oil equivalent per day (mmboe/d) to around 1.74 mmboe/d recently. Both investment and operating costs have fallen substantially with very painful consequences for oil-related employment. Thus, operating costs per boe have fallen from an average of around $23.7/boe in 2015 to $15 - $16/boe currently. The whole province is more competitive now but still relatively high cost by comparison with other major producing countries. Total employment attributed to North Sea activity (direct, indirect and induced) has fallen from 464,000 in 2014 to 260,000 in 2018, but has increased to an estimated 269,000 in 2019 according to OGUK. The exploration effort as measured by wells drilled has been in long term decline even when the oil price was $100 per barrel or more. This reflects the continuing maturity of the basin. Encouragingly, there is expected to be some modest increase in both exploration and appraisal wells drilled in 2019.

Against this background of a changing investment environment the present study sets out to provide updated projections of potential long term activity in the UKCS. The economic modelling undertaken reflects the recent changes to the operating environment noted above. The changes to oil and gas prices and their continuing volatility are considered in designing the modelling assumptions.

2. Methodology and Data

Production and expenditure projections have been made by using financial simulation modelling. The Monte Carlo technique has been used in assessing the various risks. The modelling made use of a large database consisting of more than 400 already sanctioned fields, plus information on 86 possible incremental projects, and 12 probable and 2 possible future fields activity being considered by the operators. This information was supplemented by projections of possible future incremental projects, the possible results of new exploration and a large database of 415 fields in the category of technical reserves. The location of the 415 fields are known. Estimates of their reserves have been made from information obtained from a variety of sources.

The Monte Carlo technique was used to estimate the number of possible new discoveries for the period until 2051. The modelling was based on data regarding recent trends in the exploration effort, success rates, reserves found and their type (oil, gas or condensate). For the CNS/MF, SNS, and NNS a 5-year moving averages of effort, success rate, unit costs, reserves, and type were used to find the numbers of possible discoveries, their reserves and their costs using the Monte Carlo technique. For the Irish Sea and WoS assumptions were made for some of these variables because of the limited data available over the last five years in these two regions.

To undertake the modelling, assumptions had to be made regarding future oil and gas prices, $/£ exchange rate, exploration effort, and size of future discoveries. The assumptions are discussed in turn.

The assumptions regarding future oil and gas prices are shown in Table 1.

Table 1

Future Oil and Gas prices (2019 value)		
	Real Oil Price $/bbl	Real Gas Price p/therm
Low	55	35
Medium	60	45
High	70	55

The exchange rate used was £1 = $1.2908.

The assumptions regarding exploration effort over the period are shown in Table 2.

Table 2

Exploration Effort (number of wells)				
	2019	2030	2040	2050
Low	8	5	3	1
Medium	10	7	4	2
High	12	11	8	3

The success rate for exploration was assumed to depend on the size of the effort and recent experience. Higher effort may yield more discoveries, but the success rate may be lower if the resulting higher exploration effort is concentrated on higher risk prospects. This study used three success rates as shown in Table 3.

Table 3

UKCS Success Rates	
Low Effort/ High Success	28.36%
Medium Effort/ Medium Success	25.36%
High Effort/ Low Success	22.36%

The success rate in each region varies depending on the 5-year moving average for each of the different regions.

The average size of discovery in recent years for each of the regions was calculated. It was then assumed that the average size of discovery would decline over time as shown in Table 4.

Table 4

Average discovery size (mmboe)				
	2020	2030	2040	2050
SNS	15	13	11	8
CNS/MF	25	21	17	13
NNS	15	14	12	10
WoS	40	36	31	26
IS	10	8	6	4

In the Monte Carlo modelling these reserves values were taken as the mean values of a lognormal distribution. A standard deviation of 50% was then assumed to determine the distribution of sizes of reserves found for new exploration finds. The total numbers of discoveries made over the period are shown in Table 5.

Table 5

Total number of discoveries to 2051	
Low Effort/ High Success	39
Medium Effort/ Medium Success	47
High Effort/ Low Success	65

The average development costs of the probable, possible and recent new developments was calculated for each of the five regions. For the UKCS as a whole, the average development costs were \$11.34/boe with a maximum of \$20.74/boe. Average development costs in the SNS were \$11.44/boe, in the CNS/MF area they were \$9.27/boe, in the NNS they were \$12.16/boe, and in the WoS they were \$14.85/boe. In the IS the average UKCS value of \$11.34/boe was used because of the lack of new developments in this area.

Average operating costs in the UKCS were found to be \$17.08 boe. In the SNS they were \$9.57/boe, in the CNS/MF area they were \$16.88/boe, and in the WoS they were \$12.49/boe. Average total costs were found to be \$29.97/boe in the UKCS. In the SNS they were \$22.67/boe, in the CNS/MF area they were \$27.05/boe, and in the WoS they were \$29.93/boe.

These values were used with the Monte Carlo technique to find the development costs of new discoveries from a normal distribution with a standard deviation of 20%. Operating costs were modelled as a percentage of cumulative development costs for the fields found with the percentage declining as the field size increased to reflect economies of scale.

Given the physical and financial constraints of the industry it was assumed that there would be a limit on the number of new discoveries which could be developed each year. Thus a cap on the annual number of new developments was introduced. The cap on the number of new development (excluding the incremental projects) was set at 12 for the low effort/ high success case, 15 for the medium effort/ medium success case, and 18 for the high effort/ low success case. The potential number of developments of fields in the category of technical reserves was assumed to be dependent on the difference between the numbers of fields in the categories of probable, possible and new discoveries and the cap.

It was assumed that the average development costs of the technical reserve fields would be \$5 higher per boe than the development cost for new discoveries. The mean development costs (\$ per boe) using a Monte Carlo distribution is shown below in Table 6 with the minimum and maximum values expected within three standard deviations.

Table 6

Mean Development Costs ($/boe) of Technical Reserves					
Devex	SNS	CNS/MF	NNS	WoS	IS
Mean	16.44	14.27	17.16	19.85	16.34
Min	6.58	5.71	6.86	7.94	6.53
Max	26.30	22.83	27.46	31.77	26.14

But it was also assumed that the technical reserves development costs would depend on the size of the reserves reflecting economies of scales. A formula was devised to assign a development costs to each of the technical reserve fields where the cost assigned depended on (1) the average technical reserve field development cost, and (2) the difference between the reserve size and the average size in the region. If a technical reserve field was smaller than the average size found in the region, then the technical reserve cost assigned to that field would be higher than the average technical reserve cost for the region. Similarly, if the technical reserve field was larger than the average found in the region the development cost would be less than the average technical reserve costs for the region[1]. The mean, minimum and maximum values for development costs per boe using this formula are shown in Table 7.

Table 7

Development Costs for Technical Reserve Fields ($/boe)					
Technical reserve development costs	SNS	CNS/MF	NNS	WoS	IS
Mean	18.81	16.86	17.38	24.11	19.36
Min	8.55	5.71	6.03	10.45	8.49
Max	24.09	20.70	41.50	29.08	23.77
68% of distribution between	16.1 & 21.84	13.86 & 19.77	13.78 & 20.5	19.43 & 28.46	17.42 & 22.39
95% of distribution between	14.51 & 23.65	11.8 & 20.51	9.2 & 23.36	14.03 & 29.04	11.06 & 23.42

[1] For a more detailed explanation see A.G. Kemp and L. Stephen, "The Potential Cotribution of Cluster Developments to Maximising Economic Recovery in the UKCS", North Sea Study Occasional Paper No. 144, University of Aberdeen Business School, July 2019, pp. 167 https://www.abdn.ac.uk/research/acreef/working-papers/

For the whole of the UKCS the average development costs per boe for the incremental projects is $14.02. In the CNS/MF area they are $13.05, in the NNS they are $18.29 and in the SNS they are $9.27. The average operating costs per boe is $18.86. It should be noted that 53 projects have no operating costs. Also, of the 86 incremental projects three have no production.

It is highly likely that in future years more incremental projects will come forward. Using the 5-year moving average for costs and reserves of the incremental projects, future projections of incremental production and costs have been made.

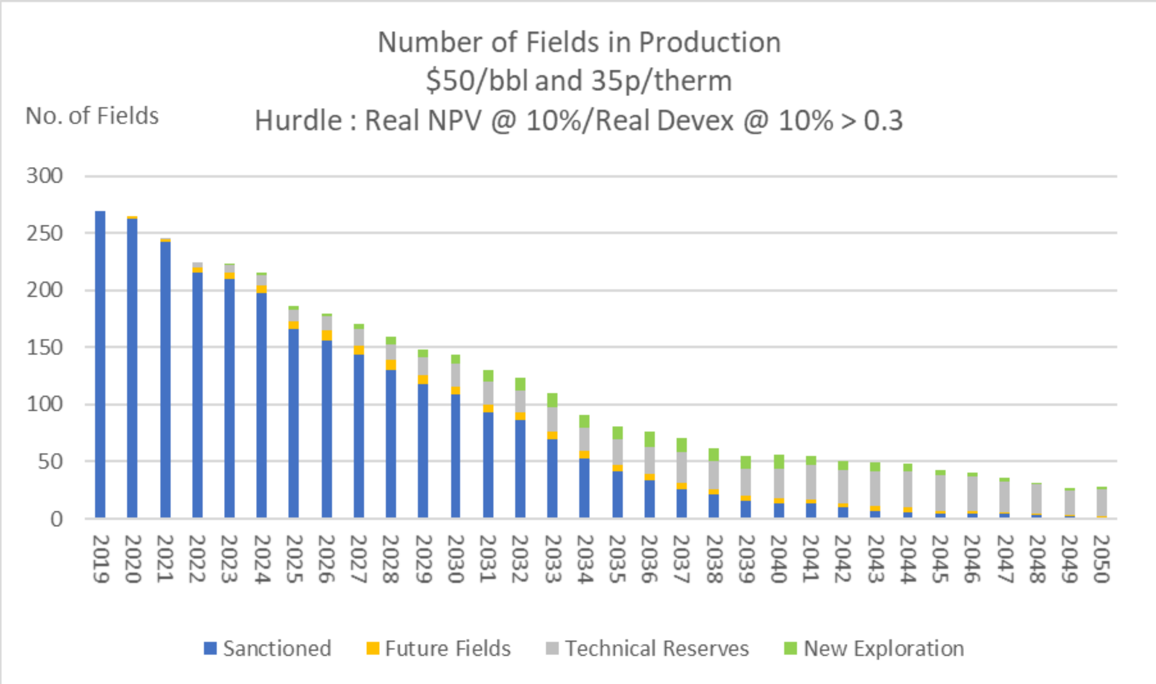
In this paper two hurdle rates have been used for probable fields, possible fields, new exploration fields, technical reserve fields and incremental projects, namely: Real Post-tax Net Present Value at 10% / Real Investment cost at 10% $\geq$ 0.3, and Real Post-tax Net Present Value at 10% / Real Investment cost at 10% $\geq$ 0.5. It is recognised that the hurdle of NPV/I $\geq$ 0.5 is extremely challenging. For the purposes of tax, it is assumed that the operator of the sanctioned fields and the incremental projects is in an ongoing tax-paying position but for the probable, possible, technical reserves, and new exploration finds it is assumed that the investor is in a project tax position.

3. Results

a) Fields in Production

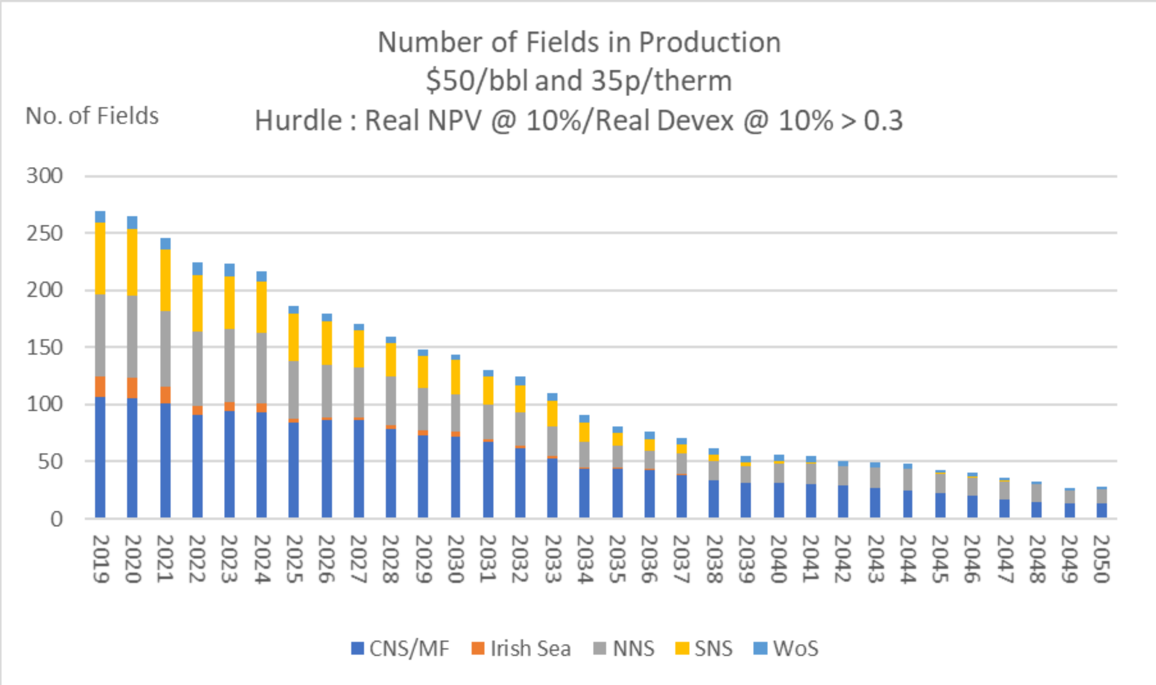
i) $50, 35 pence prices

Chart 1



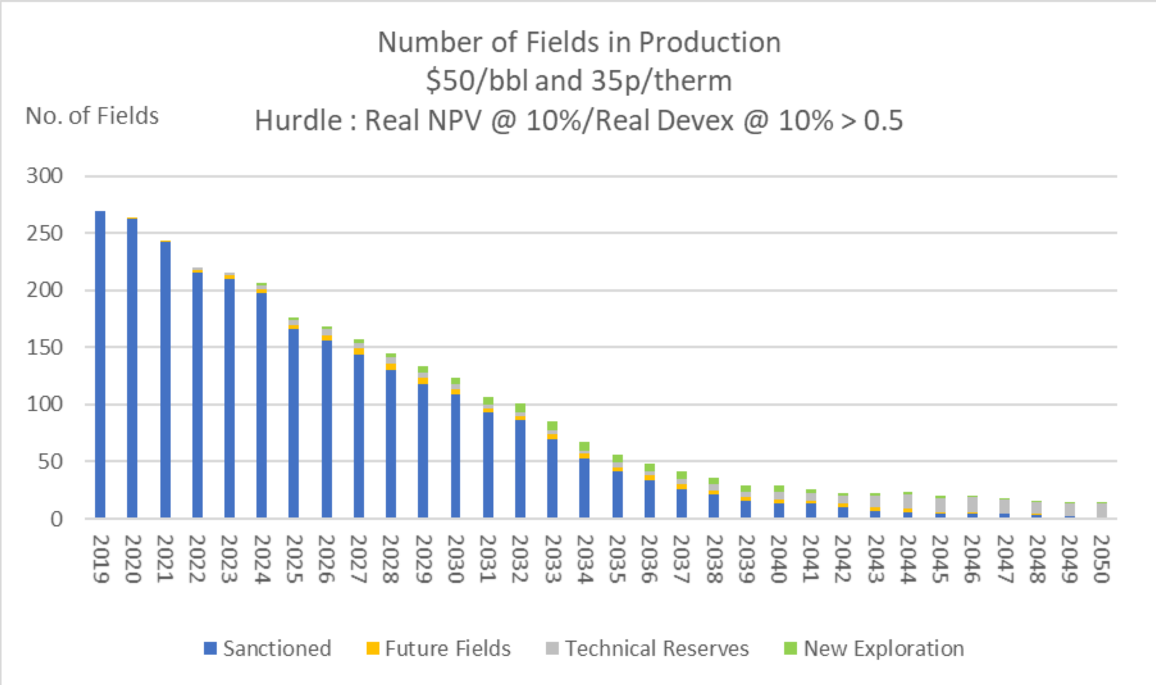
From Chart 1 it is seen that with the $50, 35 pence price case and NPV/I $\geq$ 0.3 hurdle the number of currently sanctioned fields falls to 41 in 2035 and 10 in 2042. There are 4 sanctioned fields which begin development in the period. Of the 12 probable fields 3 fail the hurdle, of the 2 possible fields 1 fails the hurdle. Of the 415 technical reserve fields 317 fail the hurdle, and of the 39 new exploration finds 17 fail. Nine probable fields and 1 possible field pass the hurdle as do 98 technical reserve finds, but only 81 of these begin production before 2051. Further 22 new exploration finds pass the 0.3 hurdle. Of the 86 incremental projects 35 fail the hurdle of which 3 fail because the host field ceases production before the developments can start. There are 3 projects which are solely expenditures.

Chart 2



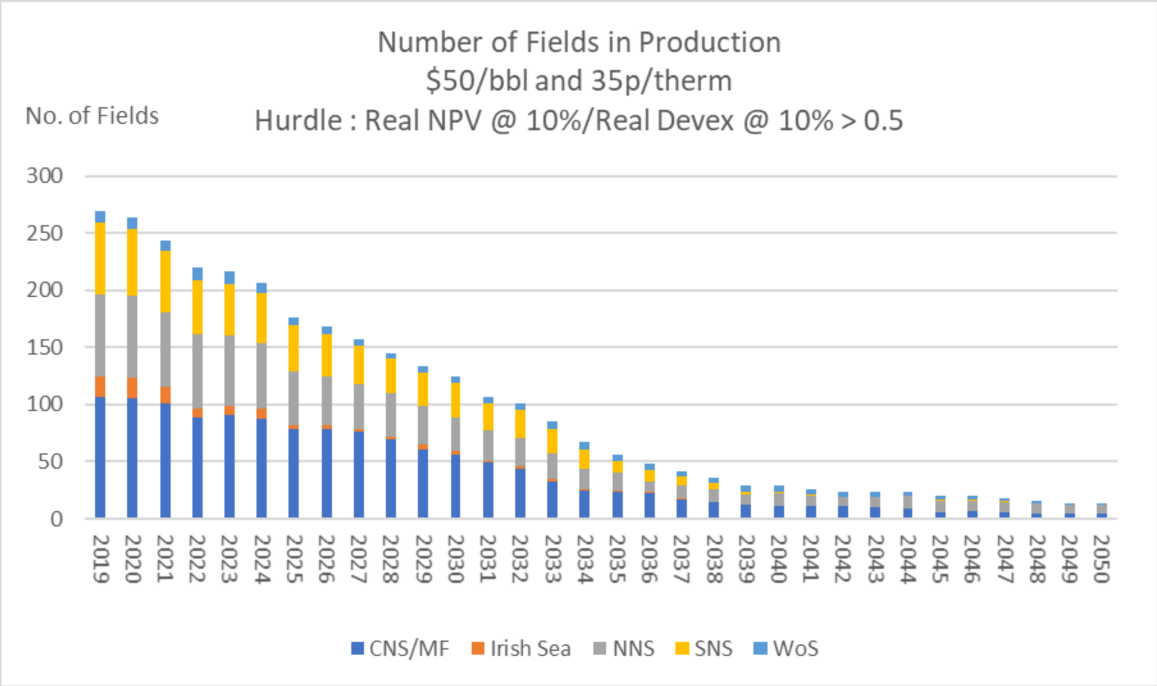
In Chart 2 the numbers of fields in production are shown by main geographic areas. Of the 468 new developments 185 are in the CNS/MF area, 16 are in the IS, 100 are in the NNS, 122 are in the SNS and 45 are in the WoS area. Of the 338 fields which fail the hurdle 112 are in the CNS/MF area, 15 are in the IS, 49 are in the NNS, 120 are in the SNS and 42 are in the WoS area. A total of 73 fields in the CNS/MF area pass the hurdle, but 9 begin development after 2050. Fifty-one fields in the NNS pass the hurdle, of which 8 begin development after 2050. In the WoS, 3 fields pass the hurdle, 2 fields in the SNS, and 1 field in the Irish Sea.

Chart 3



The results with the very high NPV/I ≥ 0.5 hurdle are shown in Chart 3. Of the 12 probable fields 6 fail, as do the 2 possible fields. Of the 415 technical reserve fields 391 fail and of the 39 new exploration finds 27 fail. Thus 6 probable fields pass the hurdle, 24 technical reserve fields pass, though 1 begins development after 2050, and 12 new exploration finds pass. Of the 86 incremental projects 44 fail the 0.5 hurdle.

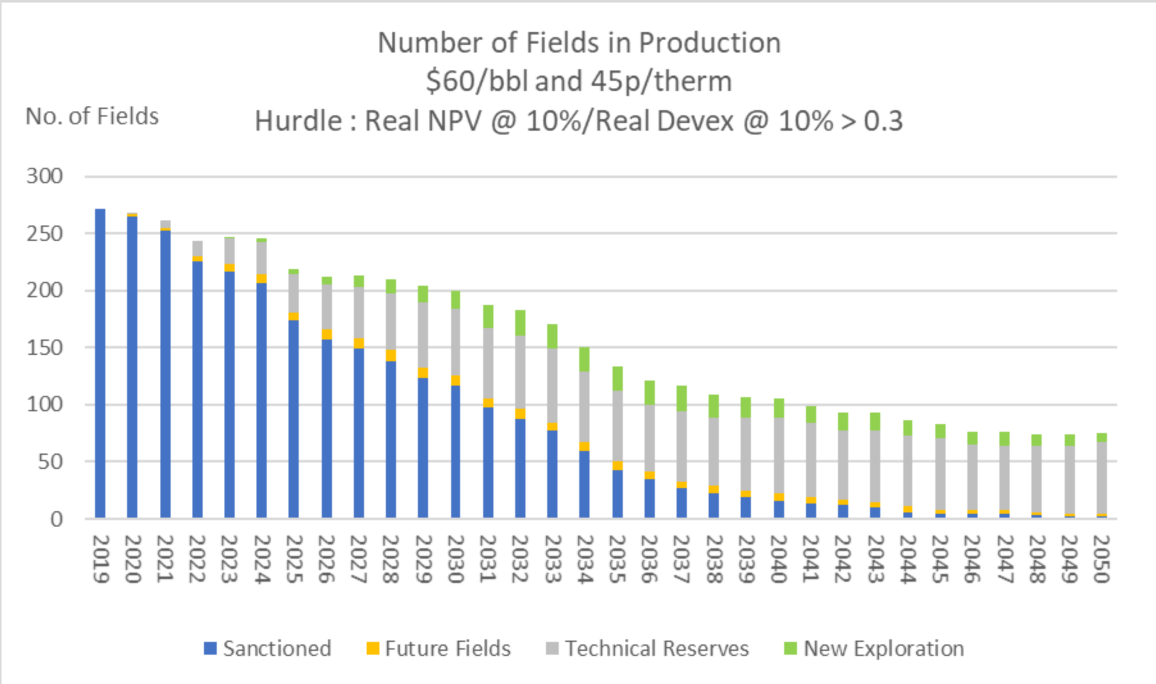
Chart 4



In Chart 4 the numbers of fields passing the NPV/I ≥ 0.5 hurdle are shown. A total of 426 fields fail the hurdle of which 171 are in the CNS/MF area, 15 in the IS, 77 in the NNS, 121 in the SNS, and 42 in the WoS area. Thus, on these assumptions 14 fields in the CNS/MF area pass the hurdle, as do 24 fields in the NNS but 1 has developed beginning after 2050. Two fields pass in the WoS region, 1 in the SNS, and 1 in the Irish Sea.

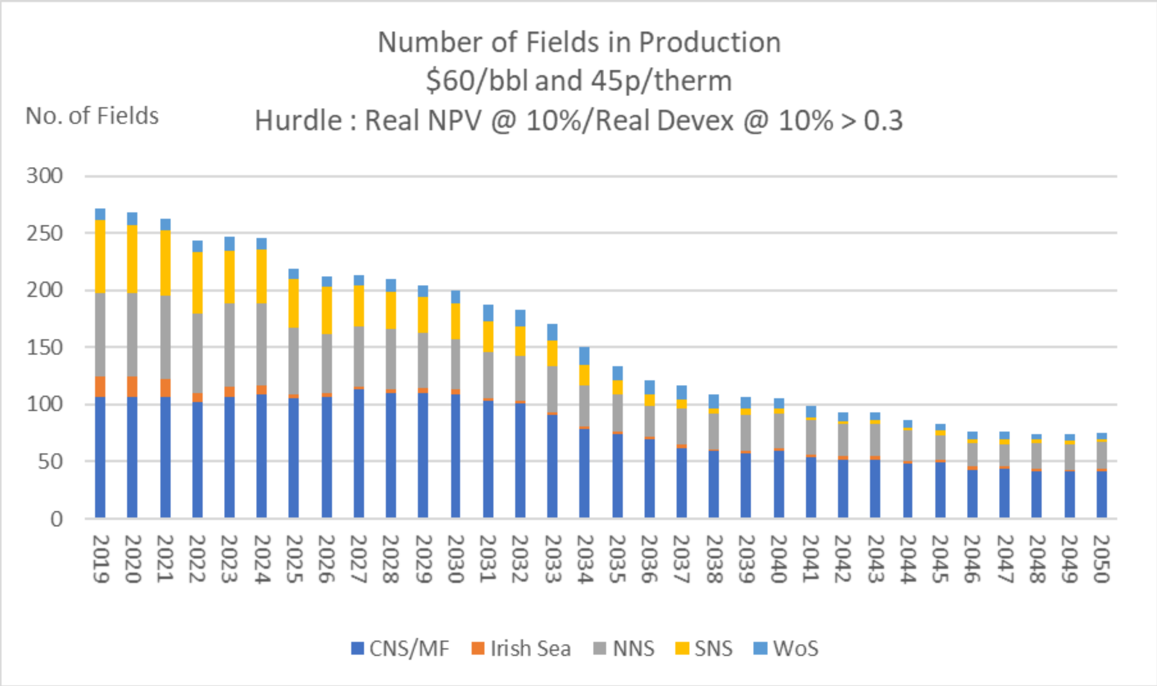
ii) $60, 45 pence prices

Chart 5



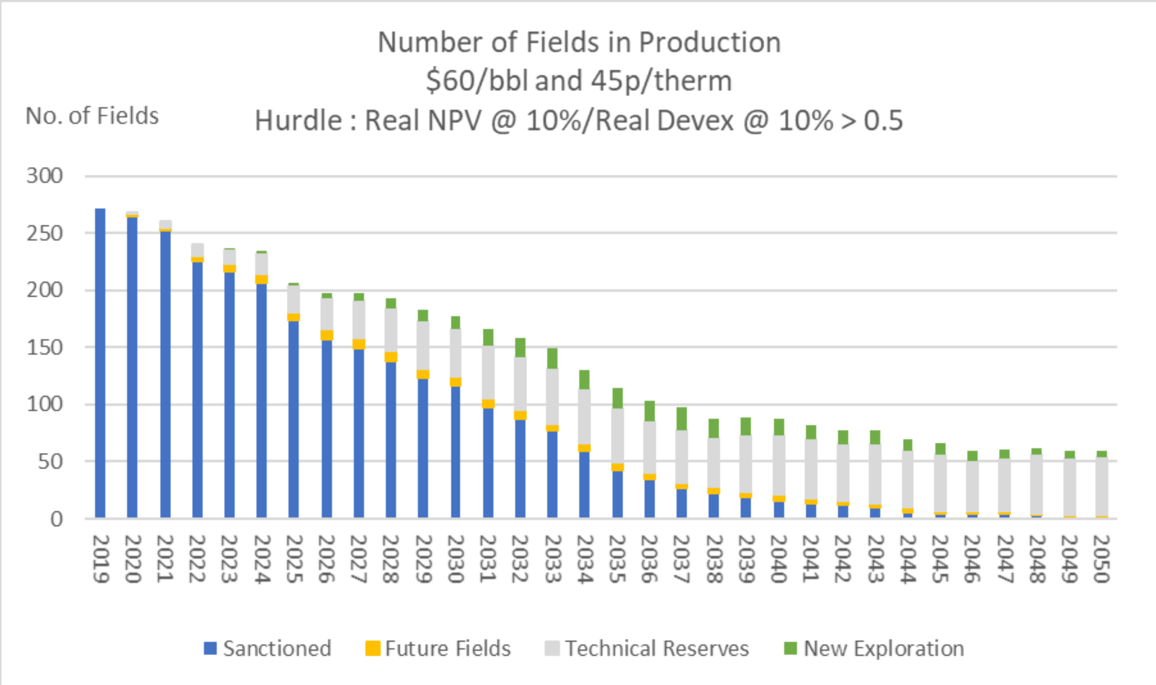
The results with $60 and 45 pence prices are shown in Chart 5. With NPV/I ≥ 0.3 hurdle 2 probable fields fail, as does 1 possible field, and 207 technical reserve fields. Of the 47 new exploration finds 3 fail. Thus, in this scenario 10 probable fields and 1 possible field pass the hurdle, as do 208 technical reserve fields, and 44 new exploration finds. Of the 86 incremental projects 29 fail the hurdle.

Chart 6



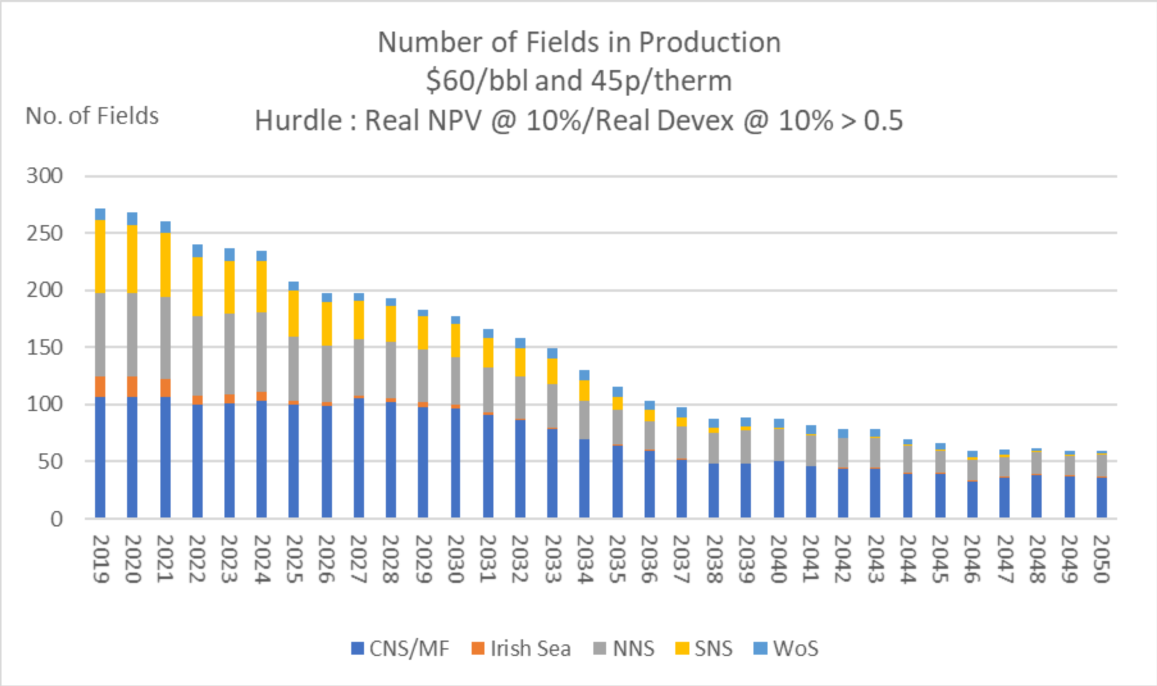
The results of this scenario by geographic region are shown in Chart 6. Of the 213 fields which fail the hurdle 30 are in the CNS/MF area, 11 are in the IS, 23 are in the NNS, 116 are in the SNS, and 33 are in the WoS area. Thus 156 fields in the CNS/MF are pass the hurdle (but 1 field has development expenditure after 2050), 80 fields in the NNS pass the hurdle (but 1 field also has development expenditure after 2050), 13 fields pass in the WoS, 7 fields in the SNS, and 7 fields in the Irish Sea.

Chart 7



The results with the hurdle of NPV/I ≥ 0.5 are shown in Chart 7. Three probable fields fail the hurdle, as does 1 possible field, 255 technical reserve fields, and 13 new exploration finds. Thus 9 probable fields and 1 possible field pass the hurdle, as do 160 technical reserve fields and 34 new exploration finds. Of the 86 incremental projects 37 fail the hurdle.

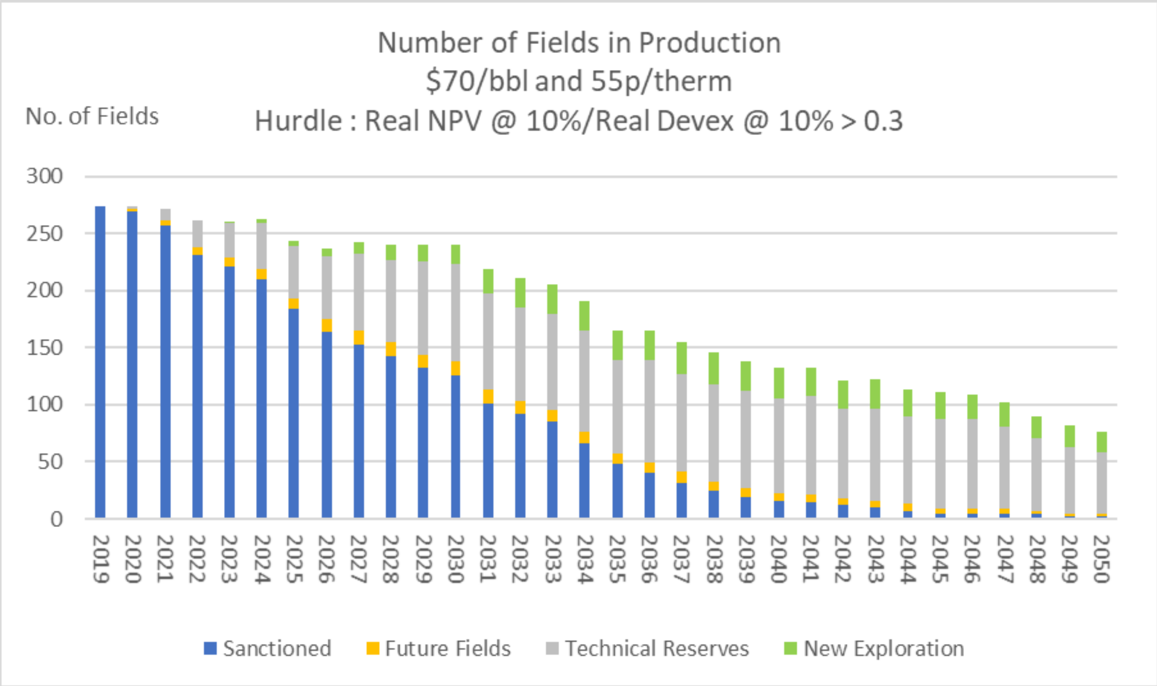
Chart 8



The results on a geographic basis are shown in Chart 8. Of the 272 fields which fail the hurdle 61 are in the CNS/MF area, 15 are in the IS, 35 are in the NNS, 120 are in the SNS and 41 are in the WoS area. Thus 125 fields in the CNS/MF are pass the hurdle (but 1 begins development after 2050), 68 fields pass in the NNS (but 1 begins development after 2050), 6 fields pass in the WoS, 3 fields in the SNS and 2 fields in the Irish Sea.

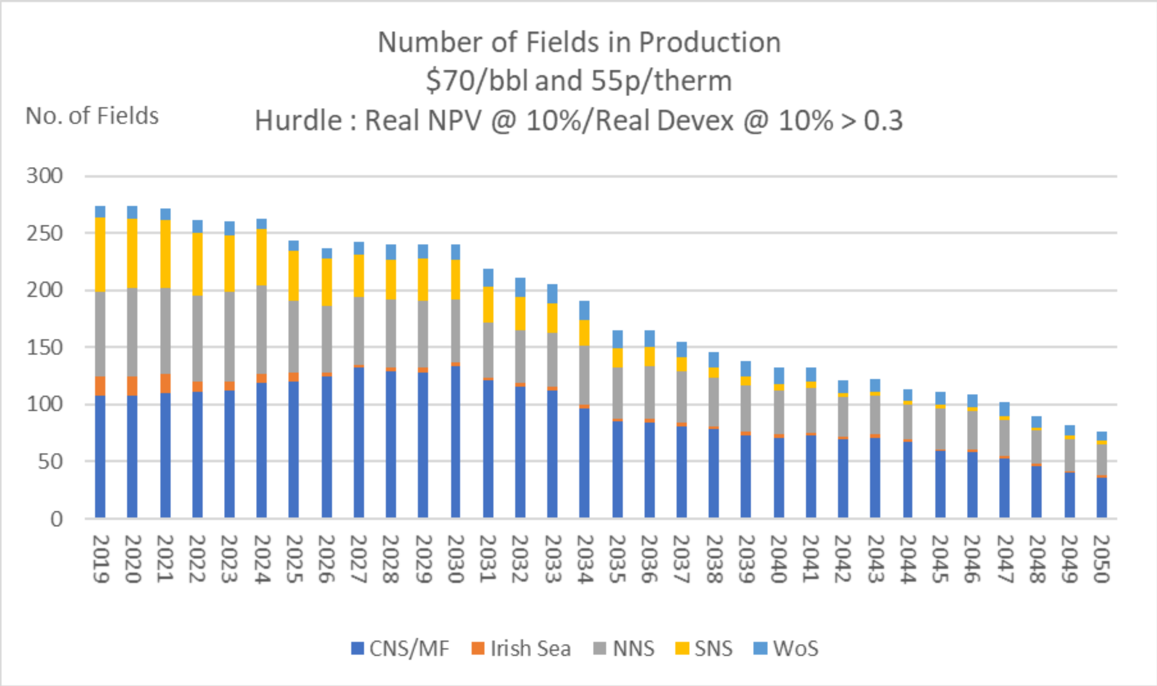
iii) $70, 55 pence prices

Chart 9



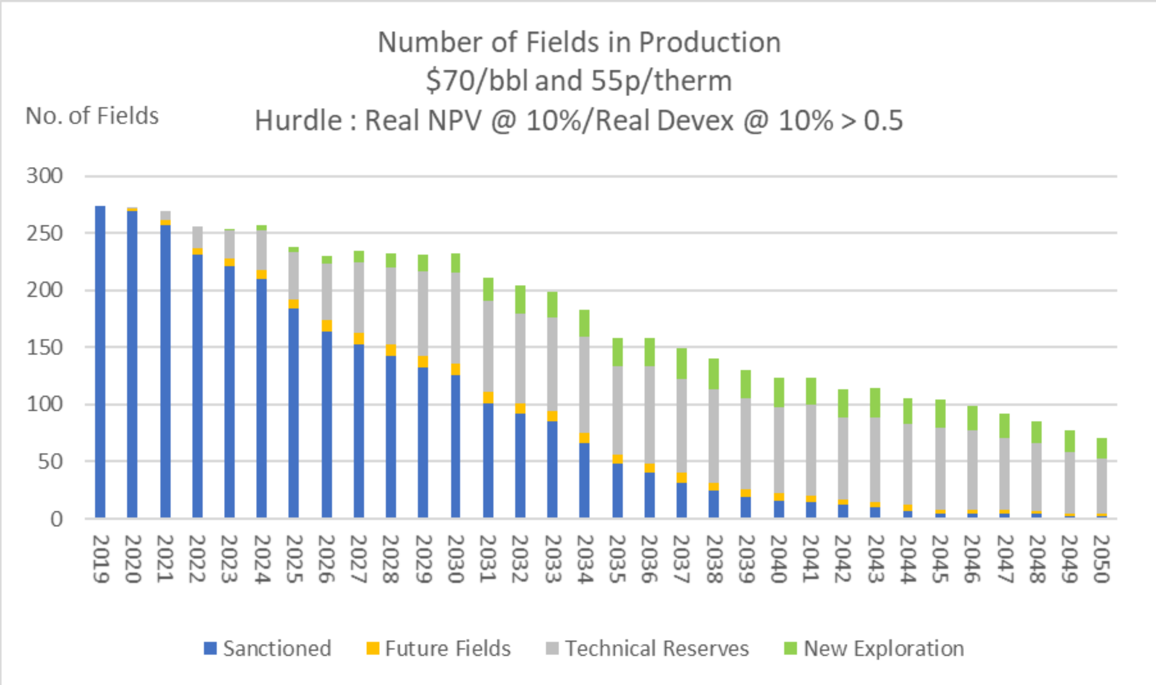
The results with $70, and 55 pence prices are shown in Chart 9. With a 0.3 hurdle 177 technical reserve fields fail. Of the 65 new exploration finds 1 fails the hurdle. In this scenario 12 probable fields and 2 possible fields pass the hurdle, as do 238 technical reserve fields, and 64 new exploration finds. Of the 86 incremental projects 21 fail the hurdle.

Chart 10



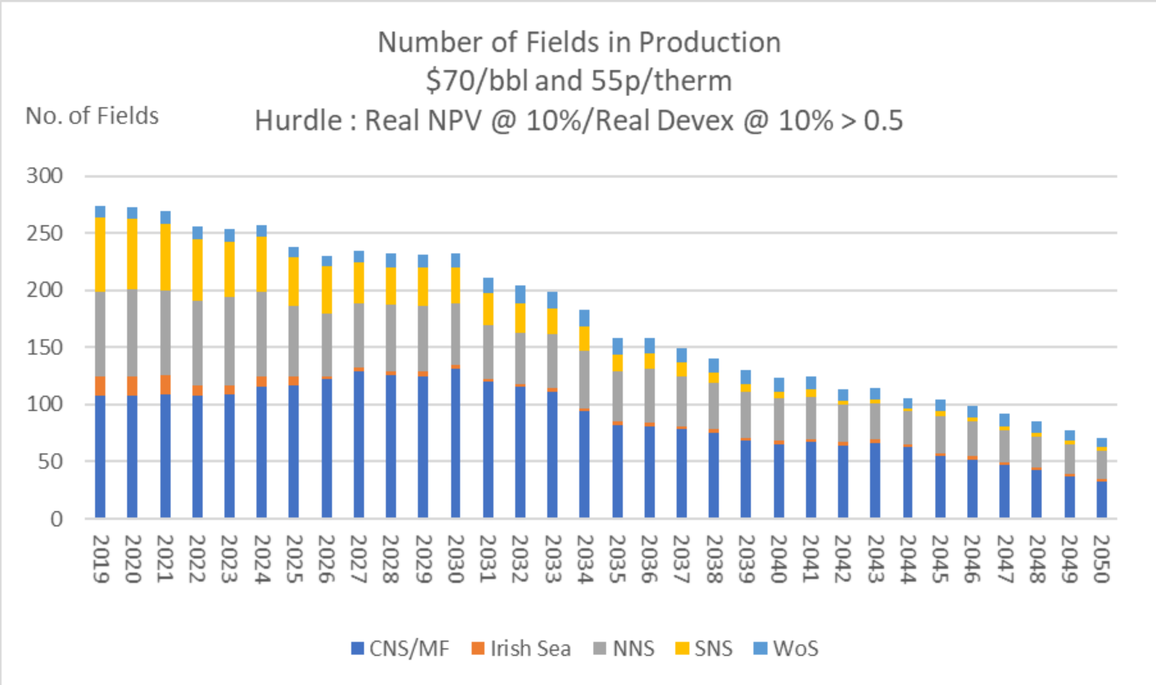
The results for the \$70, 55 pence prices and NPV/I $\geq$ 0.3 hurdle on a geographic basis are shown in Chart 10. Of the 178 fields which fail the hurdle 11 are in the CNS/MF area, 11 are in the IS, 32 are in the NNS, 112 are in the SNS, and 31 are in the WoS area. Thus 179 fields in the CNS/MF area pass the hurdle (but 1 begins development after 2050), 98 fields pass in the NNS (but 1 begins development after 2050), 20 fields pass in the WoS, 13 fields in the SNS and 6 fields in the Irish Sea.

Chart 11



The results with the NPV/I ≥ 0.5 hurdle are shown in Chart 11. One probable field, and 1 possible field fail the hurdle, 196 technical reserve fields fail, and 4 new exploration finds fail. Thus 219 technical reserve fields and 61 new exploration finds pass the hurdle. Of the 86 incremental projects 33 fail the hurdle.

Chart 12

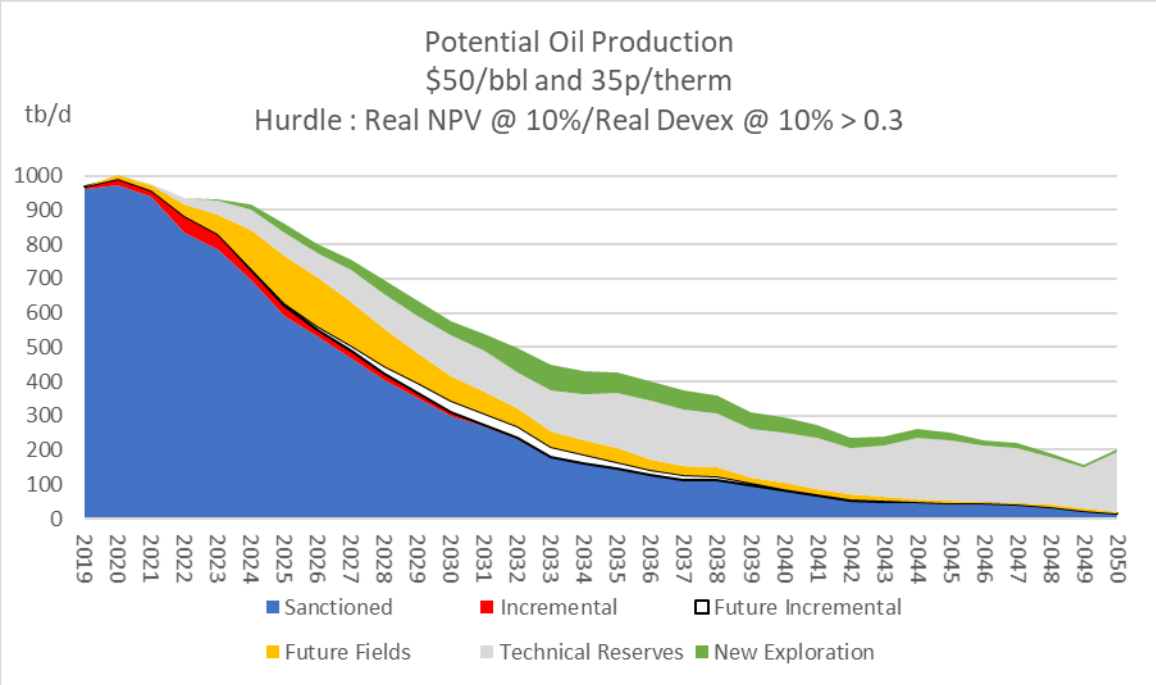


The results on a geographic basis are shown in Chart 12. Of the 202 fields which fail the 0.5 hurdle, 23 are in the CNS/MF area, 11 are in the IS, 19 are in the NNS, 115 are in the SNS, and 34 are in the WoS area. Thus 167 fields in the CNS/MF area pass the hurdle (but 1 begins development after 2050), 92 fields in the NNS pass (but 1 begins development after 2050), 17 fields pass in the WoS, 10 fields in the SNS and 6 fields in the Irish Sea.

b) Production – Oil

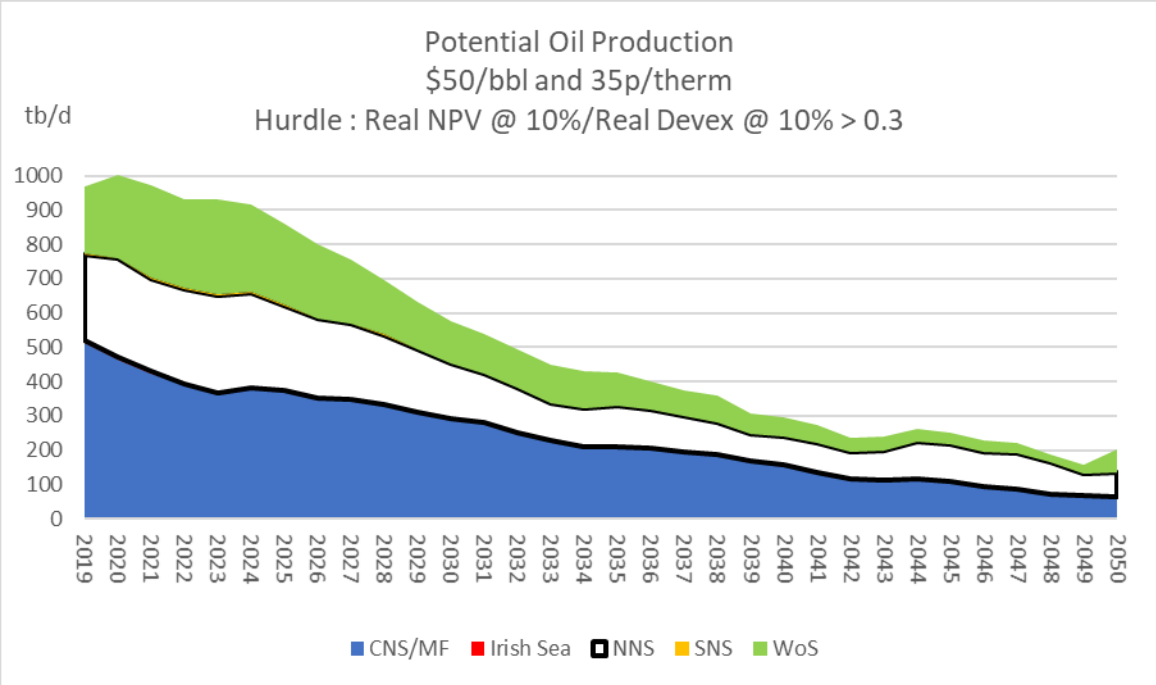
i) $50, 35 pence prices

Chart 13



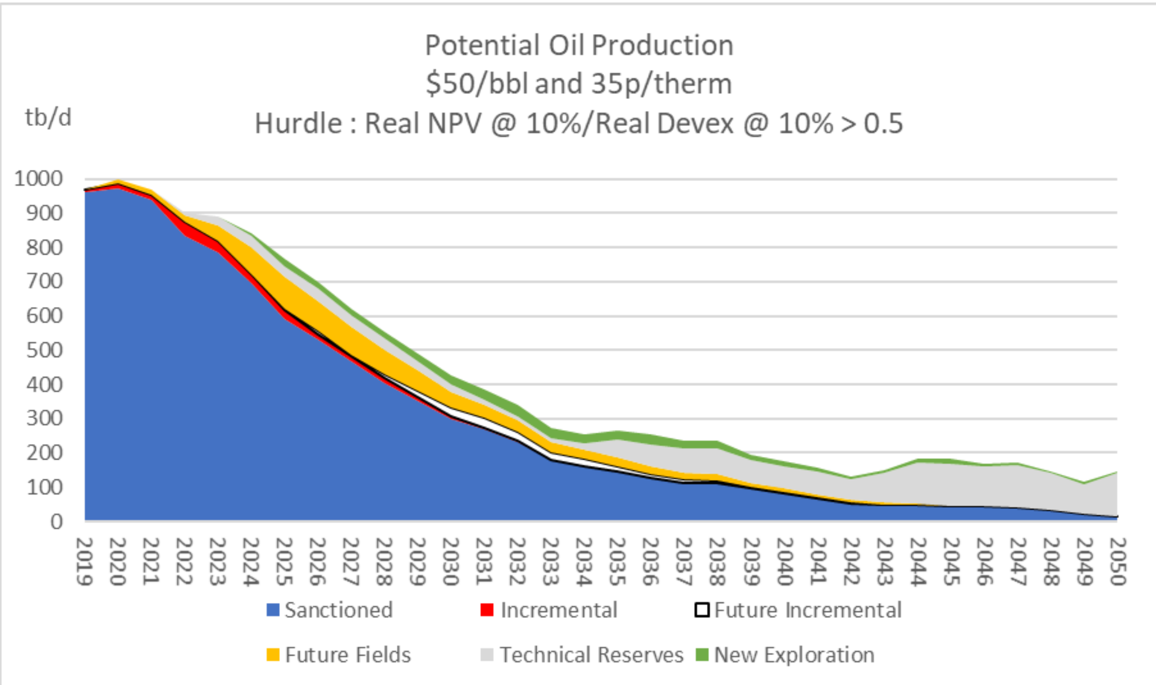
The results for oil production at the $50 price and the 0.3 hurdle are shown in Chart 13. Over the period 2019-2050 cumulative oil production is 5,982 million barrels of which 3,561 million barrels come from the already sanctioned fields, 111 million barrels may come from the current incremental projects, 118 million barrels may come from future incremental projects, 488 million barrels may come from the probable and possible fields, 1,332 million barrels may come from the technical reserve fields, and 372 million barrels may come from new exploration fields. Production is seen to decline briskly from 2025 onwards and becomes less than 200,000 b/d in 2050.

Chart 14



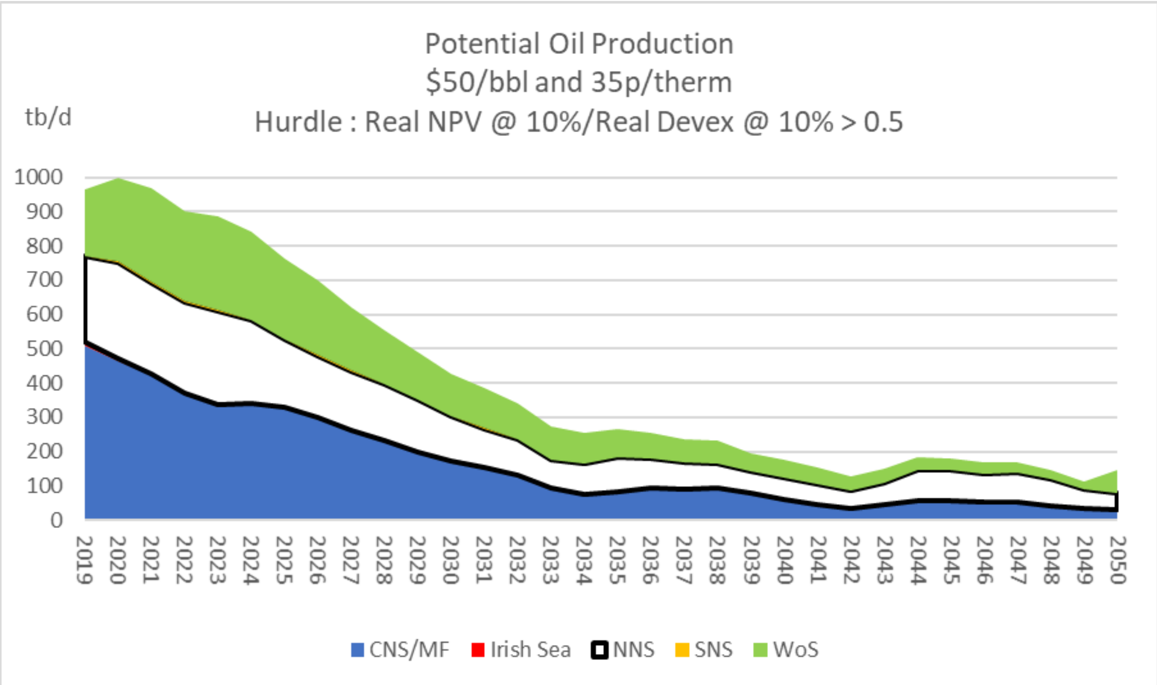
Production by geographic area is shown in Chart 14. Cumulative oil production from the CNS/MF is 2,773 million barrels, 1,781 million barres is from the NNS and 1,405 million barrels from the WoS.

Chart 15



Production with the hurdle rate ≥ 0.5 is shown in Chart 15. Cumulative oil to 2050 is 4,847 million barrels of which 3,561 million barrels come from the already sanctioned fields, 89 million barrels from current incremental projects, 86 million barrels from future incremental projects, 313 million barrels from the probable and possible fields, 626 million barrels from the technical reserve fields, and 172 million barrels from new exploration finds.

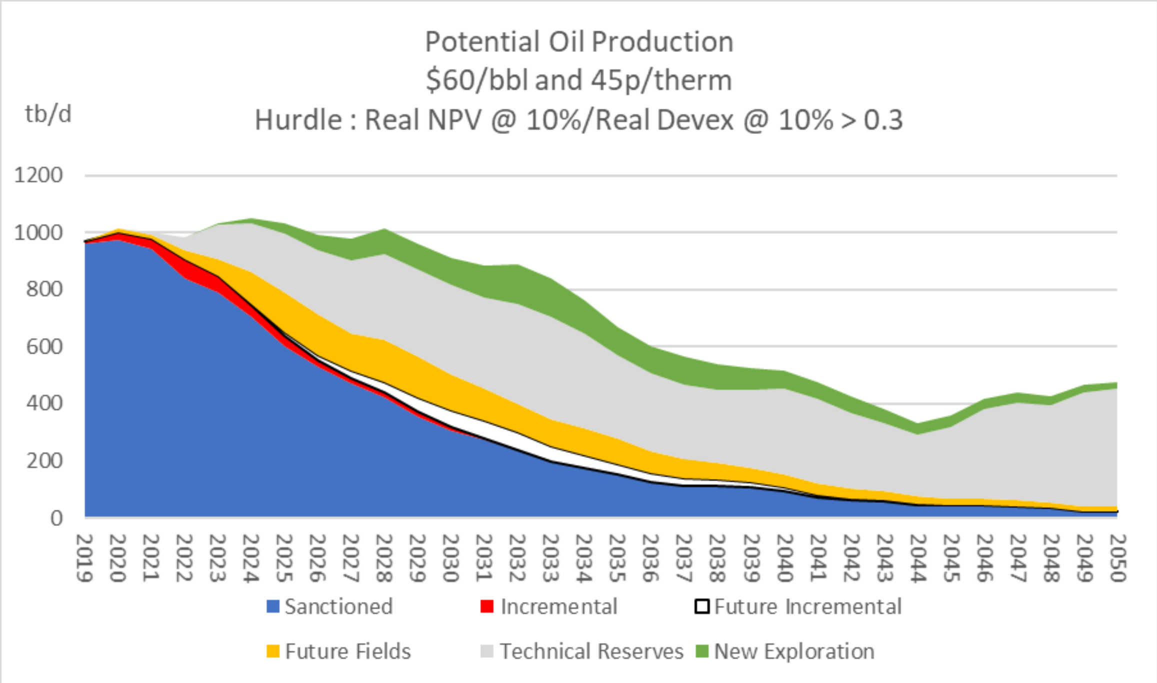
Chart 16



Prospective production to 2050 from the main geographic areas is shown in Chart 17. Cumulative oil production from the CNS/MF is 1,946 million barrels, 1,510 million barrels from the NNS, and 1,369 million barrels from the WoS.

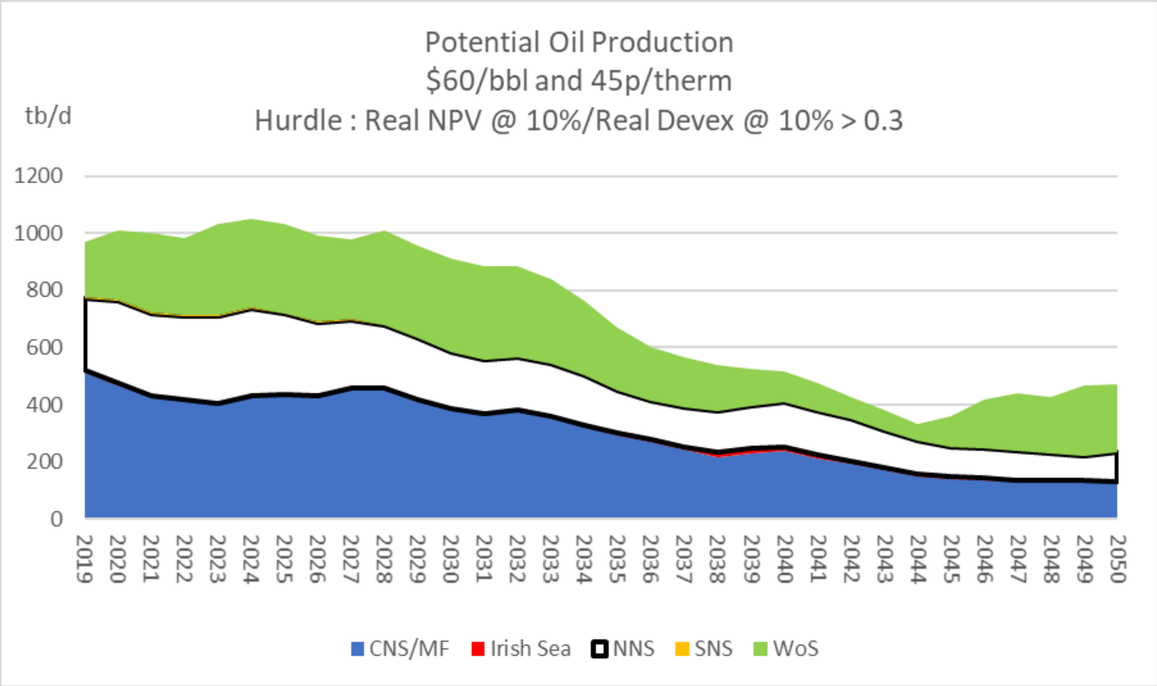
ii) $60, 45 pence prices

Chart 17



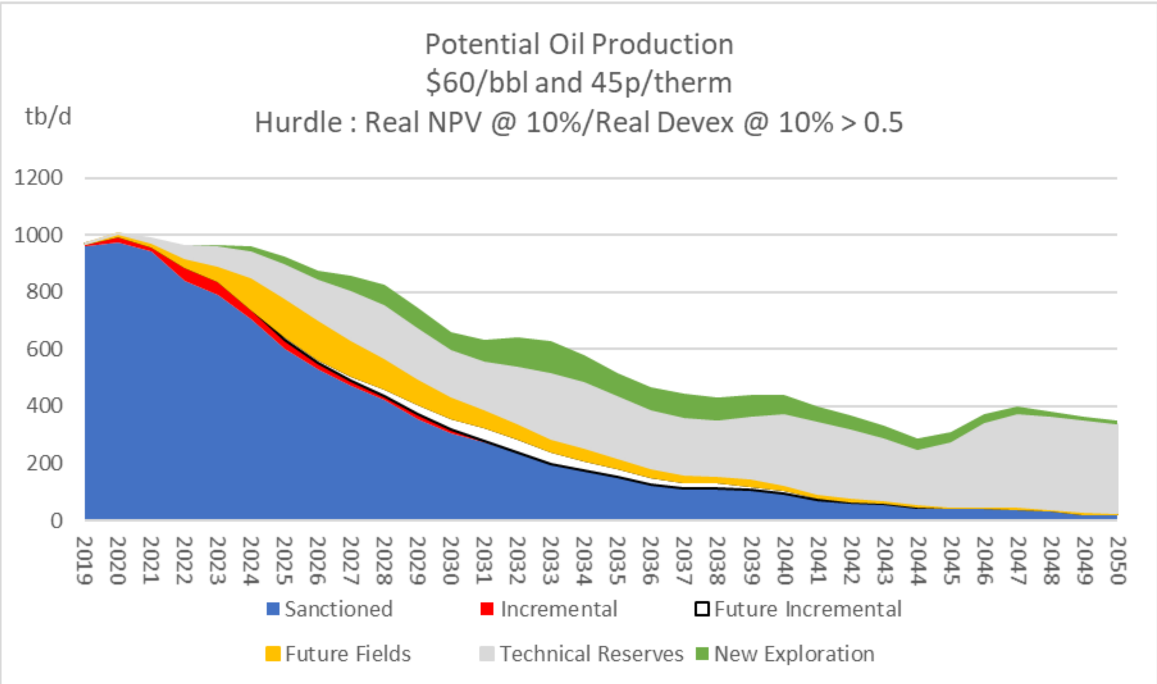
With a $60 price and NPV/I ≥ 0.3 hurdle over the period to 2050 cumulative oil production (Chart 17) is 8,370 million barrels, of which 3,625 million barrels come from already sanctioned fields, 138 million barrels from current incremental projects, 214 million barrels from future incremental projects, 767 million barrels from the probable and possible fields, 2,934 million barrels from the technical reserve fields, and 693 million barrels from new exploration finds.

Chart 18



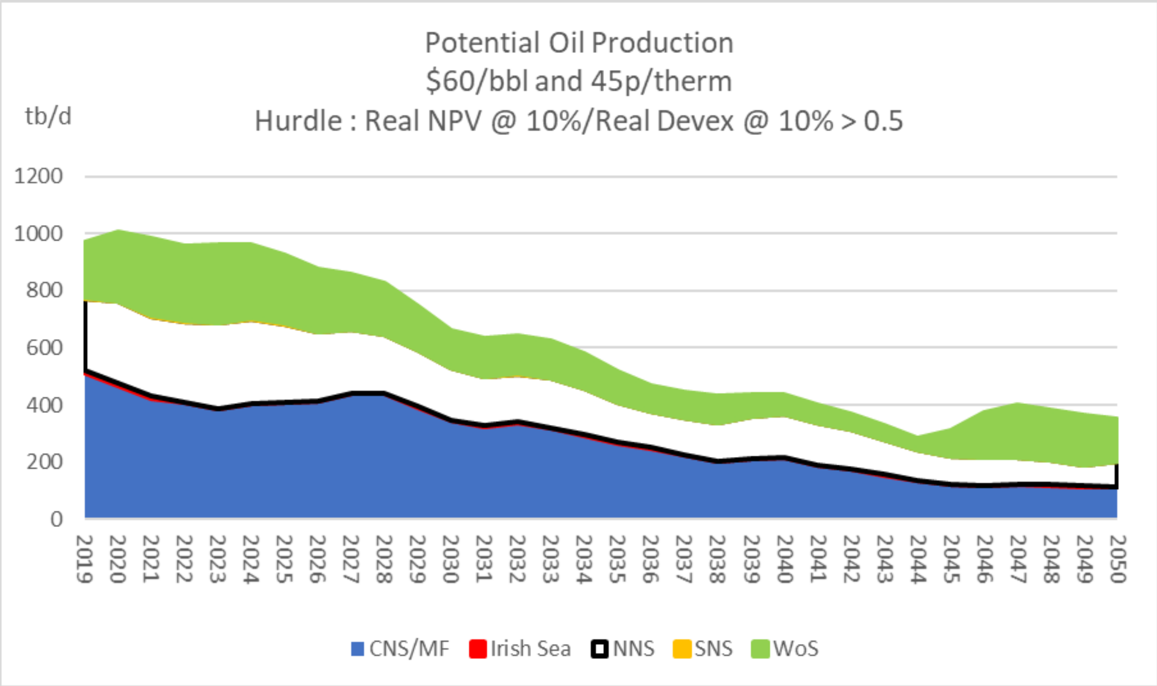
The geographic distribution of oil production is shown in Chart 18. Cumulative oil production from the CNS/MF is 3,536 million barrels, 2,150 million barrels come from the NNS, and 2,606 million barrels come from the WoS.

Chart 19



With the 0.5 hurdle, cumulative oil production (Chart 19) is 7,117 million barrels, of which 3,625 million barrels come from the already sanctioned fields, 112 million barrels come from current incremental projects, 173 million barrels come from future incremental projects, 493 million barrels come from the probable and possible fields, 2,167 million barrels from the technical reserve fields, and 549 million barrels come from new exploration finds.

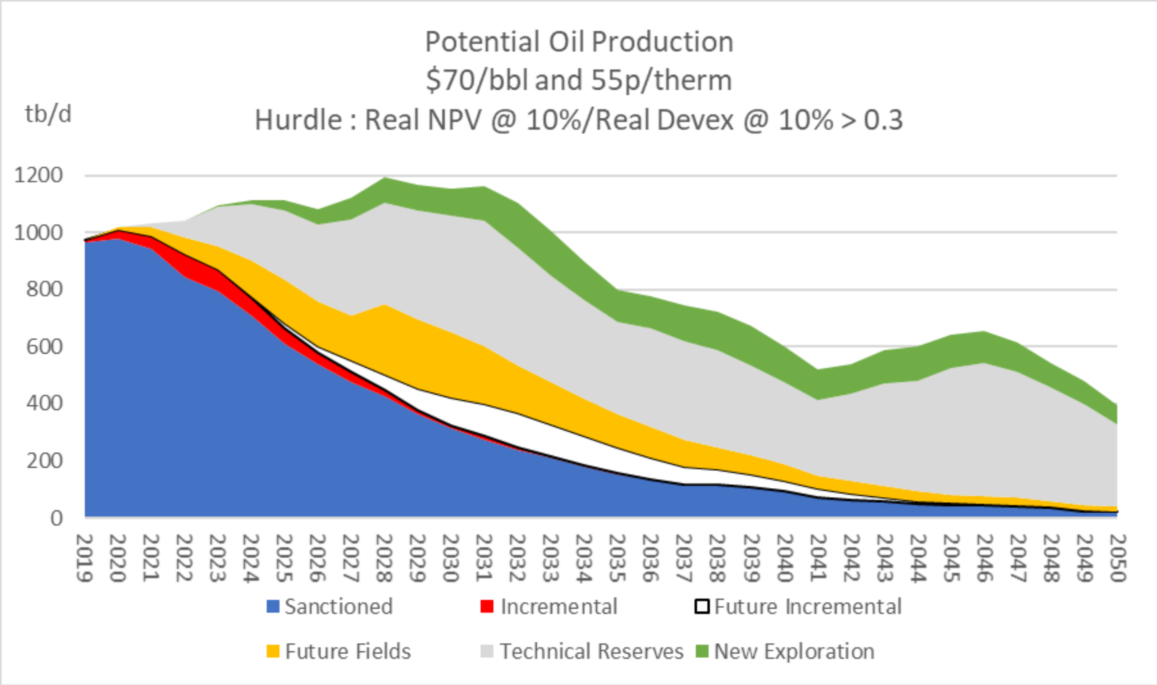
Chart 20



The geographical distribution of oil production is shown in Chart 20. Cumulative production from the CNS/MF is 3,299 million barrels, 2,041 million barrels come from the NNS and 1,751 million barrels come from the WoS.

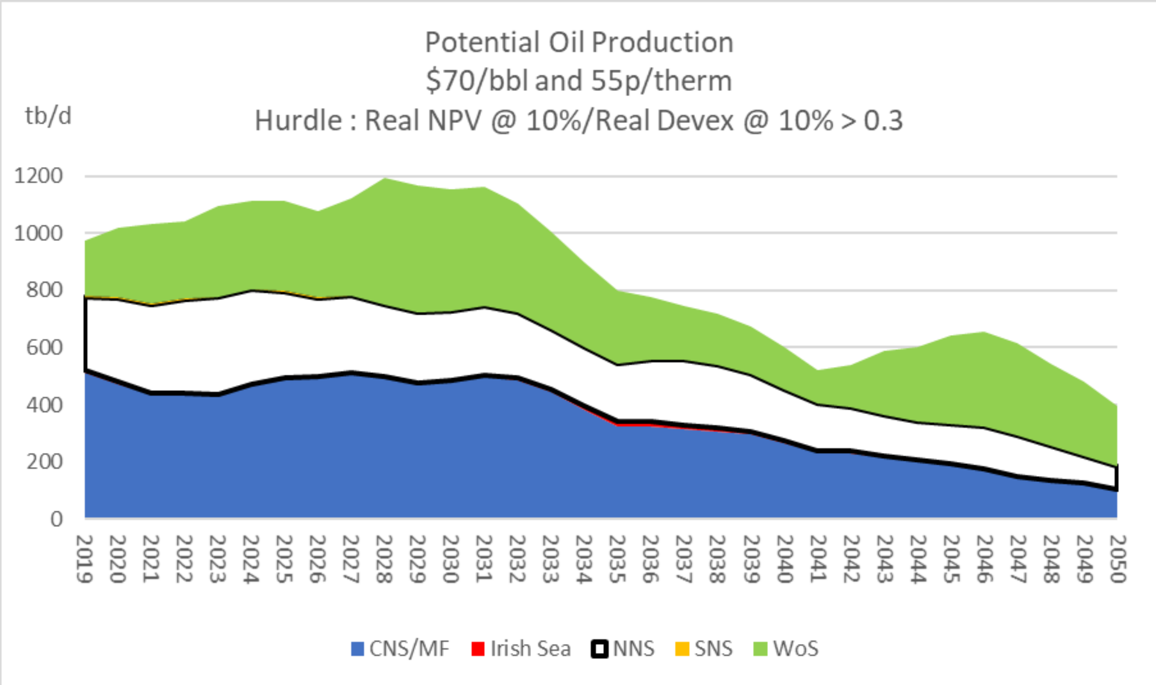
iii) $70, 55 pence prices

Chart 21



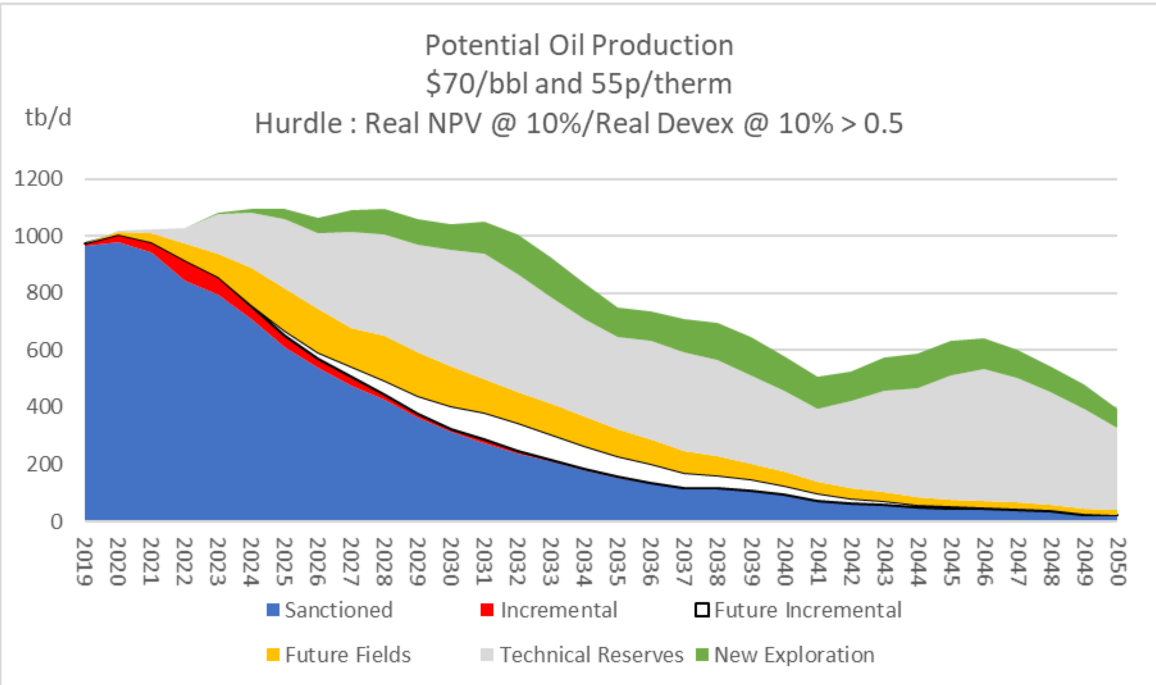
With a $70 and NPV/I ≥ 0.3 hurdle, over the period 2019-2050 cumulative oil production is 9,917 million barrels (Chart 21), of which 3,658 million barrels come from the already sanctioned fields, 194 million barrels come from current incremental projects, 447 million barrels come from future incremental projects, 1,078 million barrels come from the probable and possible fields, 3,518 million barrels come from the technical reserve fields, and 1,022 million barrels come from new exploration finds. The very large contribution from fields in the category of technical reserves is the most dramatic feature of the results.

Chart 22



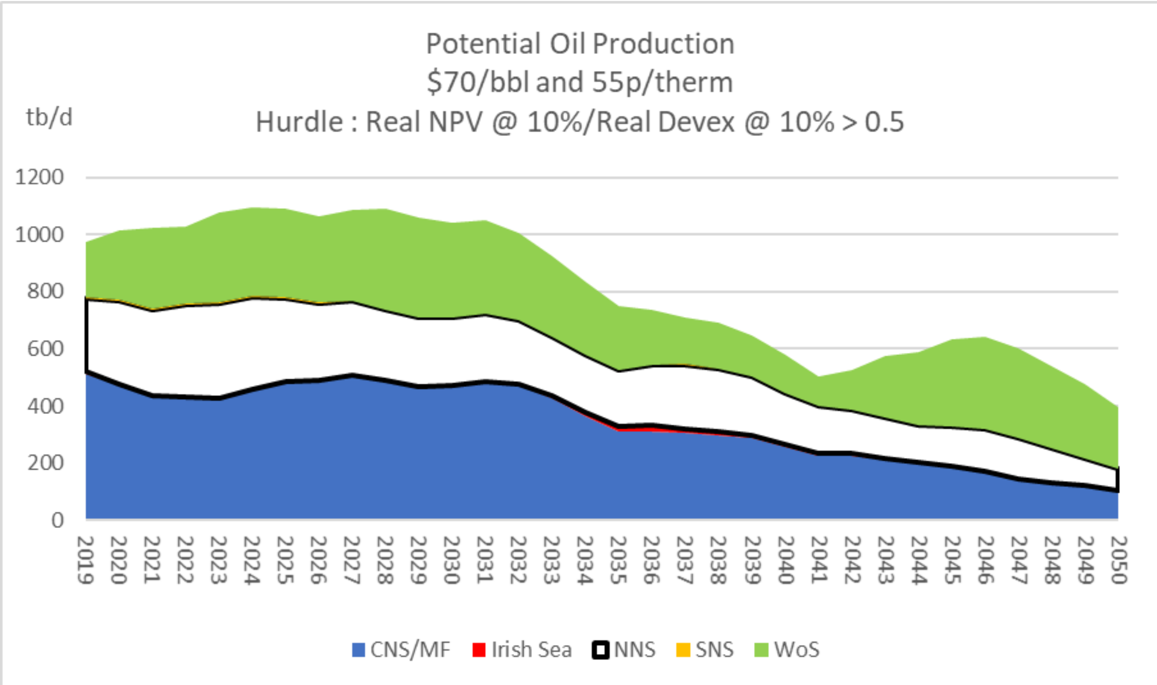
Under this price scenario, cumulative oil production to 2050 from the CNS/MF is 4,057 million barrels, while 2,518 million barrels come from the NNS and 3,263 million barrels come from the WoS.

Chart 23



With a $70 and the NPV/I ≥ 0.5 hurdle, over the period cumulative oil production is 9,515 million barrels (Chart 23), of which 3,658 million barrels come from the already sanctioned fields, 164 million barrels come from current incremental projects, 377 million barrels come from future incremental projects, 840 million barrels come from the probable and possible fields, 3,488 million barrels come from the technical reserve fields, and 988 million barrels come from new exploration finds.

Chart 24

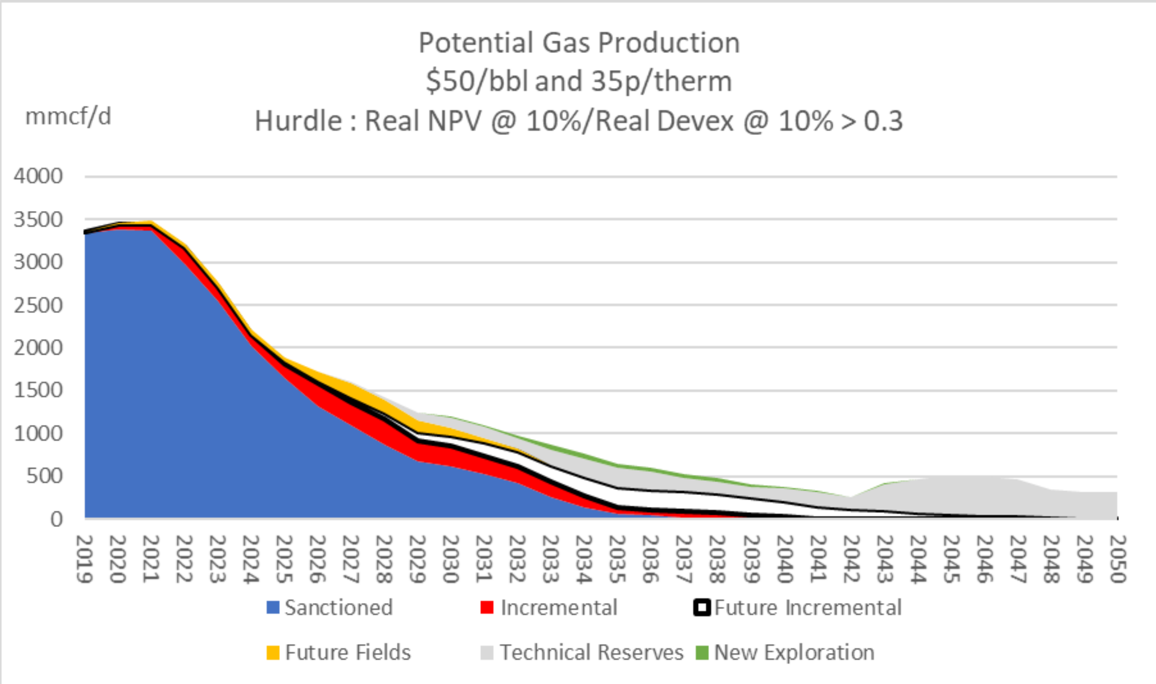


With $70 price and the NPV/I ≥ 0.5 hurdle, as seen in Chart 24, cumulative oil production from the CNS/MF is 3,963 million barrels, 2,483 million barrels from the NNS and 2,990 million barrels from the WoS.

Production – Natural Gas

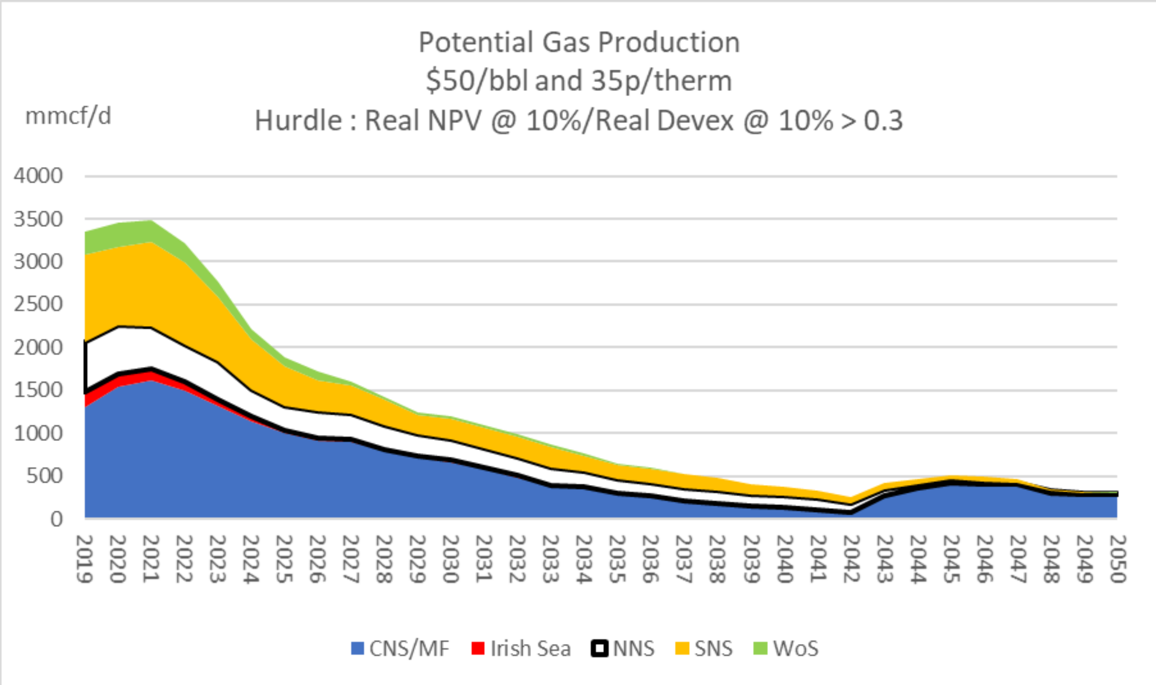
i) 35 pence price

Chart 25



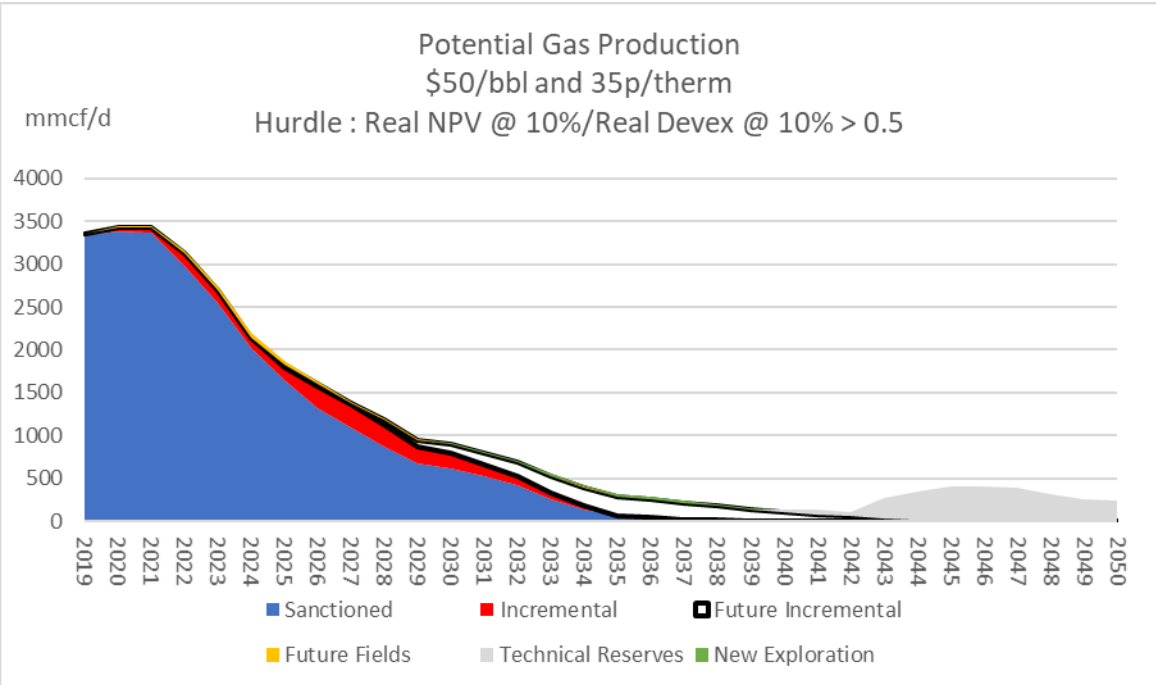
Over the period, with a $50 price and 35 pence gas price, with the NPV/I ≥ 0.3 hurdle, cumulative gas production is 2,488 million barrels of oil equivalent, of which 1,648 mmboe come from the already sanctioned fields, 205 mmboe come from the current incremental projects, 208 mmboe come from future incremental projects, 66 mmboe come from the probable and possible fields, 330 mmboe come from the technical reserve fields, and 30 mmboe come from new exploration finds. It is seen that the decline rate in gas production is much steeper than the corresponding rate for oil.

Chart 26



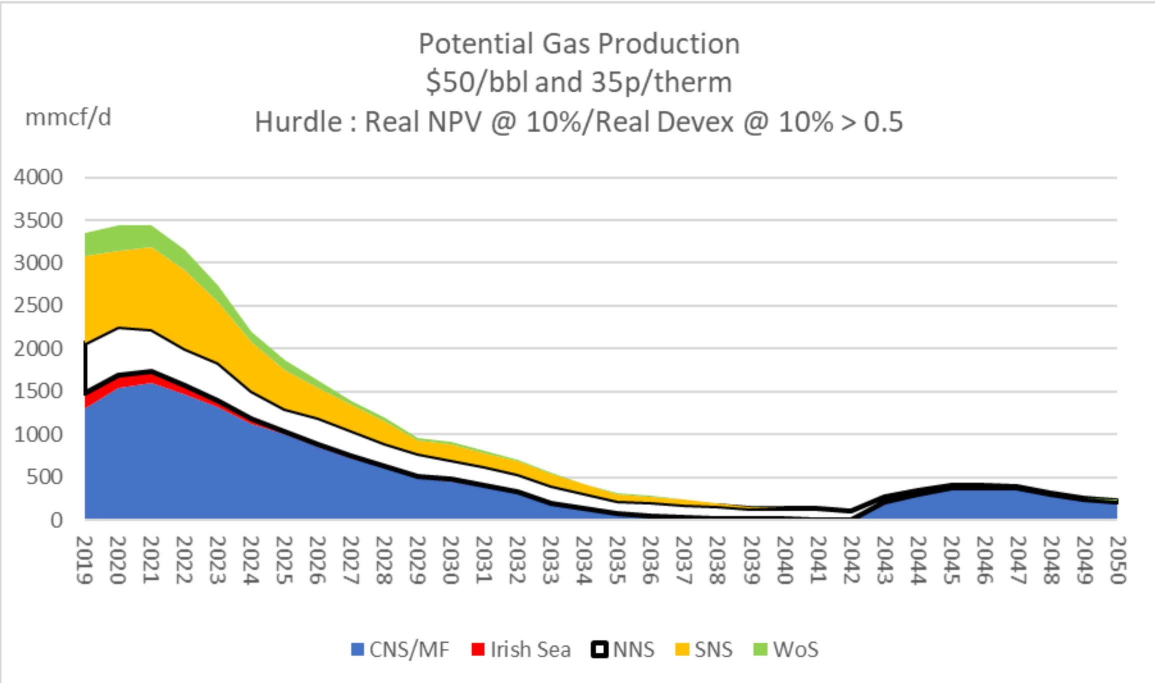
Over the period, it is seen (Chart 26) with a $50 price and 35 pence gas price and the NPV/I ≥ 0.3 hurdle, cumulative gas production from the CNS/MF area is 1,261 mmboe, 59 mmboe come from the Irish Sea, 439 mmboe come from the NNS, 606 mmboe come from the SNS and 123 mmboe come from the WoS.

Chart 27



With a \$50 price and 35 pence gas price and the NPV/I ≥ 0.5 hurdle, cumulative gas production is 2,147 million barrels of oil equivalent (Chart 27), of which 1,648 mmboe come from the already sanctioned fields, 146 mmboe come from current incremental projects, 144 mmboe come from future incremental projects, 20 mmboe come from the probable and possible fields, 177 mmboe come from the technical reserve fields, and 12 mmboe come from new exploration finds. The production decline rate under this scenario is seen to be very dramatic.

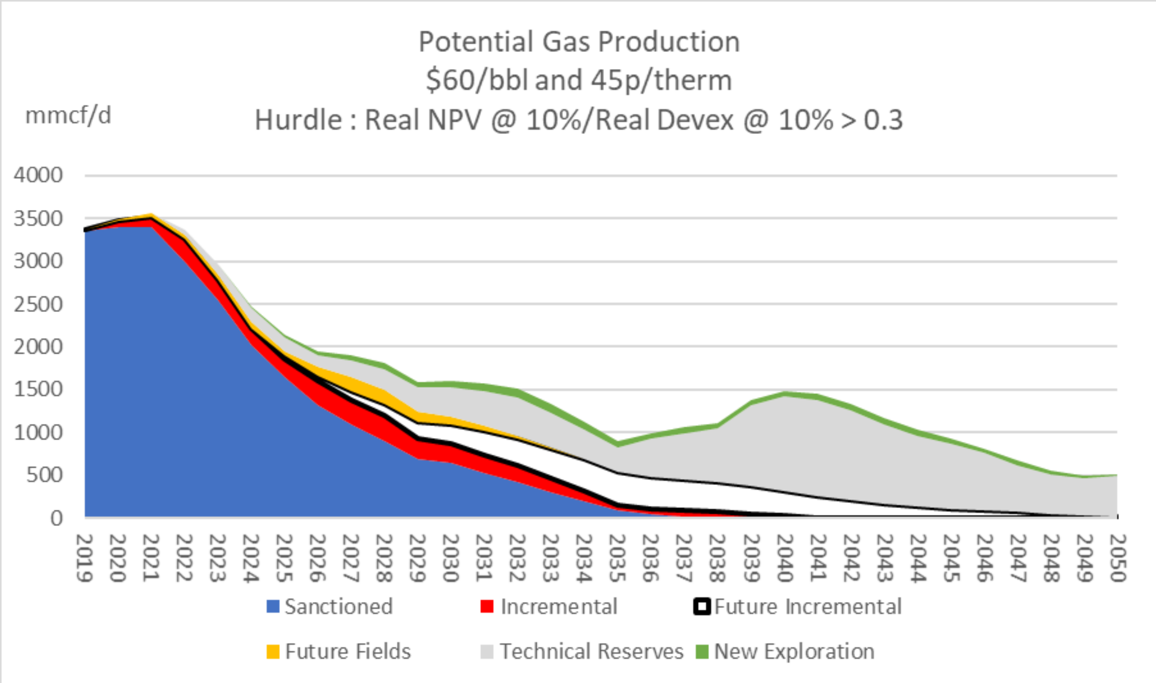
Chart 28



With these price scenario and very high hurdle, cumulative gas production from the CNS/MF area is 1,047 mmboe (Chart 28). Further, 59 mmboe come from the Irish Sea, 432 mmboe come from the NNS, 491 mmboe come from the SNS, and 118 mmboe come from the WoS. The fast decline rates apply to all geographic areas of the UKCS.

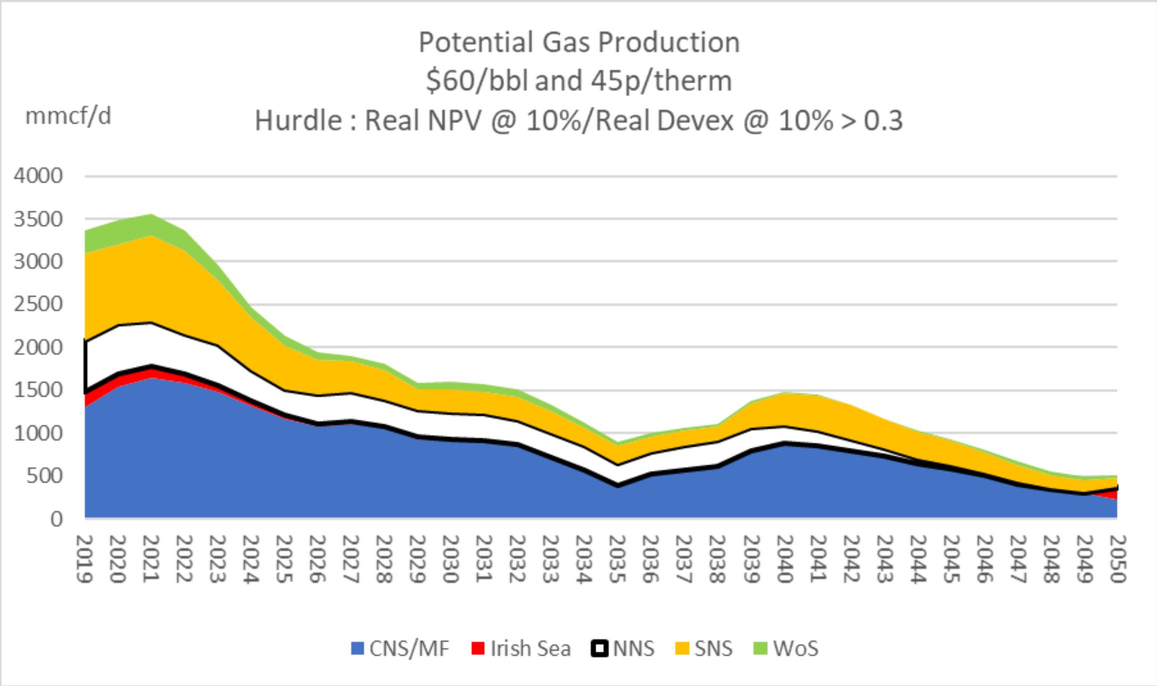
ii) 45 pence price

Chart 29



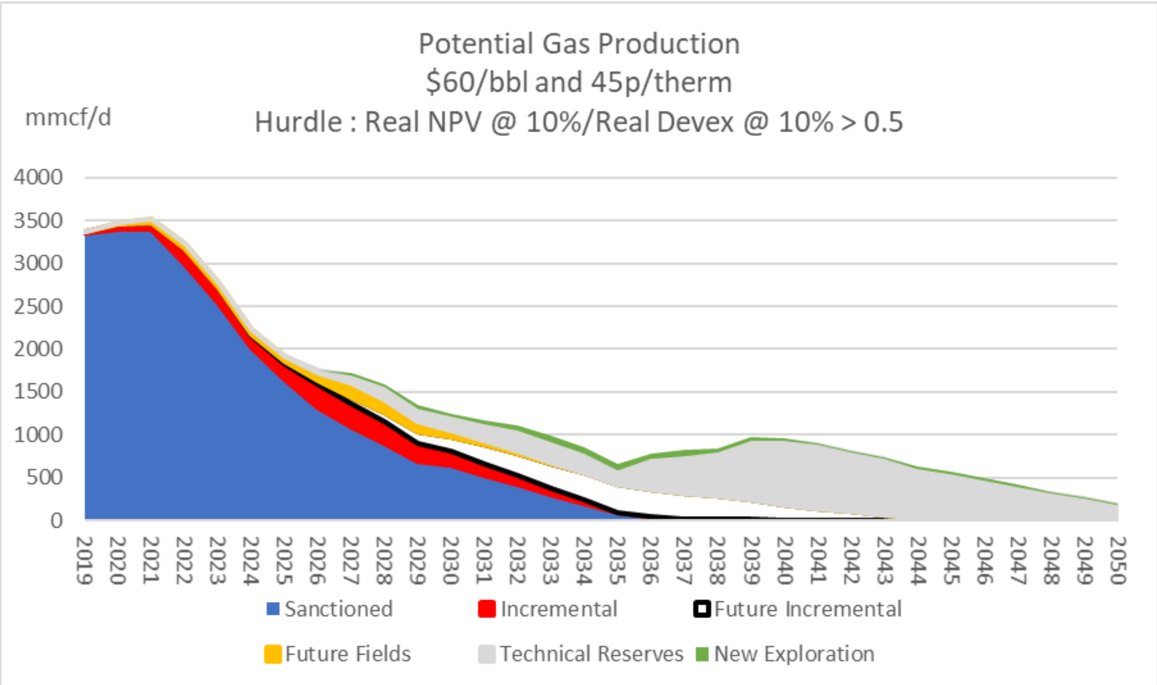
Over the period with a 45 pence price and the NPV/I ≥ 0.3 hurdle, cumulative gas production is 3,359 million barrels of oil equivalent (Chart 29), of which 1,666 mmboe come from already sanctioned fields, 227 mmboe come from current incremental projects, 343 mmboe come from future incremental projects, 66 mmboe come from the probable and possible fields, 950 mmboe come from the technical reserve fields, and 107 mmboe come from new exploration finds. There is seen to be a fast decline rate until the later 2030's when new discoveries halt the decline for a few years.

Chart 30



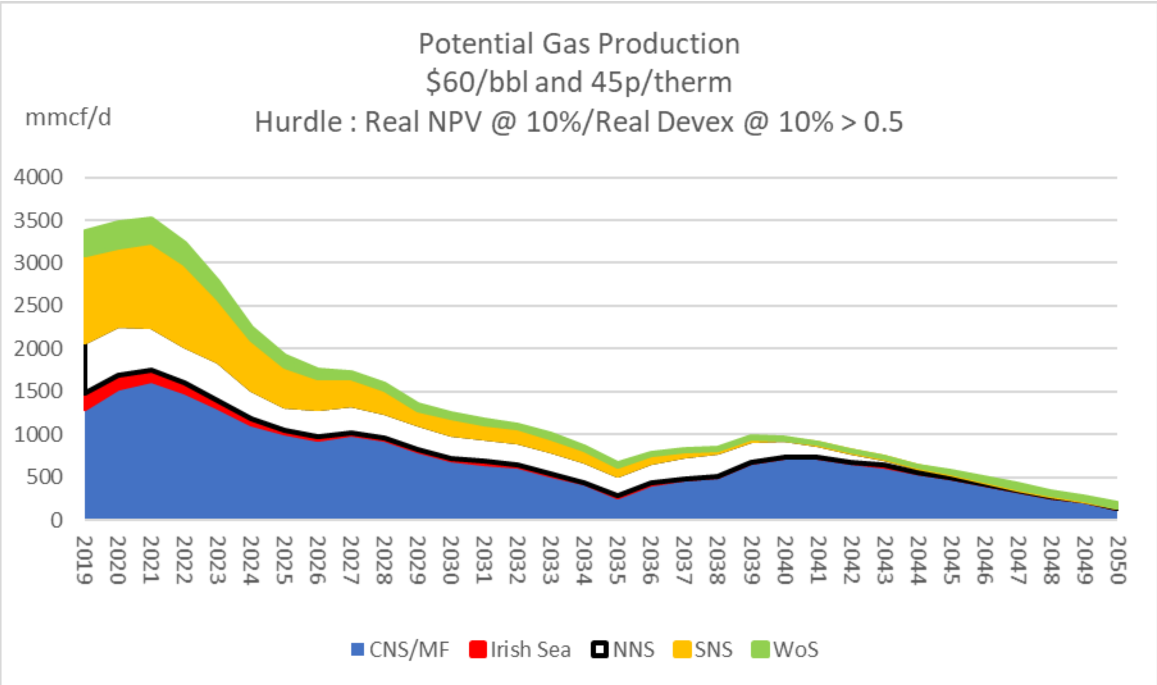
Over the period with the 45 pence price and the NPV/I ≥ 0.3 hurdle, cumulative gas production from the CNS/MF area is 1,770 mmboe (Chart 30), 73 mmboe from the Irish Sea, 541 mmboe from the NNS, 805 mmboe from the SNS, and 170 mmboe from the WoS.

Chart 31



Over the period with the 45 pence price and the NPV/I ≥ 0.5 hurdle, cumulative gas production is 2,776 million barrels of oil equivalent (Chart 31), of which 1,666 mmboe come from already sanctioned fields, 155 mmboe come from current incremental projects, 236 mmboe come from future incremental projects, 66 mmboe come from probable and possible fields, 595 mmboe come from the technical reserve fields, and 59 mmboe come from new exploration finds.

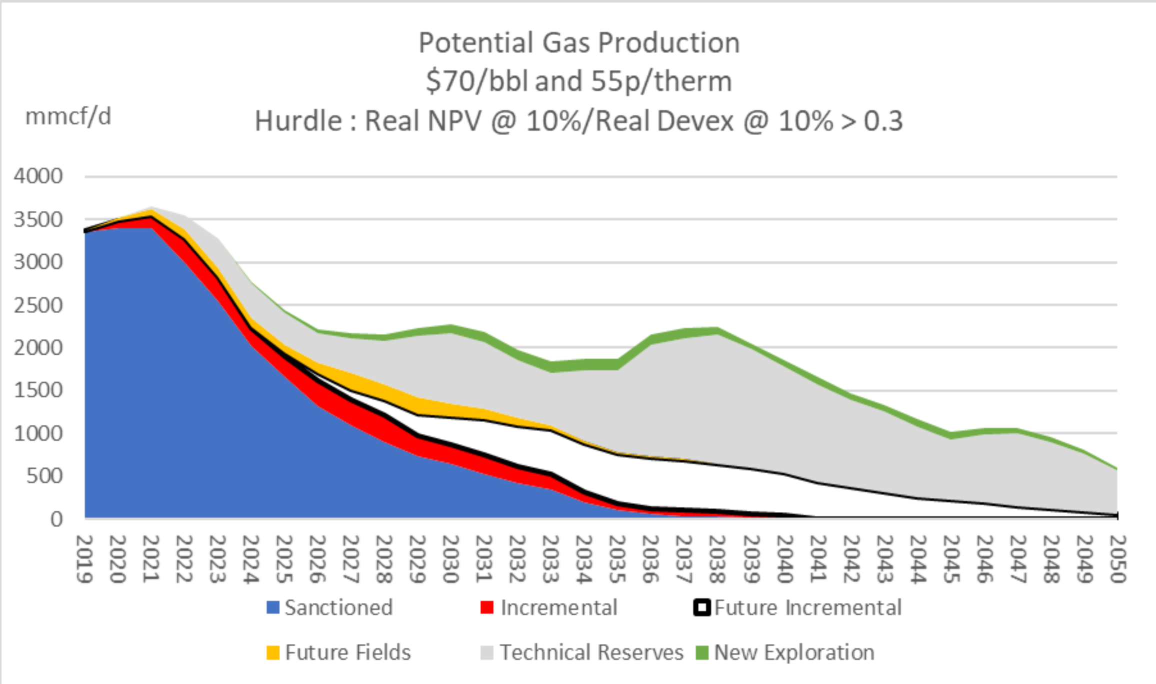
Chart 32



Over the period with the 45 pence price and the NPV/I ≥ 0.5 hurdle, cumulative gas production from the CNS/MF area is 1,535 mmboe (Chart 32), 61 mmboe come from the Irish Sea, 511 mmboe come from the NNS, 522 mmboe come from the SNS, and 147 mmboe come from the WoS.

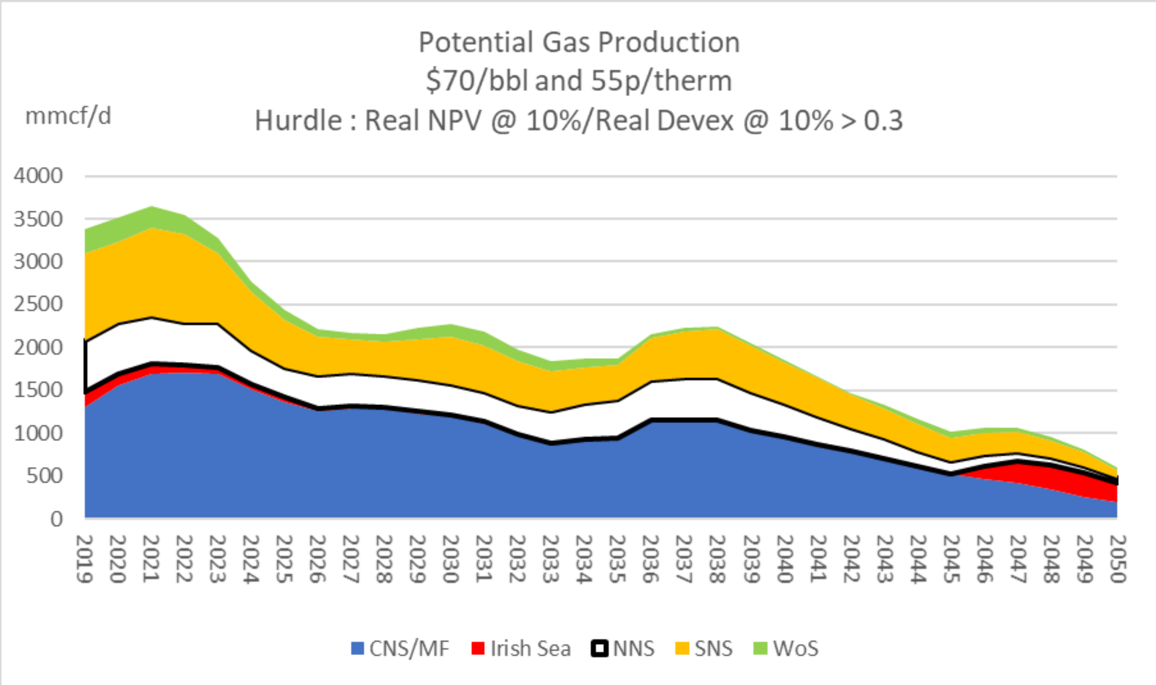
iii) 55 pence price

Chart 33



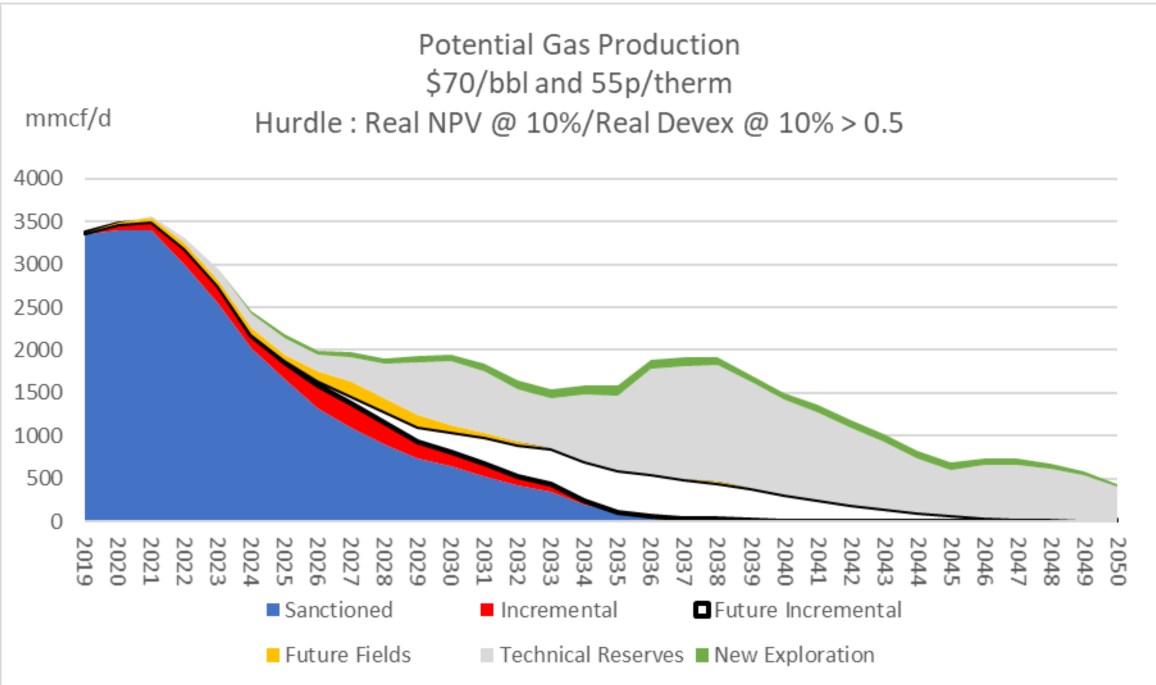
Over the period with a 55 pence price and the NPV/I ≥ 0.3 hurdle, cumulative gas production is 4,234 million barrels of oil equivalent (Chart 33). Of this 1,679 mmboe come from already sanctioned fields, 245 mmboe come from current incremental projects, 558 mmboe come from future incremental projects, 107 mmboe come from the probable and possible fields, 1,500 mmboe come from the technical reserve fields, and 145 mmboe come from new exploration finds. The relatively large contribution from technical reserves in the later part of the period is the most dramatic finding.

Chart 34



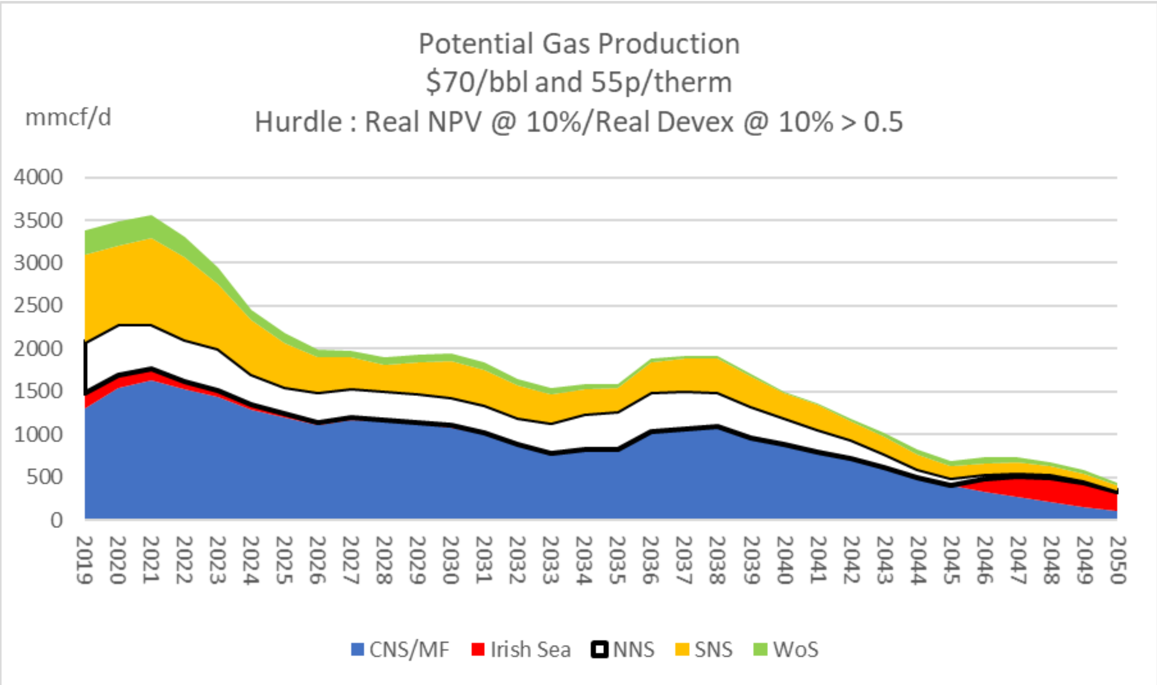
Over the period with the 55 pence price and the NPV/I ≥ 0.3 hurdle, cumulative gas production from the CNS/MF area is 2,110 mmboe (Chart 34), 143 mmboe from the Irish Sea, 733 mmboe from the NNS, 1,037 mmboe from the SNS, and 211 mmboe from the WoS.

Chart 35



Over the period with the 55 pence price and the NPV/I ≥ 0.5 hurdle, cumulative gas production is 3,668 million barrels of oil equivalent (Chart 35), of which 1,679 mmboe come from already sanctioned fields, 163 mmboe come from current incremental projects, 377 mmboe come from future incremental projects, 70 mmboe come from the probable and possible fields, 1,250 mmboe from the technical reserve fields, and 130 mmboe come from new exploration finds.

Chart 36

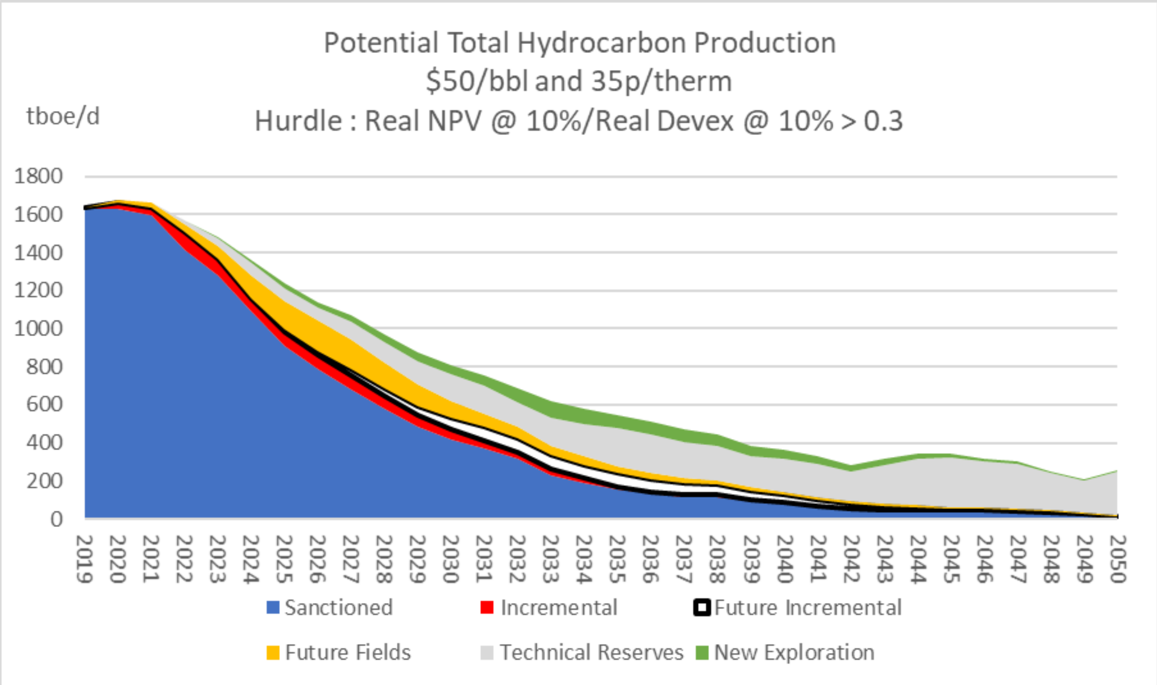


Over the period with the 55 pence price and NPV/I ≥ 0.5 hurdle, cumulative gas production from the CNS/MF area is 1,879 mmboe (Chart 36), 143 mmboe come from the Irish Sea, 652 mmboe come from the NNS, 810 mmboe come from the SNS, and 184 mmboe come from the WoS. The dominance of the CNS/MF region is the most notable feature.

Production – Total Hydrocarbons

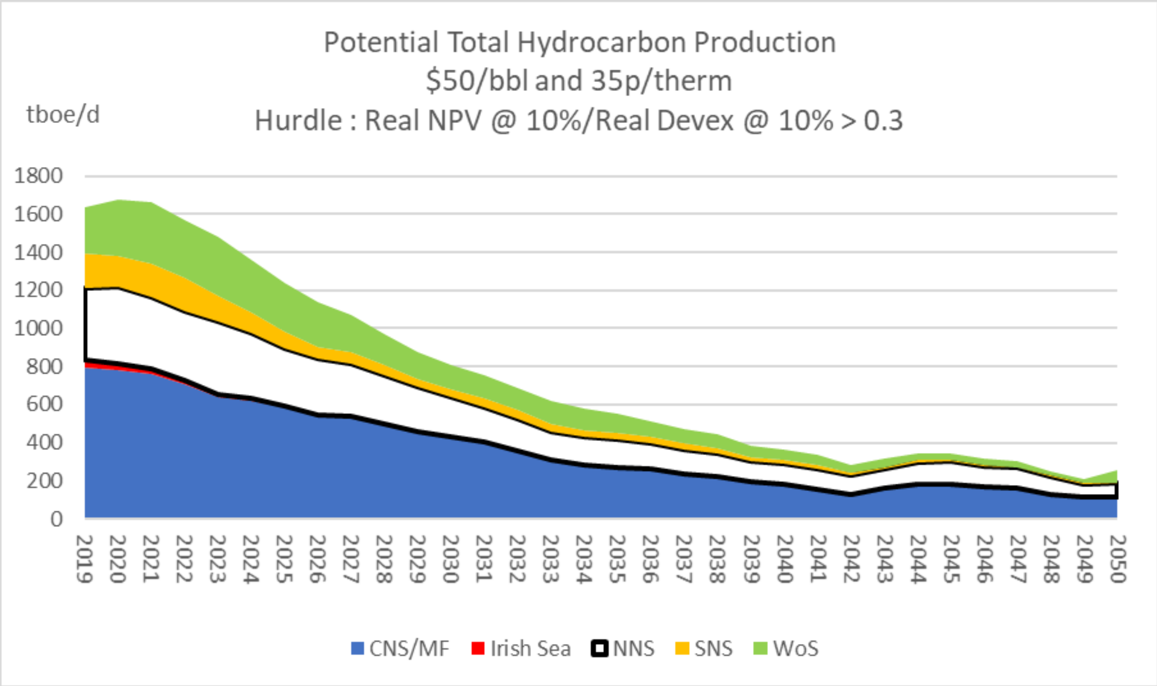
i) $50, 35 pence prices

Chart 37



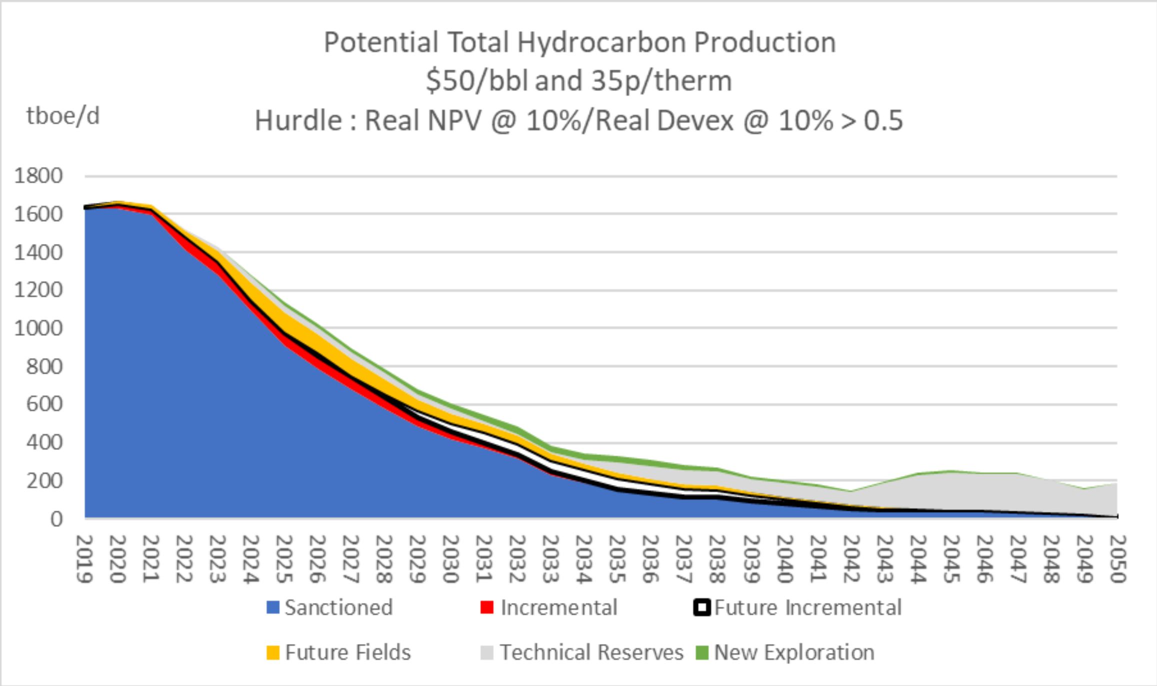
Over the period with a $50 and 35 pence price scenario and the NPV/I ≥ 0.3 hurdle, cumulative total hydrocarbon production (including NGLs) is 8,688 million barrels of oil equivalent (Chart 37). Of this 5,371 mmboe come from already sanctioned fields, 342 mmboe come from current incremental projects, 351 mmboe come from future incremental projects, 557 mmboe come from probable and possible fields, 1,662 mmboe come from the technical reserve fields, and 405 mmboe come from new exploration finds. The decline rate is seen to be quite brisk from 2021 onwards. The total economic recovery 2019-2050 of 8.7 billion boe is below the 10 billion – 20 billion range discussed as the most likely range by the OGA. The relatively low oil and gas price assumptions are the main explanatory factors. A further explanation is the very modest contribution from fields in the category of new discoveries.

Chart 38



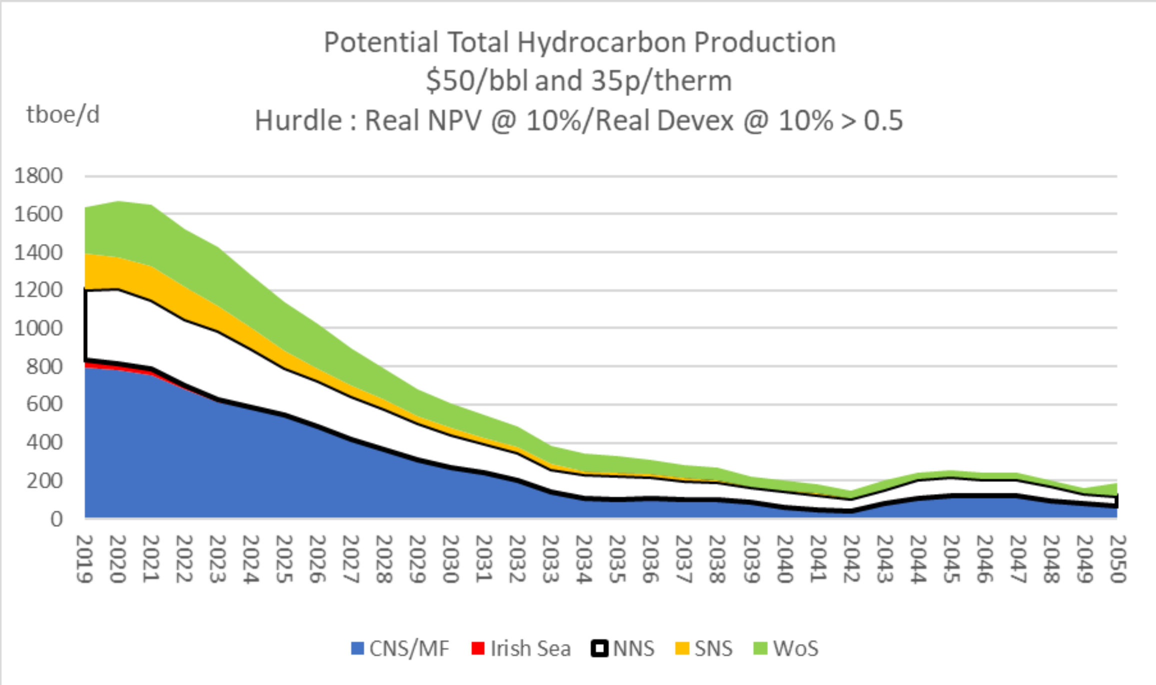
With the $50 and 35 pence prices and the NPV/I ≥ 0.3 hurdle, cumulative total hydrocarbon production from the CNS/MF area is 4,203 million barrels of oil equivalent, 75 mmboe come from the Irish Sea, 2,261 mmboe come from the NNS, 618 mmboe come from the SNS, and 1,532 mmboe come from the WoS. The results are displayed in Chart 38. The CNS/MF region displays the slowest decline rate over the period.

Chart 39



Over the period with \$50 and 35 pence prices and the NPV/I ≥ 0.5 hurdle, cumulative total hydrocarbon production is 7,207 million barrels of oil equivalent (Chart 39), of which 5,371 mmboe come from already sanctioned fields, 258 mmboe come from current incremental projects, 254 mmboe come from future incremental projects, 336 mmboe come from probable and possible fields, 802 mmboe come from the technical reserve fields, and 185 mmboe come from new exploration finds. The decline rate is seen from Chart 39 to be quite steep with only modest volumes from new developments over the whole period to 2050.

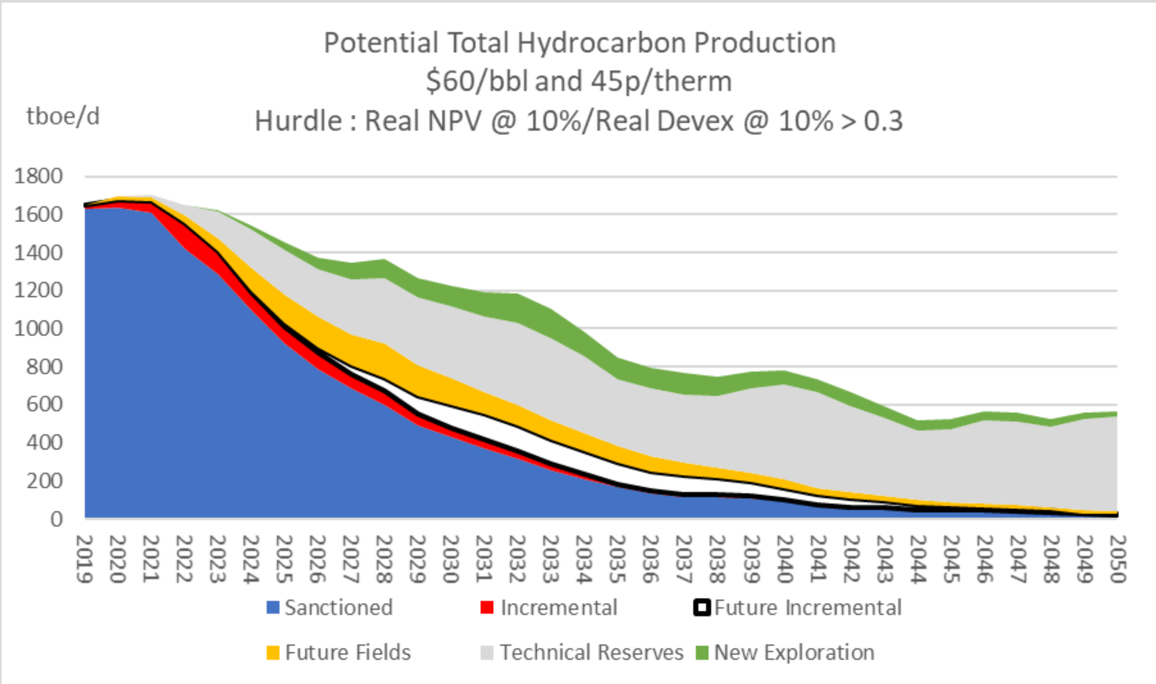
Chart 40



Cumulative total hydrocarbon production from the CNS/MF area is 3,158 million barrels of oil equivalent (Chart 40), 75 mmboe come from the Irish Sea, 1,982 mmboe come from the NNS, 501 mmboe come from the SNS, and 1,491 mmboe come from the WoS.

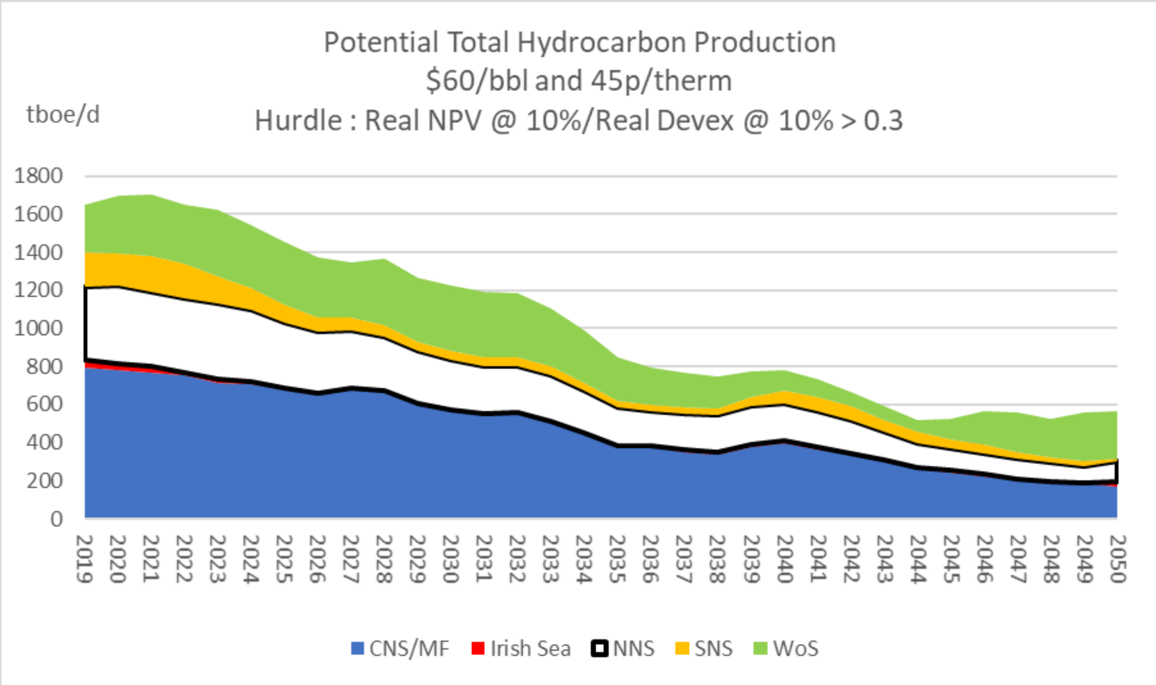
ii) $60, 45 pence

Chart 41



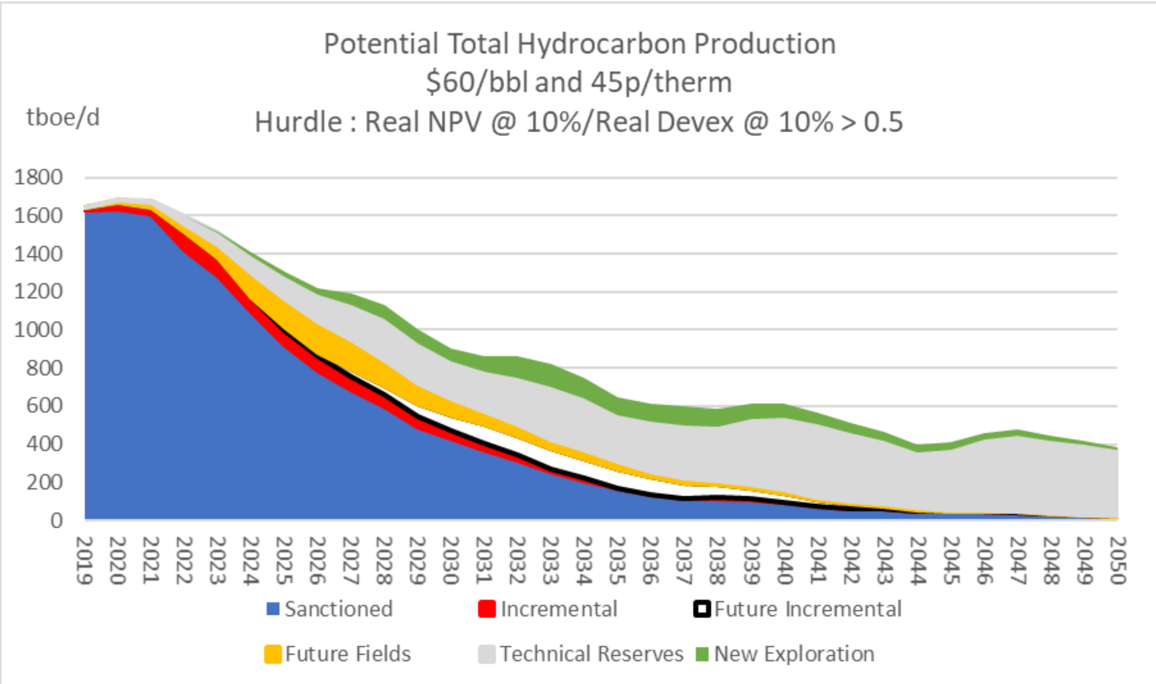
Over the period with $60 and 45 pence prices and the NPV/I ≥ 0.3 hurdle, cumulative hydrocarbon production to 2050 is 11,998 million barrels of oil equivalent (Chart 41), of which 5,454 mmboe come from already sanctioned fields, 400 mmboe come from current incremental projects, 609 mmboe come from future incremental projects, 836 mmboe come from probable and possible fields, 3,897 mmboe come from the technical reserve fields, and 803 mmboe come from new exploration finds. The prospect of total economic recovery of 12 billion boe can be compared to the 10 billion – 20 billion range postulated by the OGA. Key features of the findings shown in Chart 41 are (a) the substantial contribution from fields in the category of technical reserves and (b) the small contribution from future discoveries.

Chart 42



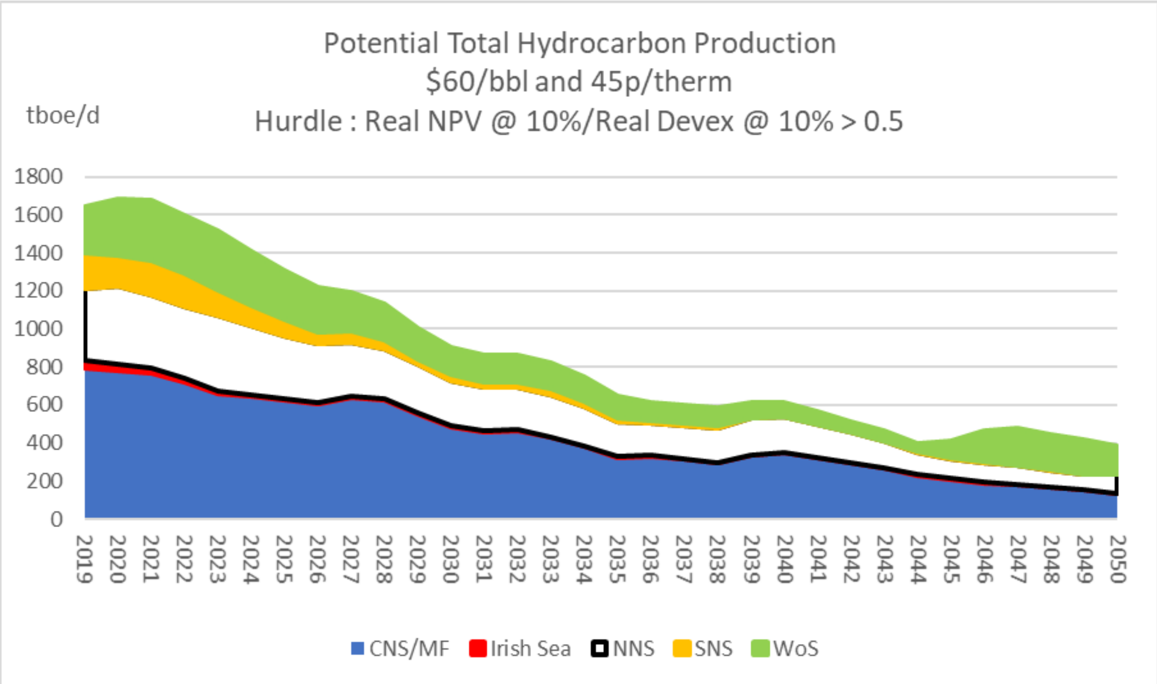
Cumulative total hydrocarbon production from the CNS/MF area is 5,520 million barrels of oil equivalent (Chart 42), 140 mmboe come from the Irish Sea, 2,737 mmboe come from the NNS, 821 mmboe come from the SNS, and 2,780 mmboe come from the WoS.

Chart 43



With \$60 and 45 pence prices and the NPV/I ≥ 0.5 hurdle, cumulative total hydrocarbon production is 10,130 million barrels of oil equivalent (Chart 43), of which 5,454 mmboe come from already sanctioned fields, 292 mmboe come from current incremental projects, 447 mmboe come from future incremental projects, 562 mmboe come from probable and possible fields, 2,764 mmboe come from the technical reserve fields, and 611 mmboe come from new exploration finds. The dominant feature for long term output is the substantial contribution from fields in the category of technical reserves.

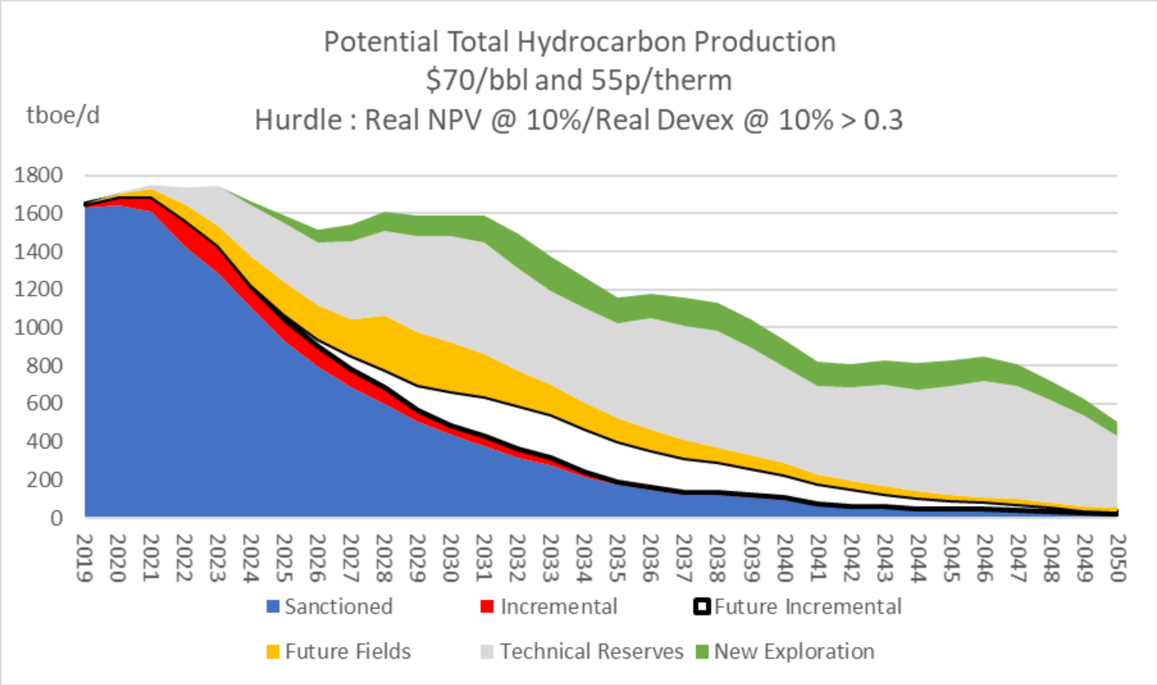
Chart 44



With \$60 and 45 pence prices and the NPV/I ≥ 0.5 hurdle, cumulative total hydrocarbon production from the CNS/MF area is 5,018 million barrels of oil equivalent (Chart 44), 81 mmboe come from the Irish Sea, 2,597 mmboe come from the NNS, 533 mmboe come from the SNS, and 1,902 mmboe come from the WoS.

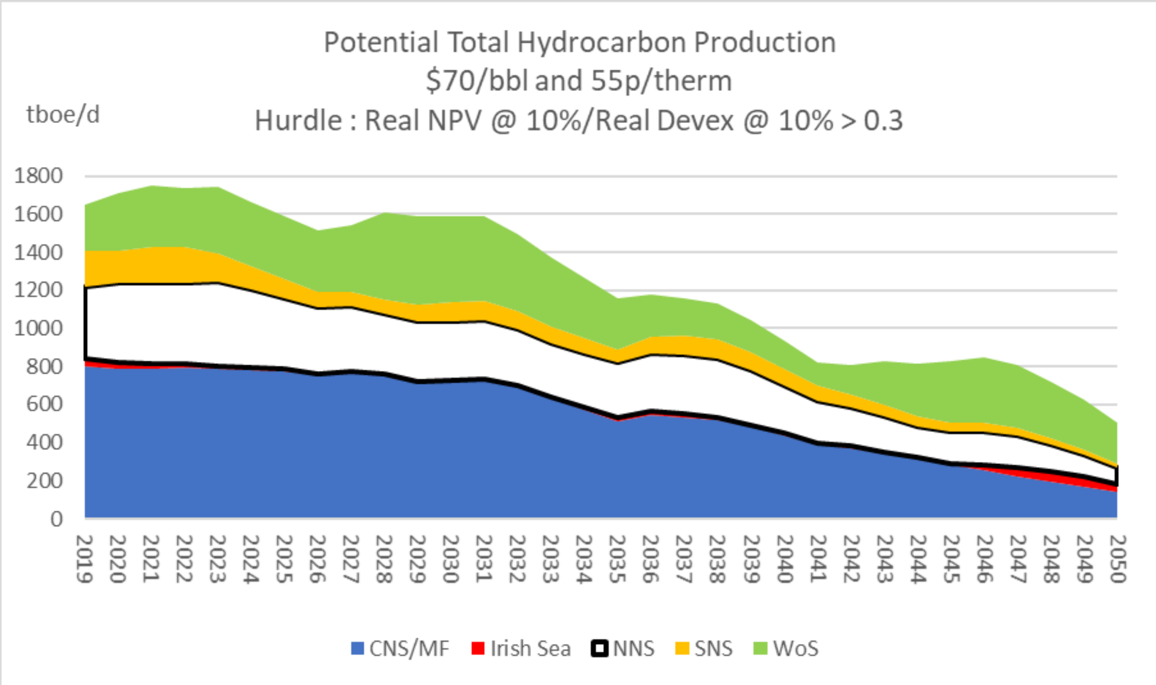
iii) $70, 55 pence

Chart 45



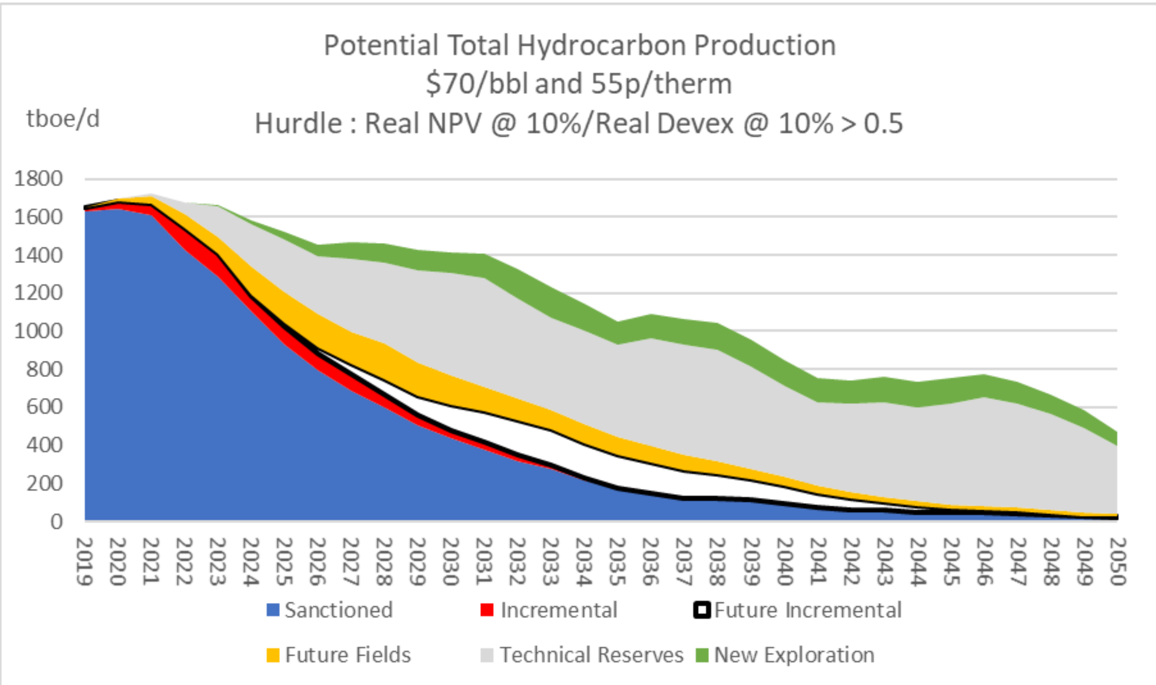
Over the period with $70 and 55 pence prices and the NPV/I ≥ 0.3 hurdle, cumulative total hydrocarbon production is 14,458 million barrels of oil equivalent (Chart 45), of which 5,501 mmboe come from already sanctioned fields, 474 mmboe come from current incremental projects, 1,087 mmboe come from future incremental projects, 1,192 mmboe come from probable and possible fields, 5,032 mmboe come from the technical reserve fields, and 1,172 mmboe come from new exploration finds. The cumulative total of 14.46 billion boe is well inside the 10 billion – 20 billion boe range postulated by the OGA. The most notable feature of the results is the very large contribution from fields in the category of technical reserves. There is also a substantial increase in total recovery compared to the $60, 45 pence price scenario.

Chart 46



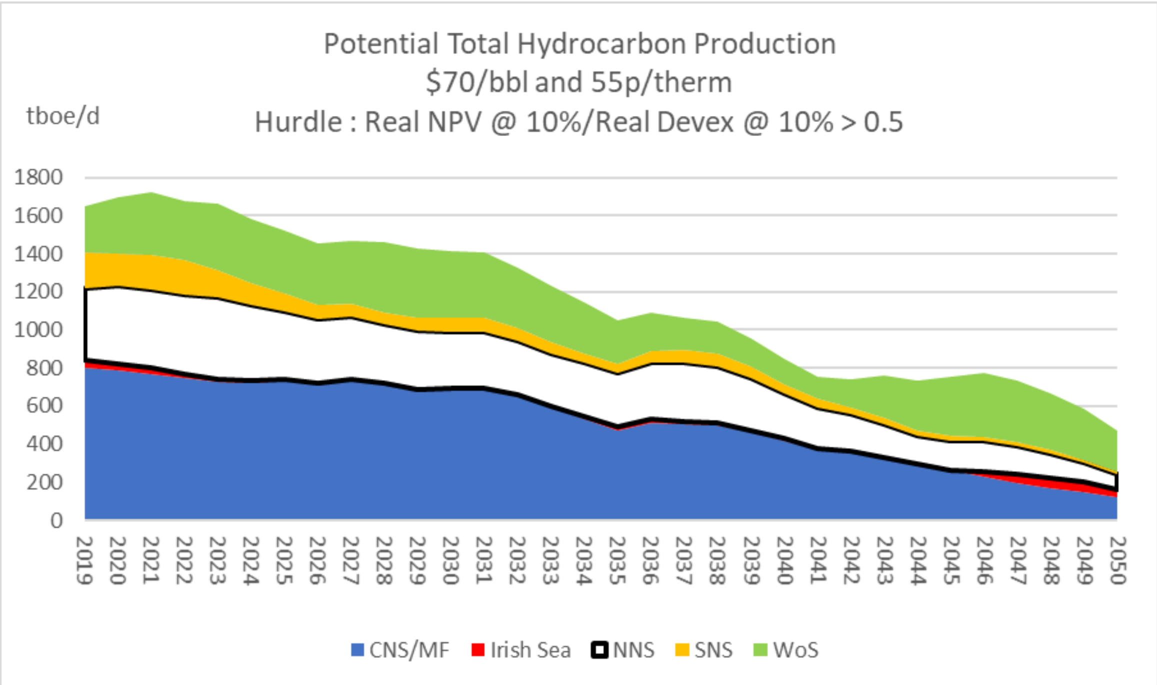
Cumulative total hydrocarbon production from the CNS/MF area is 6,409 million barrels of oil equivalent (Chart 46), 211 mmboe from the Irish Sea, 3,305 mmboe from the NNS, 1,056 mmboe from the SNS, and 3,478 mmboe from the WoS.

Chart 47



Over the period with $70 and 55 pence prices and the NPV/I ≥ 0.5 hurdle, cumulative total hydrocarbon production is 13,459 million barrels of oil equivalent (Chart 47), of which 5,501 mmboe come from already sanctioned fields, 353 mmboe come from current incremental projects, 814 mmboe come from future incremental projects, 916 mmboe come from probable and possible fields, 4,752 mmboe come from the technical reserve fields, and 1,123 mmboe come from new exploration finds. The striking long term features of the results are again (a) the very large reliance on fields in the category of technical reserves and (b) the modest contribution from future discoveries.

Chart 48

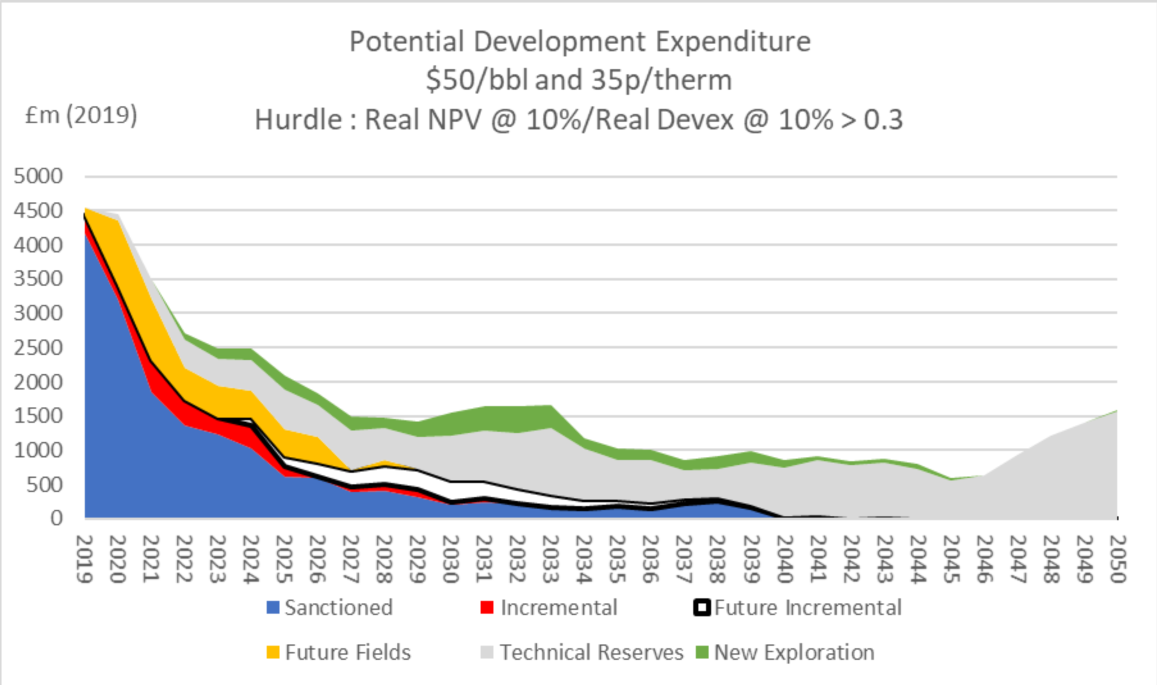


Cumulative total hydrocarbon production from the CNS/MF area is 6,055 million barrels of oil equivalent (Chart 48), 211 mmboe come from the Irish Sea, 3,189 mmboe come from the NNS, 827 mmboe come from the SNS, and 3,179 mmboe come from the WoS.

c) Development Expenditure

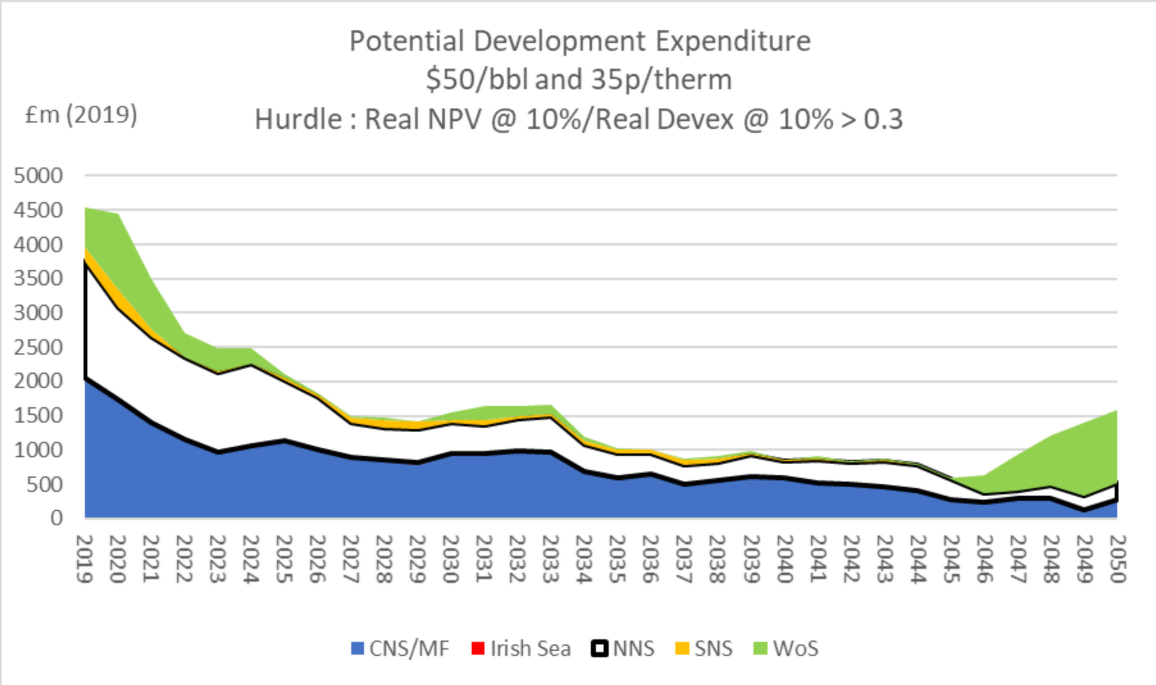
i) $50 and 35 pence prices

Chart 49



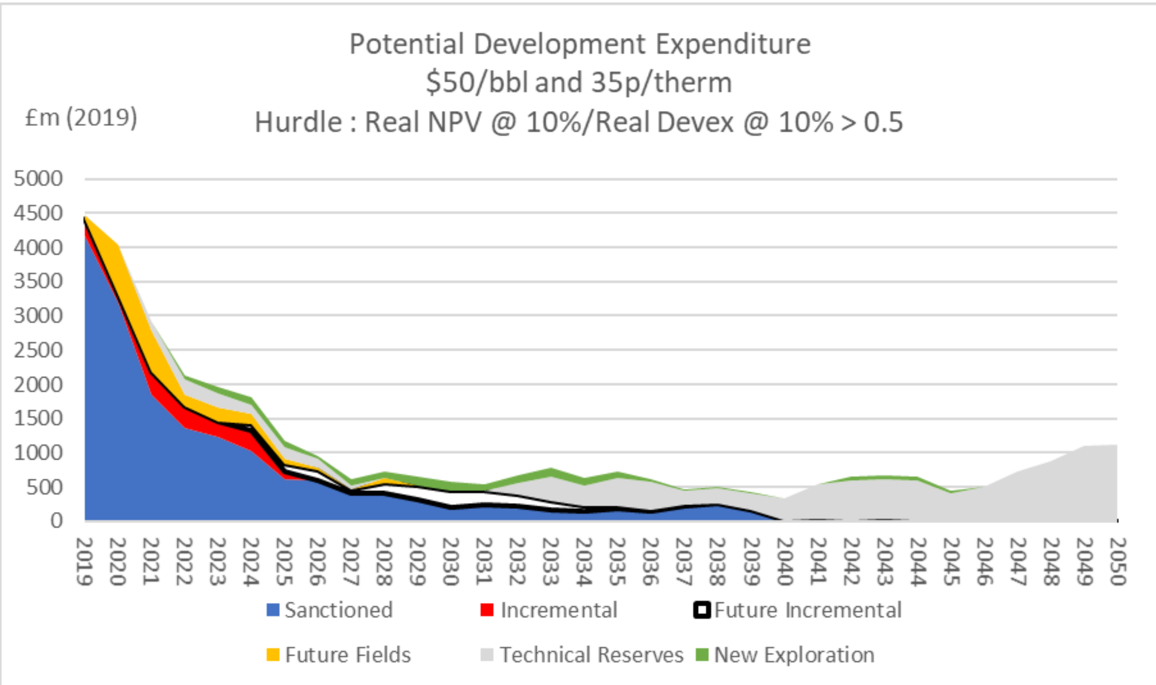
Over the period to 2050, with $50 and 35 pence prices and the NPV/I ≥ 0.3 hurdle, cumulative development costs are £51,585m at 2019 prices (Chart 49), with £17,235m coming from already sanctioned fields, £2,453m coming from current incremental projects, £2,788m coming from future incremental projects, £4,119m coming from probable and possible fields, £20,849m coming from technical reserve fields, and £4,142m coming from new exploration finds. From Chart 49 it is seen that field development investment falls dramatically from 2019/2020 levels to only c.£2.5 billion in 2023, and c.£1.5 billion in 2027. After that it ceases to fall for many years. The long term investment levels are heavily dependent on the development of fields in the category of technical reserves.

Chart 50



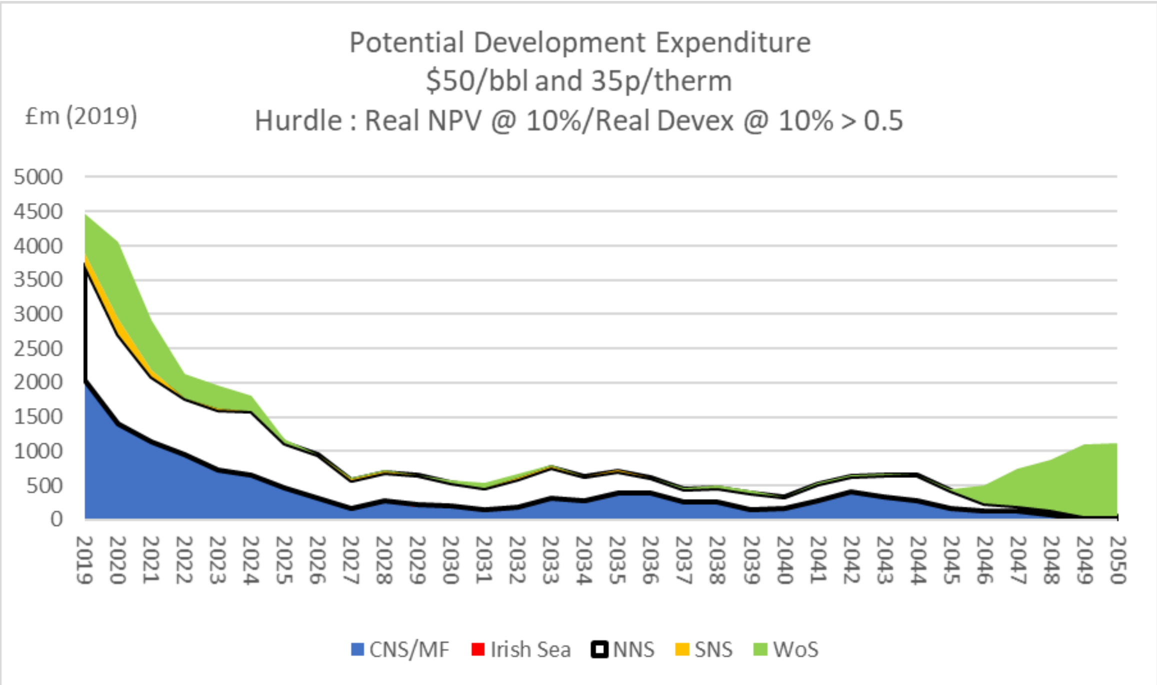
Cumulative development costs in the CNS/MF area are £24,416m (Chart 50), £113m in the Irish Sea, £17,611m in the NNS, £1,558m in the SNS, and £7,887m in the WoS.

Chart 51



Over the period to 2050, with $50 and 35 pence prices and NPV/I ≥ 0.5 hurdle, cumulative development costs are £35,044m (Chart 51) with £17,235m coming from already sanctioned fields, £1,673m coming from current incremental projects, £1,682m coming from future incremental projects, £2,074m coming from probable and possible fields, £10,653m coming from technical reserve fields, and £1,727m coming from new exploration finds. The dramatic decline in development investment from current levels is the key finding.

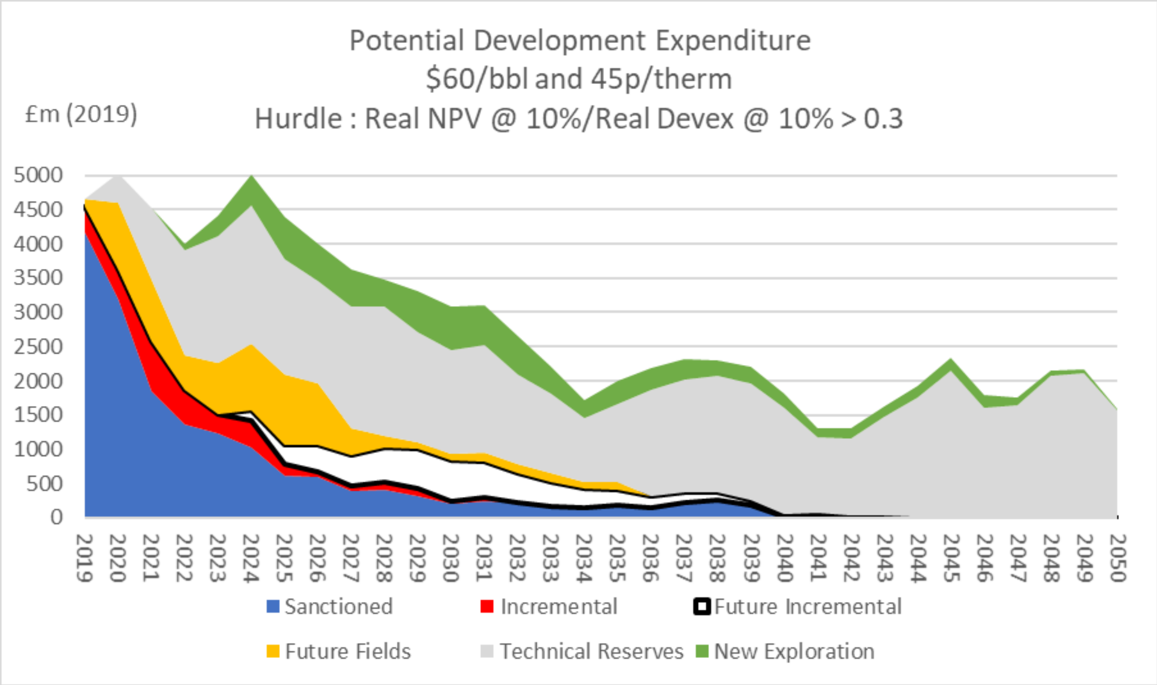
Chart 52



With $50 and 35 pence prices and the NPV/I ≥ 0.5 hurdle, cumulative development costs in the CNS/MF area are £12,766m (Chart 52), £113m in the Irish Sea, £14,096m in the NNS, £626m in the SNS, and £7,444m in the WoS. Development activity in the WoS region is very muted after c. 2024 under this price and high hurdle scenario.

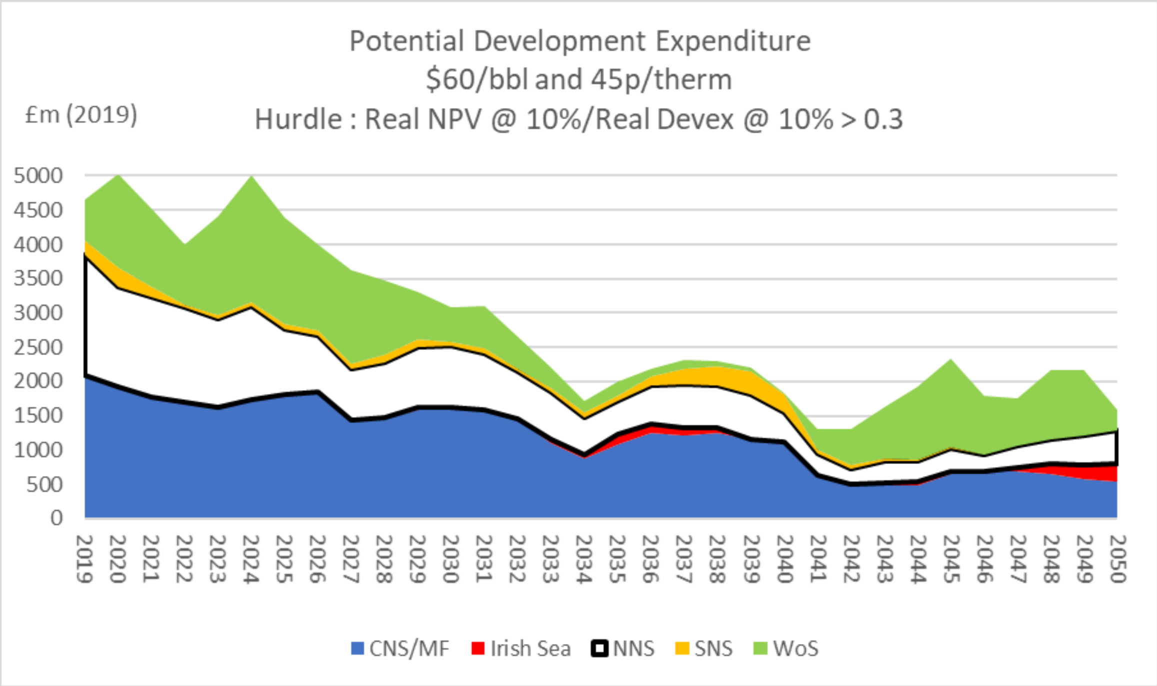
ii) $60 and 45 pence prices

Chart 53



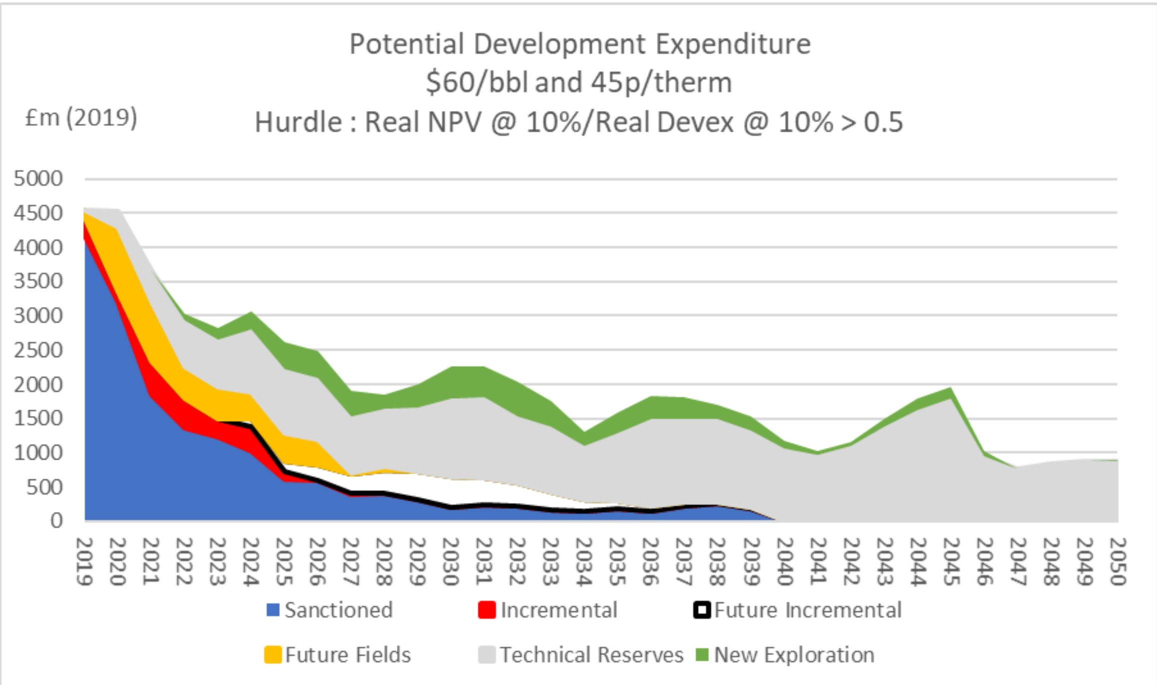
Over the period to 2050, with $60 and 45 pence prices and NPV/I ≥ 0.3 hurdle, cumulative development costs are £89,928m (Chart 53), with £17,266m coming from already sanctioned fields, £3,324m from current incremental projects, £5,410m from future incremental projects, £7,504m from probable and possible fields, £47,611m from technical reserve fields, and £8,813m from new exploration finds. It is seen that development investment falls very sharply from most categories of fields with much longer term reliance being on the development of many fields in the category of technical reserves.

Chart 54



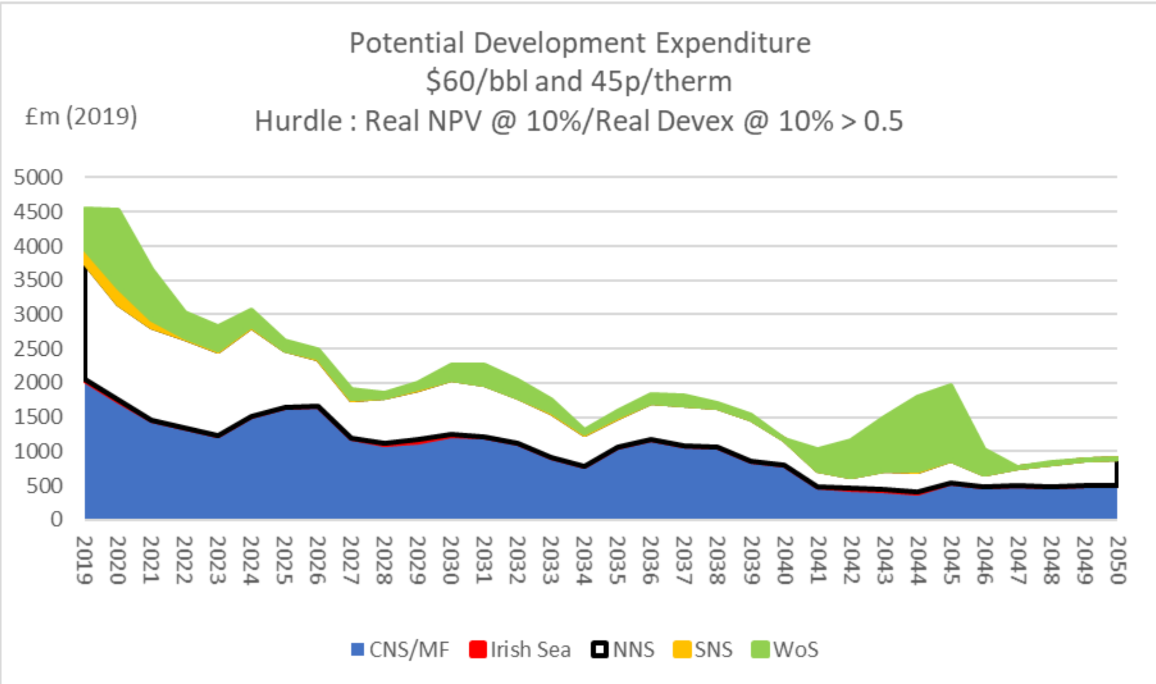
Cumulative development costs in the CNS/MF area are £38,551m (Chart 54), £1,483m in the Irish Sea, £23,325m in the NNS, £3,044m in the SNS and £23,526m in the WoS.

Chart 55



Over the period to 2050, with $60 and 45 pence prices and the NPV/I $\geq$ 0.5 hurdle, cumulative development costs are £63,543m (Chart 55) with £17,266m coming from already sanctioned fields, £2,082m from current incremental projects, £3,377m from future incremental projects, £4,119m from probable and possible fields, £30,393m from technical reserve fields, and £6,307m from new exploration finds. The long term reliance on the development of fields in the category of technical reserves helps to mitigate the sharp decline in investment in other categories of fields.

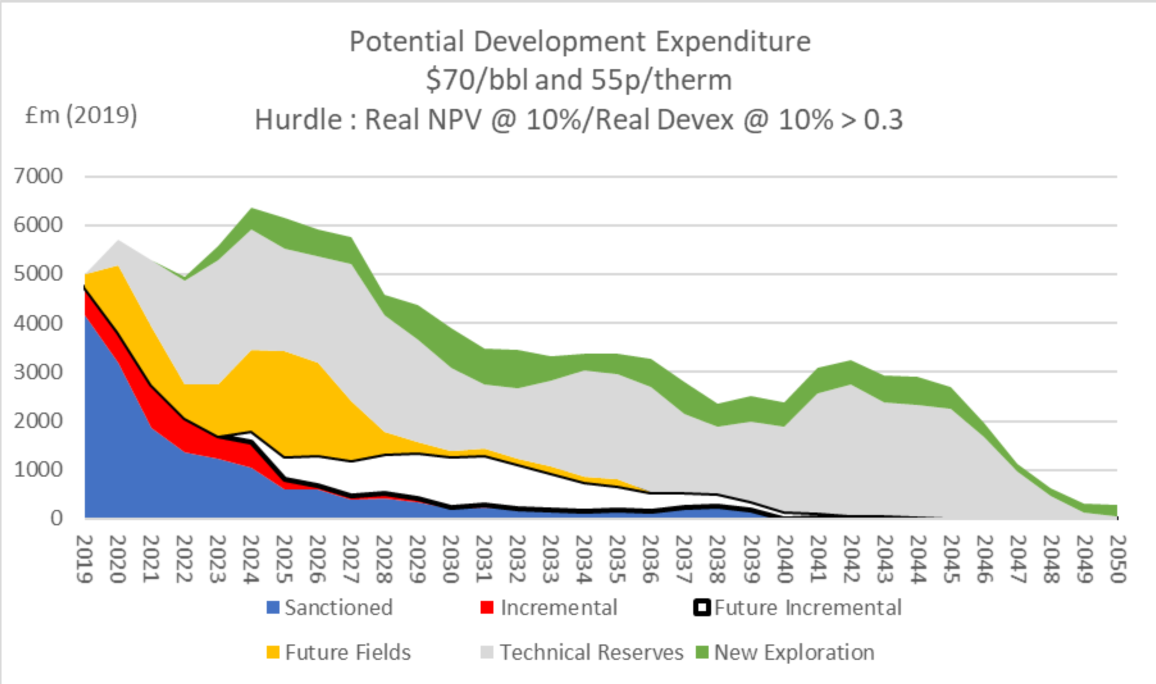
Chart 56



Cumulative development costs in the CNS/MF area are £32,128m (Chart 56), £155m in the Irish Sea, £21,191m in the NNS, £781m in the SNS, and £9,289m in the WoS.

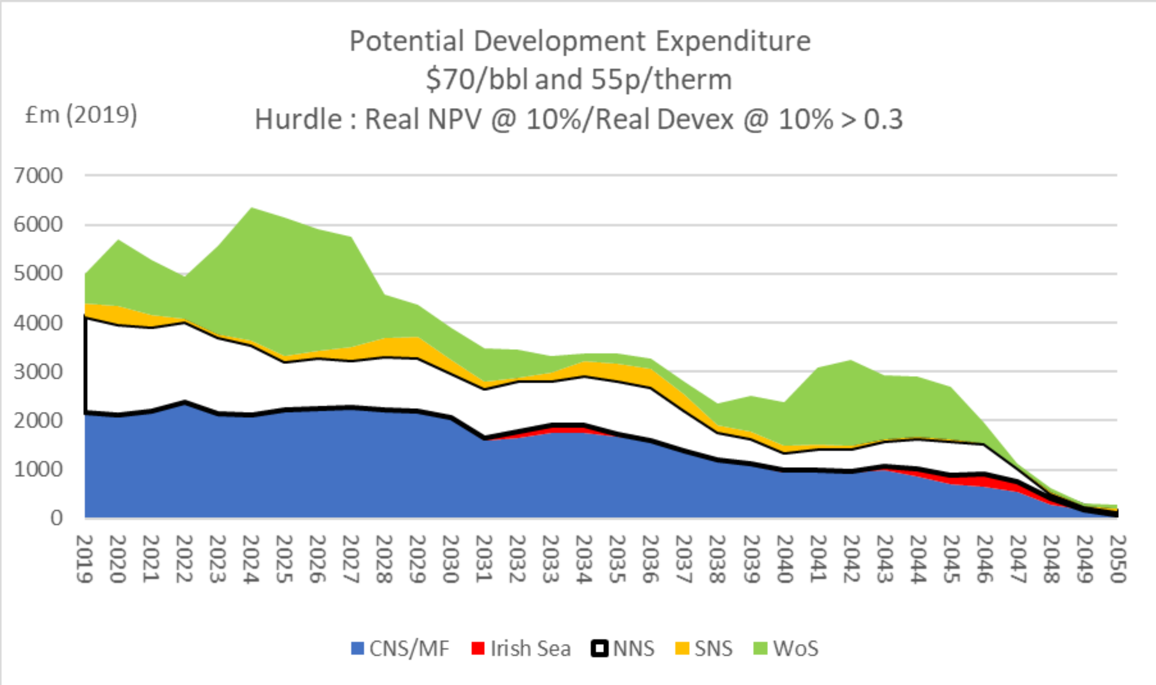
iii) $70 and 55 pence prices

Chart 57



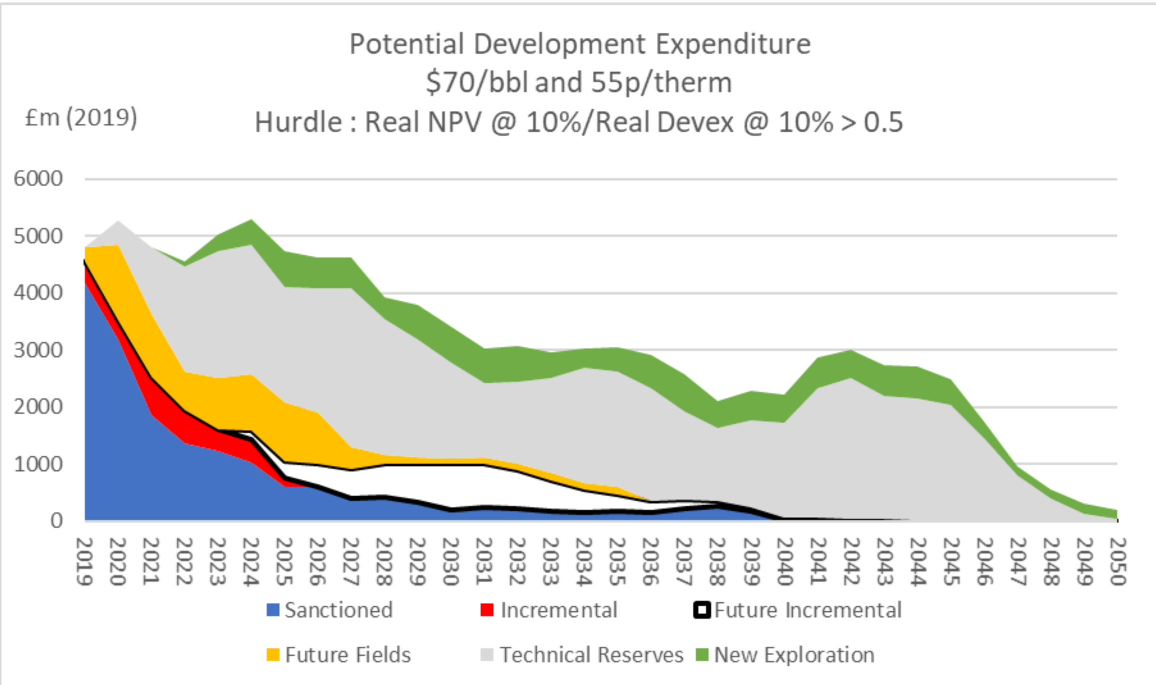
Over the period to 2050 with $70 and 55 pence prices and NPV/I ≥ 0.3 hurdle, cumulative development costs are £112,984m (Chart 57), with £17,275m coming from already sanctioned fields, £4,421m from current incremental projects, £10,222m from future incremental projects, £12,789m from probable and possible fields, £54,668m from technical reserve fields, and £13,610m from new exploration finds. There is a major investment in fields in the category of technical reserves which plays a vital role in enhancing long term investment activity.

Chart 58



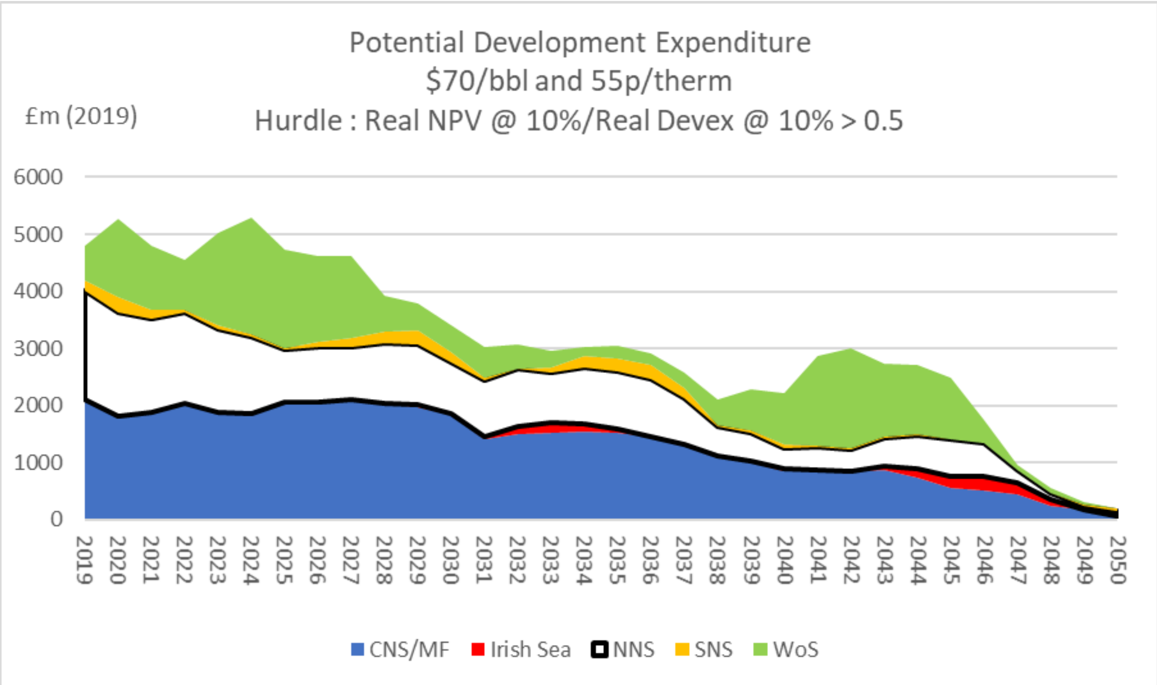
Cumulative development costs in the CNS/MF area are £47,015m (Chart 58), £1,818m in the Irish Sea, £28,765m in the NNS, £4,989m in the SNS and £30,396m in the WoS.

Chart 59



Over the period to 2050 with $70 and 55 pence prices and NPV/I ≥ 0.5 hurdle, cumulative development costs are £99,677m (Chart 59), with £17,275m from already sanctioned fields, £2,959m from current incremental projects, £6,823m from future incremental projects, £8,462m from probable and possible fields, £51,324m from technical reserve fields, and £12,835m from new exploration finds. The long term reliance on investment in fields in the category of technical reserves is again highlighted.

Chart 60

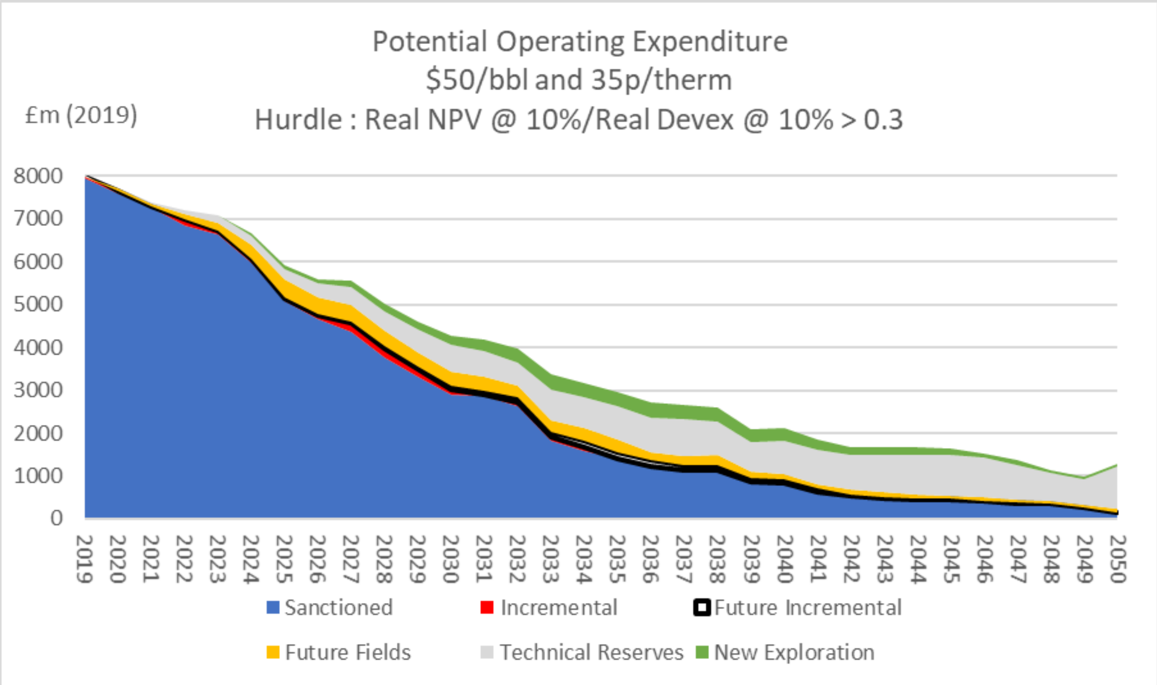


Cumulative development costs in the CNS/MF area are £42,128m (Chart 60), £1,818m in the Irish Sea, £27,180m in the NNS, £2,989m in the SNS, and £25,562m in the WoS.

d) Operating Expenditure

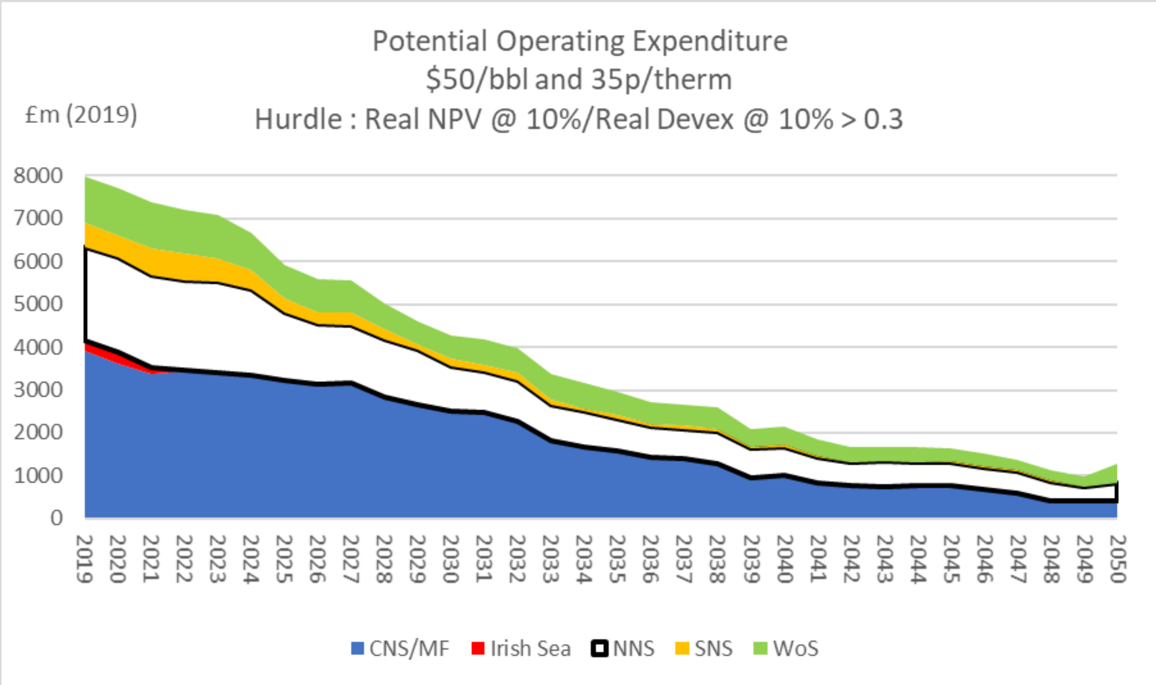
i) $50 and 35 pence prices

Chart 61



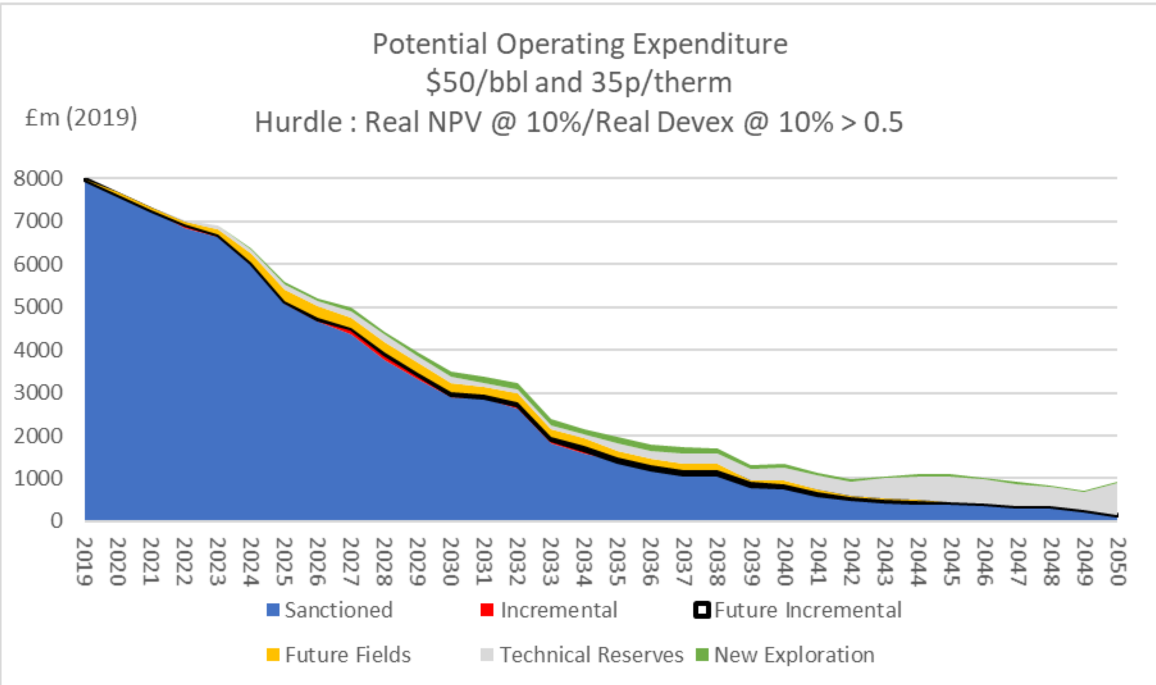
Over the period to 2050 with \$50 and 35 pence prices and NPV/I ≥ 0.3 hurdle, cumulative operating costs are £119,616m at 2019 prices with £85,722m coming from already sanctioned fields, £1,708m from current incremental projects, £1,751m from future incremental projects, £6,248m from probable and possible fields, £18,726m from technical reserve fields, and £5,462m from new exploration finds. The most obvious feature of the results is the sharp, continuous fall in operating expenditures from around £8 billion in 2019 to around £1.3 billion in 2050.

Chart 62



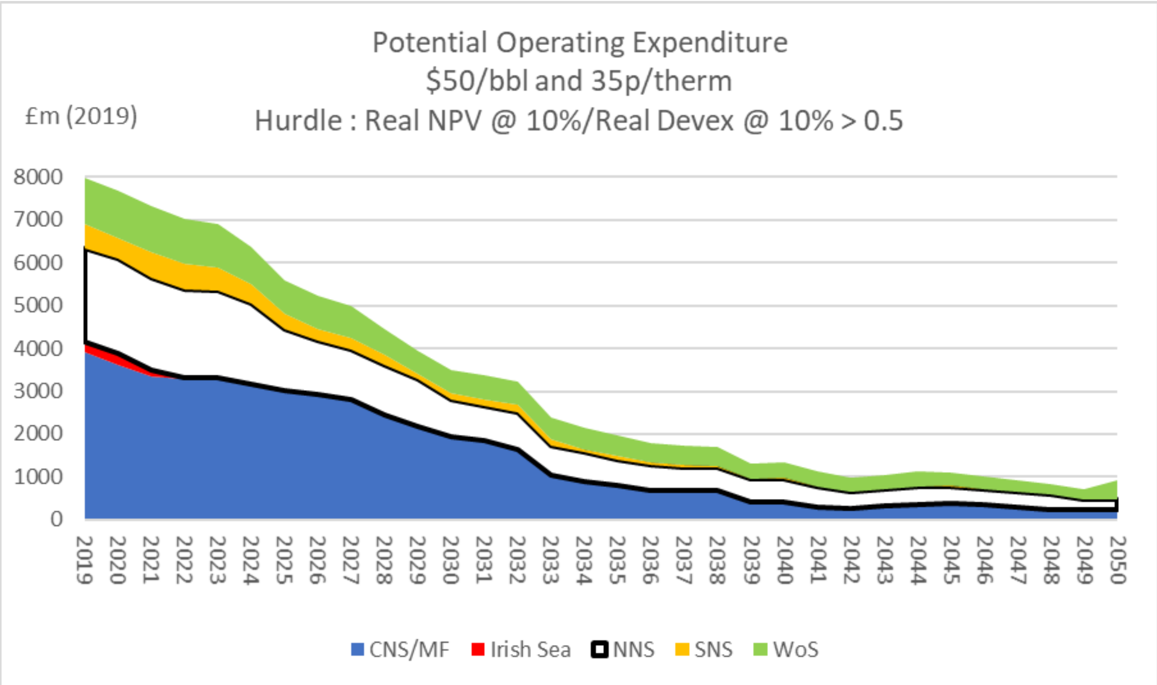
Cumulative operating costs in the CNS/MF area are £60,662m (Chart 62), £847m in the Irish Sea, £33,732m in the NNS, £5,881m in the SNS and £18,495m in the WoS.

Chart 63



Over the period to 2050 with $50 and 35 pence prices and NPV/I ≥ 0.5 hurdle, cumulative operating costs are £101,737m (Chart 63), with £85,722m coming from already sanctioned fields, £1,156m from current incremental projects, £1,154m from future incremental projects, £3,567m from probable and possible fields, £7,855m from technical reserves, and £2,282m from new exploration finds. The decline rate is spectacular reflecting the very small numbers of new developments.

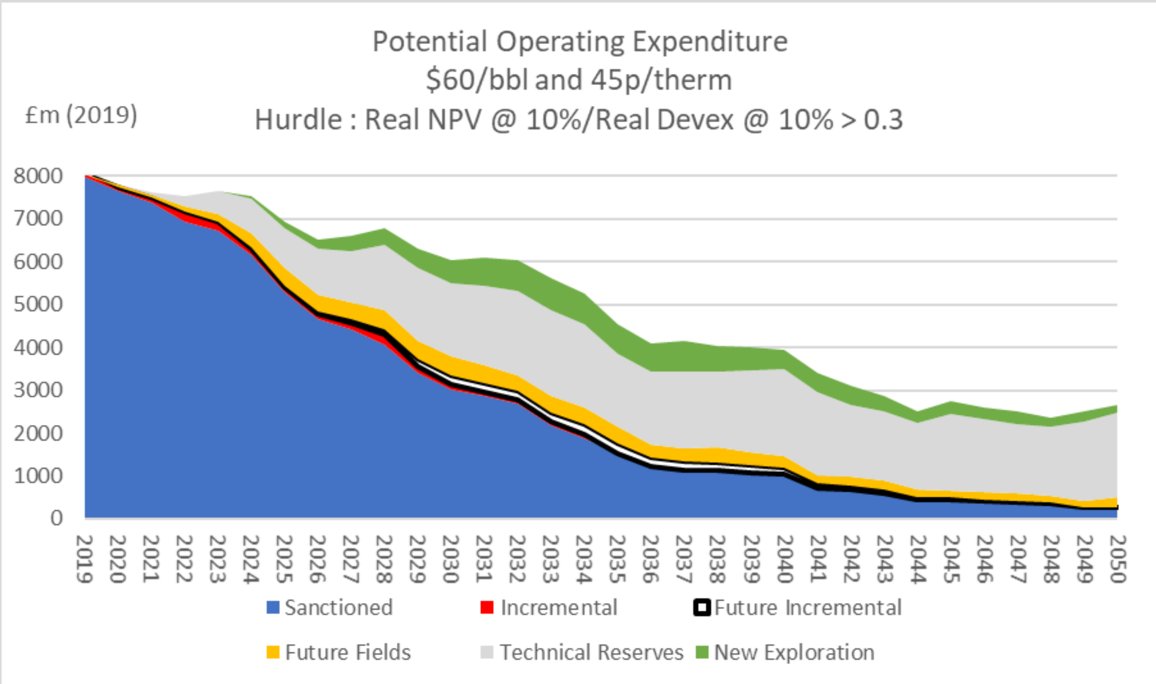
Chart 64



Cumulative operating costs in the CNS/MF area are £47,828m (Chart 64), £847m in the Irish Sea, £29,589m in the NNS, £5,532m in the SNS, and £17,941m in the WoS.

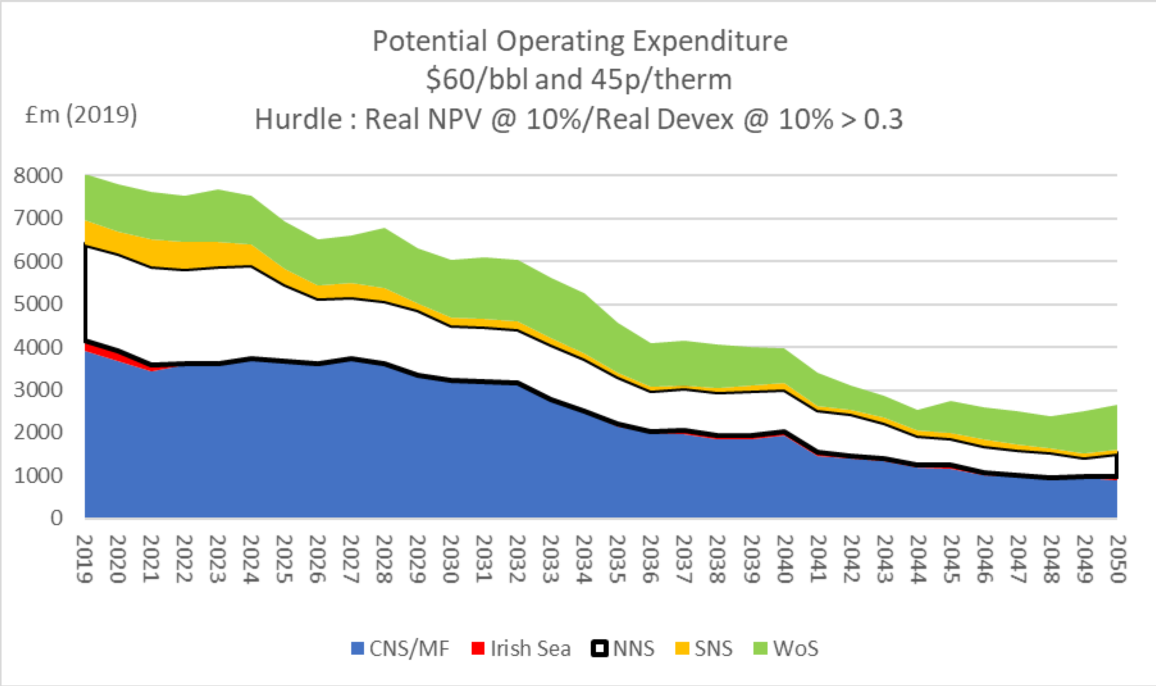
ii) $60 and 45 pence prices

Chart 65



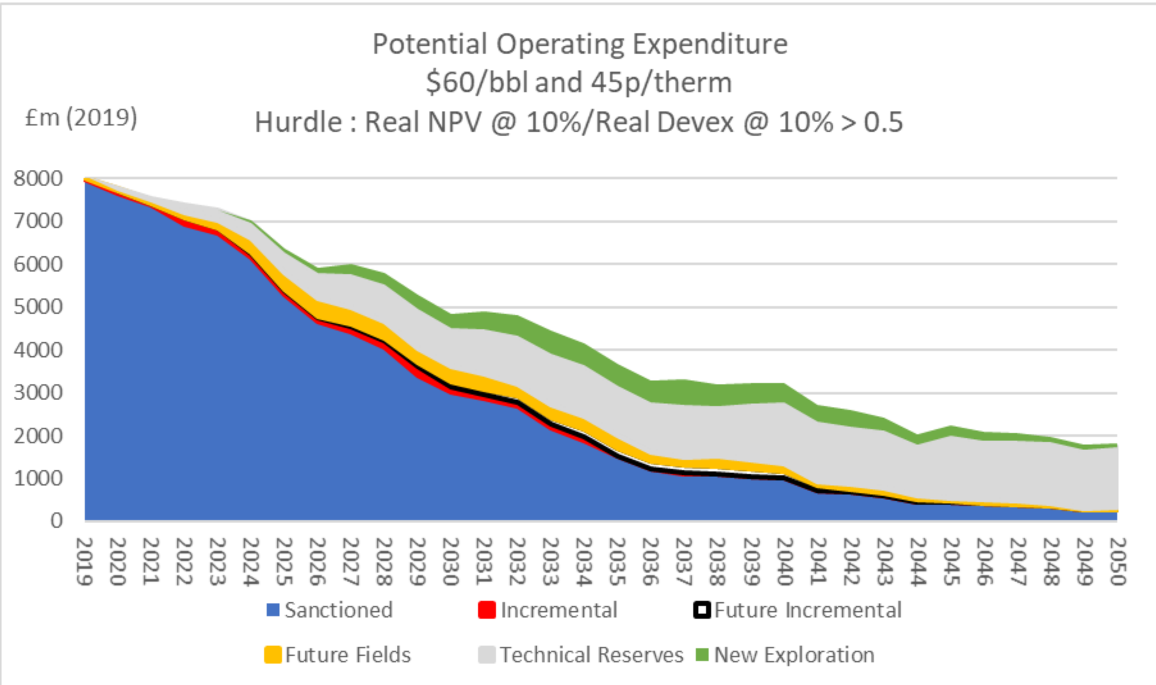
Over the period to 2050 with $60 and 45 pence prices and NPV/I ≥ 0.3 hurdle, cumulative operating costs to 2050 are £160,466m (Chart 65), with £88,953m coming from already sanctioned fields, £2,115m from current incremental projects, £3,230m from future incremental projects, £8,587m from the probable and possible fields, £45,917m from technical reserve fields, and £11,664m from new exploration finds. A key feature is the much slower decline rate in annual expenditure in this scenario compared to the $50, 35 pence case. But the level still declines at a smart rate from c.£8 million in 2019 to c.£2.7 billion in 2050.

Chart 66



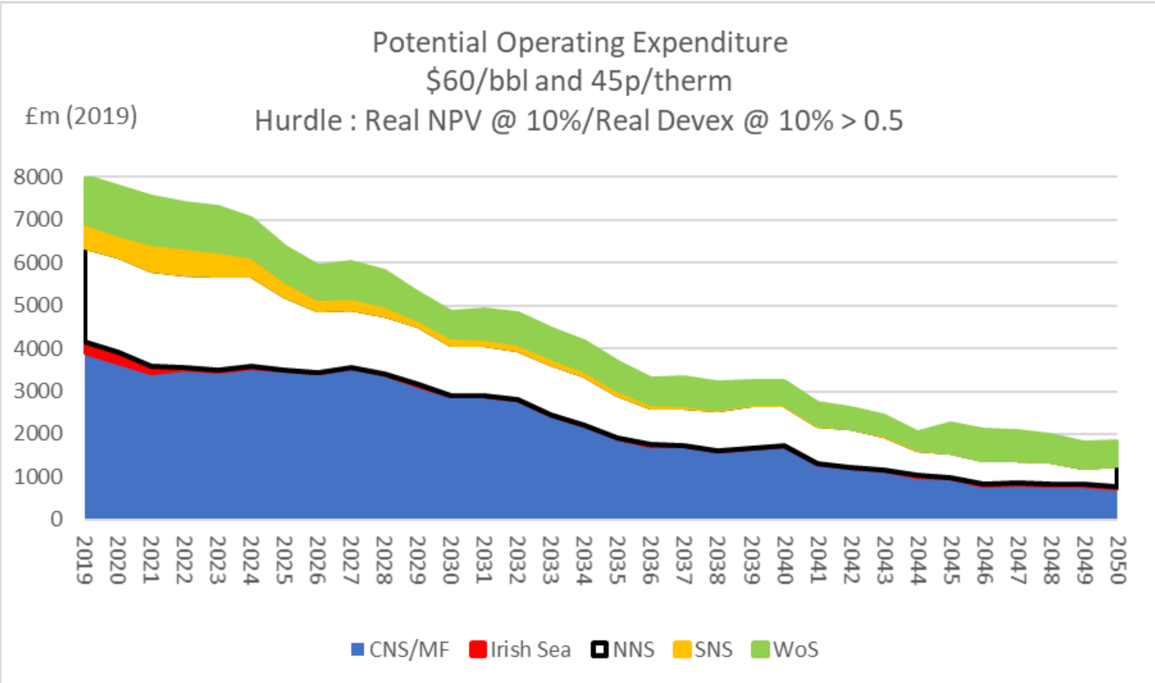
Cumulative operating costs in the CNS/MF area are £77,705m (Chart 66), £1,839m in the Irish Sea, £40,574m in the NNS, £7,387m in the SNS, and £32,960m in the WoS.

Chart 67



Over the period to 2050, with $60 and 45 pence prices and NPV/I ≥ 0.5 hurdle, cumulative operating costs are £139,218m (Chart 67), with £88,953m coming from already sanctioned fields, £1,541m from current incremental projects, £2,357m from future incremental projects, £6,441m from probable and possible fields, £31,191m from technical reserve fields, and £8,736m from new exploration finds. The importance of technical reserves in the long term is highlighted.

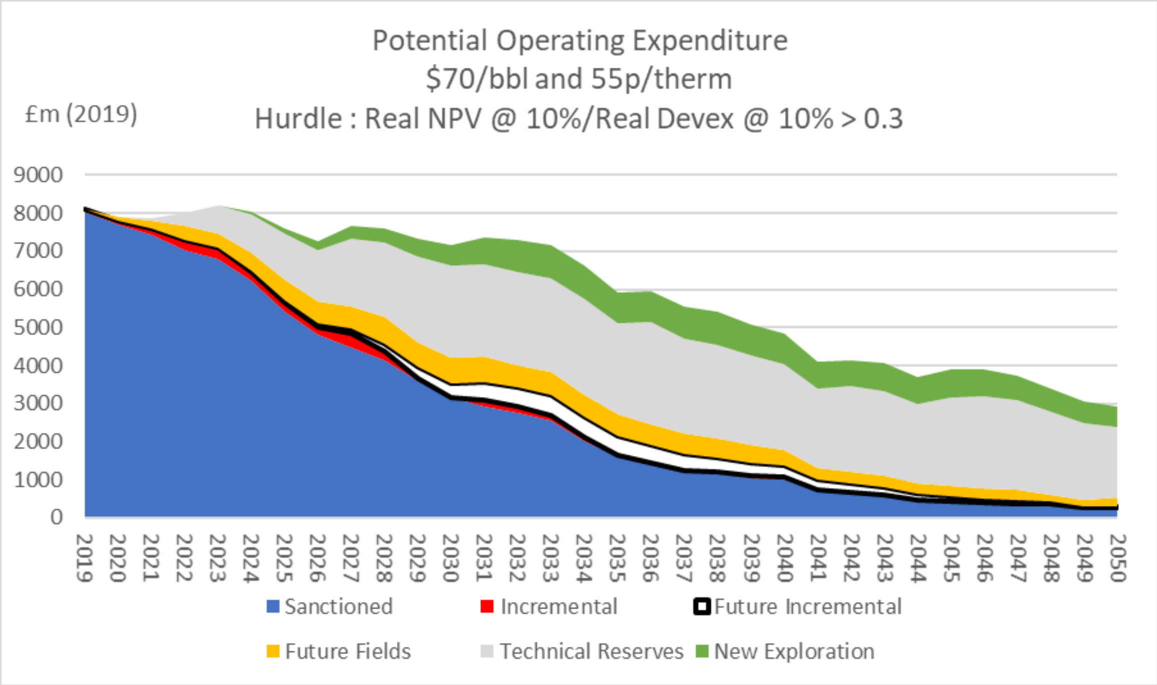
Chart 68



With $60 and 45 pence prices and NPV/I ≥ 0.5 hurdle, cumulative operating costs in the CNS/MF area are £71,908m (Chart 68), £903m in the Irish Sea, £38,557m in the NNS, £5,845m in the SNS, and £22,005m in the WoS.

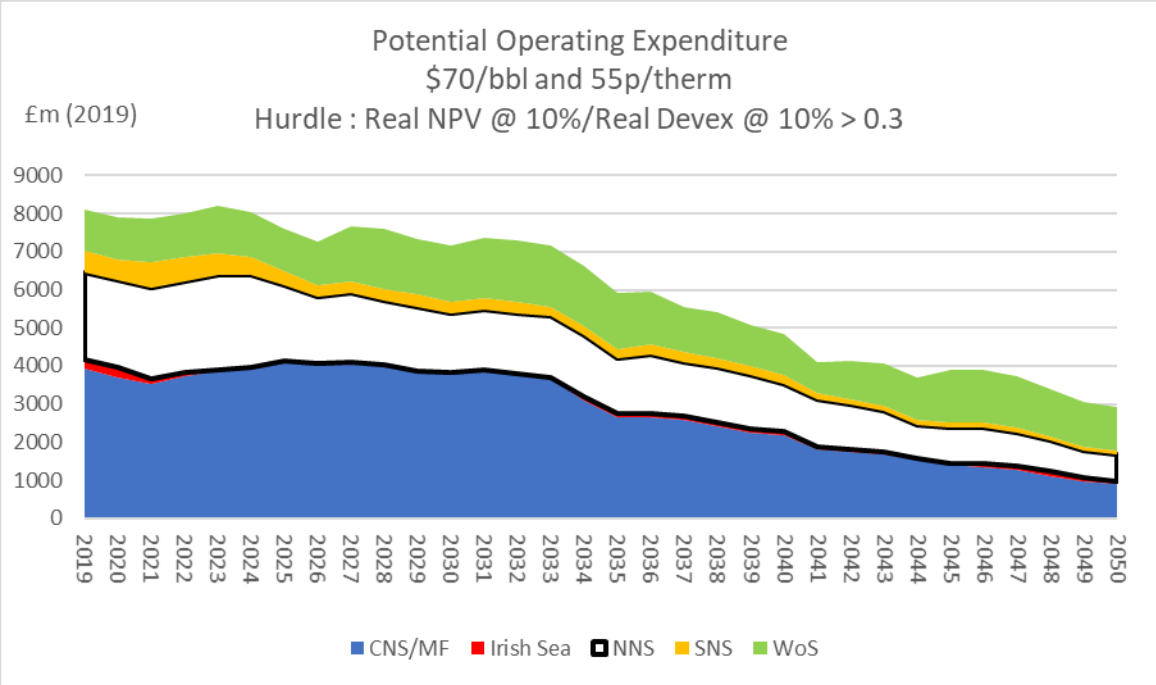
iii) $70 and 55 pence prices

Chart 69



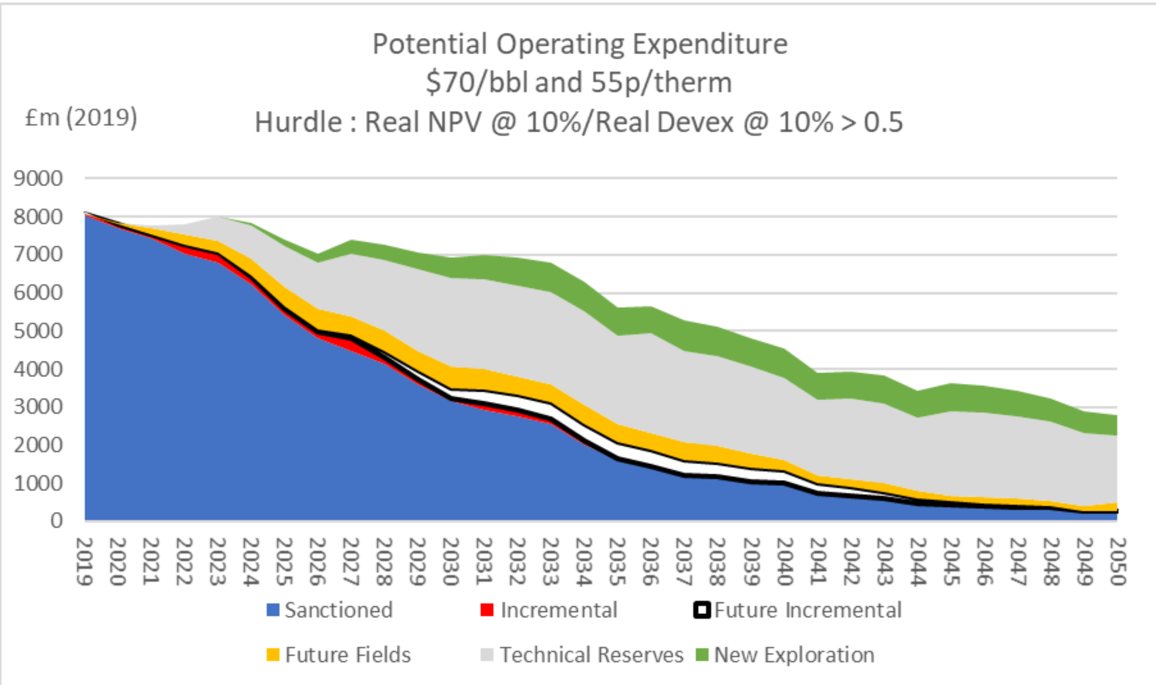
Over the period to 2050, with $70 and 55 pence prices and NPV/I ≥ 0.3 hurdle, cumulative operating costs are £190,883m (Chart 69), with £91,123m coming from already sanctioned fields, £3,076m from current incremental projects, £7,036m from future incremental projects, £13,191m from probable and possible fields, £59,290m from technical reserve fields, and £17,168m from new exploration finds. In this price scenario the decline rate in expenditure is much more gradual compared to the other two price scenarios. Annual operating costs are c.£8 billion for a few years from 2019 and by 2050 are around £2.9 billion in 2050.

Chart 70



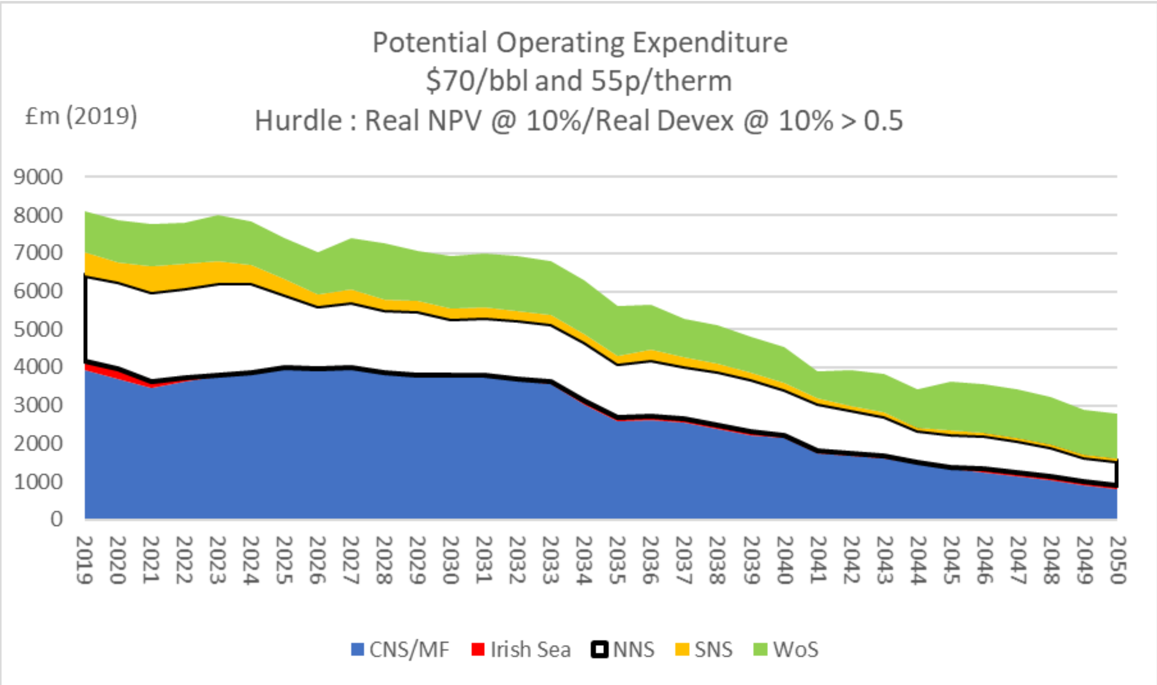
Cumulative operating costs in the CNS/MF area are £89,640m (Chart 70), £2,310m in the Irish Sea, £48,941m in the NNS, £9,243m in the SNS, and £40,748m in the WoS.

Chart 71



Over the period to 2050 with $70 and 55 pence prices and NPV/I ≥ 0.5 hurdle, cumulative operating costs are £183,072m (Chart 71), with £91,123m coming from already sanctioned fields, £2,588m from current incremental projects, £5,972m from future incremental projects, £10,636m from probable and possible fields, £56,424m from technical reserve fields, and £16,329m from new exploration finds. There is a major contribution from technical reserve fields in the longer term.

Chart 72

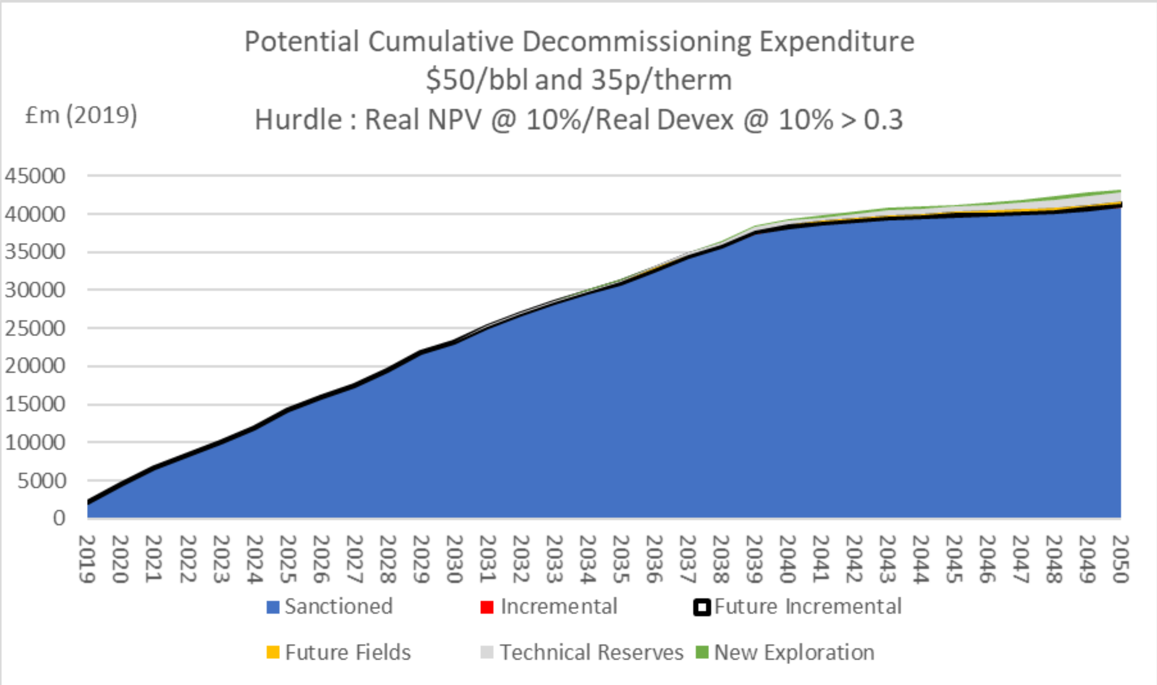


Cumulative operating costs in the CNS/MF area are £87,270m (Chart 72), £2,310m in the Irish Sea, £47,523m in the NNS, £8,388m in the SNS, and £37,580m in the WoS.

e) Decommissioning Activity

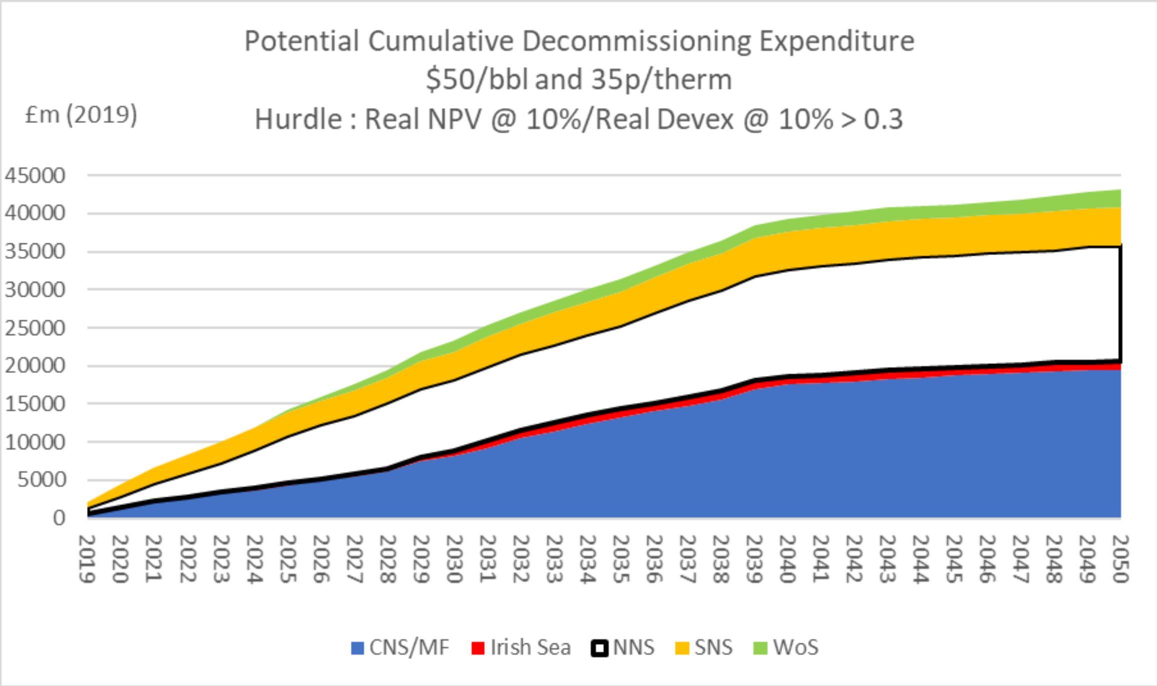
i) Cumulative Expenditure to 2050

Chart 73



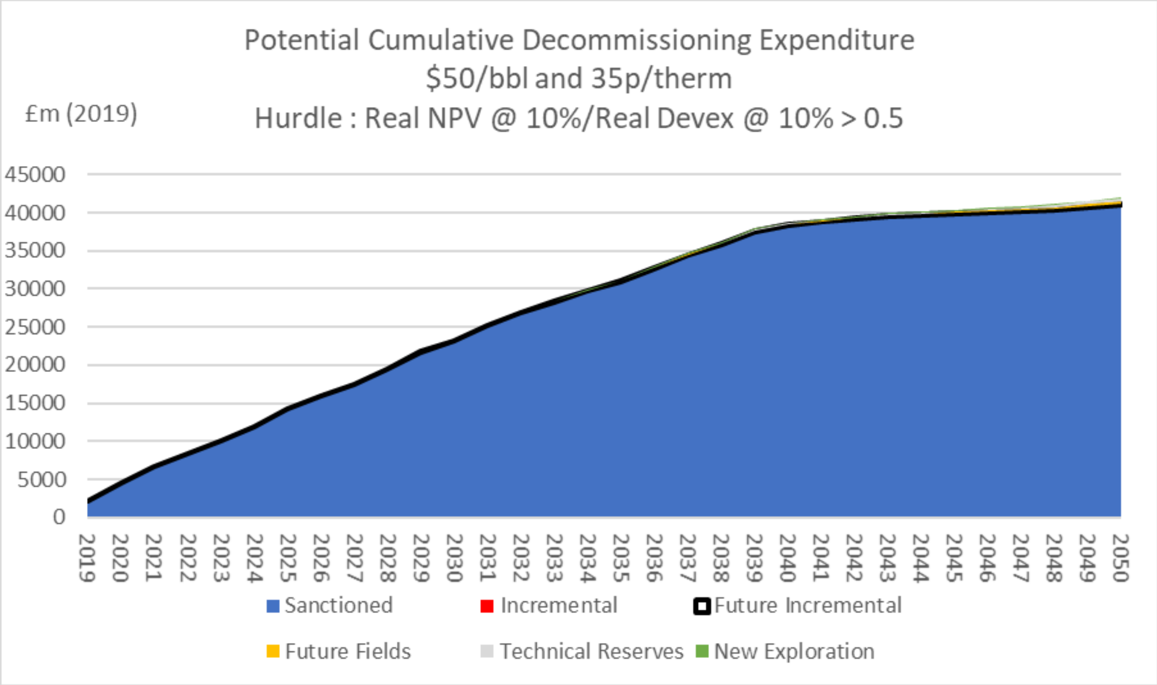
With \$50 and 35 pence prices and NPV/I ≥ 0.3 hurdle, cumulative decommissioning costs could be £43,153m by 2050 (Chart 73), with 95% coming from already sanctioned fields. They could account for £40,910m, current incremental projects could account for £184m, future incremental projects could account for £191m, probable and possible fields could account for £335m, technical reserves could account for £1,167m, and new exploration finds could account for £365m. Around 50% of the decommissioning spend will occur before 2029, and 80% will occur before 2037.

Chart 74



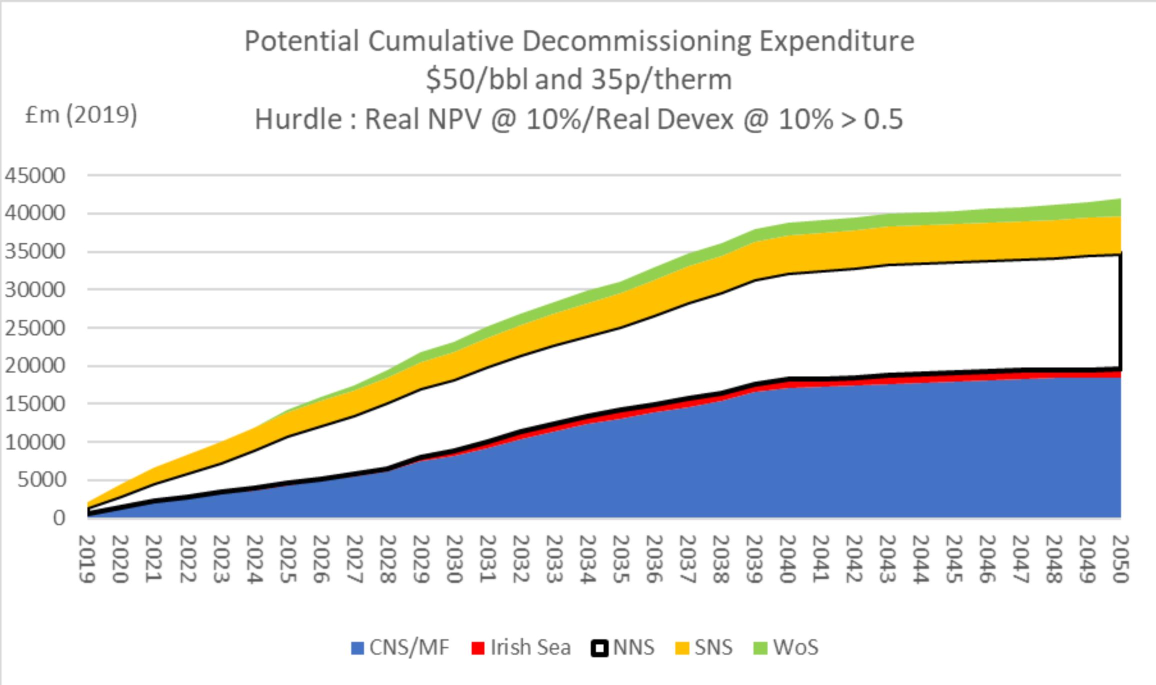
Cumulative decommissioning costs in the CNS/MF area could be £19,483m by 2050 (Chart 74), accounting for more than 45% of the decommissioning spend. Cumulative costs could be £1,111m in the Irish Sea which is less than 3% of the total spend. There could be £15,268m in the NNS, which is more than 35% of the decommissioning spend. There could be £4,950m in the SNS, which is more than 11% of the total spend. There could be £2,324m in the WoS which is more than 5% of the total spend.

Chart 75



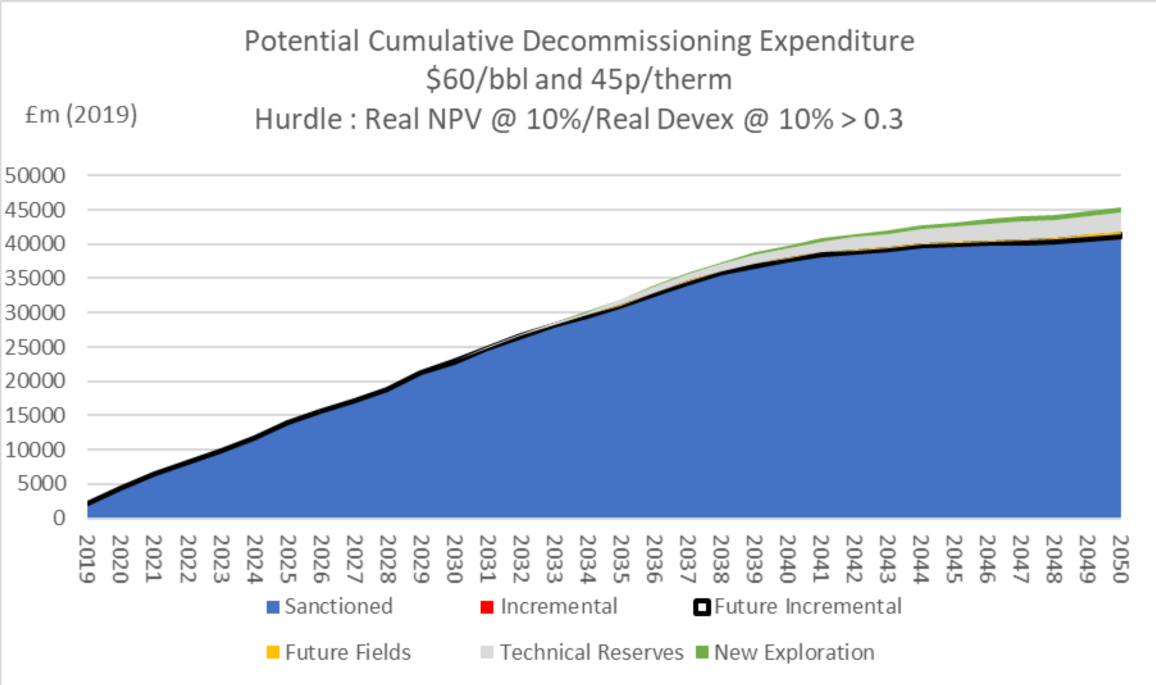
With $50 and 35 pence prices and NPV/I ≥ 0.5 hurdle, cumulative decommissioning costs could be £41,943m by 2050, with 98% of this coming from already sanctioned fields. They could account for £40,910m, current incremental projects could account for £154m, future incremental projects could account for £158m, probable and possible fields could account for £242m, technical reserve fields could account for £327m and new exploration finds could account for £152m of the total spend. As much as 50% of the decommissioning spend will occur before 2029 and 80% will occur before 2037. The reduction in the total decommissioning spend in this scenario compared to the scenario with the same oil and gas prices but lower hurdle rate is due to the smaller number of new developments under this scenario with the higher hurdle.

Chart 76



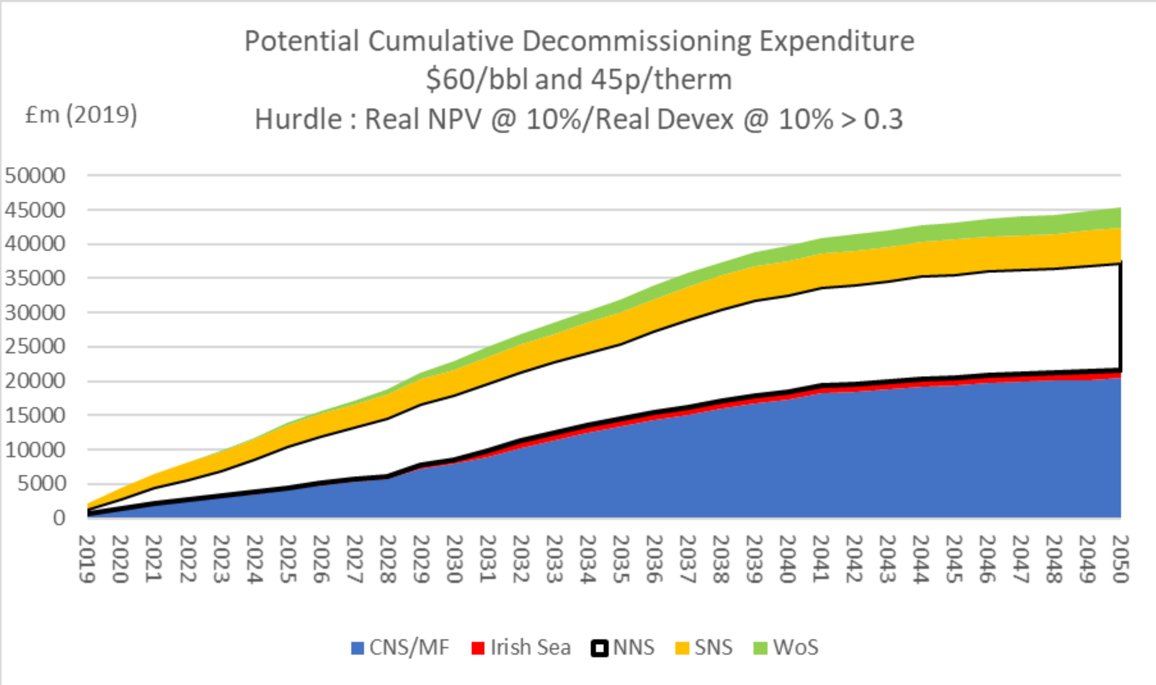
Cumulative decommissioning costs in the CNS/MF area could be £18,514m by 2050 (Chart 76), accounting for more than 44% of the total decommissioning spend. Cumulative costs could be £1,111m in the Irish Sea, which is less than 3% of the total spend. Expenditure could be £15,081m in the NNS, which is 36% of the total decommissioning spend. It could be £4,940m in the SNS, which is less than 12% of the total spend, and it could be £2,297m in the WoS which is more than 5% of the total decommissioning spend.

Chart 77



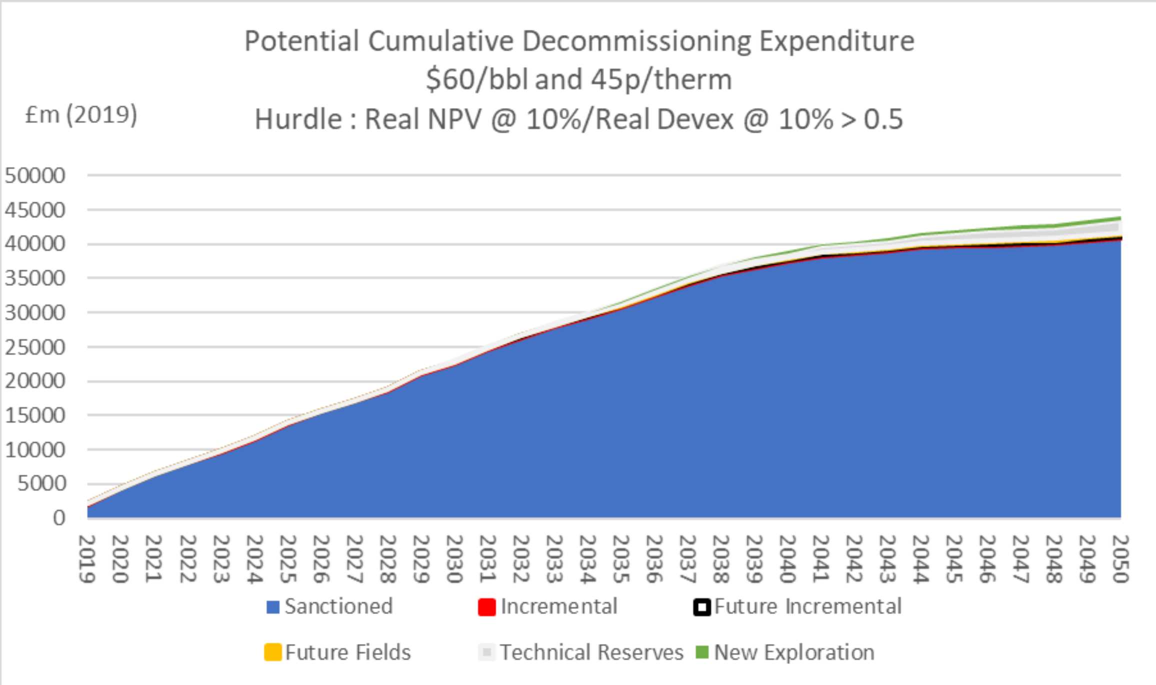
With $60 and 45 pence prices and NPV/I ≥ 0.3 hurdle, cumulative decommissioning costs could be £45,441m by 2050 with 90% of this coming from already sanctioned fields (Chart 77). These fields account for £40,910m of the total decommissioning spend. Current incremental projects could account for £203m, future incremental projects £313m, probable and possible fields £335m, technical reserves £2,921m, and new exploration finds £758m of the overall decommissioning spend. 50% of the decommissioning spend will occur before 2030 and 80% will occur before 2038. More new fields are developed under this price scenario compared to the $50, 35 pence case and reach their COP dates before 2050.

Chart 78



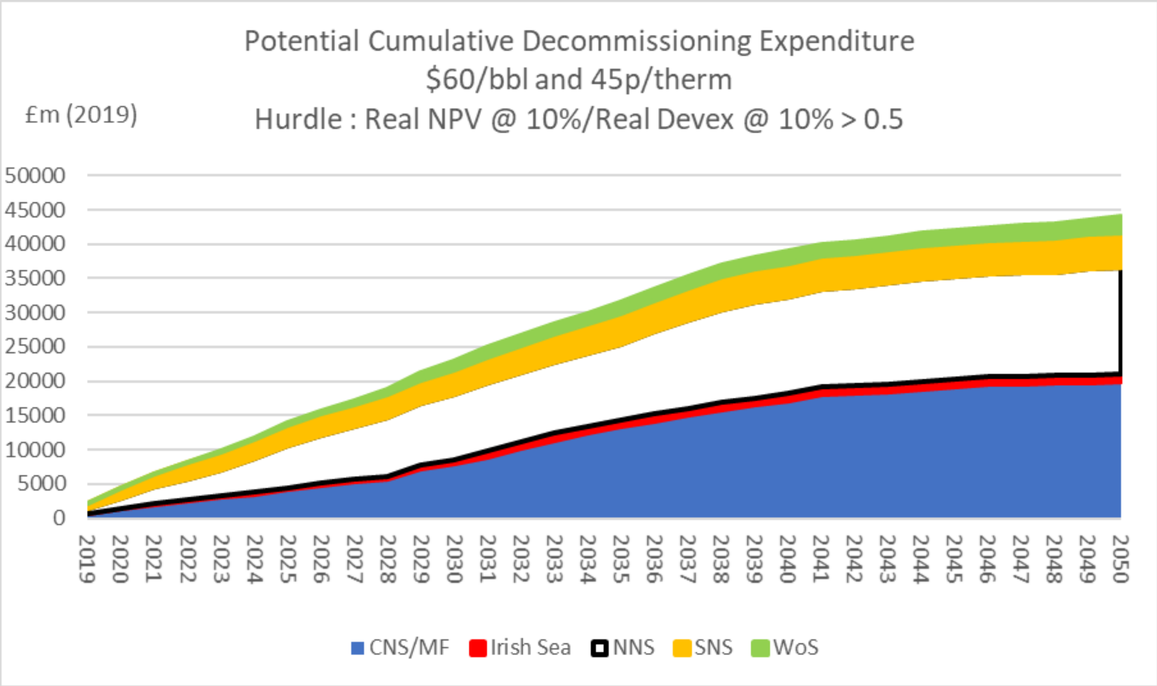
Cumulative decommissioning costs in the CNS/MF area could be £20,448m by 2050 accounting for 45% of the overall decommissioning spend (Chart 78). Cumulative costs could be £1,167m in the Irish Sea, which is less than 3% of the total spend, £15,685m in the NNS, which is almost 35% of the total spend, £4,985m in the SNS, which is 11% of the total spend, and £3,156m in the WoS which is almost 7% of the overall decommissioning spend.

Chart 79



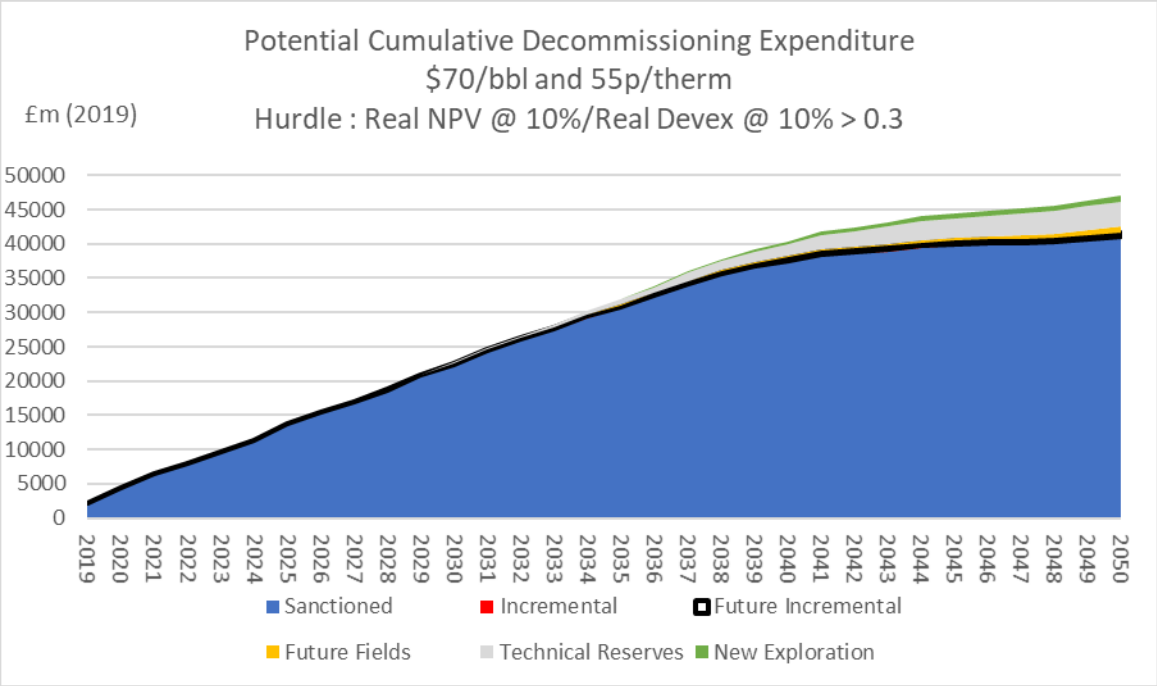
With $60 and 45 pence prices and NPV/I ≥ 0.5 hurdle, cumulative decommissioning costs could be £44,061m by 2050, with 93% of this coming from already sanctioned fields (Chart 79). The sanctioned fields could account for £40,910m of the total, current incremental projects £182m, future incremental projects £279m, probable and possible fields £335m, technical reserves £1,808m, and new exploration finds £547m of the total decommissioning spend. Overall 50% of the decommissioning spend will occur before 2030, and 80% will occur before 2037.

Chart 80



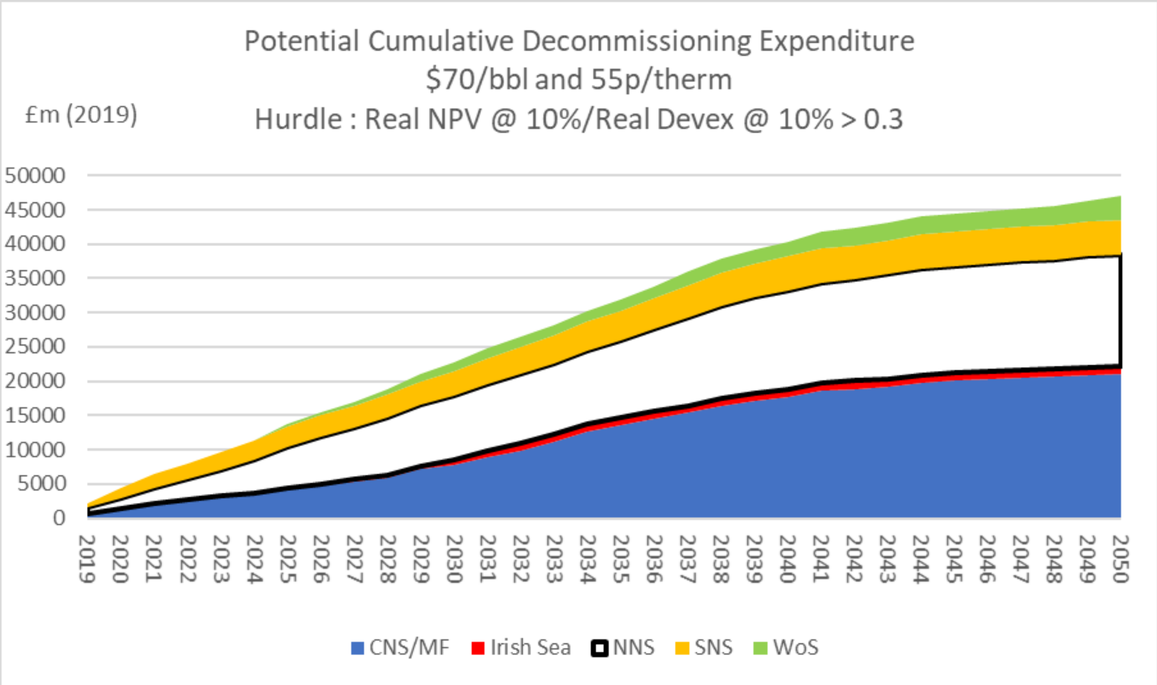
With \$60 and 45 pence prices and NPV/I ≥ 0.5 hurdle, cumulative decommissioning costs in the CNS/MF area could be £20,012m by 2050, accounting for more than 45% of the total spend. They could be £1,111m in the Irish Sea, which is less than 3% of the total spend, £15,545m in the NNS, which is more than 35% of the overall spend, £4,947m in the SNS which is more than 11% of the total spend, and £2,447m in the WoS which is almost 6% of the overall decommissioning spend.

Chart 81



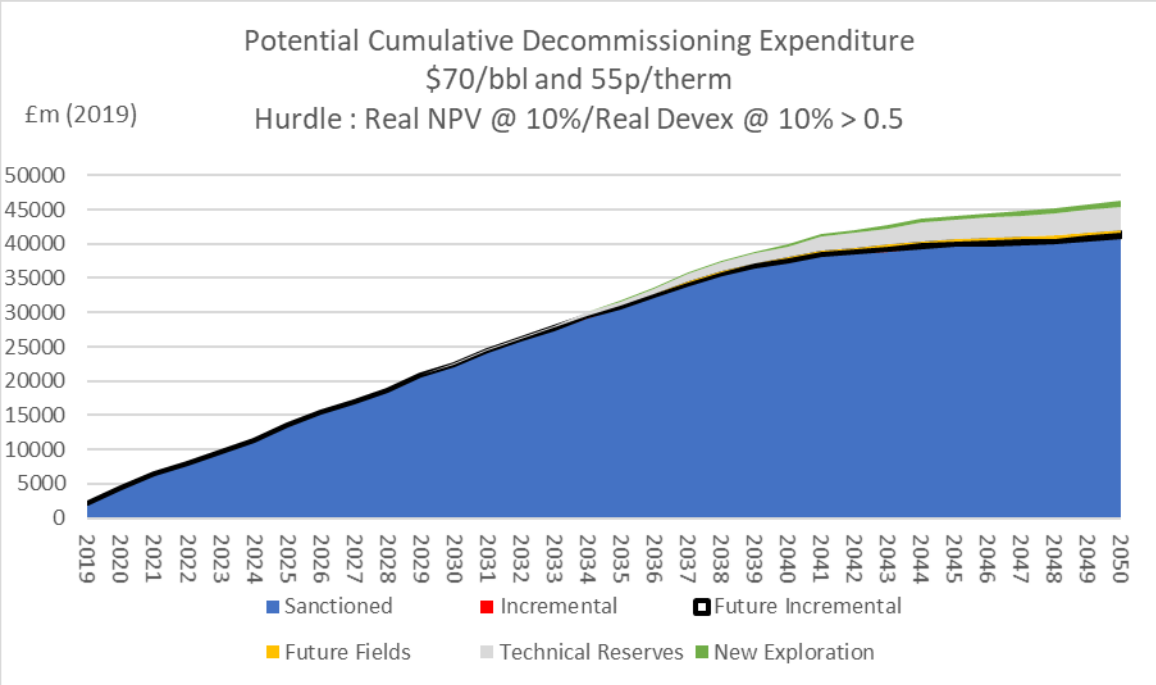
With $70 and 55 pence prices and NPV/I ≥ 0.3 hurdle, cumulative decommissioning costs could be £47,048m by 2050, with 87% coming from already sanctioned fields. They could account for $40,910m of the total decommissioning spend, current incremental projects could account for £239m, future incremental projects could account for £558m, probable and possible fields could account for £830m, technical reserve fields could account for £3,572m, and new exploration finds could account for £939m of the total spend. Overall 50% of the decommissioning spend will occur before 2031, and 80% will occur before 2038.

Chart 82



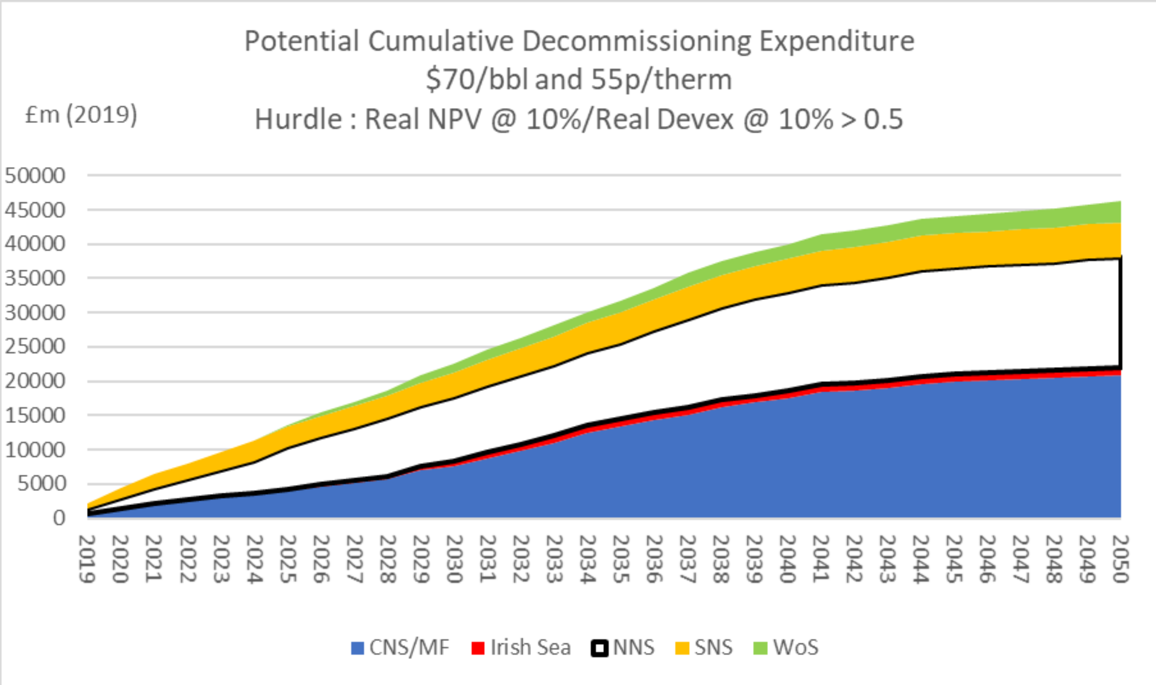
Cumulative decommissioning costs in the CNS/MF are could be £21,058m by 2050, accounting for almost 45% of the decommissioning spend (Chart 82). Cumulative costs could be £1,177m in the Irish Sea, which is less than 3% of the total spend. It could be £16,127m in the NNS, which is more than 34% of the overall spend, £5,107m in the SNS, which is almost 11% of the total, and £3,580m in the WoS, which is more than 7% of the overall decommissioning spend.

Chart 83



With $70 and 55 pence prices and NPV/I ≥ 0.5 hurdle, cumulative decommissioning costs could be £46,302m by 2050, with 88% coming from already sanctioned fields. They could account for £40,910m of the total spend, current incremental projects could account for £203m, future incremental projects could account for £472m, probable and possible fields could account for £494m, technical reserve fields could account for £3,354m, and new exploration finds could account for £870m of the total spend. Overall 50% of the decommissioning spend will occur before 2031, and 80% will occur before 2038.

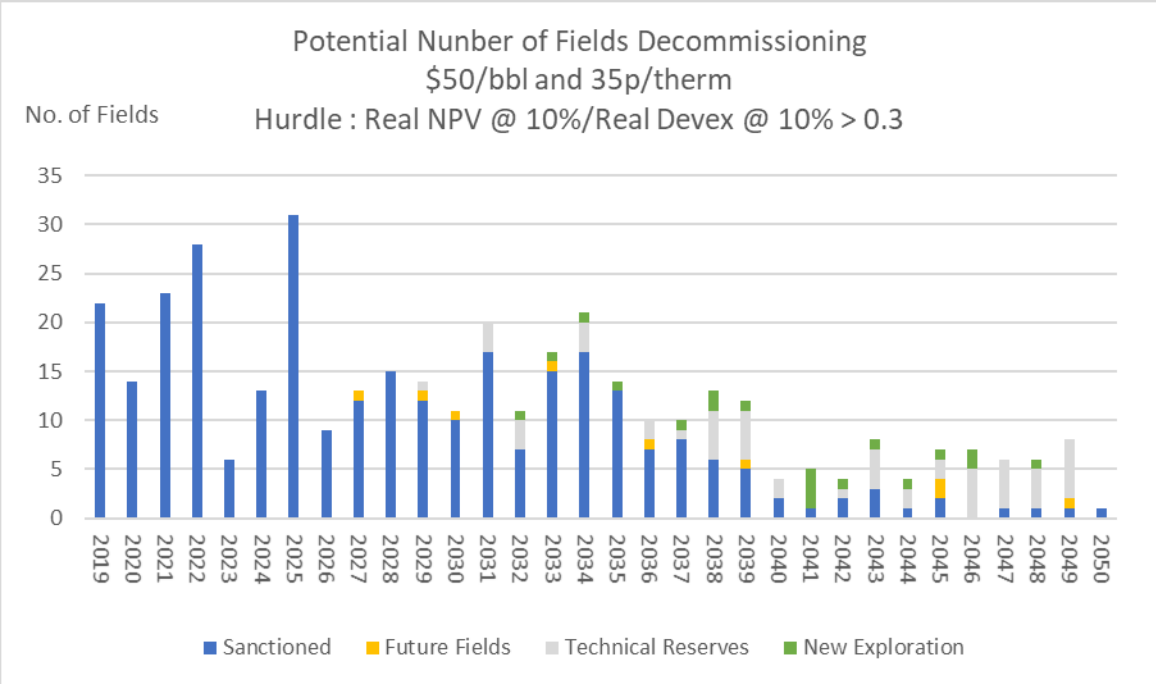
Chart 84



With \$70 and 55 pence prices and MPV/I ≥ 0.5 hurdle, cumulative decommissioning costs in the CNS/MF area could be £20,781m by 2050 accounting for almost 45% of the total spend (Chart 84). Cumulative costs could be £1,177m in the Irish Sea, which is less than 3% of the overall spend, £16,070m in the NNS, which is almost 35% of the total, £5,059m in the SNS, which is almost 11% of the total, and £3,215m in the WoS which is almost 7% of the aggregate spend.

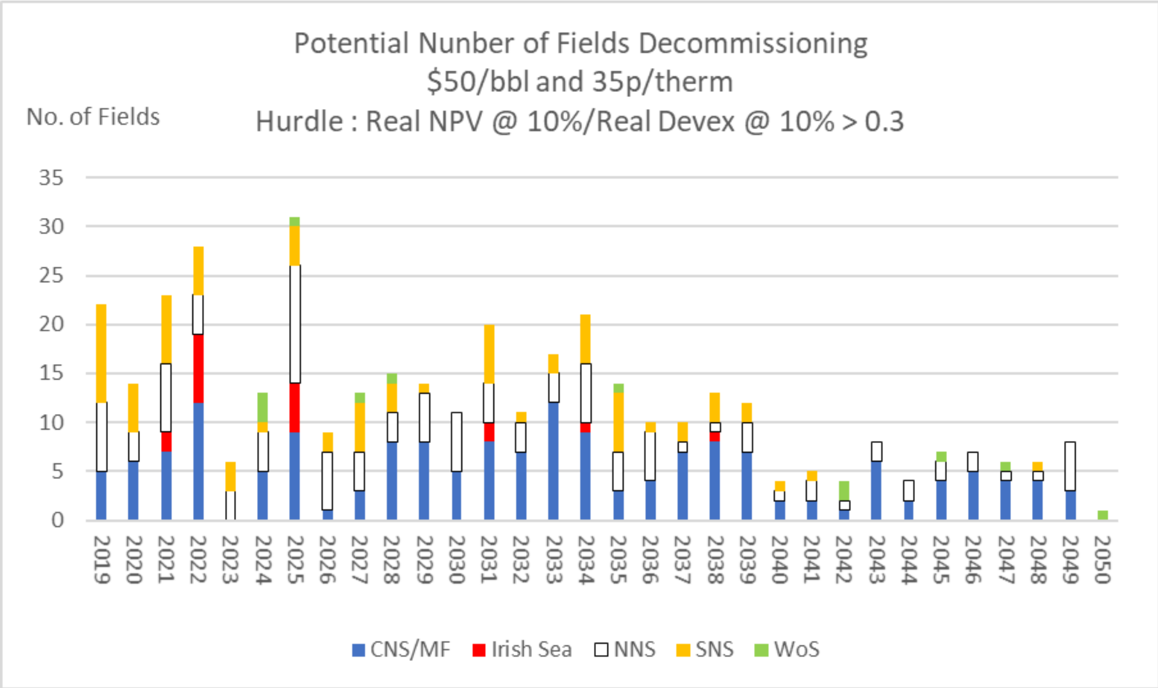
ii) Number of Fields Being Decommissioned

Chart 85



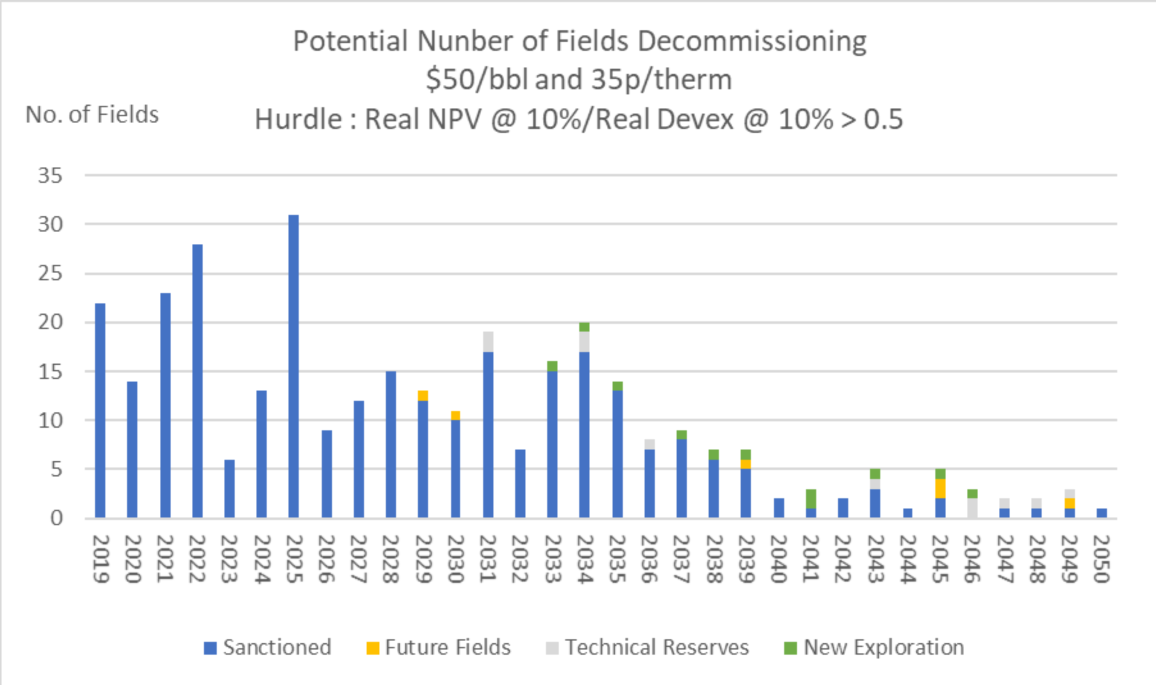
With \$50 and 35 pence prices and NPV/I ≥ 0.3 hurdle, there will be 137 fields either engaged in or having completed decommissioning by 2025. By 2030 the compounding number becomes 199, and by 2050 there will be 387 fields either engaged in or having completed decommissioning. By 2035, 264 sanctioned fields, 4 probable and possible fields, 10 technical reserve fields, and 4 new exploration finds will be either engaged in or having completed decommissioning. By 2050, 305 sanctioned fields, 9 probable and possible fields, 54 technical reserve fields and 19 new exploration finds will be either engaged in or have completed decommissioning. Details are shown in Chart 85.

Chart 86



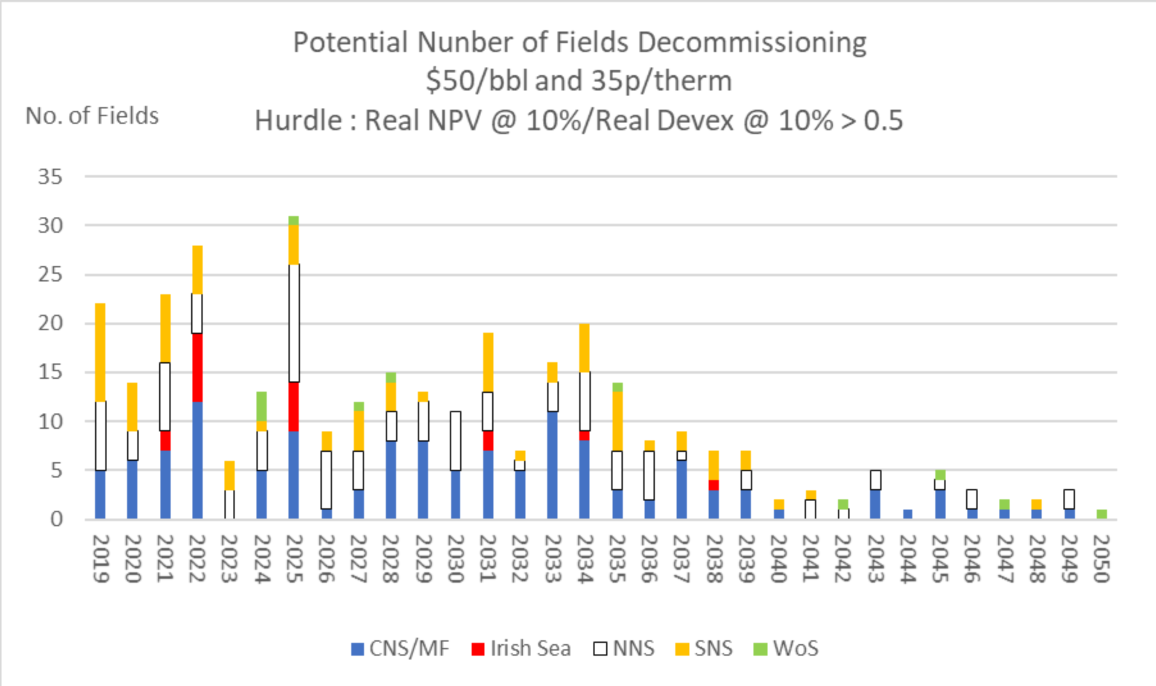
By 2035, 108 CNS/MF fields, 17 Irish Sea fields, 84 NNS fields, 66 SNS fields and 7 WoS fields will be either engaged in or have completed decommissioning. By 2050, 167 CNS/MF fields, 18 Irish Sea fields, 113 NNS fields, 77 SNS fields and 12 WoS fields will be either engaged in or have completed decommissioning. Details are shown in Chart 86.

Chart 87



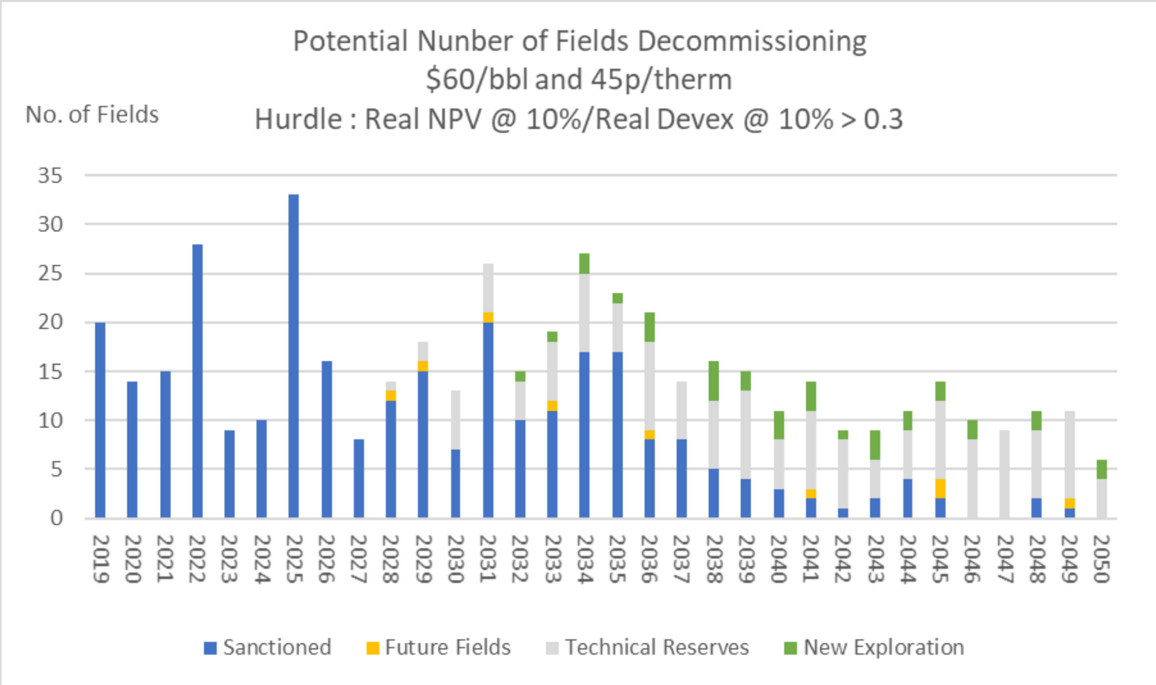
With \$50 and 35 pence prices and NPV/I ≥ 0.5 hurdle, there will be 137 fields either engaged in or having completed decommissioning by 2025. By 2030 there will be 197 fields either engaged in or having completed decommissioning, and by 2050 there will be 333 fields either engaged in or having completed decommissioning. By 2035, 264 sanctioned fields, 2 probable or possible fields, 4 technical reserve fields and 3 new exploration finds will be either engaged in or have completed decommissioning. By 2050, 305 sanctioned fields, 6 probable or possible fields, 11 technical reserve fields and 11 new exploration finds will be either engaged in or have completed decommissioning. Details are in Chart 87.

Chart 88



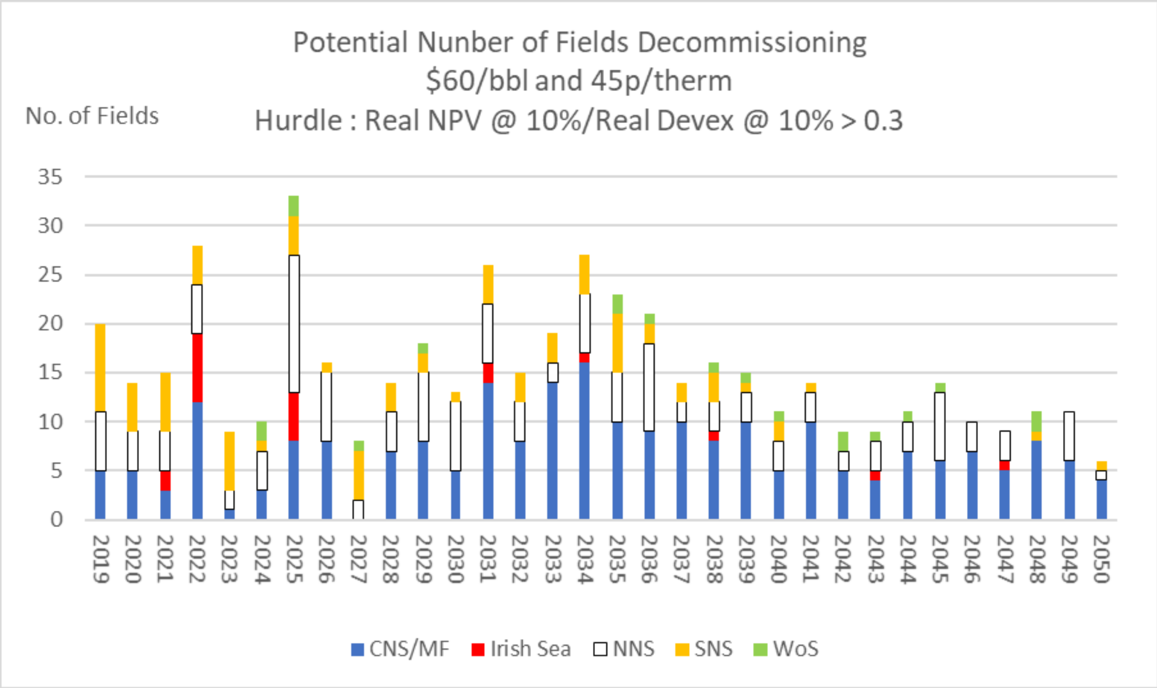
By 2035, 103 CNS/MF fields, 17 Irish Sea fields, 81 NNS fields, 65 SNS fields and 7 WoS fields will be either engaged in or have completed decommissioning. By 2050, 129 CNS/MF fields, 18 Irish Sea fields, 99 NNS fields, 76 SNS fields and 11 WoS fields will be either engaged in or have completed decommissioning. Details are in Chart 88.

Chart 89



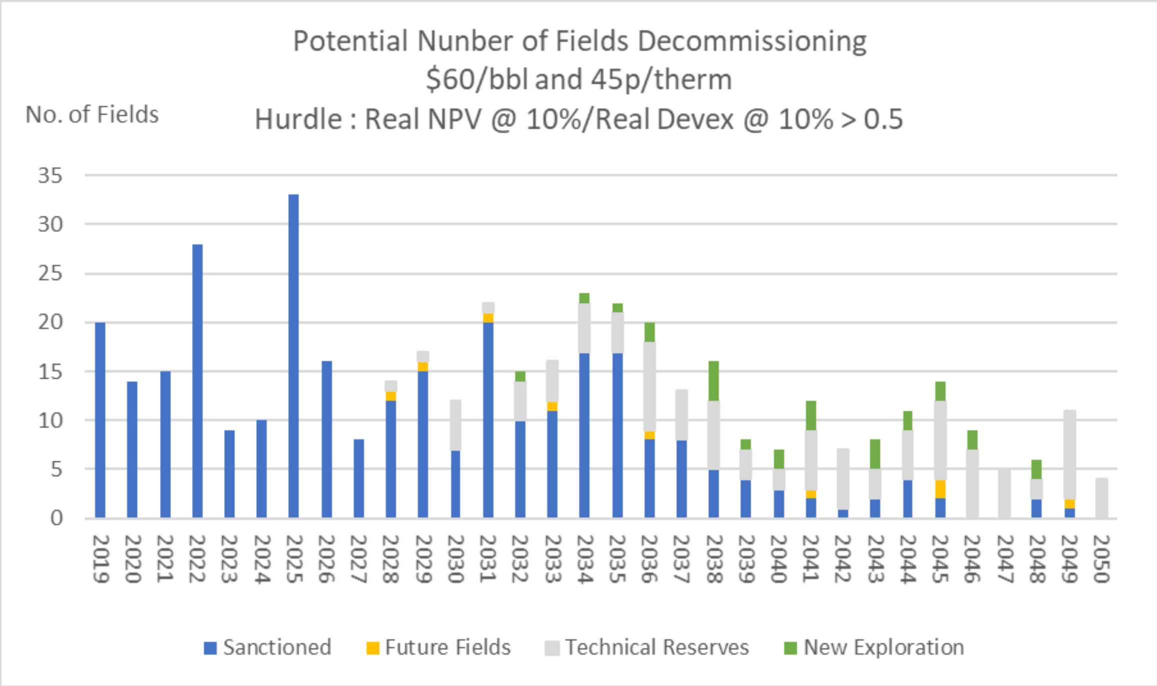
With \$60 and 45 pence prices and NPV/I ≥ 0.3 hurdle, there will be 129 fields either engaged in or having completed decommissioning by 2025. By 2030 there will be 198 fields either engaged in or having completed decommissioning, and by 2050 there will be 489 fields either engaged in or having completed decommissioning. By 2035, 262 sanctioned fields, 4 probable or possible fields, 37 technical reserve fields and 5 new exploration finds will be either engaged in or have completed decommissioning. By 2050, 304 sanctioned fields, 9 probable or possible fields, 142 technical reserve fields and 34 new exploration finds will be either engaged in or have completed decommissioning. Details are shown in Chart 89.

Chart 90



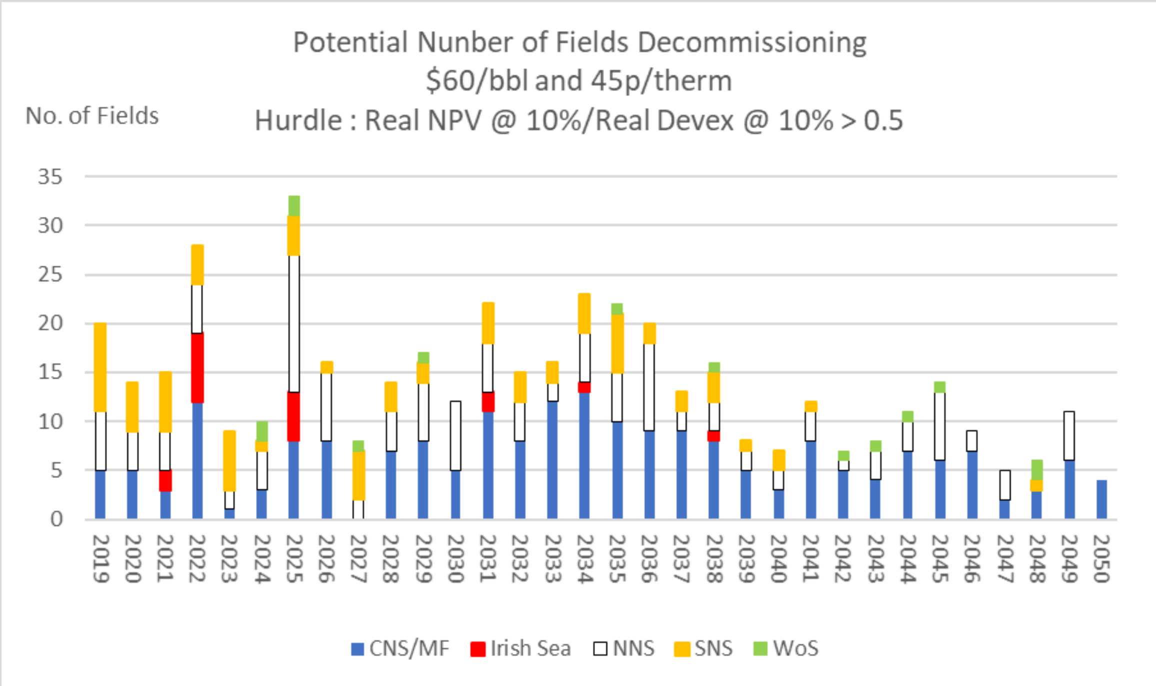
By 2035, 127 CNS/MF fields, 17 Irish Sea fields, 89 NNS fields, 67 SNS fields, and 8 WoS fields will be either engaged in or have completed decommissioning. By 2050, 231 CNS/MF fields, 20 Irish Sea fields, 139 NNS fields, 80 SNS fields and 19 WoS fields will be either engaged in or have completed decommissioning. Details are shown in Chart 90.

Chart 91



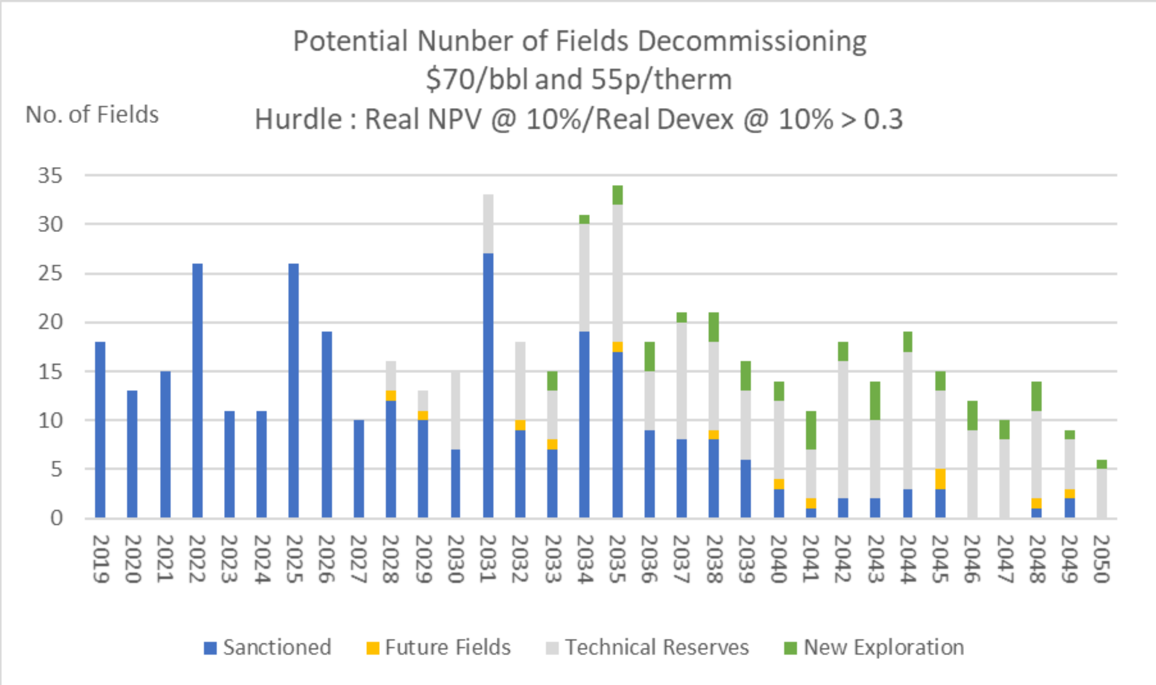
With $60 and 45 pence prices and NPV/I ≥ 0.5 hurdle, there will be 129 fields either engaged in or have completed decommissioning by 2025. By 2030 there will be 196 fields either engaged in or having completed decommissioning, and by 2050 there will be 445 fields either engaged in or having completed decommissioning. By 2035, 262 sanctioned fields, 4 probable or possible fields, 25 technical reserve fields and 3 new exploration finds will be either engaged in or have completed decommissioning. By 2050, 304 sanctioned fields, 9 probable or possible fields, 106 technical reserve fields and 26 new exploration finds will be either engaged in or have completed decommissioning. Details are shown in Chart 91.

Chart 92



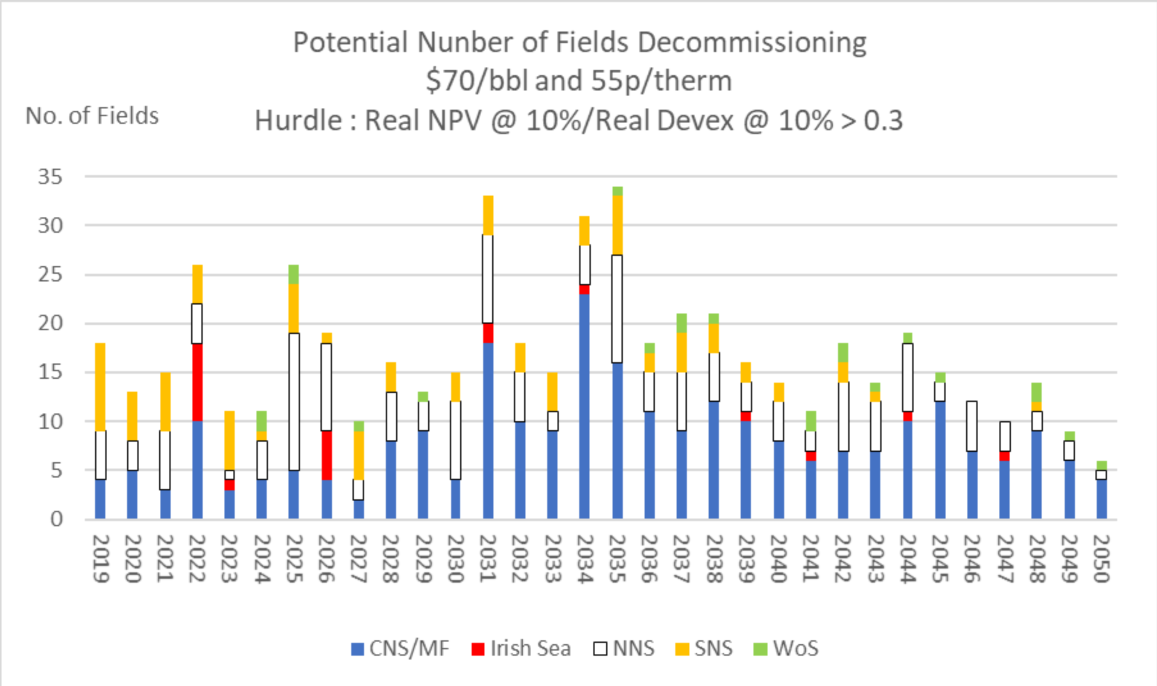
By 2035, 119 CNS/MF fields, 17 Irish Sea fields, 86 NNS fields, 65 SNS fields and 7 WoS fields will be either engaged in or have completed decommissioning. By 2050, 205 CNS/MF fields, 18 Irish Sea fields, 131 NNS fields, 77 SNS fields and 14 WoS fields will be either engaged in or have completed decommissioning. Details are shown in Chart 92.

Chart 93



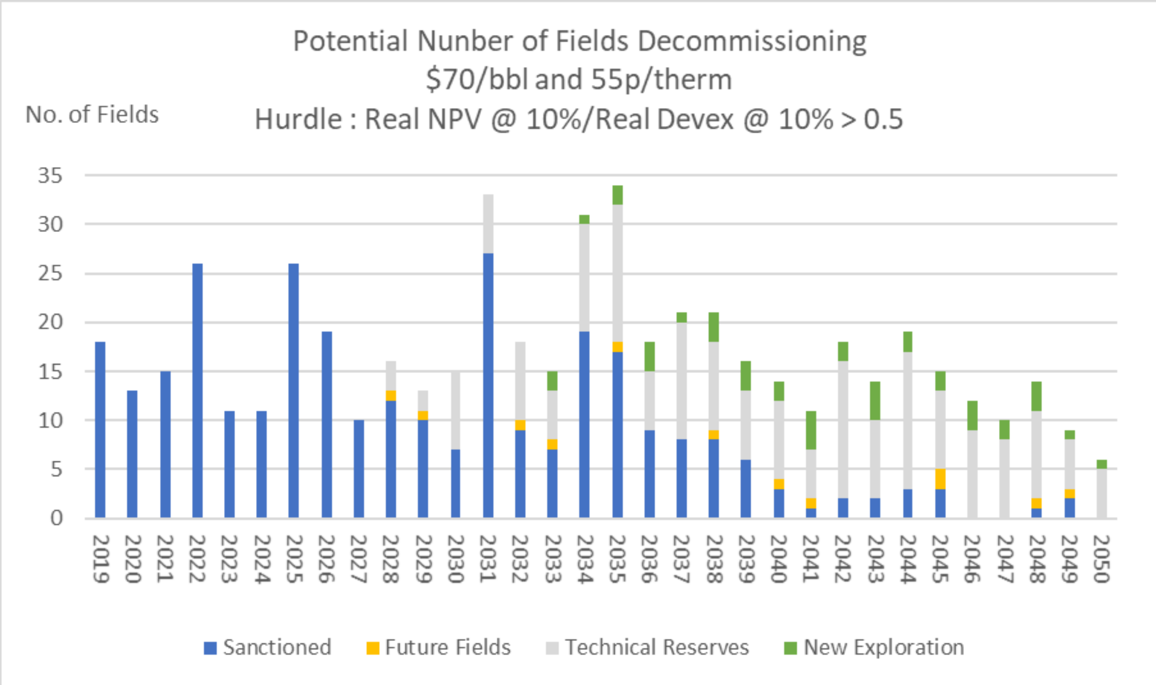
With \$70 and 55 pence prices and NPV/I ≥ 0.3 hurdle, there will be 120 fields either engaged in or having completed decommissioning by 2025. By 2030 there will be 193 fields either engaged in or having completed decommissioning, and by 2050 there will be 542 fields either engaged in or having completed decommissioning. By 2035, 257 sanctioned fields, 5 probable or possible fields, 57 technical reserve fields, and 5 new exploration finds will be either engaged in or have completed decommissioning. By 2050, 305 sanctioned fields, 12 probable or possible fields, 184 technical reserve fields and 41 new exploration finds will be either engaged in or have completed decommissioning. Details are shown in Chart 93.

Chart 94



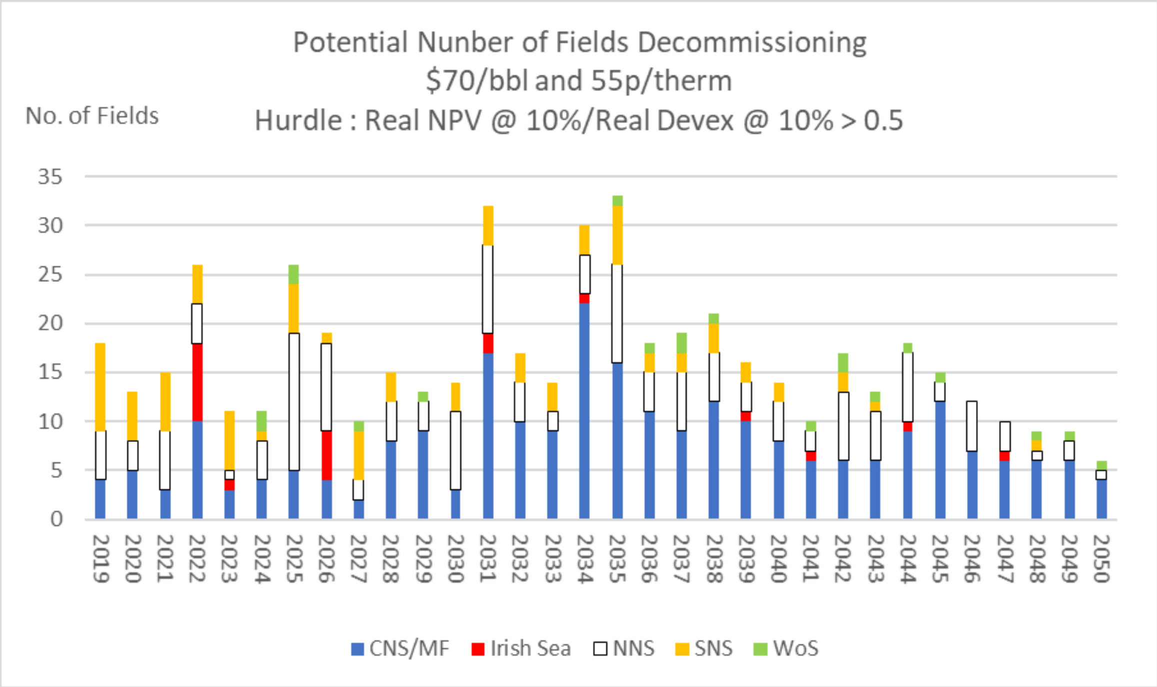
By 2035, 137 CNS/MF fields, 17 Irish Sea fields, 95 NNS fields, 68 SNS fields and 7 WoS fields will be either engaged in or have completed decommissioning. By 2050, 261 CNS/MF fields, 21 Irish Sea fields, 153 NNS fields, 85 SNS fields and 22 WoS fields will be either engaged in or have completed decommissioning. Details are shown in Chart 94.

Chart 95



With \$70 and 55 pence prices and NPV/I ≥ 0.5 hurdle, there will be 120 fields either engaged in or having completed decommissioning by 2025. By 2030 there will be 191 fields either engaged in or having completed decommissioning and by 2050 there will be 524 fields either engaged in or having completed decommissioning. By 2035, 257 sanctioned fields, 4 probable or possible fields, 51 technical reserve fields and 5 new exploration finds will be either engaged in or have completed decommissioning. By 2050, 305 sanctioned fields, 10 probable or possible fields, 170 technical reserve fields and 39 new exploration finds will be either engaged in or have completed decommissioning. Details are shown in Chart 95.

Chart 96

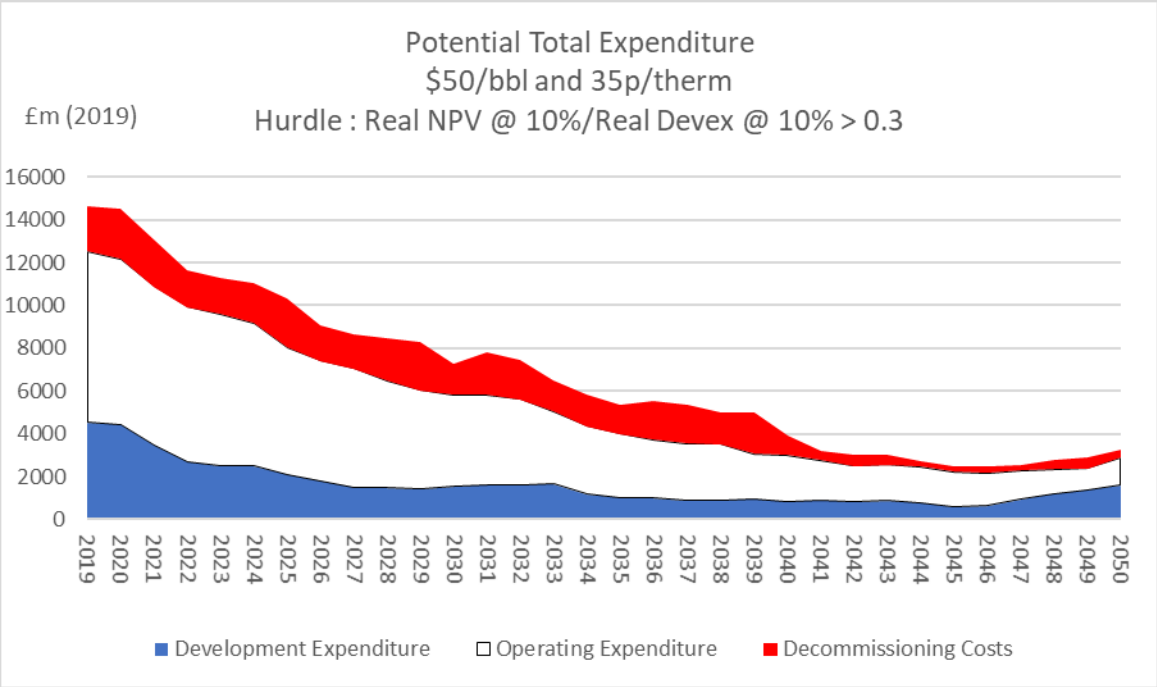


By 2035, 134 CNS/MF fields, 17 Irish Sea fields, 92 NNS fields, 67 SNS fields and 7 WoS fields will be either engaged in or have completed decommissioning. By 2050, 252 CNS/MF fields, 21 Irish Sea fields, 149 NNS fields, 82 SNS fields and 20 WoS fields will be either engaged in or have completed decommissioning. Details are shown in Chart 96.

f) Total Field Expenditure

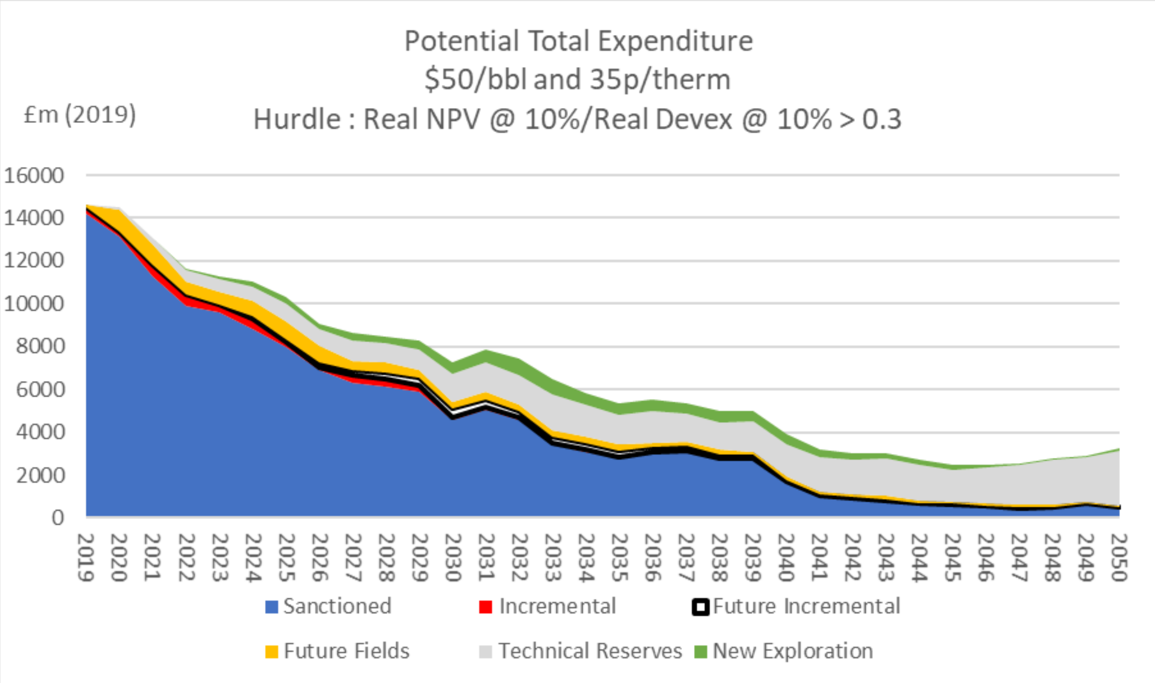
i) $50 and 35 pence prices

Chart 97



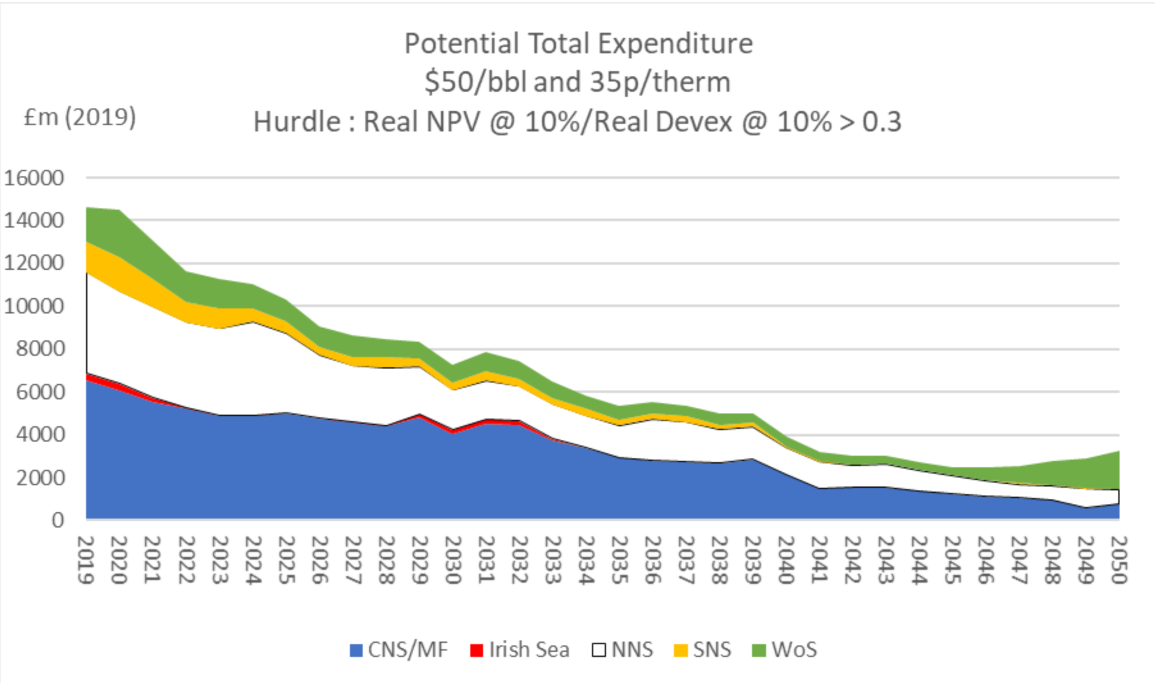
With $50 and 35 pence prices and NPV/I ≥ 0.3 hurdle, total field expenditure (development, operating and decommissioning expenditure) falls from the current level of just over £14.6 billion to just over £3.2 billion by 2050. The decline in total expenditure is fairly steady. Operating expenditure constitute by far the largest element.

Chart 98



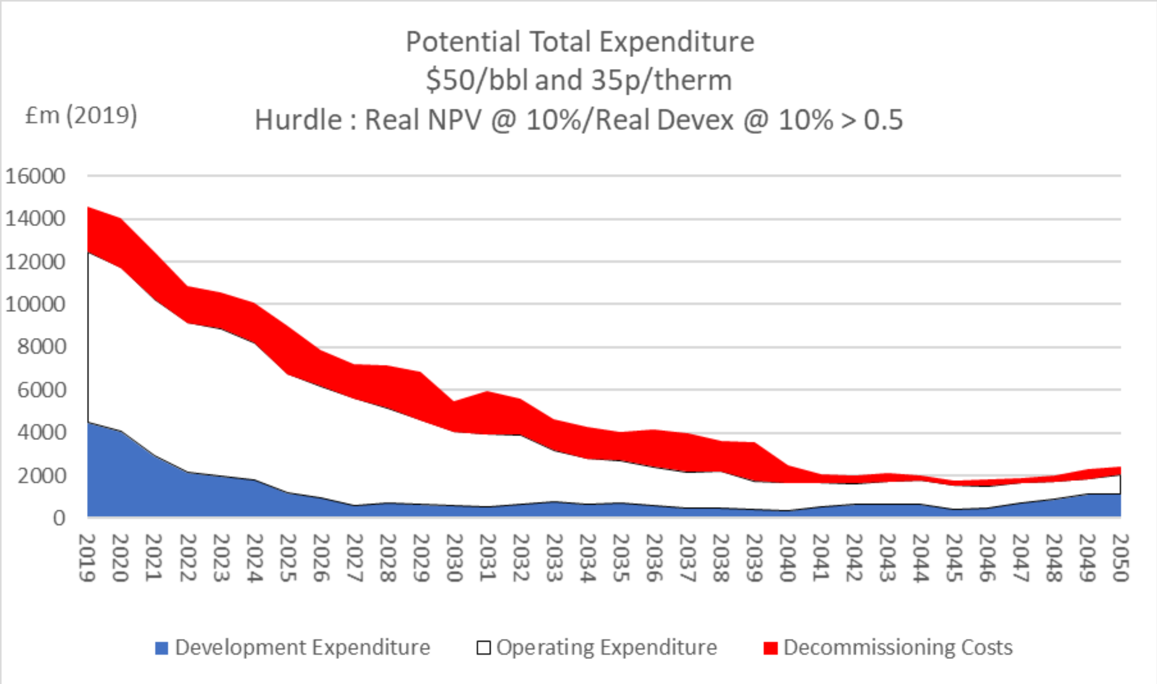
Total field expenditure is shown in Chart 98 by categories of fields and projects. Sanctioned dominate until late in the period but by 2041 expenditure from technical reserve fields becomes more important than that from already sanctioned fields.

Chart 99



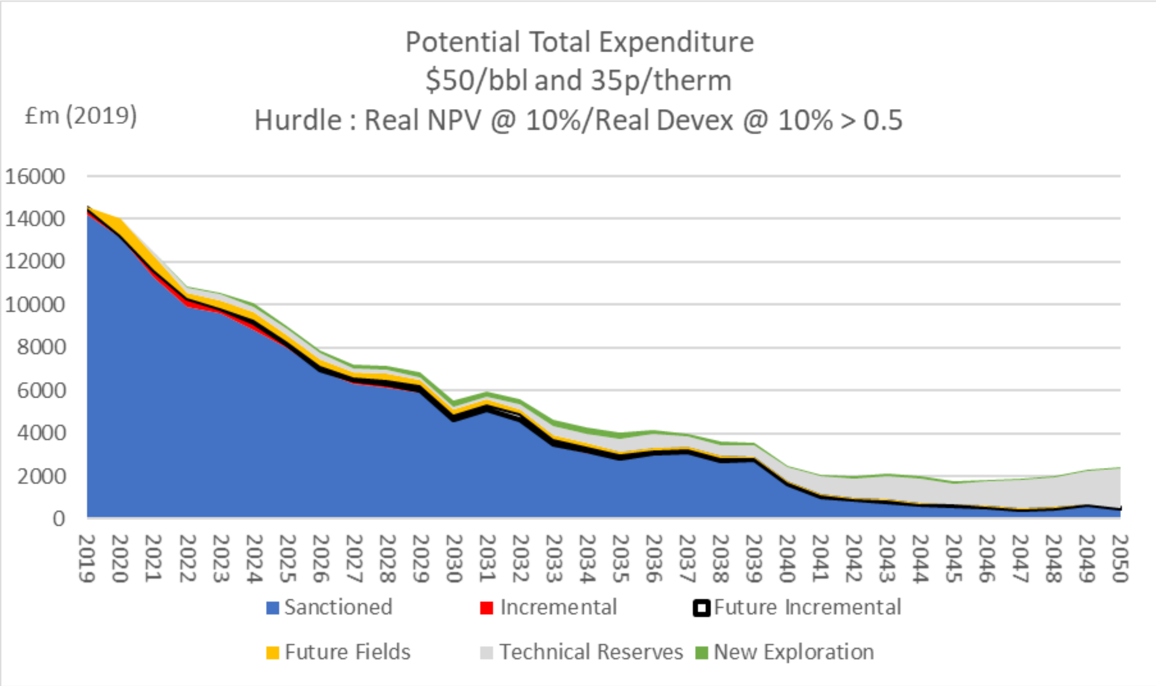
The contributions of the various geographic areas to total expenditure are shown in Chart 99.

Chart 100



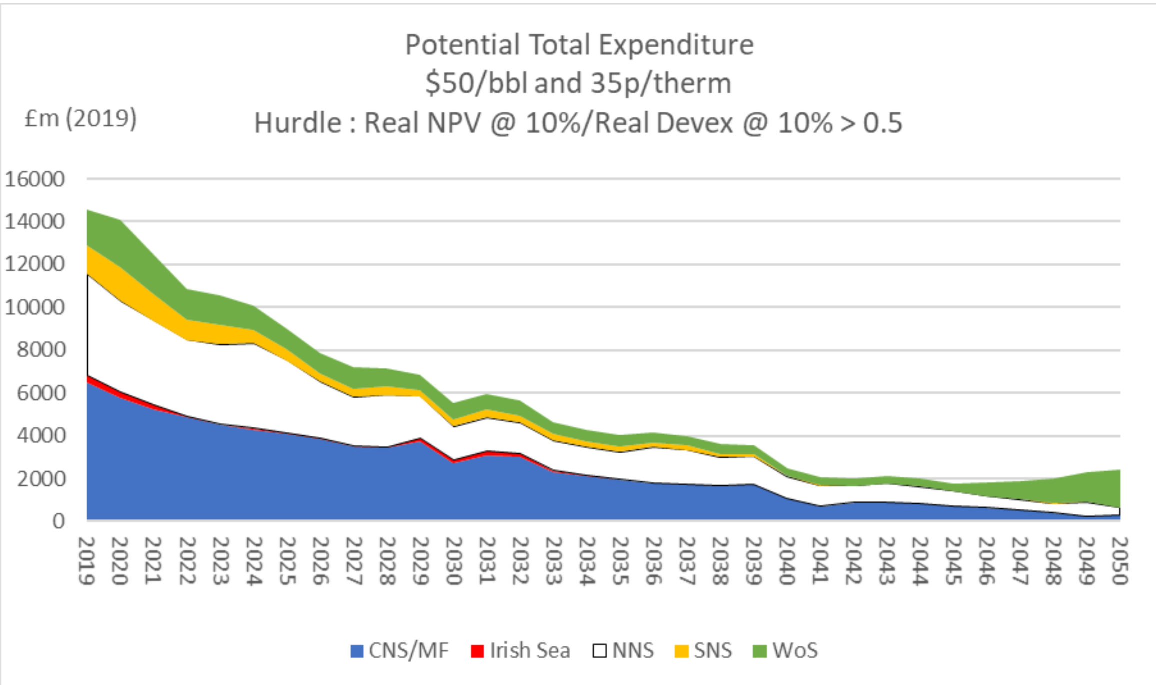
With $50 and 35 pence prices and NPV/I ≥ 0.5 hurdle, total field expenditure (development, operating and decommissioning expenditure) falls from the current level of just over £14.5 billion to almost £2.4 billion by 2050.

Chart 101



Total expenditure by category of fields and projects is shown in Chart 101. For most of the period currently sanctioned fields dominate.

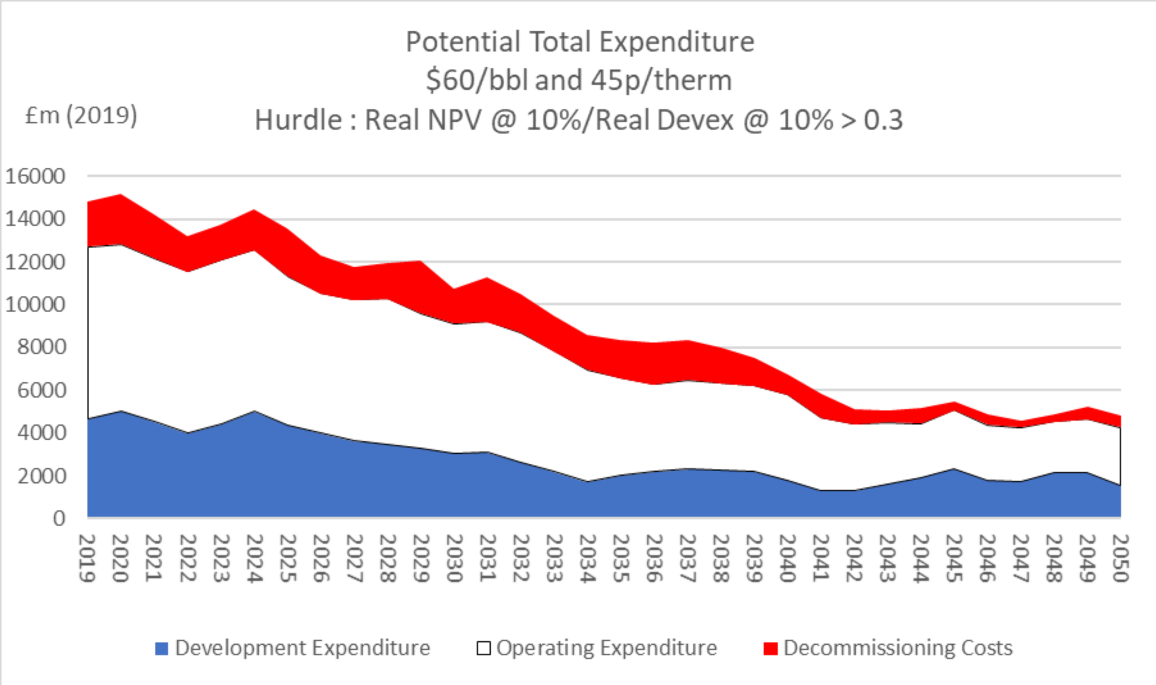
Chart 102



From Chart 102 it is seen that the CNS/MF area and the NNS area contributions to total expenditure are most significant for most of the period to 2050.

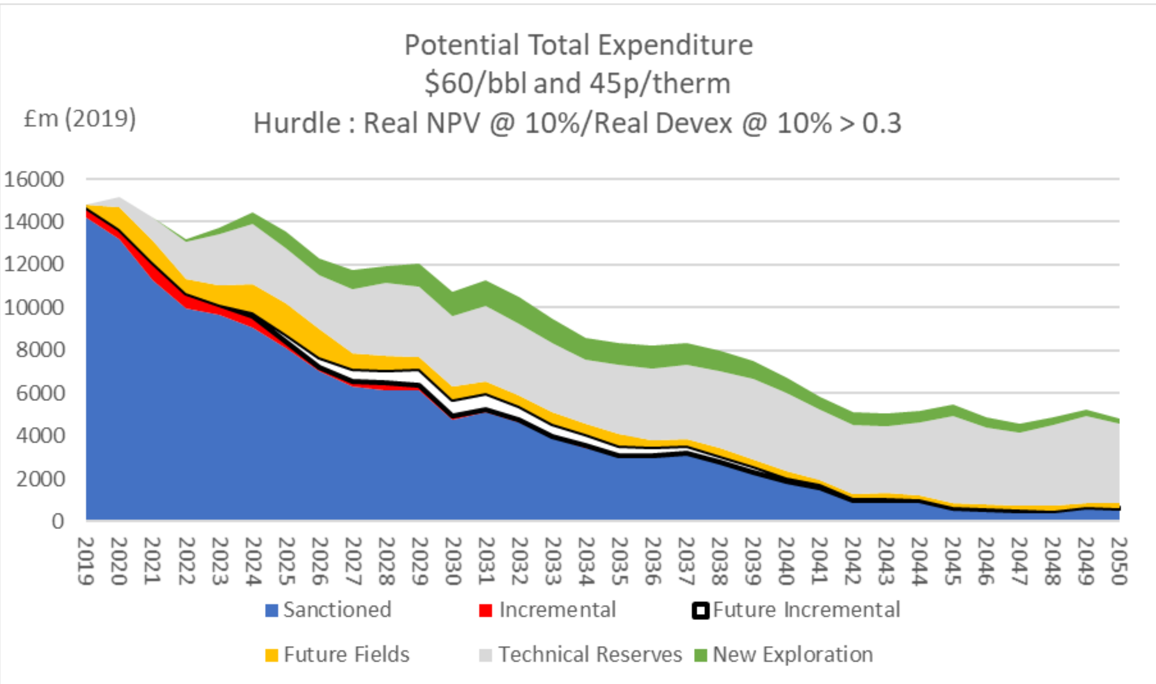
ii) $60 and 45 pence prices

Chart 103



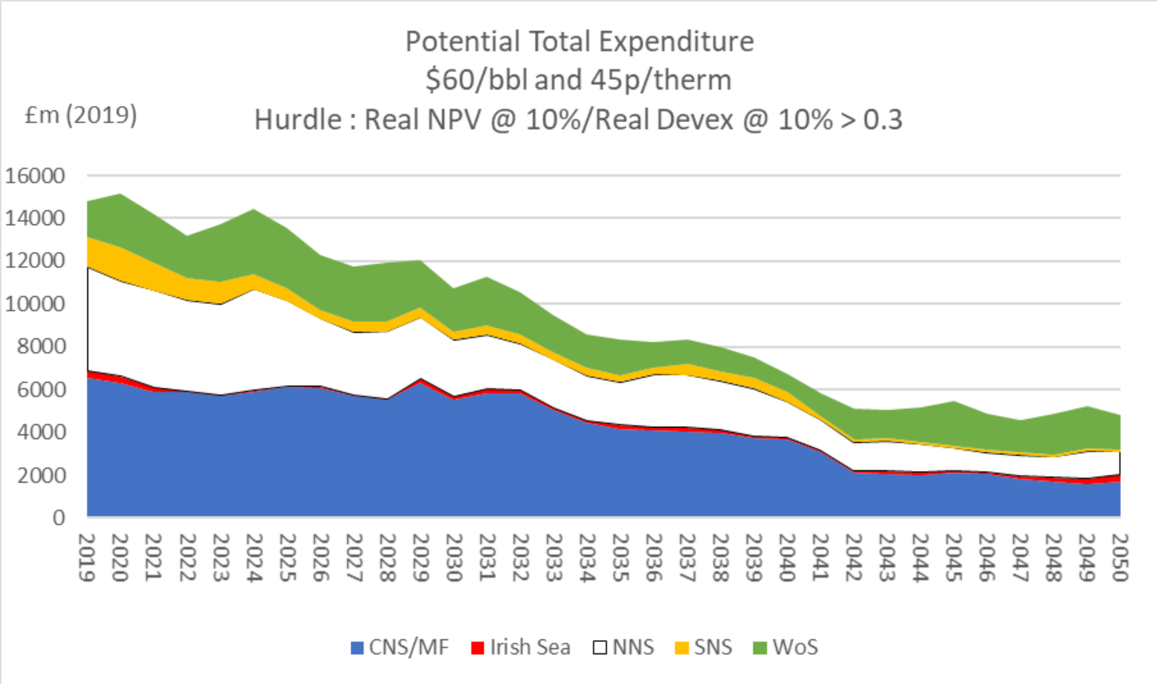
With $60 and 45 pence prices and NPV/I ≥ 0.3 hurdle, total field expenditure (development, operating and decommissioning expenditure) falls from the current level of just under £14.8 billion to just over £4.8 billion by 2050.

Chart 104



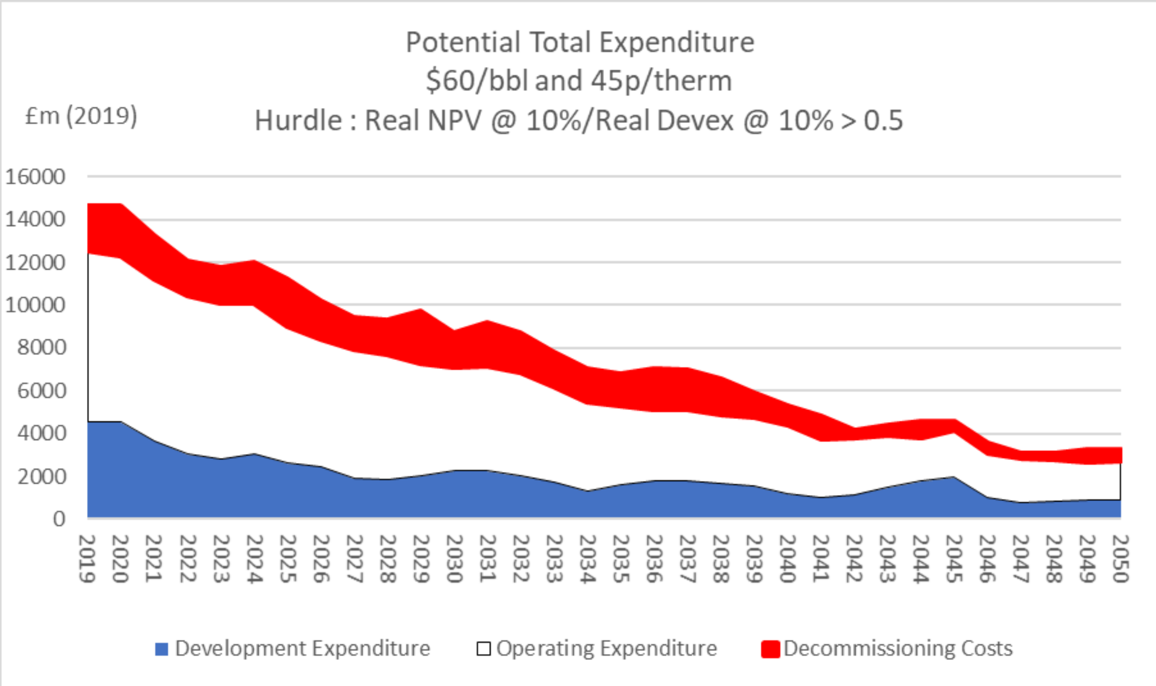
In Chart 104 it is seen that over the longer term total expenditure from technical reserve fields becomes increasingly important over the period.

Chart 105



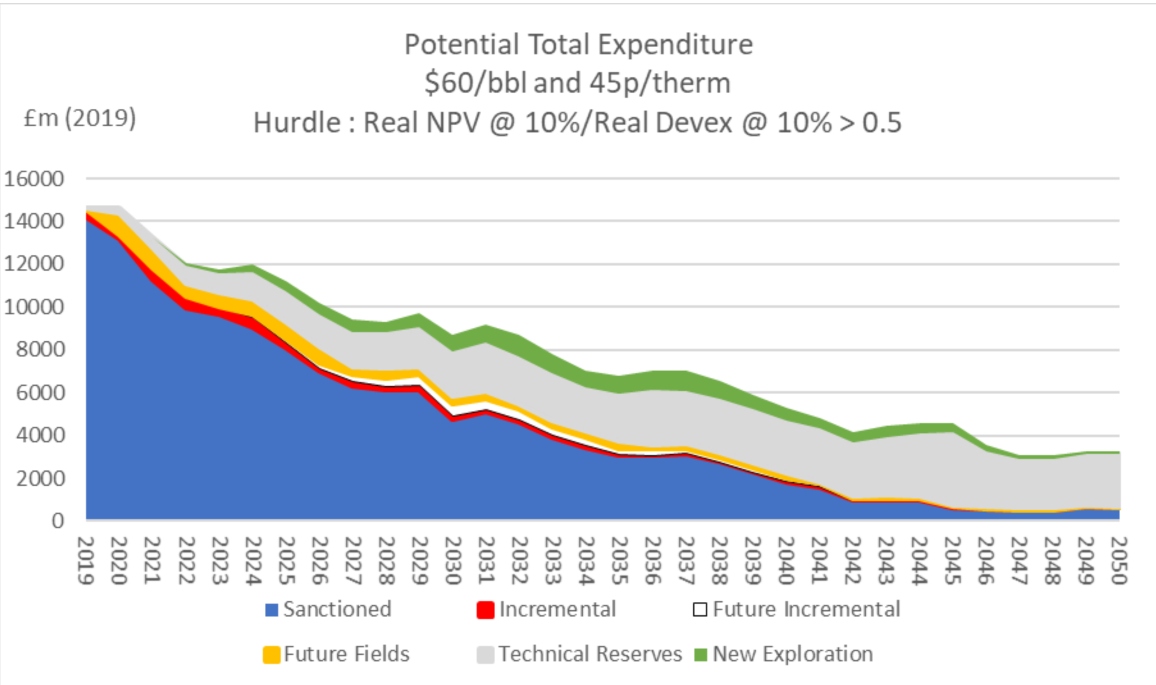
From Chart 105 it is seen that the CNS/MF and NNS areas make the most significant contributions to aggregate expenditure.

Chart 106



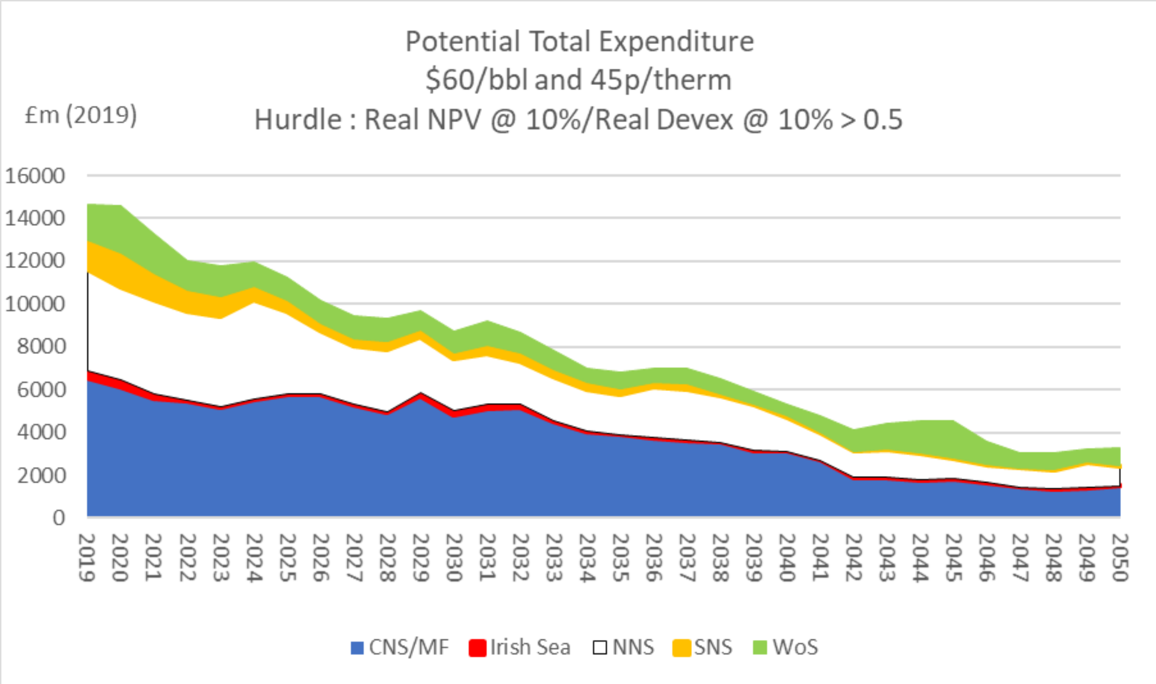
With $60 and 45 pence prices and NPV/I ≥ 0.5 hurdle, total field expenditures (development, operating and decommissioning expenditure) falls from the current level of just over £14.6 billion to just over £3.2 billion by 2050. The decline in total expenditure is fairly steady.

Chart 107



From Chart 107 the composition of total expenditure from the various categories of fields and projects is shown.

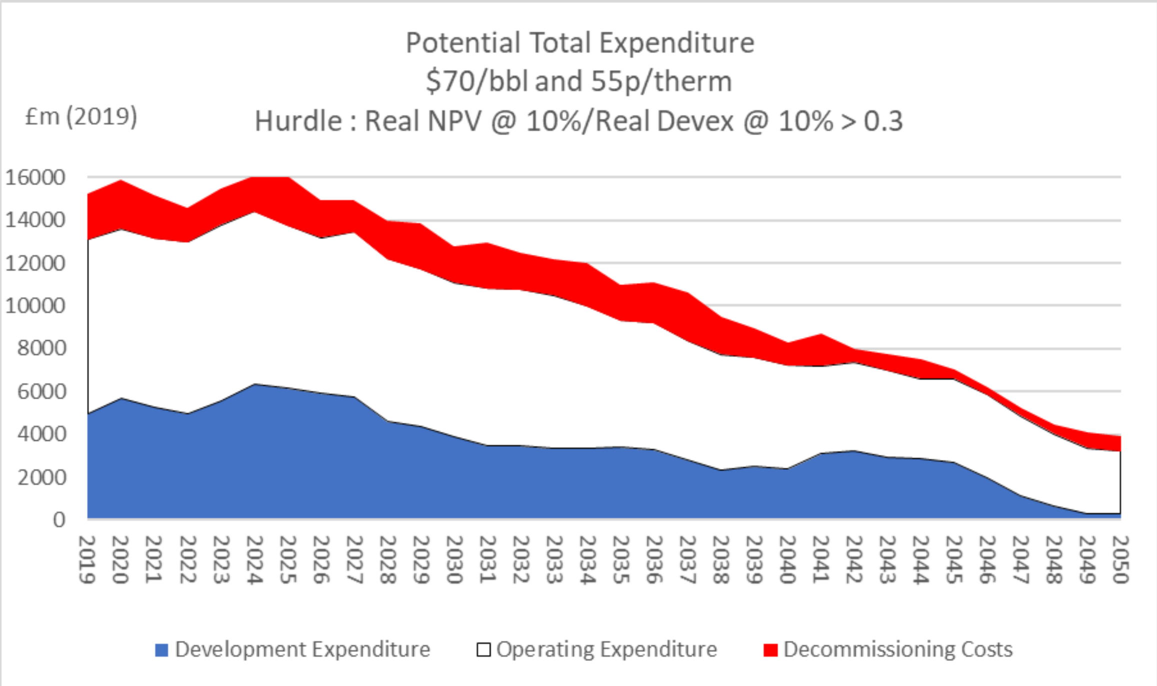
Chart 108



From Chart 108 it is seen that the CNS/MF and NNS areas contributions to total expenditure are most significant.

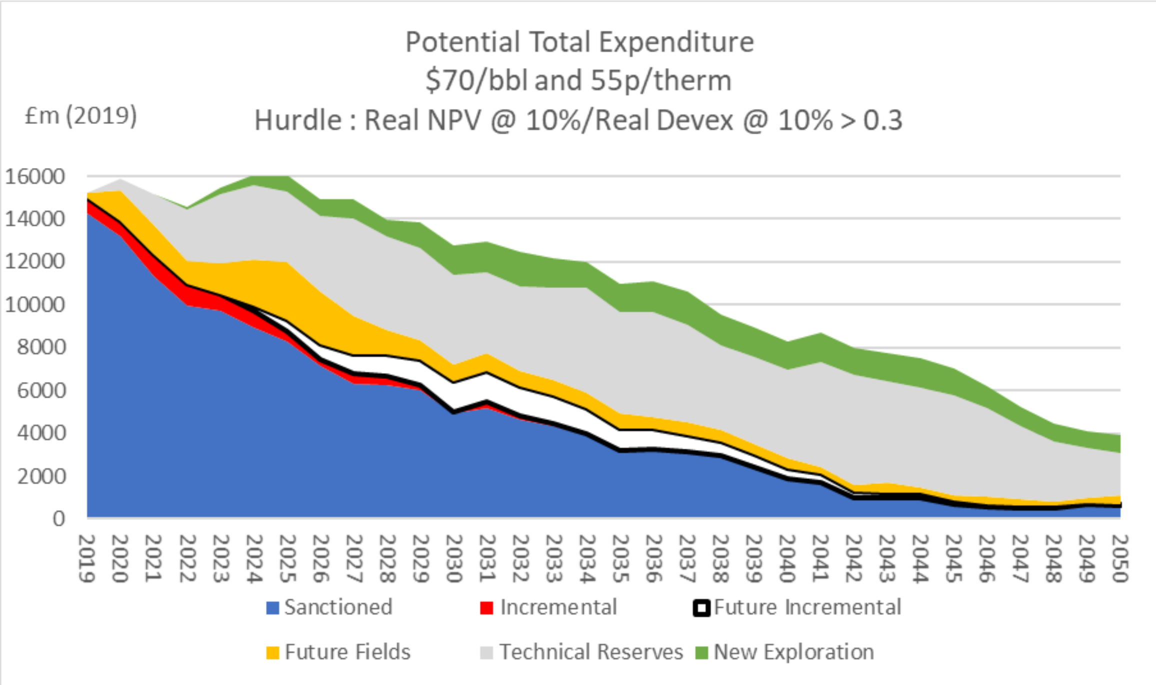
iii) $70 and 55 pence prices

Chart 109



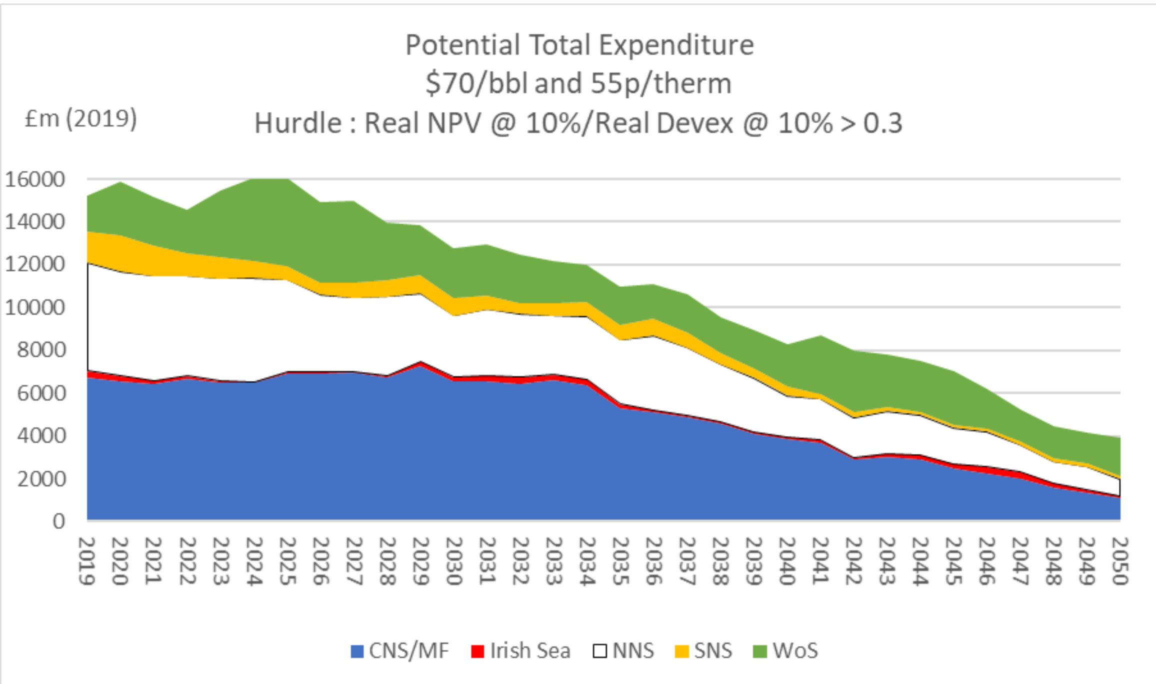
With $70 and 55 pence prices and NPV/I ≥ 0.3 hurdle, total field expenditure (development, operating and decommissioning expenditure) falls from the current level of just over £15.2 billion to almost £3.9 billion by 2050. (The 2050 expenditure is lower than that at $60 because some of technical reserve fields are developed earlier). Total expenditure is increasingly dominated by operating costs. Details are shown in Chart 109.

Chart 110



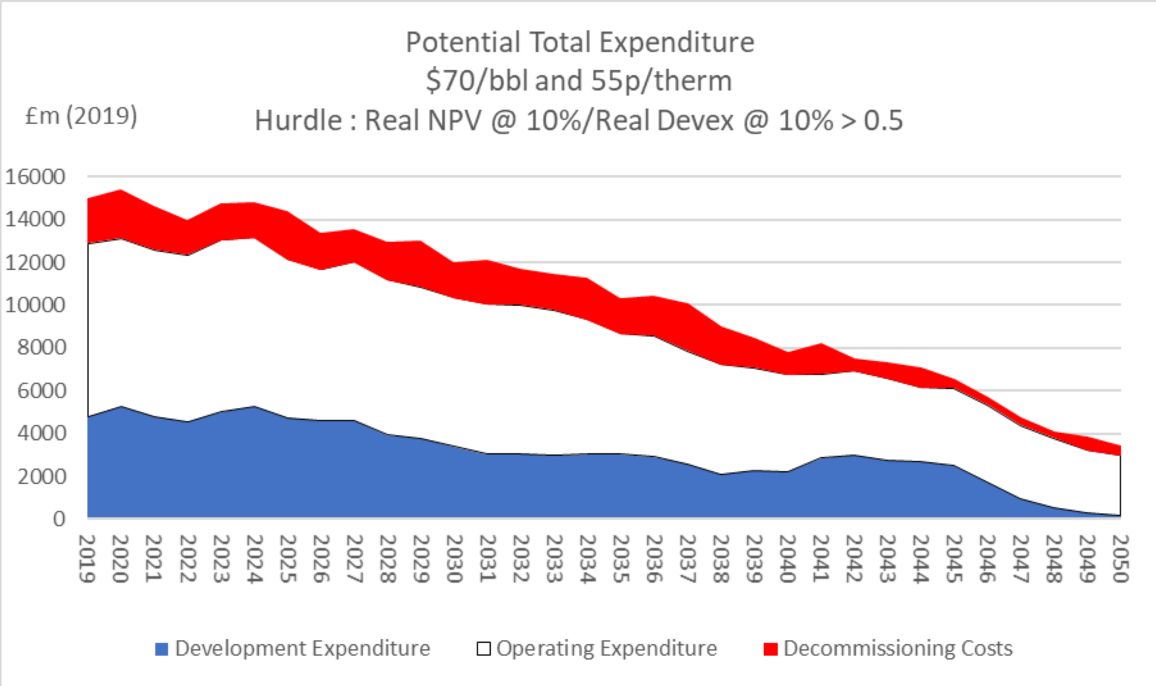
The long run increasingly importance of total expenditure from technical reserve fields is shown in Chart 110.

Chart 111



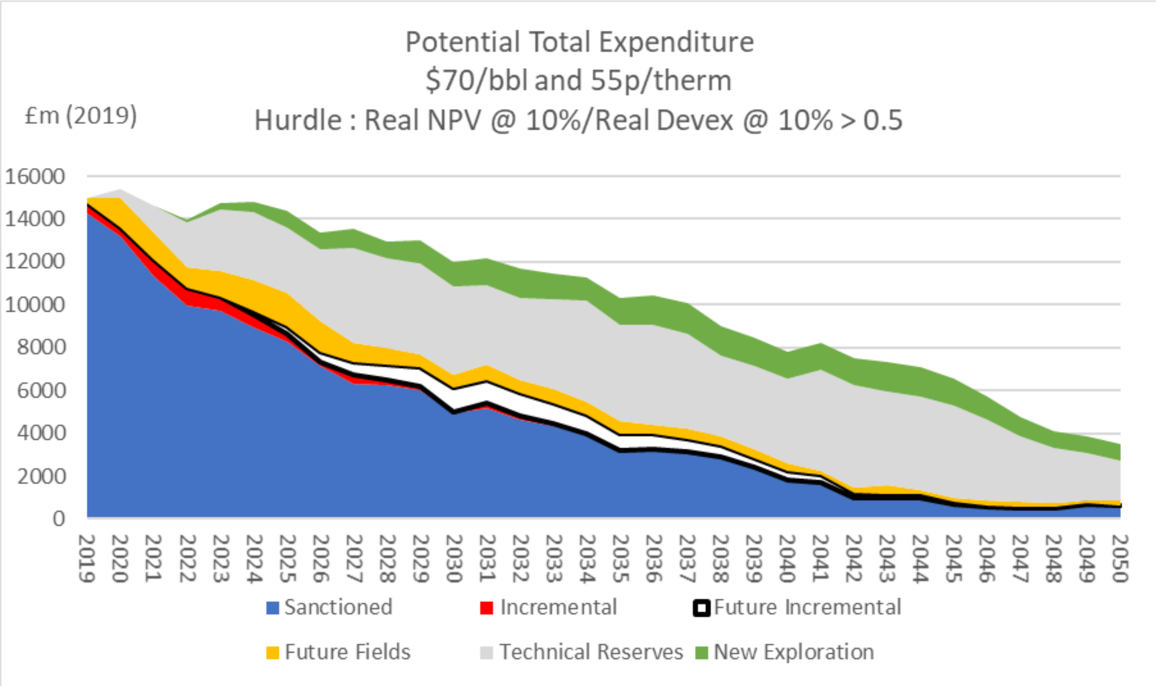
From Chart 111 it is seen that the CNS/MF and NNS areas contribute most significantly to total expenditure.

Chart 112



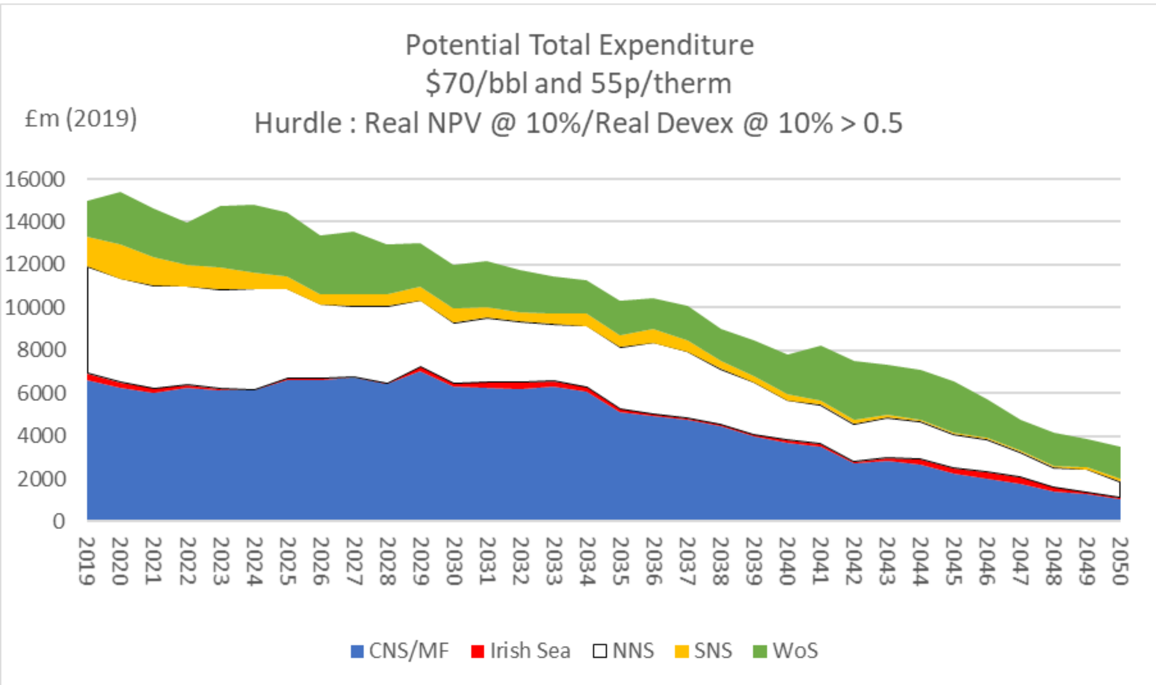
With \$70 and 55 pence prices and NPV/I ≥ 0.5 hurdle, total field expenditure (development, operating and decommissioning expenditure) falls from the current level of just under £15 billion to over £3.4 billion by 2050. (The 2050 expenditure is lower than that at \$60 because some of technical reserve fields are developed earlier). The total expenditure is fairly flat until after 2025 when a moderate decline starts. Total expenditure is increasingly dominated by operating costs.

Chart 113



From Chart 113 it is seen that by 2034 total expenditure from technical reserve fields becomes more important than that from already sanctioned fields.

Chart 114



From Chart 114 it is seen that the CNS/MF and the NNS areas make the most significant contributions to total expenditure with the WoS area becoming more important by 2045.

4. Summary and Conclusions

In this study prospective activity in the form of field investment, oil and gas production, operating costs and decommissioning costs relating to the UKCS has been projected over the period 2019-2050. This has been achieved by financial simulation modelling, including the liberal use of the Monte Carlo technique to assess both exploration risks and the development cost risks of fields in the category of technical reserves. The modelling was undertaken on a very large, updated field database incorporating key details of fields and projects in the categories of (a) sanctioned fields, (b) probable and possible fields, (c) current and future incremental projects, (d) technical reserves, and (e) future discoveries. The modelling was undertaken separately for the 5 main regions of the UKCS namely (1) SNS, (2) CNS/MF, (3) NNS, (4) WoS, and (5) IS to reflect accurately the unique features of the different areas in terms of costs, size, product composition (oil, gas or condensate). Data on the production profiles and costs of fields in the categories of sanctioned, probable and possible developments were obtained from various sources, but costs and production profile estimates for fields in the categories of technical reserves and future discoveries were made by the present authors. There are no less than 415 fields in the category of technical reserves. Information on location, product characteristics, and potential reserves was available to the authors. An average premium of $5 per boe on development costs above the average for current new developments was assumed for these technical reserves.

For future discoveries the exploration effort from 2019 onwards was based on trends over the past 5 years plus judgement on the effect of different oil and gas prices. It has assumed that the higher the oil/gas price the higher the effort but the lower the success rate. Again, this exercise was conducted separately for each of the 5 regions of the UKCS.

The modelling was conducted under 3 oil/gas price scenarios used for screening investments namely (a) \$50 per barrel and 35 pence per therm all in real terms at 2019 prices, (b) \$60 and 45 pence, and (c) \$70 and 55 pence. For tax purposes the present system was employed. It was assumed that for all new developments the licensee would be making the investment on a project basis and thus would carry forward his allowances and would utilise the Ring Fence Expenditure Supplement (RFES). For assessing the investments, a hurdle of post-tax NPV@10% / pre-tax Devex@10% $\geq$ 0.3 was employed to reflect capital rationing. A very high hurdle rate of NPV/I $\geq$ 0.5 was used as a sensitivity to indicate the (substantial) difference to the results.

Under the \$50, 35 pence price case total hydrocarbon production from the UKCS was found to decline at a sharp pace from current levels resulting in only around 257,000 boe/d being produced in 2050. Total economic recovery over the period is 8.7 bn boe. Much of the total recovery (nearly 62%) comes from currently sanctioned fields. The contribution of future discoveries is quite small reflecting the relatively low exploration effort. Of the 415 technical reserve fields only 81 pass the investment hurdle. The CNS/MF region is the most productive accounting for over 48% of the total.

In this scenario field development expenditure falls at a sharp pace and cumulates to only £51.6 billion by 2050 at 2019 prices. Of this £17.2 billion comes from currently sanctioned fields and £20.8 billion from technical reserves. Operating expenditures also fall sharply throughout the period from around £8 billion in

2019 to around £1.3 billion in 2050. Again, most of this category of expenditure comes from currently sanctioned fields.

Decommissioning expenditures cumulate to £43.15 billion by 2050. It is noteworthy that this relatively low number emanates from the correspondingly low number of future developments. Of this total 95% emanates from currently sanctioned fields. Over 45% of the total decommissioning costs come from the CNS/MF region, while 35% comes from the NNS region. By 2050 no less than 387 fields will have either been decommissioned or will be in undergoing decommissioning.

Under the \$60, 45 pence price case and NPV/I ≥ 0.3 hurdle cumulative total hydrocarbon production 2019-2050 of 12 billion boe. The decline rate over the period is quite brisk from 2022 onwards. Of the total over 45% comes from currently sanctioned fields and 32.5% comes from technical reserves. With this price scenario 207 fields in this category pass the investment hurdle compared to only 81 at the \$50, 35 pence case. There is thus a major price sensitivity to activity among fields in this category. The CNS/MF accounts for 46% of cumulative total recovery.

Over the period to 2050 cumulative development expenditure is nearly £90 billion at 2019 prices a substantial increase over the £51.6 billion with the \$50, 35 pence scenario. Investment in technical reserve fields with the \$60, 45 pence scenario cumulates to £47.6 billion compared to £20.8 billion at the low price case. With the \$60, 45 pence scenario 207 fields in the category of technical reserves pass the NPV/I ≥ 0.3 hurdle, compared to only 81 in the low price case. Thus, the major increase in aggregate investment expenditure is principally due to many more fields in this category becoming viable.

Over the period to 2050 cumulative operating expenditure is £160.5 billion, well above the £119.6 billion with the low price case. But the annual decline rate from 2019 levels is continuous. Of the total, over the period over 55% comes from already sanctioned fields, but those attributable to technical reserves now predominate in the later parts of the period.

Over the period to 2050 decommissioning costs could accumulate to £45.4 billion, a modest increase from the total under the lower price case. Around 90% of the total still emanates from fields in the already sanctioned category. Around 50% of the total spend still occur before 2030 and 80% before 2038. In this scenario 198 fields will have reached the decommissioning stage by 2030 and by 2050 no less than 489 will have reached this stage.

Over the period to 2050 total annual field expenditures fall from nearly £15 billion to just over £4.8 billion in 2050. For the later part of the period fields in the category of technical reserves account for the greater part of the total.

Under the $70, 5 pence case cumulative total hydrocarbon recovery is 14.5 billion boe. Of this already sanctioned fields account for 38% of the total. But as much as 34.8% now comes from technical reserve fields. Over the period 238 fields in this category pass the NPV/I ≥ 0.3 hurdle. The overall decline rate is now much more gentle, primarily as a consequence of the development of far more fields in the technical reserve category. At 2050 production is significantly higher than under the other 2 price scenarios.

Over the period to 2050 cumulative development expenditure under the $70, 55 pence case is £113 billion, a significant increase over the levels with the $60, 45 pence case. In the high price case investment in the technical reserve fields account for over 48% of total investment. Of the overall total 41.6% is in the CNS/MF region.

Over the period to 2050 cumulative operating expenditure is £191 billion at 2019 prices. Of this total 48% comes from sanctioned fields and 31% from technical reserve fields. Over the later part of the period technical reserves become more important and dominate the total from the mid-2030's. Altogether there is no decline at all for the next few years and then a quite gentle rate of decline.

Over the period to 2050 cumulative decommissioning expenditure is £47 billion. Of this nearly 87% emanates from sanctioned fields. Around 45% of total spend emanates from the CNS/MF area. By 2030 193 fields will have decommissioned or be engaged in this activity. By 2050 a grant total of 542 fields will have decommissioned or be engaged in the activity, including 305 sanctioned fields and 184 technical reserve fields.

Over the period to 2050 total field expenditure in the $70, 55 pence case falls from a peak of £16 billion in 2025 to around £3.9 billion in 2050. Operating costs increasingly dominate the total over the period.

A key finding of the whole study is the high degree of activity levels to oil/gas price variations which are well within the range achieved over recent years. A substantial uncertainty relates to the prospects for fields which are discovered but are not yet seriously being examined for development. But the development or not of these same fields will increasingly determine the pace of activity and the associated long term production decline rate. To prevent a sharp rate of decline policy should be geared to facilitating the development of these fallow fields which currently exceed 400 in number. Such policies could include the encouragement of cluster developments along with the promotion of technologies which reduce offshore CO_2 emissions by replacing the use of diesel and gas for power generation with electricity from renewable sources. These will reduce the overall costs when the environmental damage costs are included. This forms the subject of a future research paper.