North Sea Oil and Gas at a Crossroads: How Can Policy Help?

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and
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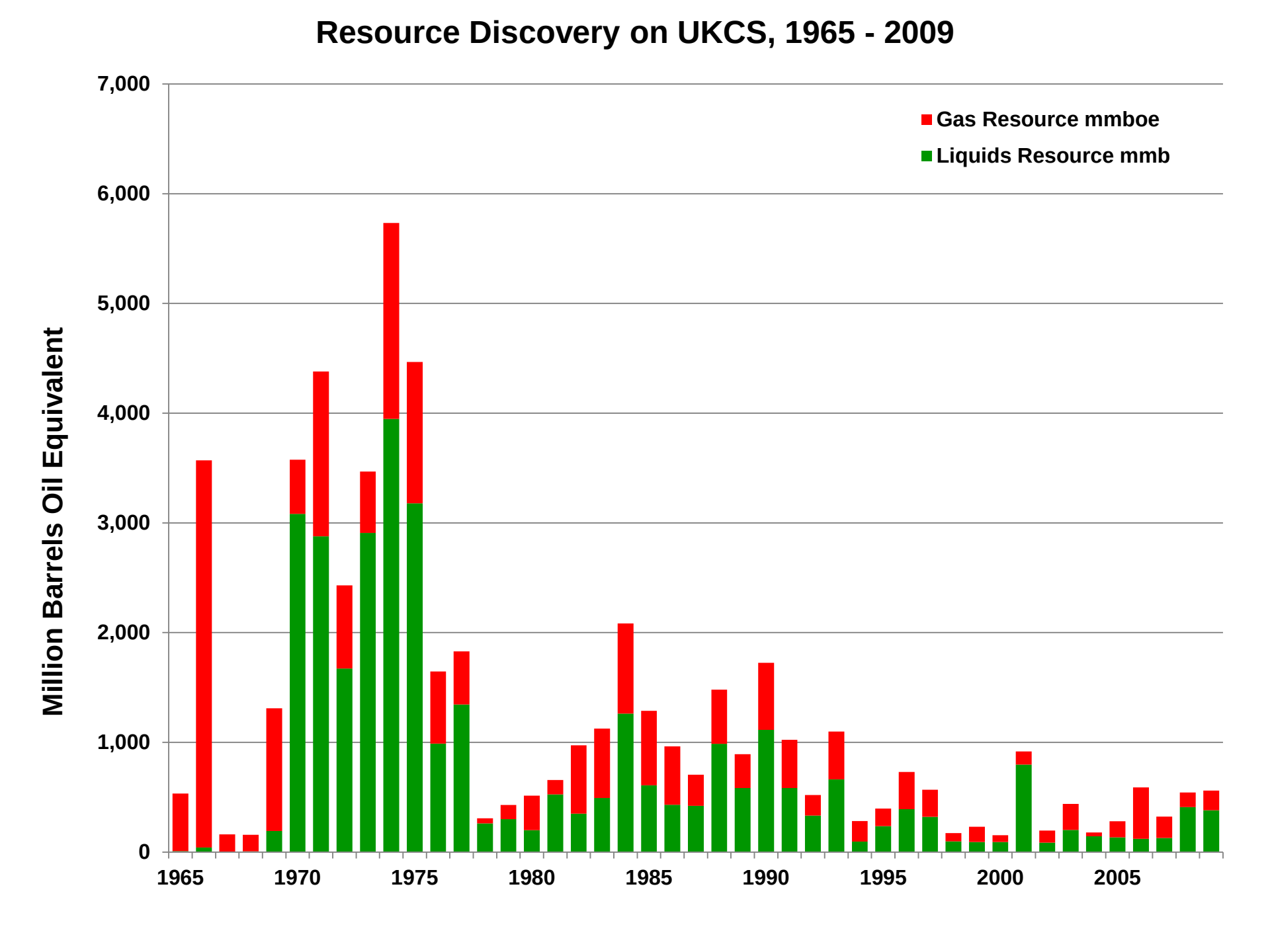
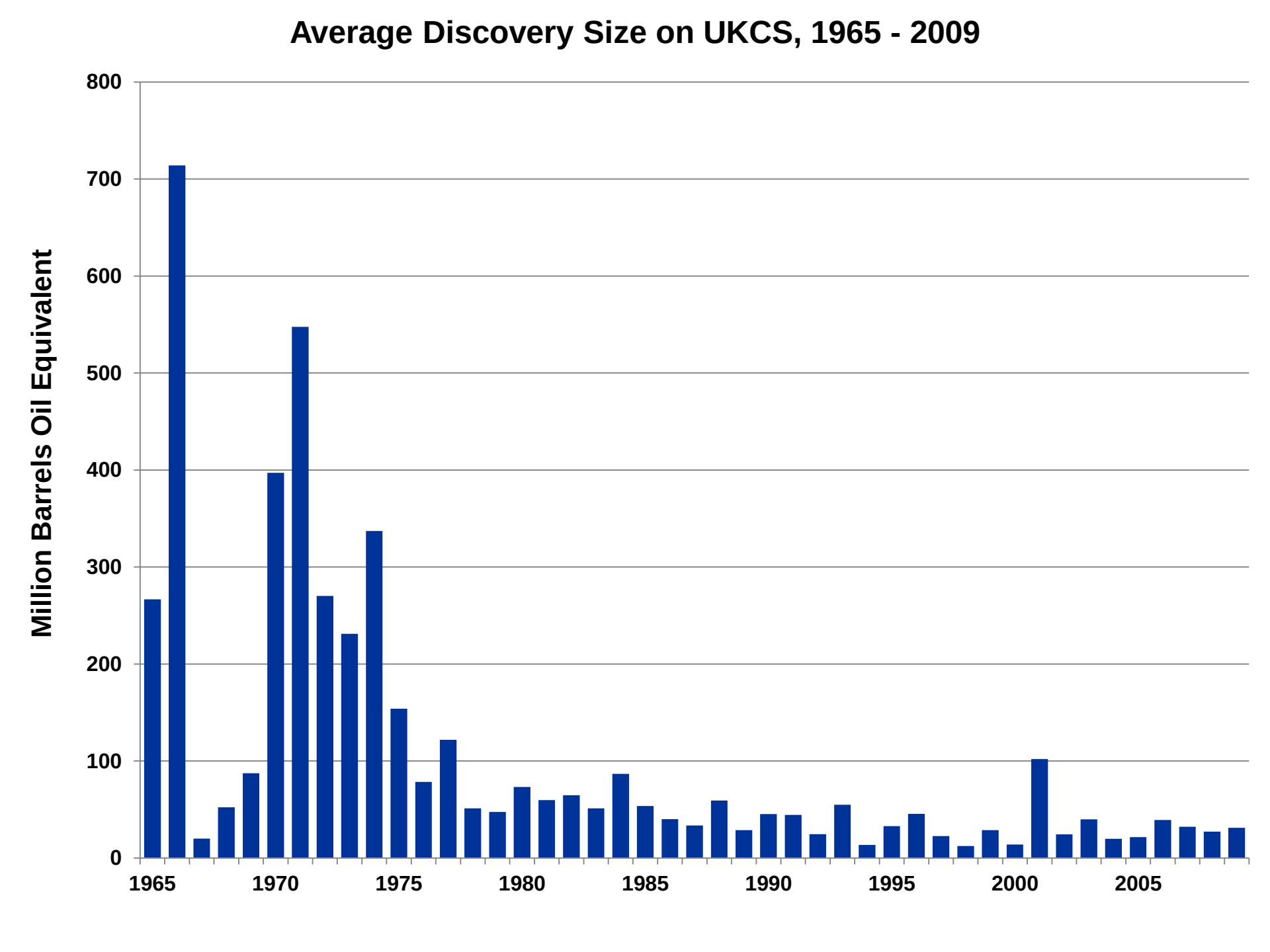
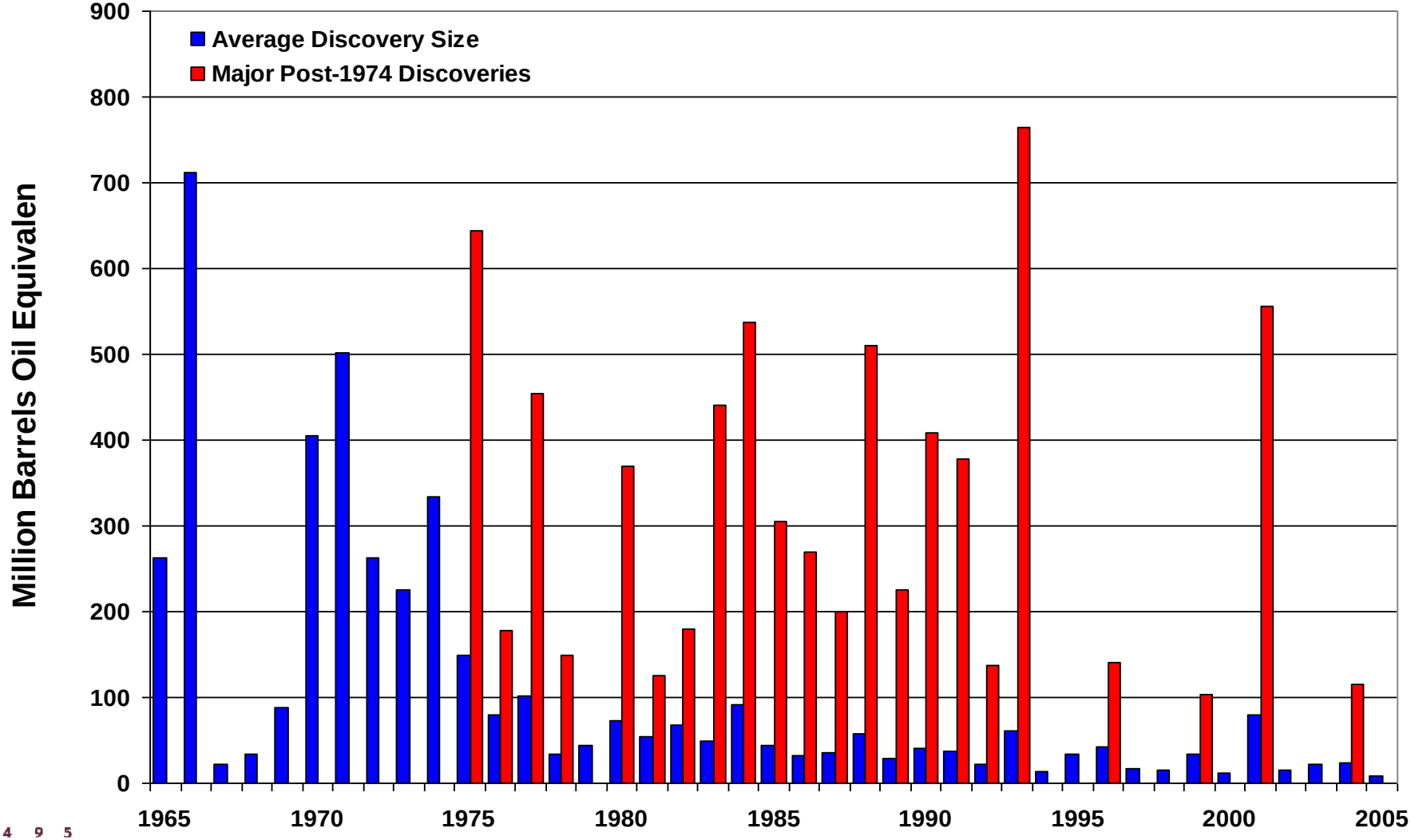

Resource Discovery on UKCS, 1965 - 2009
Million Barrels Oil Equivalent
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
1965
1970
1975
1980
1985
1990
1995
2000
2005
Gas Resource mmboe
Liquids Resource mmb


Average Discovery Size on UKCS, 1965 - 2009
Million Barrels Oil Equivalent
800
700
600
500
400
300
200
100
0
1965
1970
1975
1980
1985
1990
1995
2000
2005

Average Discovery Size on UKCS, 1965 - 2005, with Major Post-1974 Discoveries



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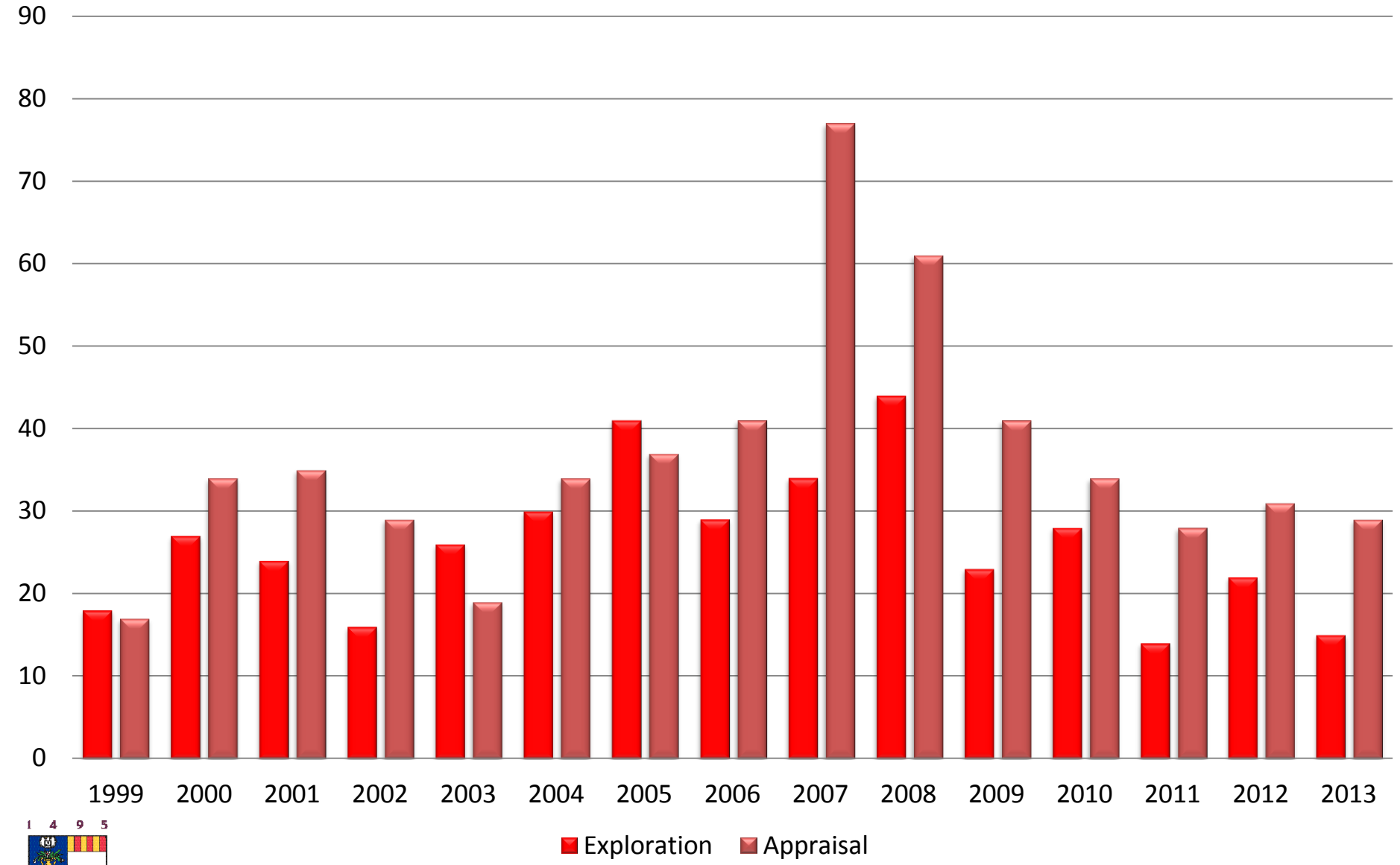
Number of E&A Wells Drilled in UKCS 1999-2013



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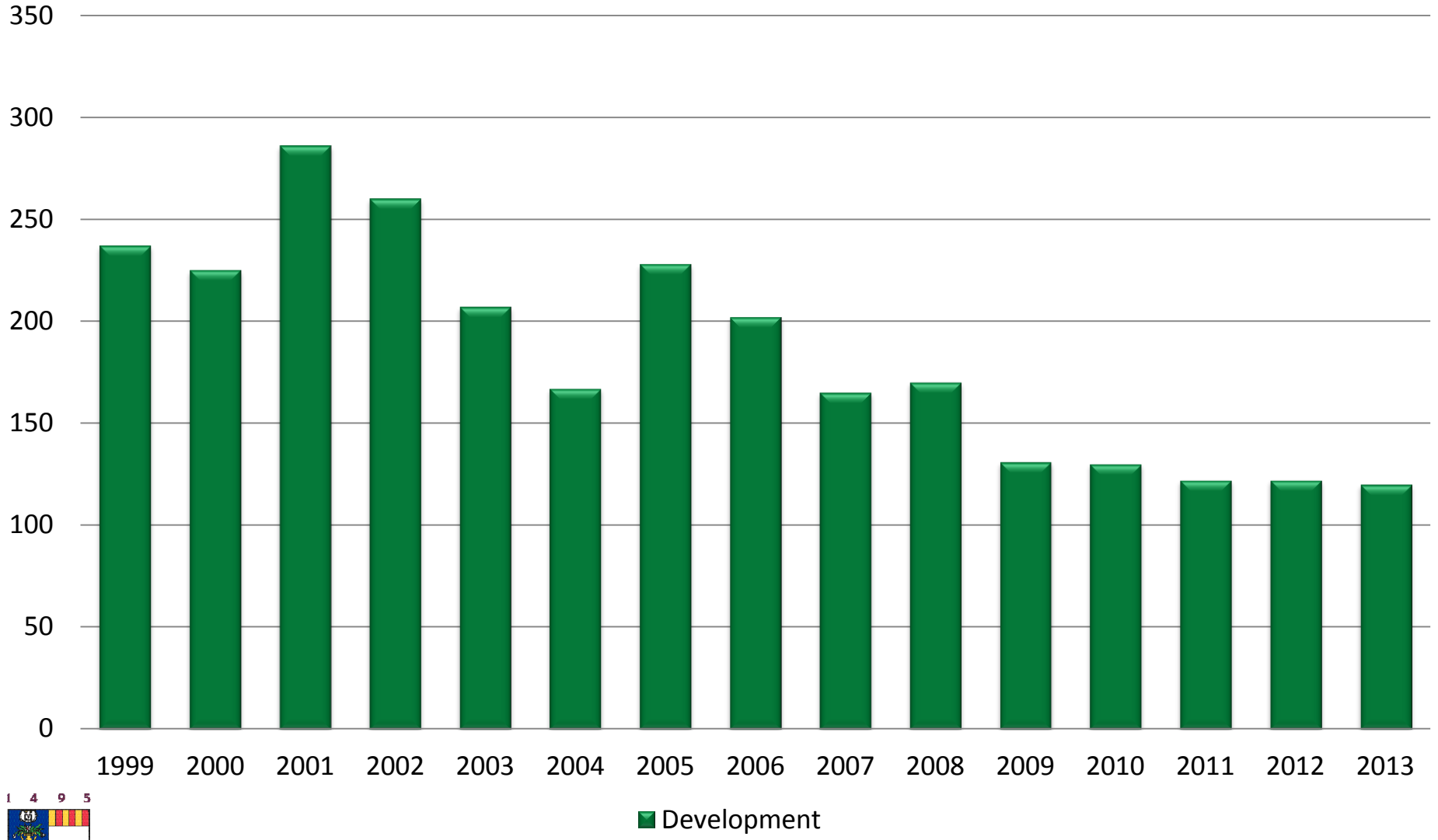
Source: DECC

Number of Development Wells drilled in UKCS 1999-2013



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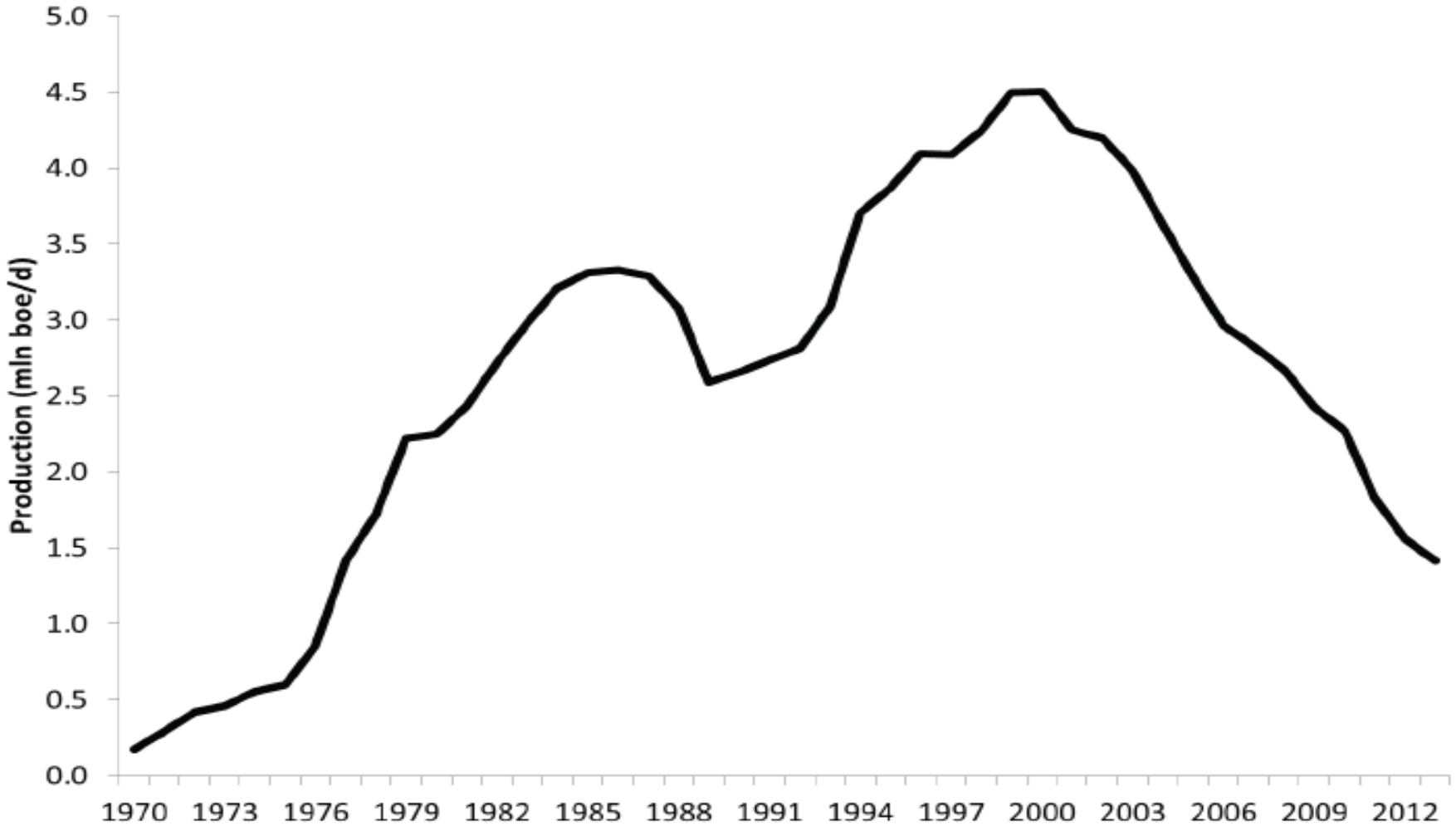
Source: DECC

Annual Production from the UKCS (Oil and gas combined)



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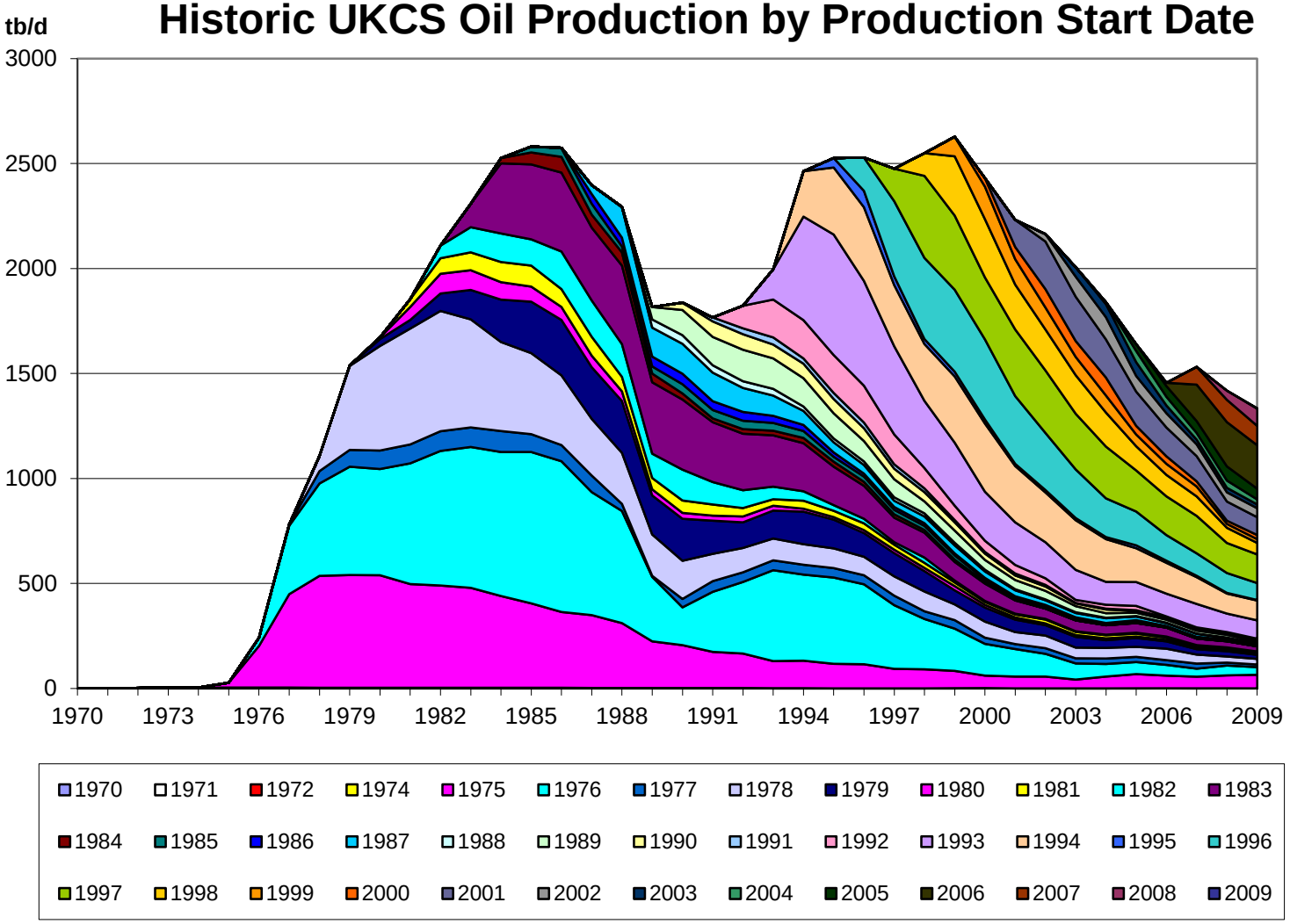
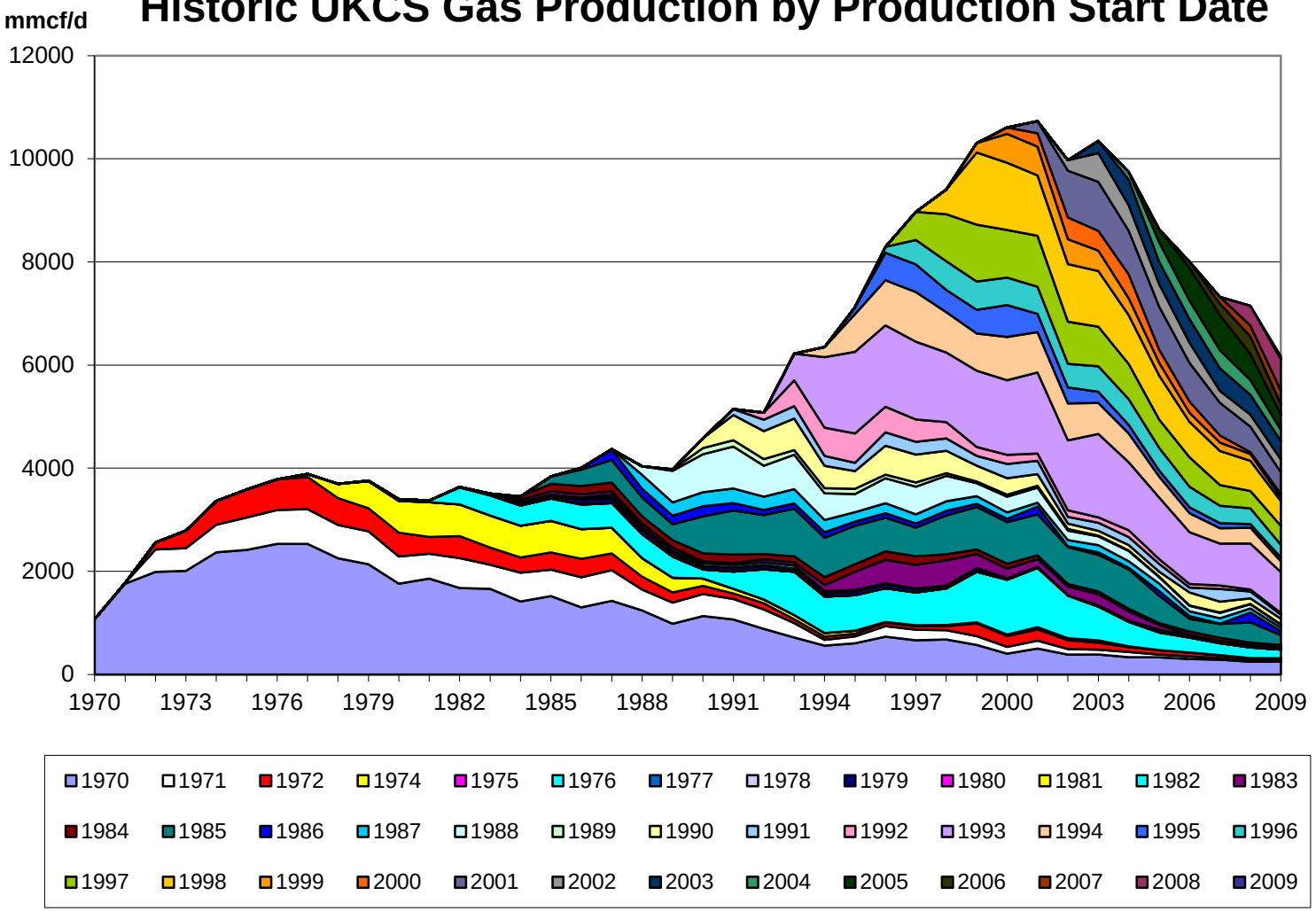
Source: DECC

Historic UKCS Oil Production by Production Start Date



Historic UKCS Gas Production by Production Start Date



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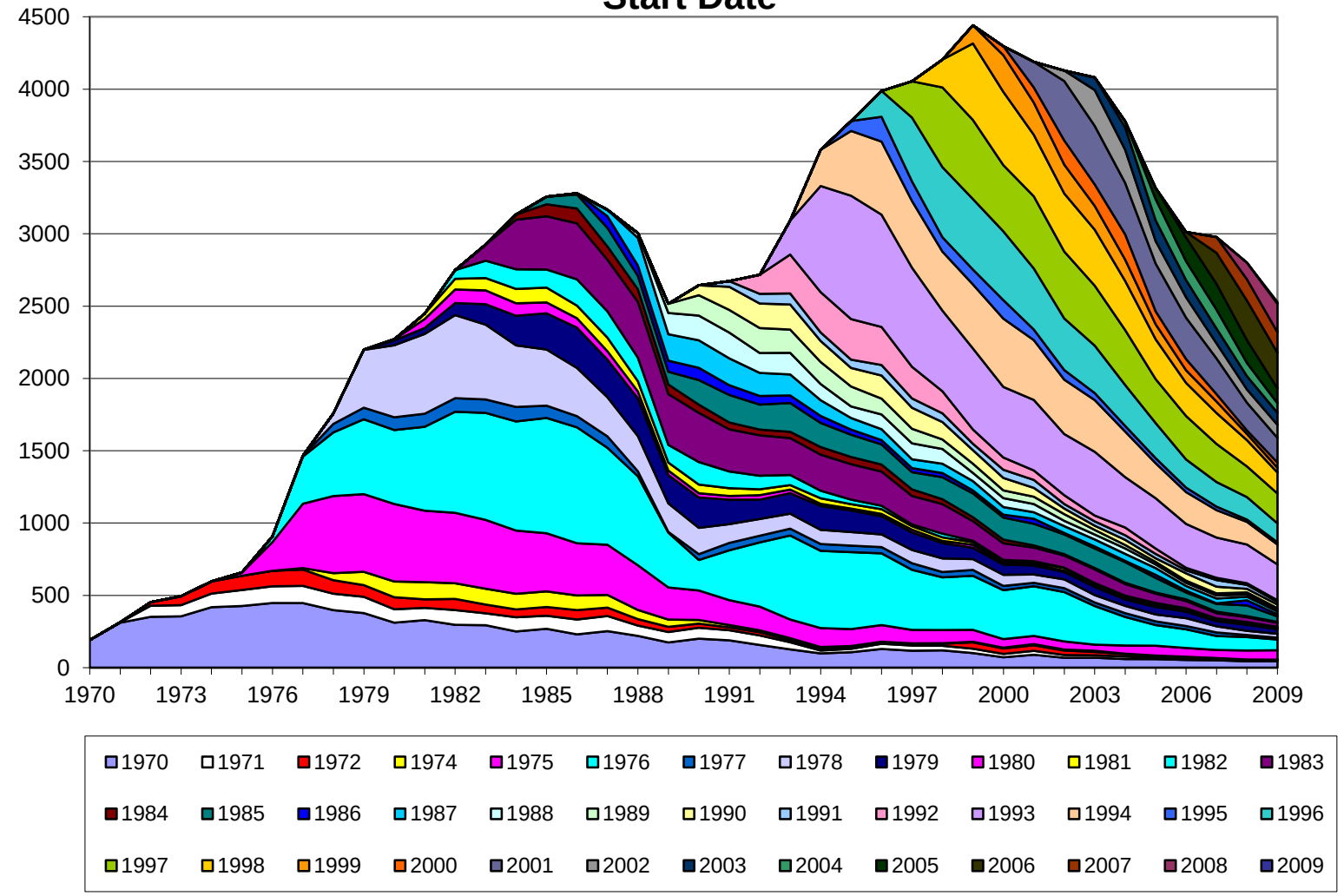
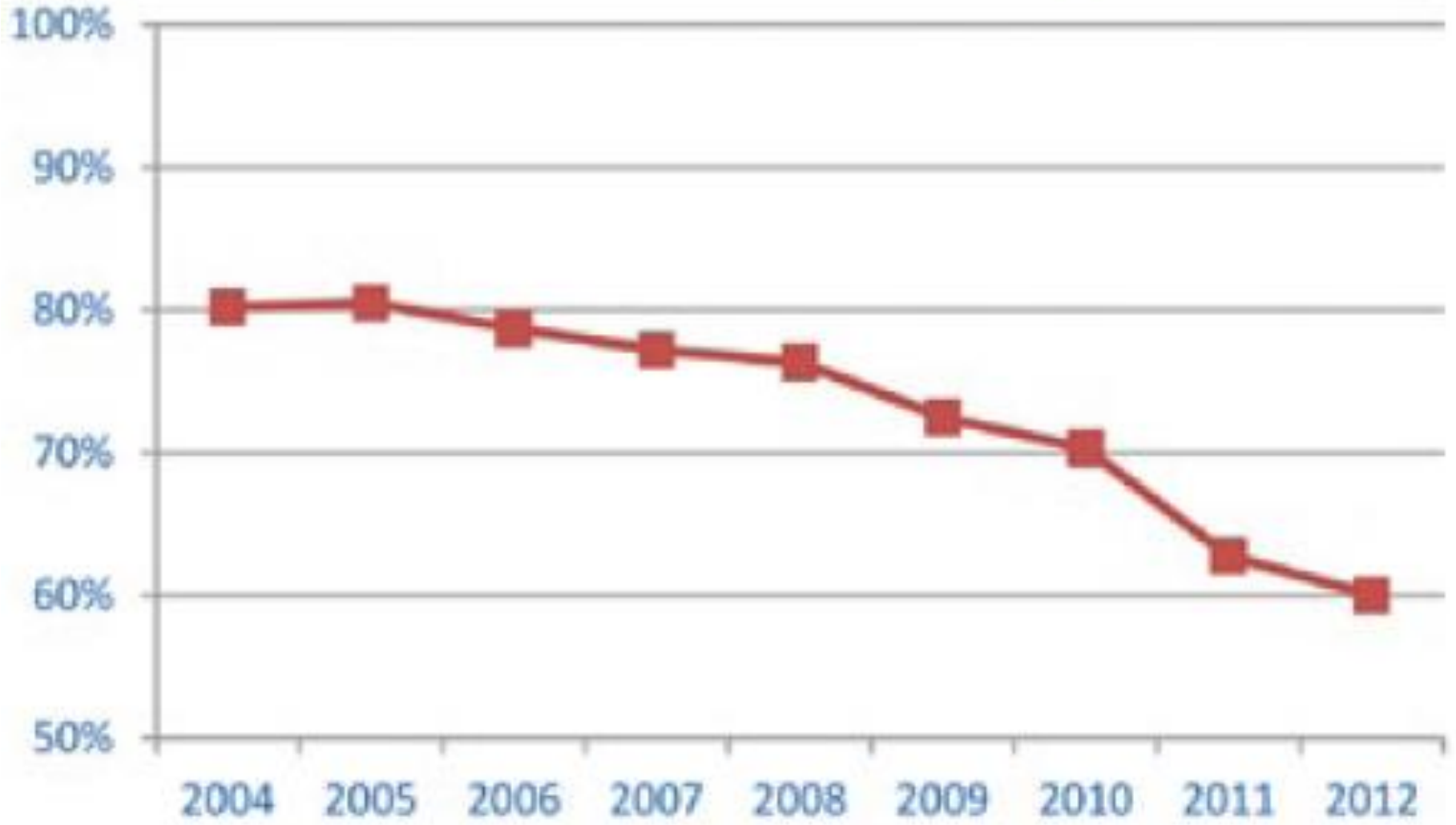
Historic UKCS Total Hydrocarbon Production by Production Start Date



Production Efficiency



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Source: DECC

Capital Expenditure in the UKCS (£ bn. 2013)

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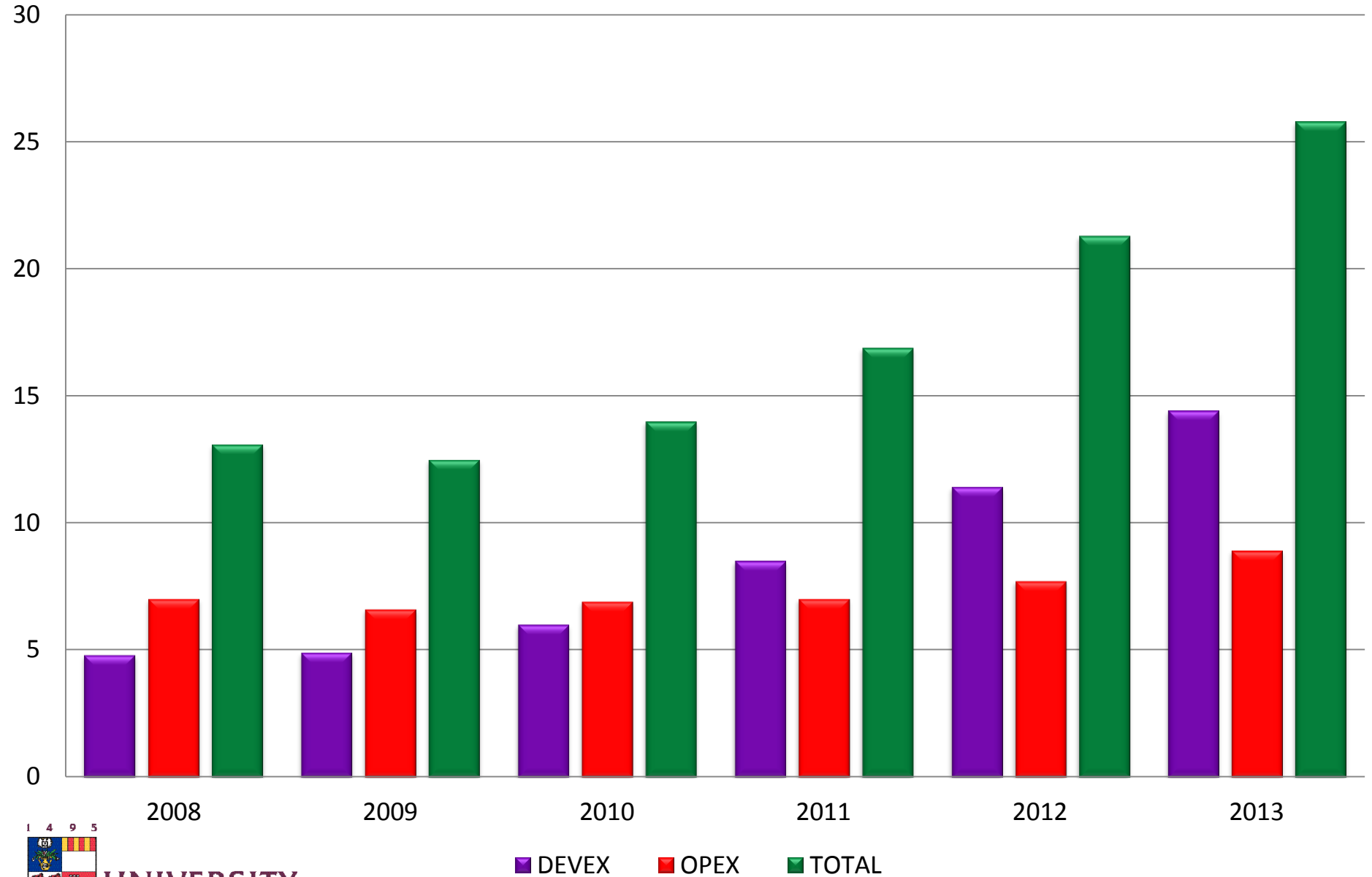
Expenditure in UKCS (£bn., MOD)



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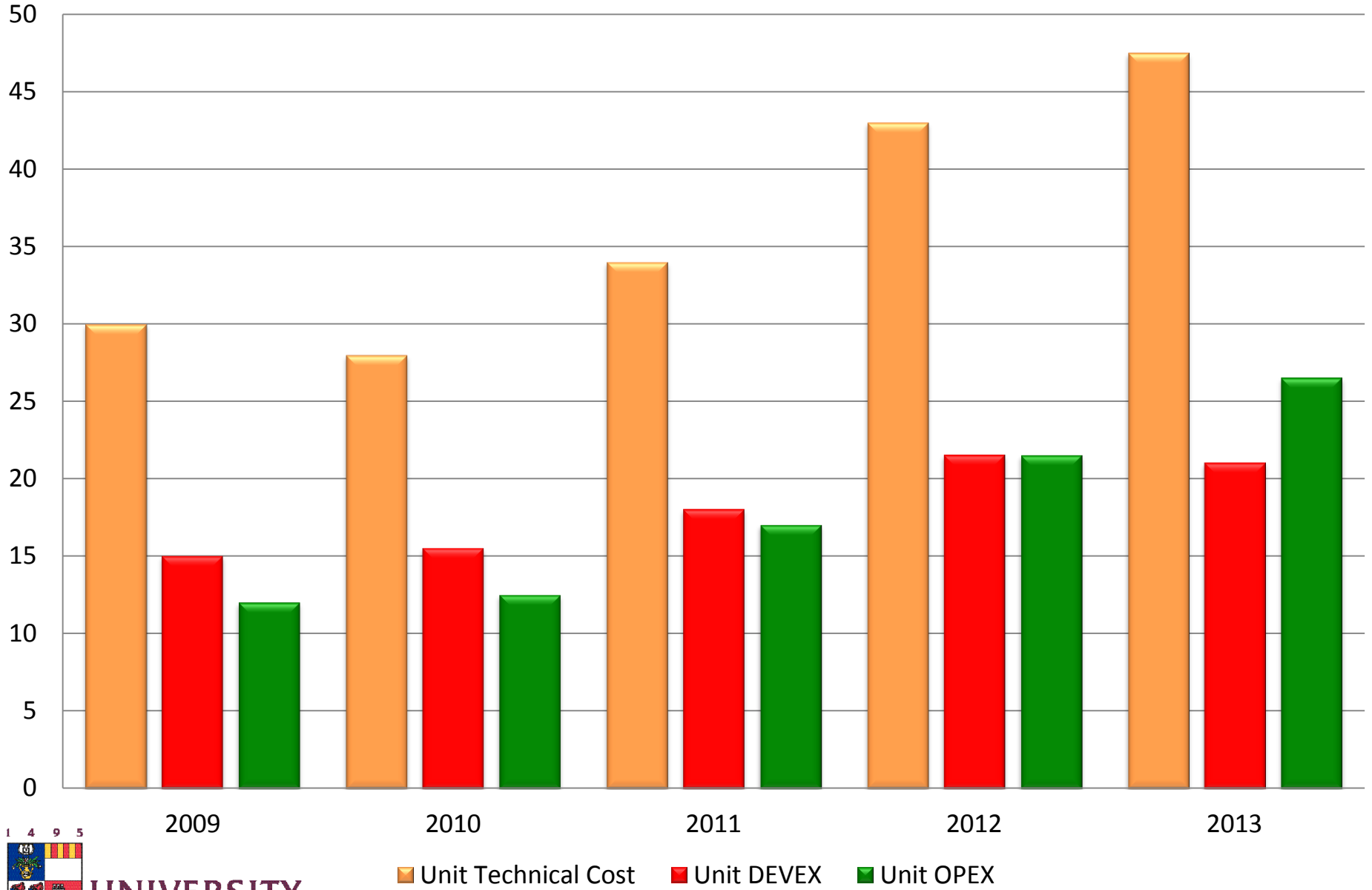
Source: OGUK

Unit Cost ($/boe, MOD)



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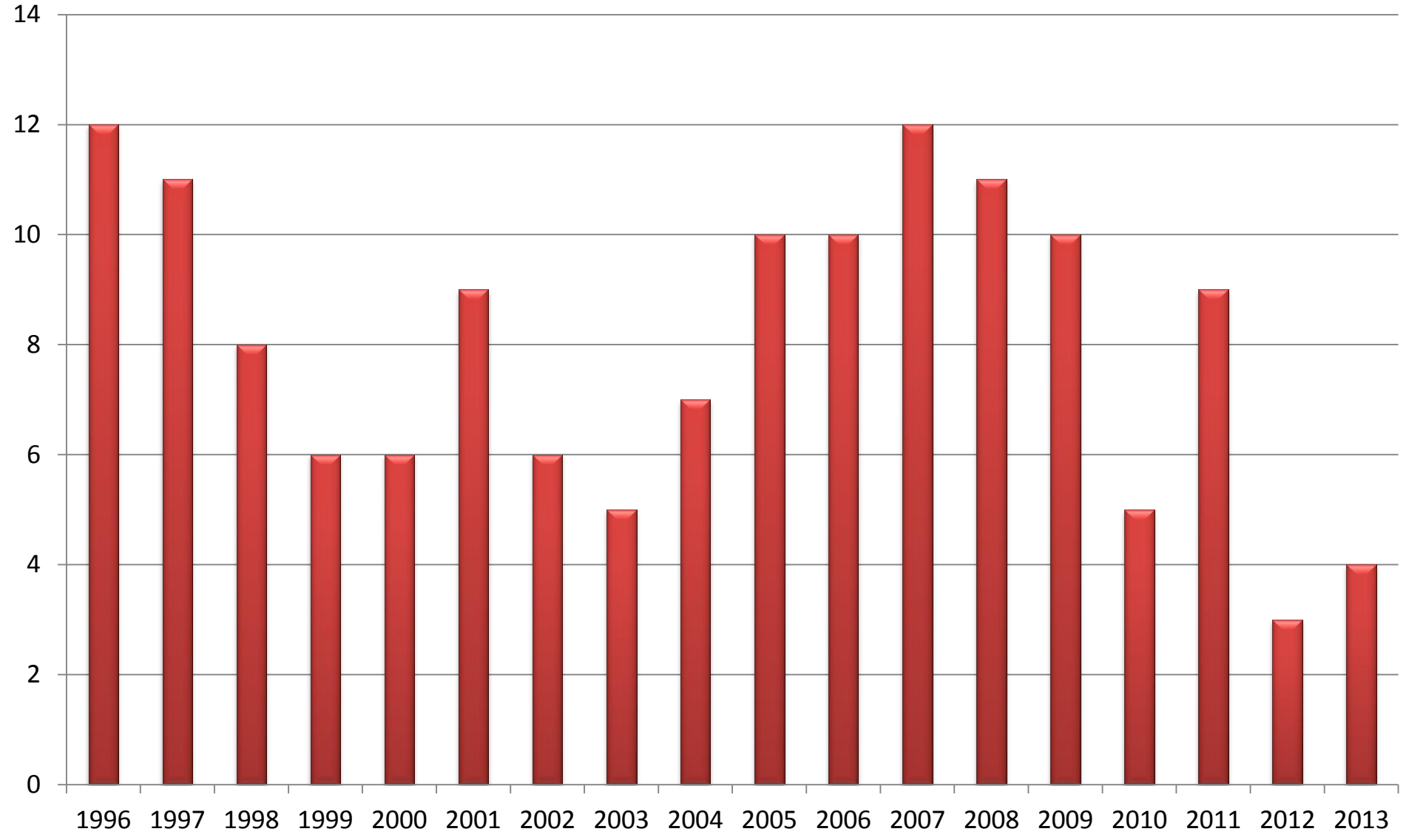
Source: OGUK

Significant Discoveries 1996-2013



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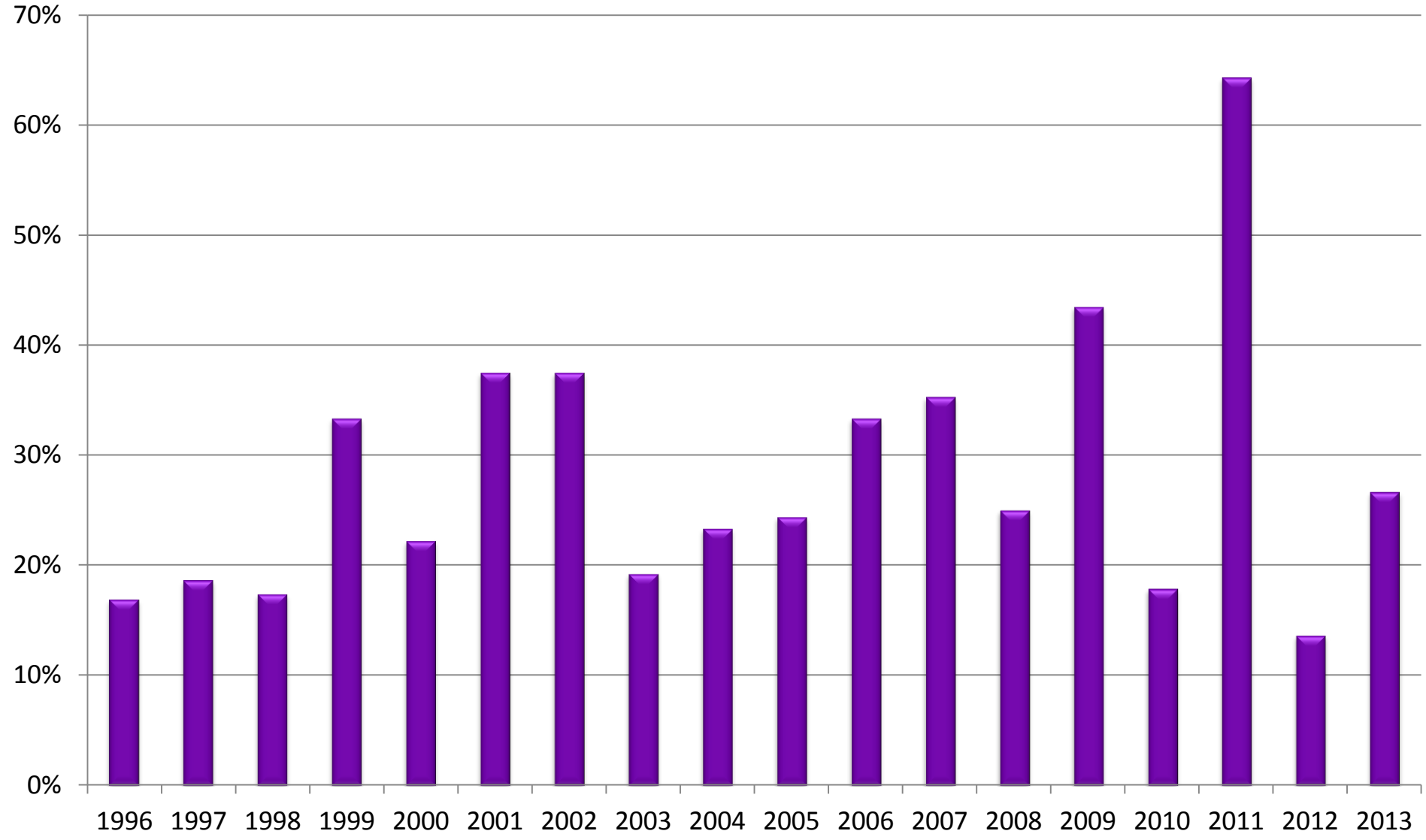
Source: DECC

Exploration Success Rates (%)



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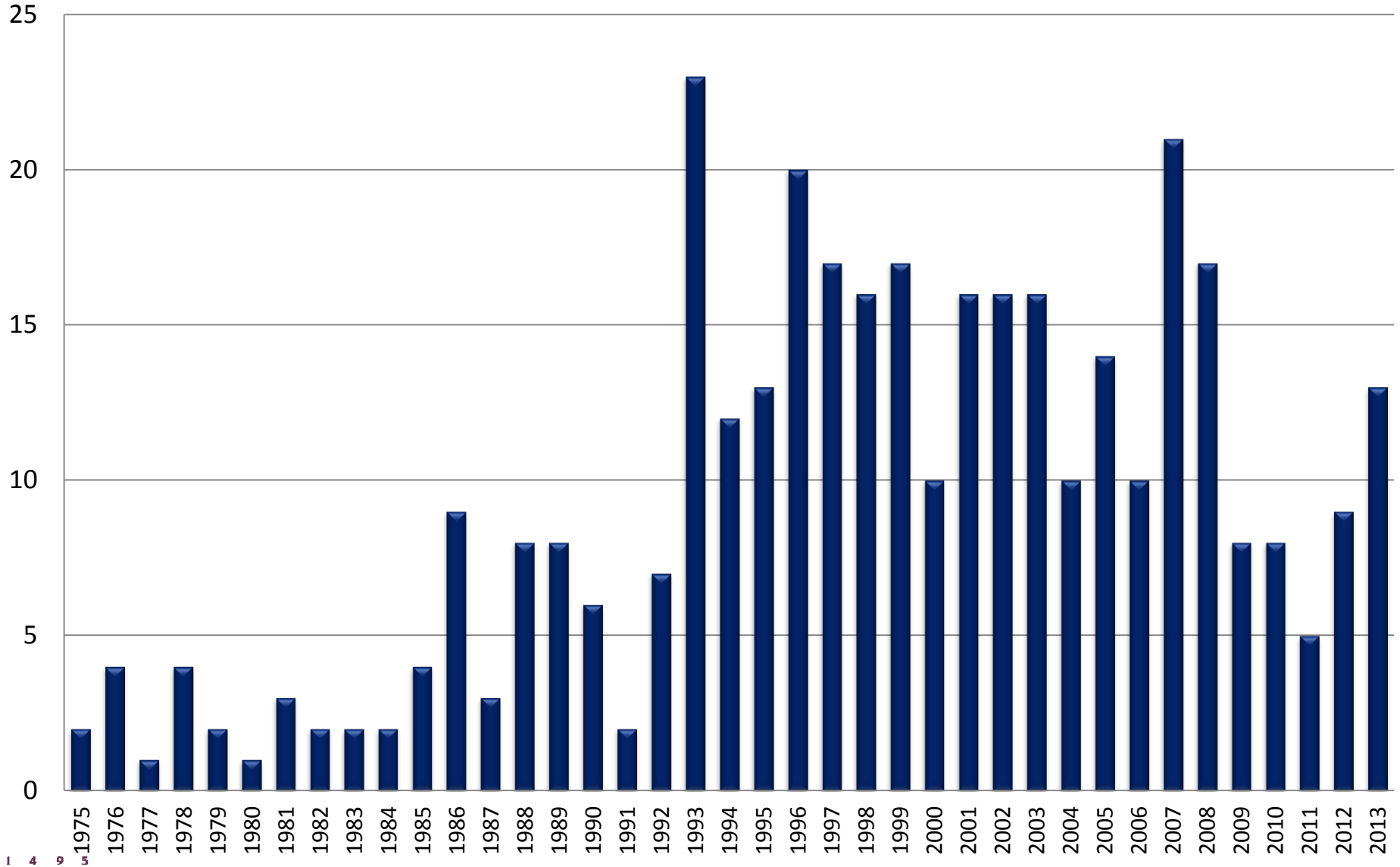
Source: DECC

Number of New Fields Coming Onstream (UKCS)



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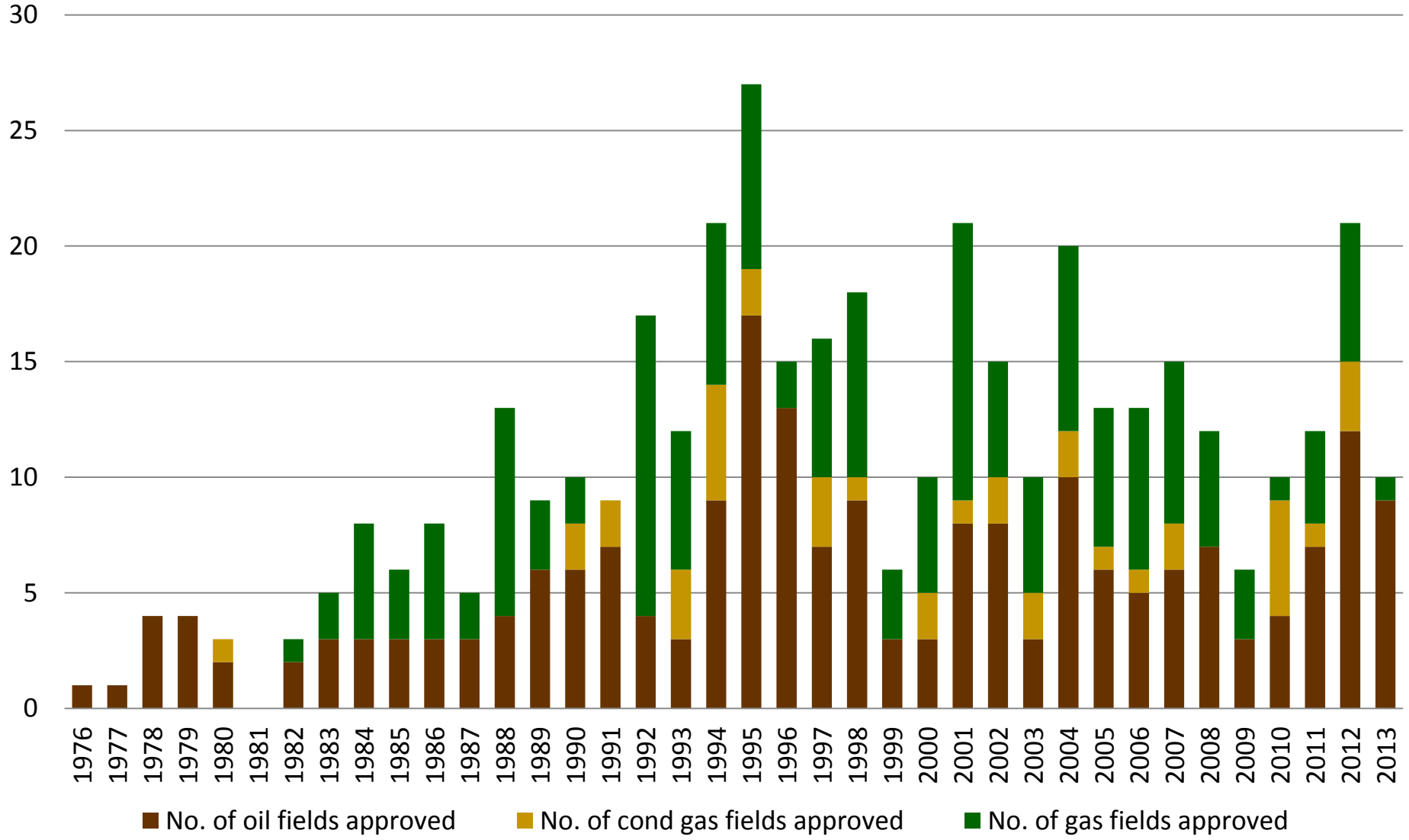
Source: DECC

Offshore Field Approvals (UKCS)



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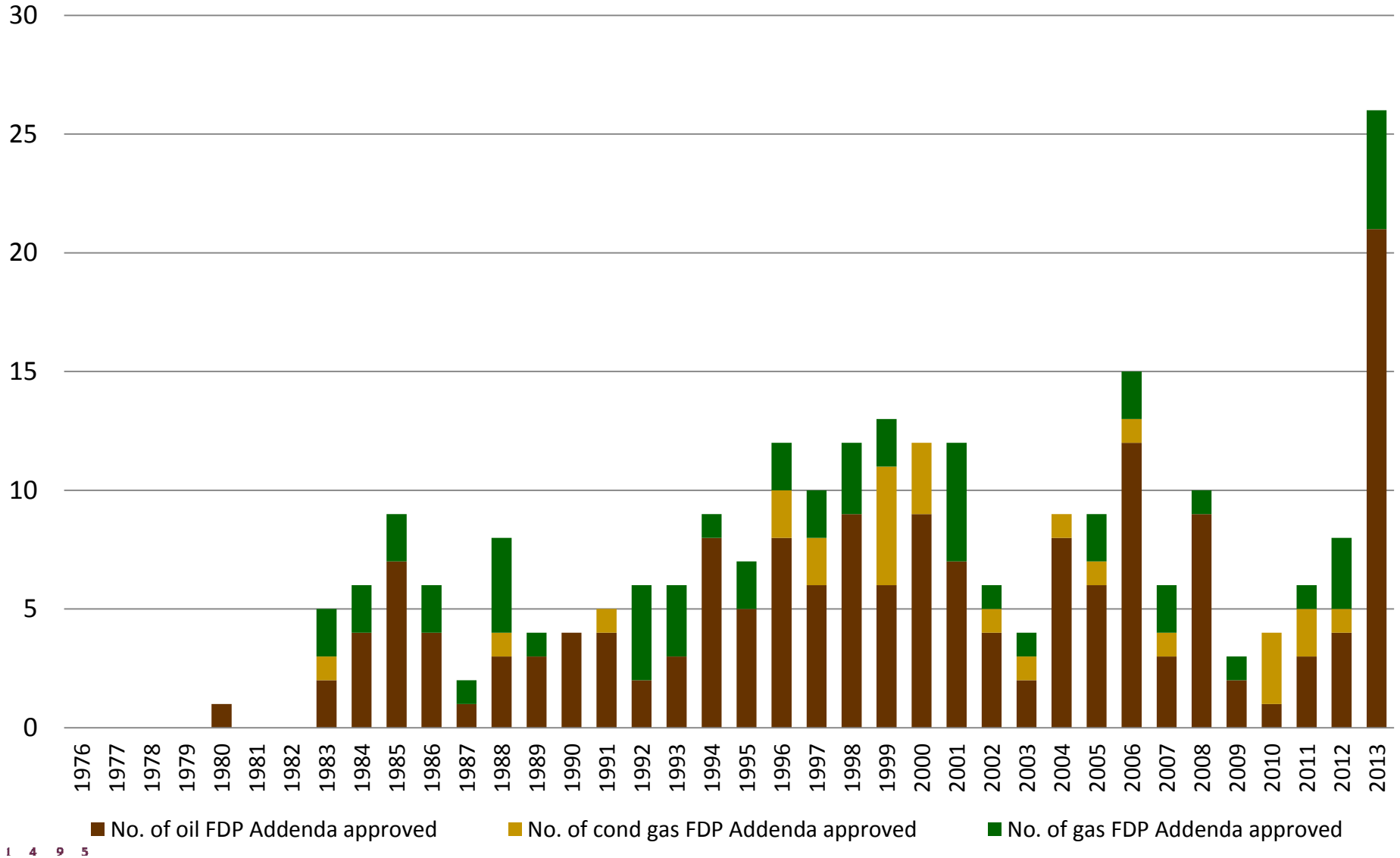
Source: DECC

Offshore FDP Addenda Approvals (UKCS)



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Source: DECC

Economic Model

Large field-based financial simulation model incorporating Monte Carlo technique for risk analysis. Model incorporates all evolving taxation arrangements since 1960's. Large field database with following features:

a) Historic production, investment costs (drilling and facilities separately), operating costs (tariffs separately), decommissioning costs. Data from successive OGUK field database plus other sources (e.g. DECC production data)

b) Data on sanctioned fields, probable and possible fields and incremental projects all relating to future activity source fromOGUK field database. All these incorporate key data and expected phasing through time.

c) Currently numbers of fields are as follows:

(i) Sanctioned fields	379
(ii) Incremental projects	171
(iii) Probable fields	23
(iv) Possible fields	20

d) Separate database of fields classified as technical reserves. Information from private and public sources. Total number currently is 254. Some were formerly in possible category where substantial data exist. For many only data relate to location, type (oil, gas, condensate), block number, and expected size of reserves.

e) Future incremental projects. Current incremental projects are generally planned to be executed over 3-year period. Future incremental projects are modelled to continue trends in sizes, costs, types, and locations experienced over the last few years. A 5-year running average of past trends employed to make projections. Such data includes the considerable numbers of incremental projects where there is no directly attributable income.

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New discoveries modelled according to the following procedures:

a) Exploration effort based on combination of (i) trend since 2000 and (ii) prospective oil/gas price behaviour (sustained).

b) Success rates based on combination of (i) experience in period since 2000 and (ii) size of effort. In relation to (ii) it is assumed that higher effort is associated with more discoveries but lower success rate than with medium effort. Similarly with medium and low effort. For whole of UKCS success rates:

under High Effort = 25%

Medium Effort = 28%

Technological progress maintains these success rates in the period to 2050.

c) The aggregate historic data on (i) exploration effort and (ii) discoveries were disaggregated according to main regions, namely SNS, CNS/MF, NNS, WOS and IS. Regional trends were established for relative exploration effort, discoveries and success rates. This includes splitting according to type (oil, gas and condensate).

Investment Screening Prices

	Oil Price (real) $/bbl	Gas Price (real) P/therm
High	90	58
Medium	70	45

The numbers of exploration wells (linear trend) in relation to the 2 price cases

	2014	2030	2040	2045
High	26	20	16	12
Medium	22	15	10	7

Mean Discovery Size (Mmboe)		
	2014	2045
SNS	10	5
CNS/MF	30	12
NNS	25	10
WoS	75	25
IS	12	4

d) Using the above information the Monte Carlo technique was employed to project discoveries in all 5 regions in the period to 2040.

e) In the Monte Carlo modelling it was assumed that the size distribution of discoveries would be lognormal following historic evidence. The SD was set at 50% of the mean value. The mean size of field decline through the period was again based on historic evidence. Monte Carlo modelling was also used to calculate the field development costs. For each region the average development cost (per boe) of fields sanctioned recently plus the probable and possible fields was calculated. The SD was assumed to be 20% of the mean.

Total Number of Discoveries to 2045	
High effort/Lower Success Rate	157
Medium Effort/Medium Success Rate	131

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Costs of New Discoveries and Technical Reserves

1. For new discoveries average based on costs of probable and possible fields

Future Fields Costs

	Devex $/boe		
	Min	**Mean**	**Max**
SNS (7)	4.66	15.92	40.31
CNS/MF (25)	4.91	28.37	178.02
NNS (11)	12.57	25.79	41.11
WoS (8)	6.95	24.74	46.22
IS (2)	13.52	23.37	33.22
All First devex after 2012 (53)	4.66	25.45	178.02
All Sanctioned (10)	4.66	22.09	66.98
All Probable (23)	7.14	20.88	41.11
All Possible (20)	6.95	32.39	178.02

Future Fields Costs

	Opex **$/boe**		
	Min	**Mean**	**Max**
SNS (7)	5.60	13.97	26.43
CNS/MF (25)	0.00	18.45	85.69
NNS (11)	0.00	20.65	48.62
WoS (8)	8.67	19.78	37.77
IS (2)	0.72	2.20	3.68
All First devex after 2012 (53)	0.00	17.90	85.69
All Sanctioned (10)	0.00	9.15	27.46
All Probable (23)	3.68	18.99	37.77
All Possible (20)	1.54	21.02	85.69

Future Fields Costs			
	Total Costs **$/boe**		
	Min	**Mean**	**Max**
SNS (7)	24.21	34.99	57.99
CNS/MF (25)	17.43	53.68	220.68
NNS (11)	27.99	51.70	77.46
WoS (8)	16.56	46.64	60.66
IS (2)	20.31	39.16	58.01
All First devex after 2012 (53)	16.56	49.19	220.68
All Sanctioned (10)	17.43	47.72	131.31
All Probable (23)	20.31	42.48	62.47
All Possible (20)	16.56	57.64	220.68

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Incremental Projects			
	Devex **$/boe**		
	Min	**Mean**	**Max**
SNS (30 + 5 Spends)	0.00	11.89	31.22
CNS/MF (57 + 35 Spends)	0.00	21.93	101.51
NNS (21 + 12 Spends)	0.00	22.82	62.51
WoS (5 + 6 Spends)	0.00	12.54	29.12
All Projects (113 + 58 Spends)	0.00	19.01	101.51

Incremental Projects			
	Opex **$/boe**		
	Min	**Mean**	**Max**
SNS (30+ 5 Spends)	-197.96	15.53	481.16
CNS/MF (57+ 35 Spends)	0.00	9.43	128.80
NNS (21+ 12 Spends)	-4.49	6.35	36.89
WoS (5+ 6 Spends)	0.00	6.73	20.28
All Projects (113 + 58 Spends)	-197.96	10.36	481.16

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Incremental Projects			
	Total Costs **$/boe**		
	Min	**Mean**	**Max**
SNS (30 + 5 Spends)	-197.96	28.00	481.16
CNS/MF (57 + 35 Spends)	0.00	32.96	155.92
NNS (21 + 12 Spends)	13.20	124.88	2005.63
WoS (5 + 6 Spends)	5.53	19.28	36.67
All Projects (113 + 58 Spends)	-197.96	48.12	2005.63

2. For fields in the category of technical reserves average development costs were set at $5 per boe higher than those for probable and possible fields. Annual operating costs are modelled as a percentage of accumulated development costs with the percentage increasing the smaller the field size. Monte Carlo modelling was employed to determine the distribution of sizes of reserves and field development costs with SD equal to 50% mean values for reserves and 20% for development costs.

Investment Hurdle Criteria

NPV (post tax) / I (pre tax) ≥ 0.3/ ≥ 0.5
with discount rate
of 10% in real terms

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Physical and Financial Capacity Constraints

The annual numbers of field developments going ahead were assumed to be constrained by the capacity (physical and financial) of the industry. Over the longer term the ceilings on the total numbers of potential field developments (excluding incremental investments) were assumed to be as follows:

High Price	18
Medium Price	15

Operation of Model

The model calculates the post-tax returns on the probable and possible fields, and the new discoveries as they are made. If they pass the investment hurdle they go ahead. The fields in the technical reserves category are then tested. Generally there is no knowledge of the possible timing of any developments.

Operation of Model

To determine the order in which they may be developed each field is given a number and the Monte Carlo technique is used to draw randomly from a uniform distribution.

A selected field is then tested against the investment hurdle criterion. If it passes and the total for the year is within the financial and capacity constraint the development proceeds.

Operation of Model

If it fails the investment hurdle it does not proceed. Generally it was found that in the early years not many technical reserves fields were called on. In (much) later years when the numbers of fields in the probable, possible and new discoveries categories were low more technical reserves were called on. But many failed investment hurdle.

Phasing of New Developments

In the light of experience over the past few years some rephasing of the timing of the commencement dates of new field developments and incremental projects from those projected by operators was undertaken relating to the probability that the project would go ahead. Where the operator indicated that a new field development had a probability ≥ 80% of going ahead the date was left unchanged. Where the probability… (cont.)

Phasing of New Developments

… ≥ 60% < 80% the commencement date was slipped by 1 year. Where the probability ≥ 40% < 60% the date was slipped by 2 years. Where the probability was ≥ 20% < 40% the date was slipped by 3 years, and where the probability was < 20% it was slipped by 4 years. If an incremental project had a probability of proceeding ≥ 50% the date was retained but where it was < 50% it was slipped by 1 year.

Wood Review Recommendations

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Recommendation 1: Government and Industry to develop and commit to a new strategy for Maximising Economic Recovery from the UKCS (MER UK)

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Recommendation 2: Create a new arm's length regulatory body charged with effective stewardship and regulation of UKCS hydrocarbon recovery, and maximising collaboration in exploration, development and production across the Industry

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Recommendation 3: The Regulator should take additional powers to facilitate implementation of MER UK

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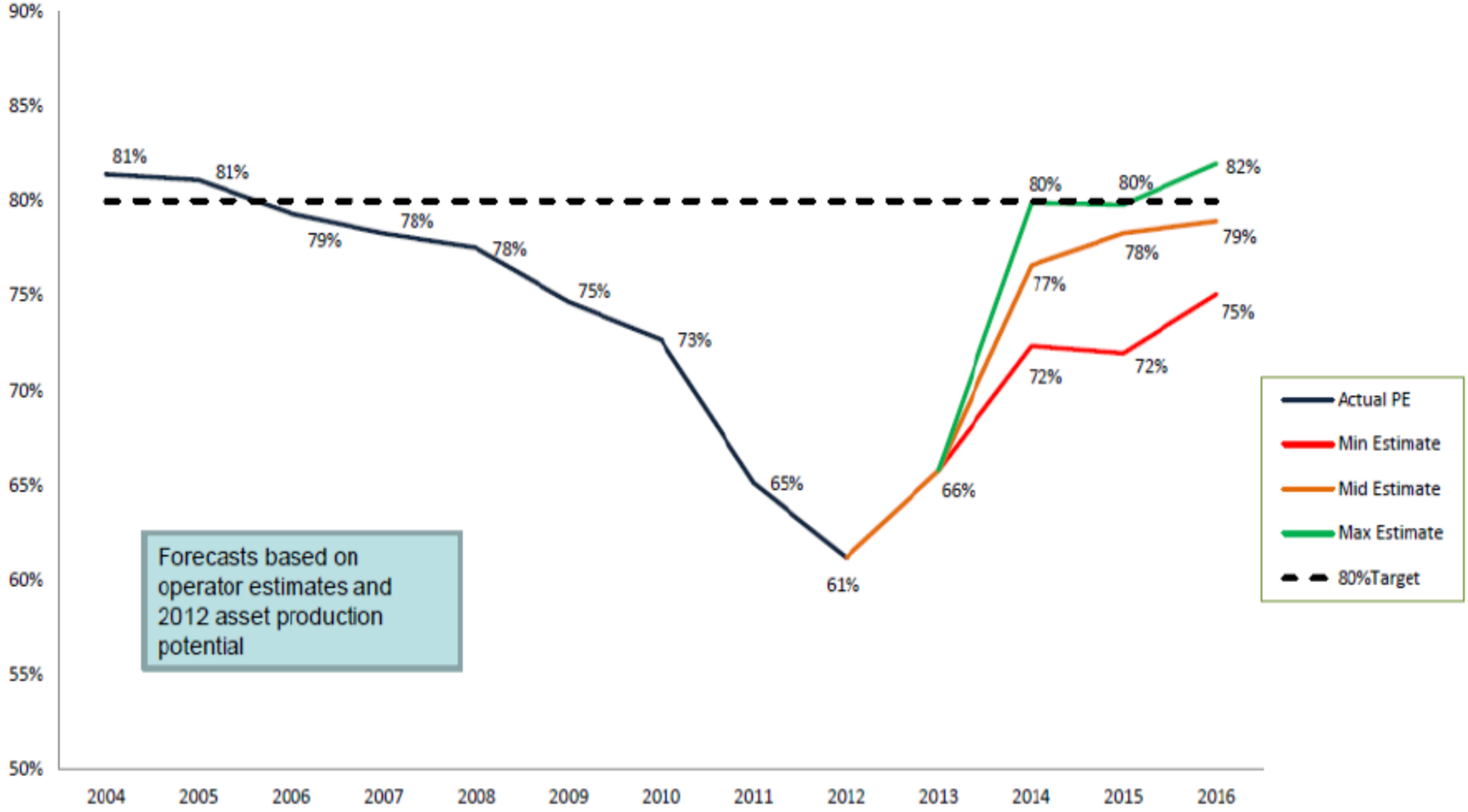
Recommendation 4: Develop and implement important Sector Strategies

- Exploration (including access to data)
- Asset Stewardship (including Production Efficiency and Improved Oil Recovery)
- Regulation Development (starting with the Southern North Sea)
- Infrastructure
- Technology (including Enhanced Oil Recovery and Carbon Capture and Storage)
- Decommissioning

Production efficiency

UK Continental Shelf PE (actual and forecast)



Production Efficiency Assumptions

Two cases are modelled. The first, termed Production Efficiency Problem Largely Resolved, assumes that over the next 5 years production efficiency in sanctioned fields is at 72% and subsequently at 80%. The “loss” of production in the interim is recovered in the period to 2025 as a set amount each year based on the average loss.

Production Efficiency Assumptions

The second case, termed Production Efficiency Problem Partly Resolved, assumes that over the next 5 years production efficiency in the sanctioned fields averages 60% after which it recovers to 80%. The “loss” of production in the interim is not recovered.

Tax Position of Investor

The model can assess the projects under two tax situations, namely:

(1) Where investor is initially in full tax-paying position

(2) Where investor is initially not in tax-paying position

Modelling Outputs

1. Annual production by category and region
2. Annual development costs by category and region
3. Annual operating costs by category and region
4. Annual decommissioning costs by category and region

Modelling Outputs

5. Annual tax revenues. But taxable income requires adjustments for:

(a) E and A costs

(b) Non field-specific overhead costs

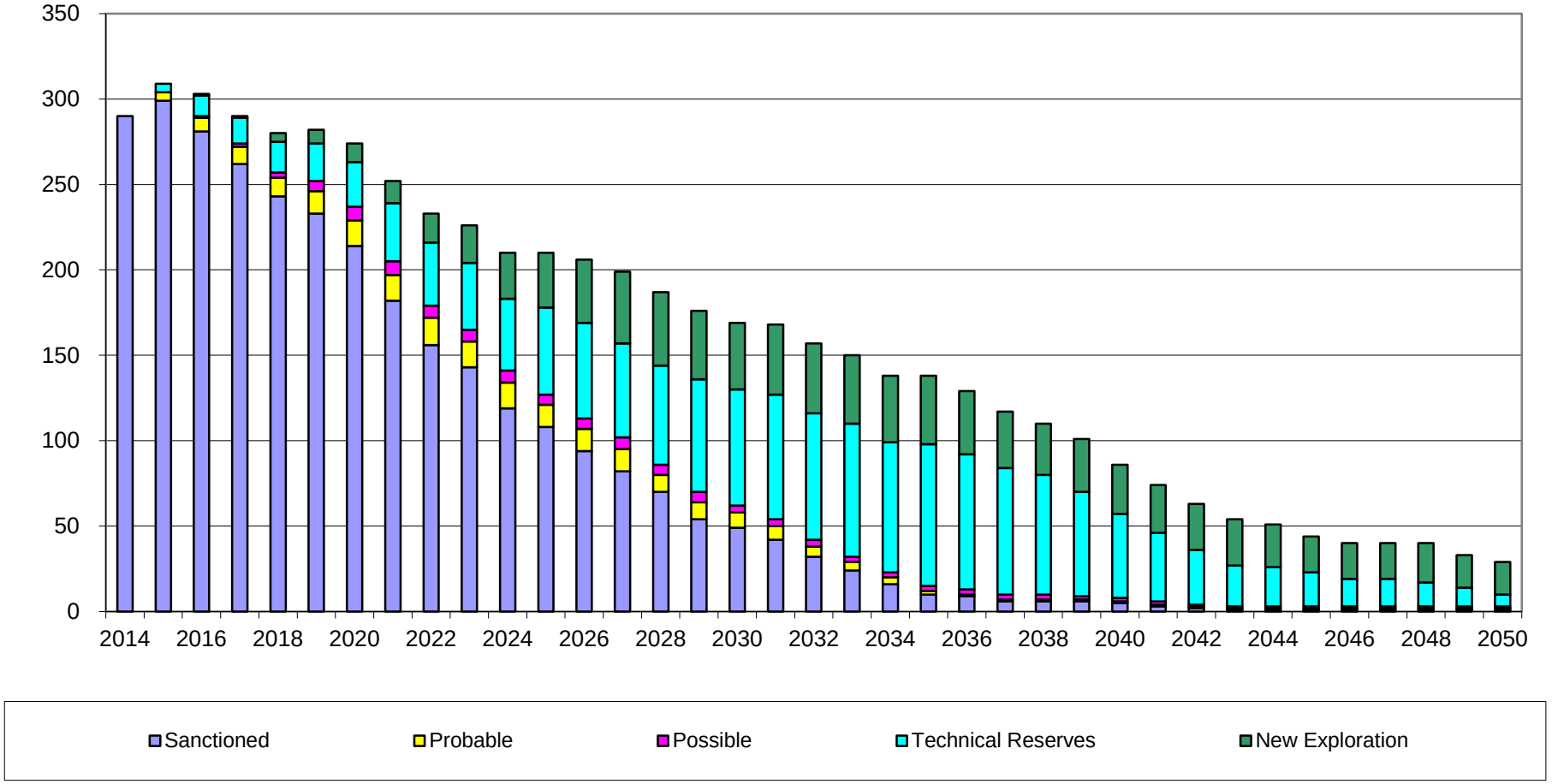
(c) R and D costs

(d) Loan interest (for CT)

Production Efficiency Problem Partly Resolved

$90, 58 pence
Hurdle NPV/I > 0.3
BY CATEGORY

Potential Number of fields in Production
$90/bbl and 58p/therm
Hurdle : Real NPV @ 10% / Real Devex @ 10% > 0.3
Production efficiency problem partly resolved



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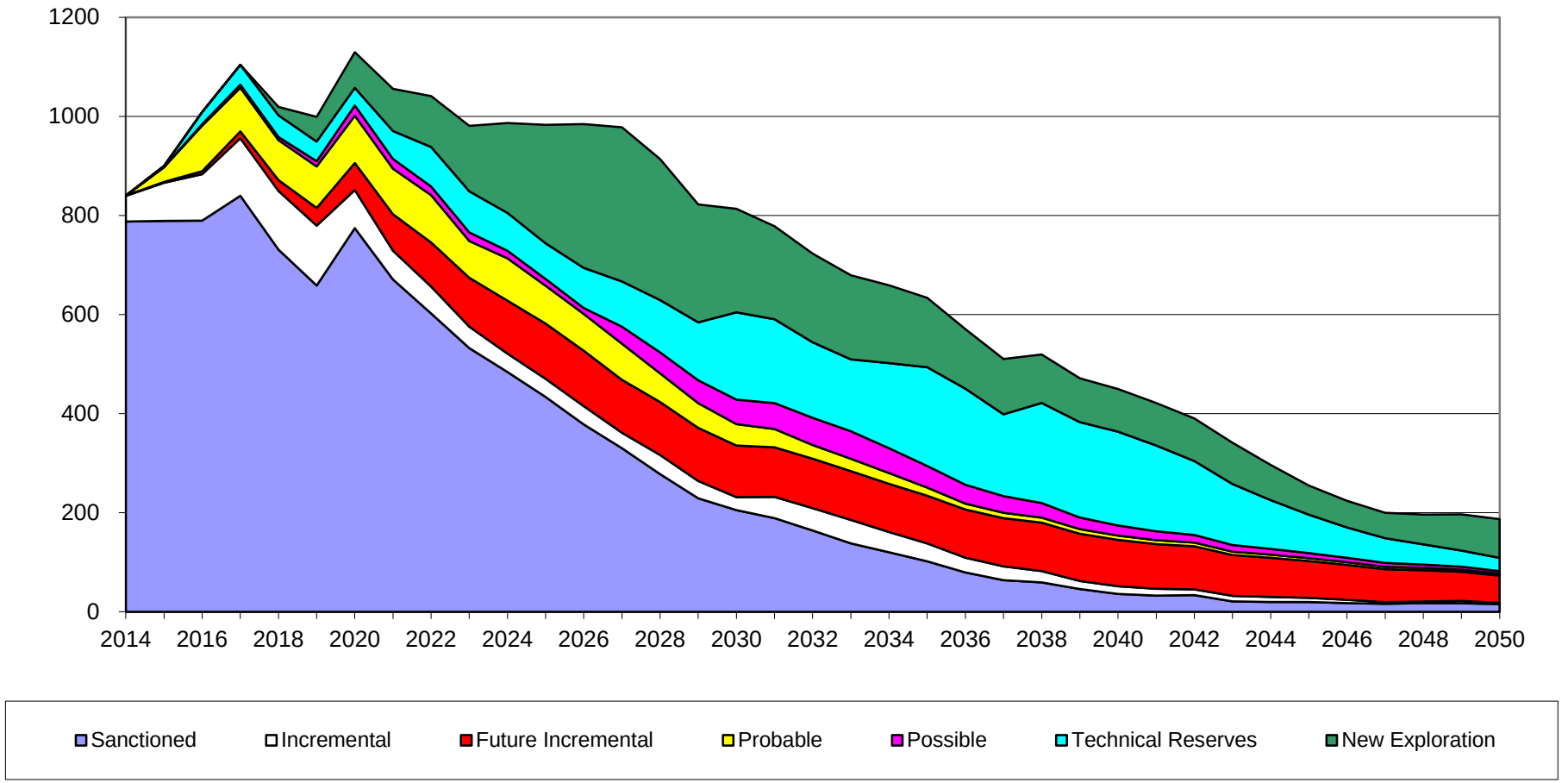
Potential Oil Production
$90/bbl and 58p/therm
Hurdle : Real NPV @ 10% / Real Devex @ 10% > 0.3
Production efficiency problem partly resolved



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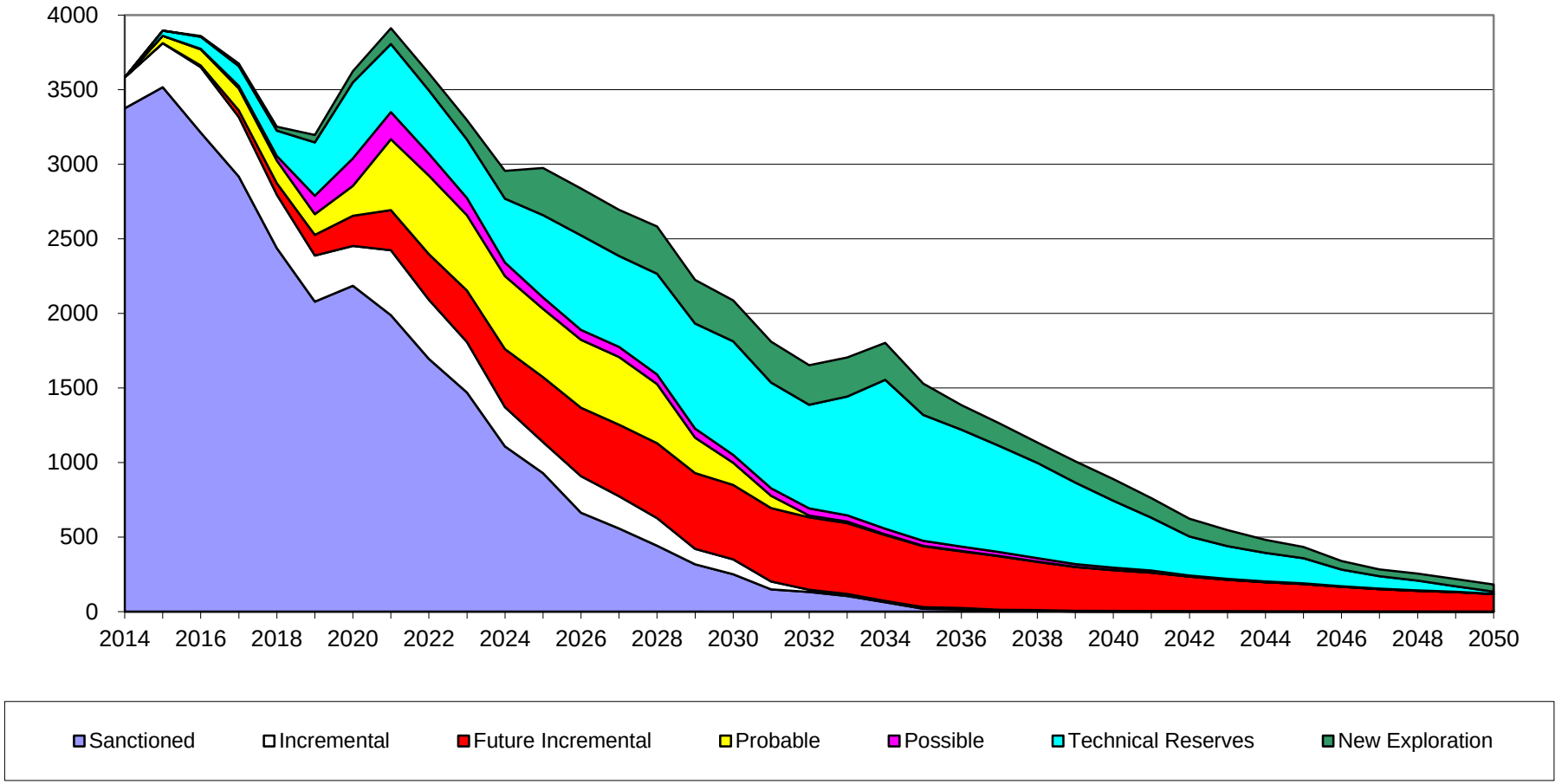
Potential Gas Production
$90/bbl and 58p/therm
Hurdle : Real NPV @ 10% / Real Devex @ 10% > 0.3
Production efficiency problem partly resolved



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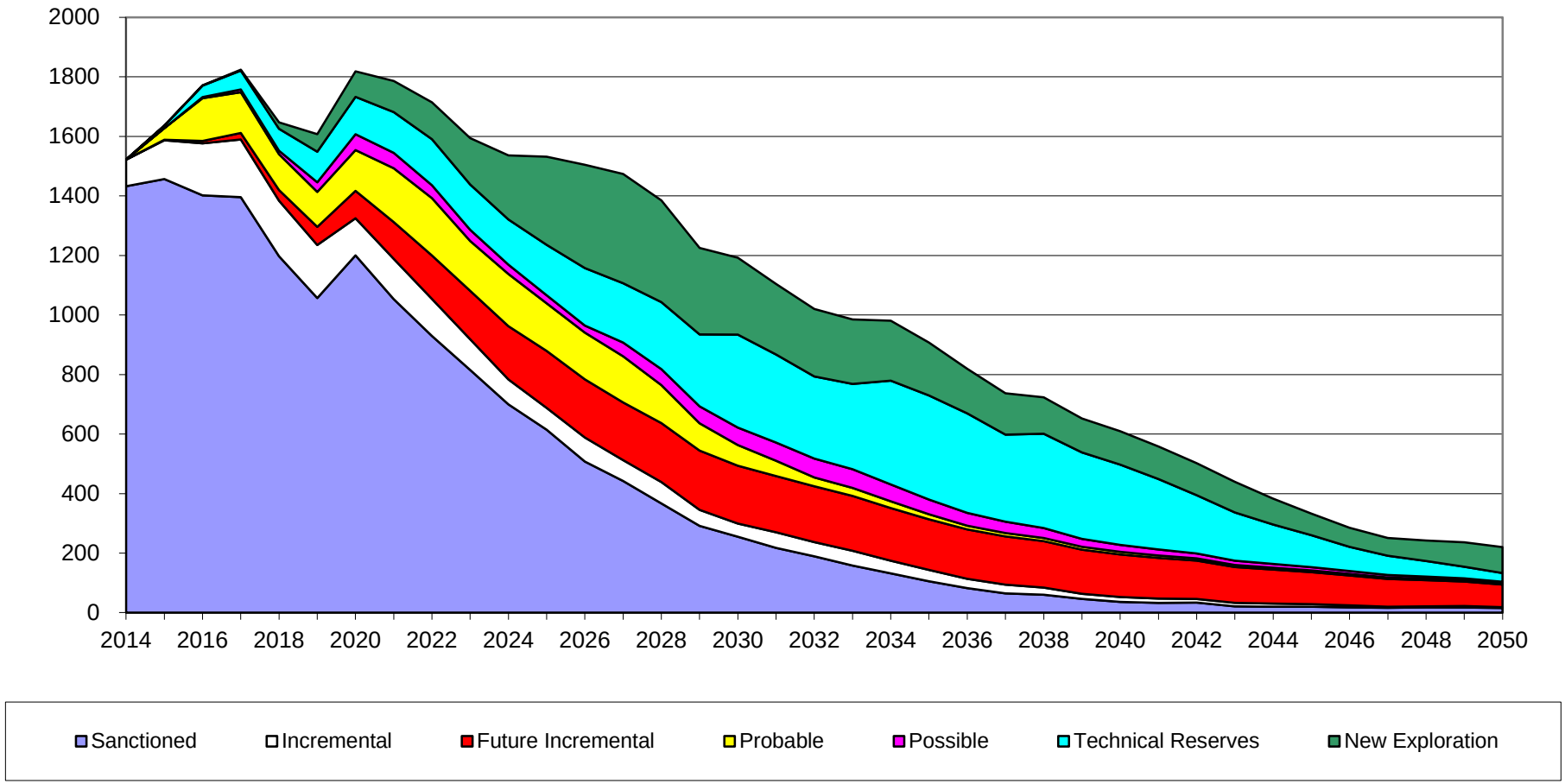
Potential Total Hydrocarbon Production
$90/bbl and 58p/therm
Hurdle : Real NPV @ 10% / Real Devex @ 10% > 0.3
Production efficiency problem partly resolved



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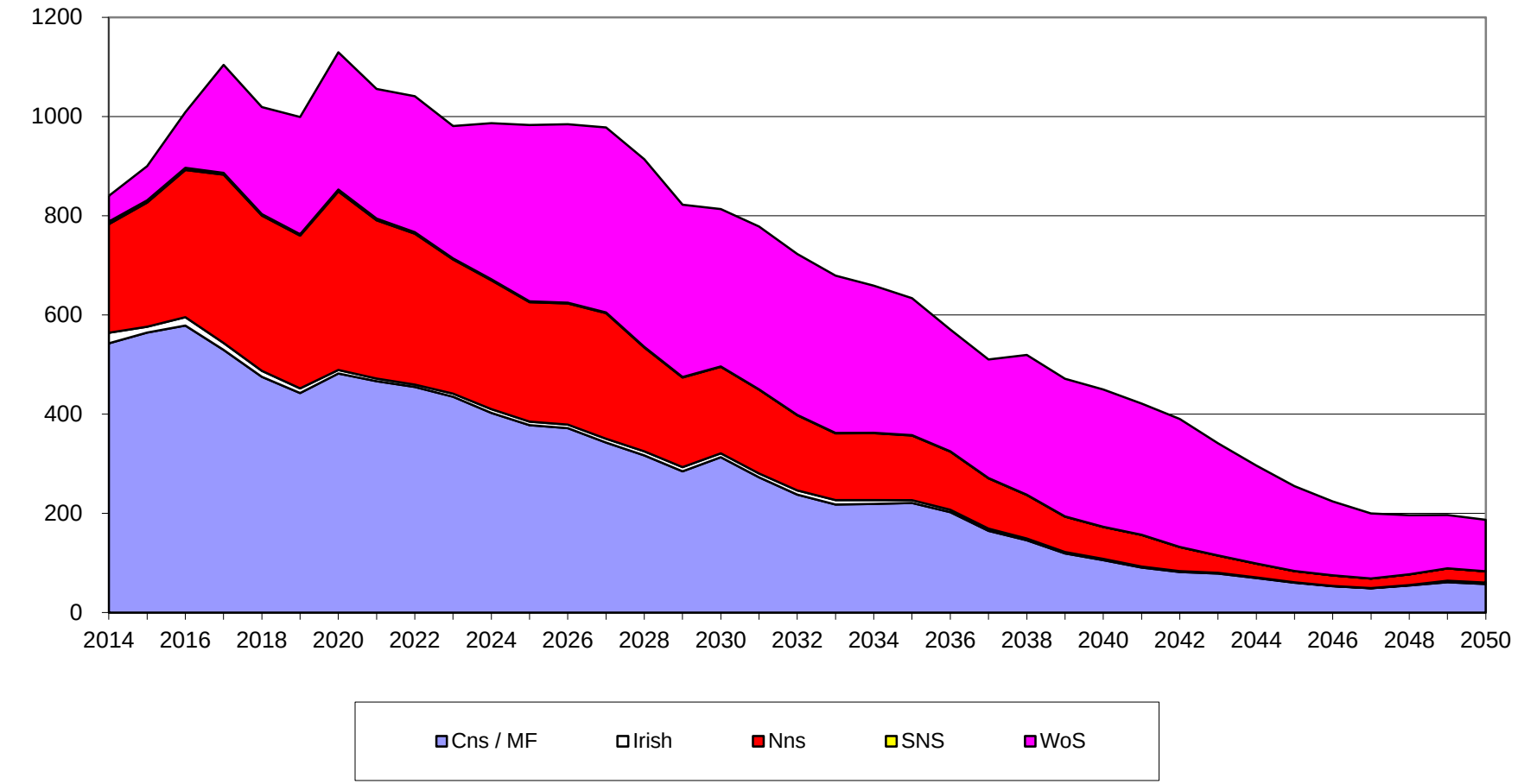
$90, 58 pence
Hurdle NPV/I > 0.3
BY AREA

Potential Oil Production
$90/bbl and 58p/therm
Hurdle : Real NPV @ 10% / Real Devex @ 10% > 0.3
Production efficiency problem partly resolved



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Potential Gas Production
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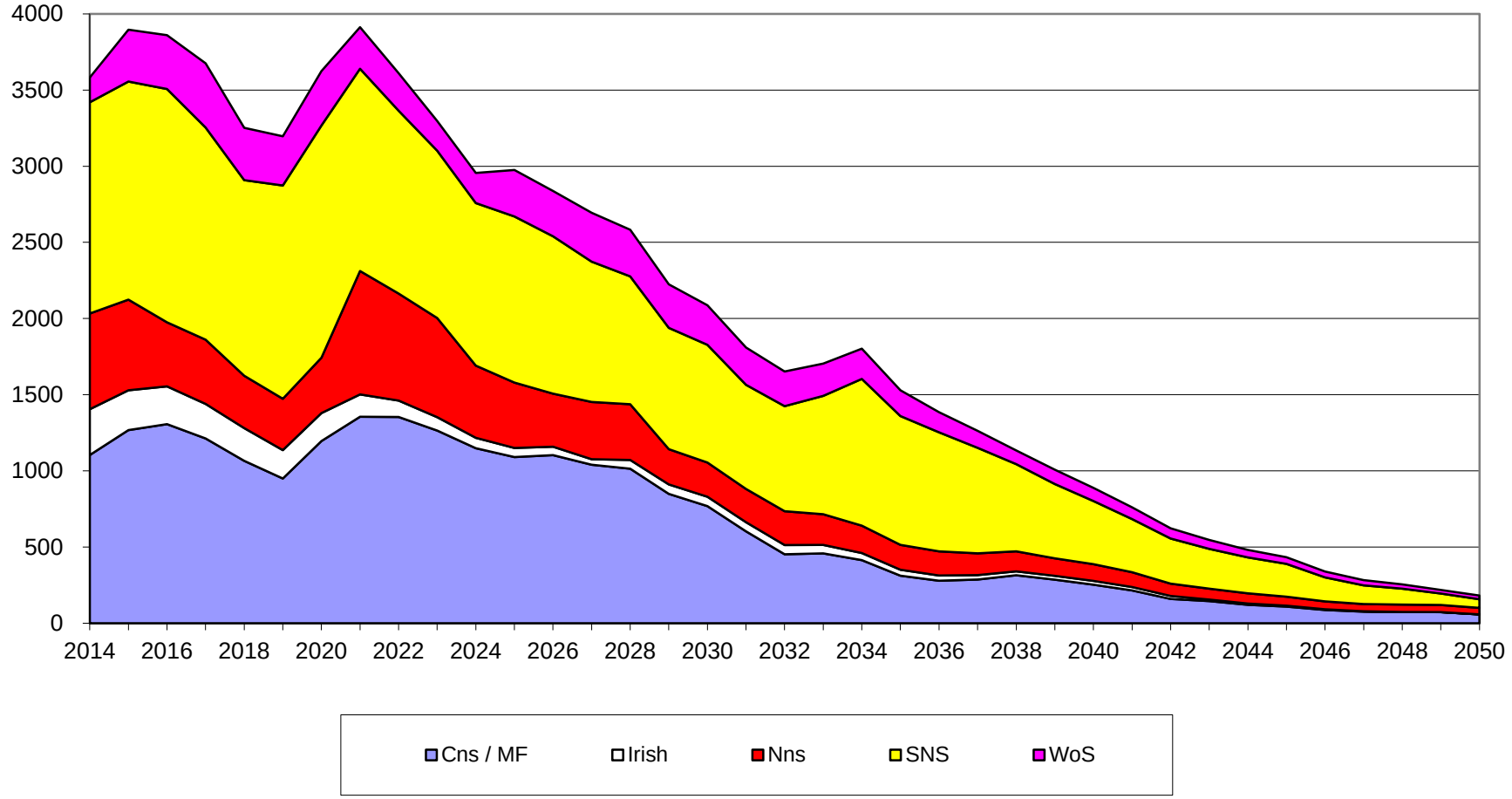

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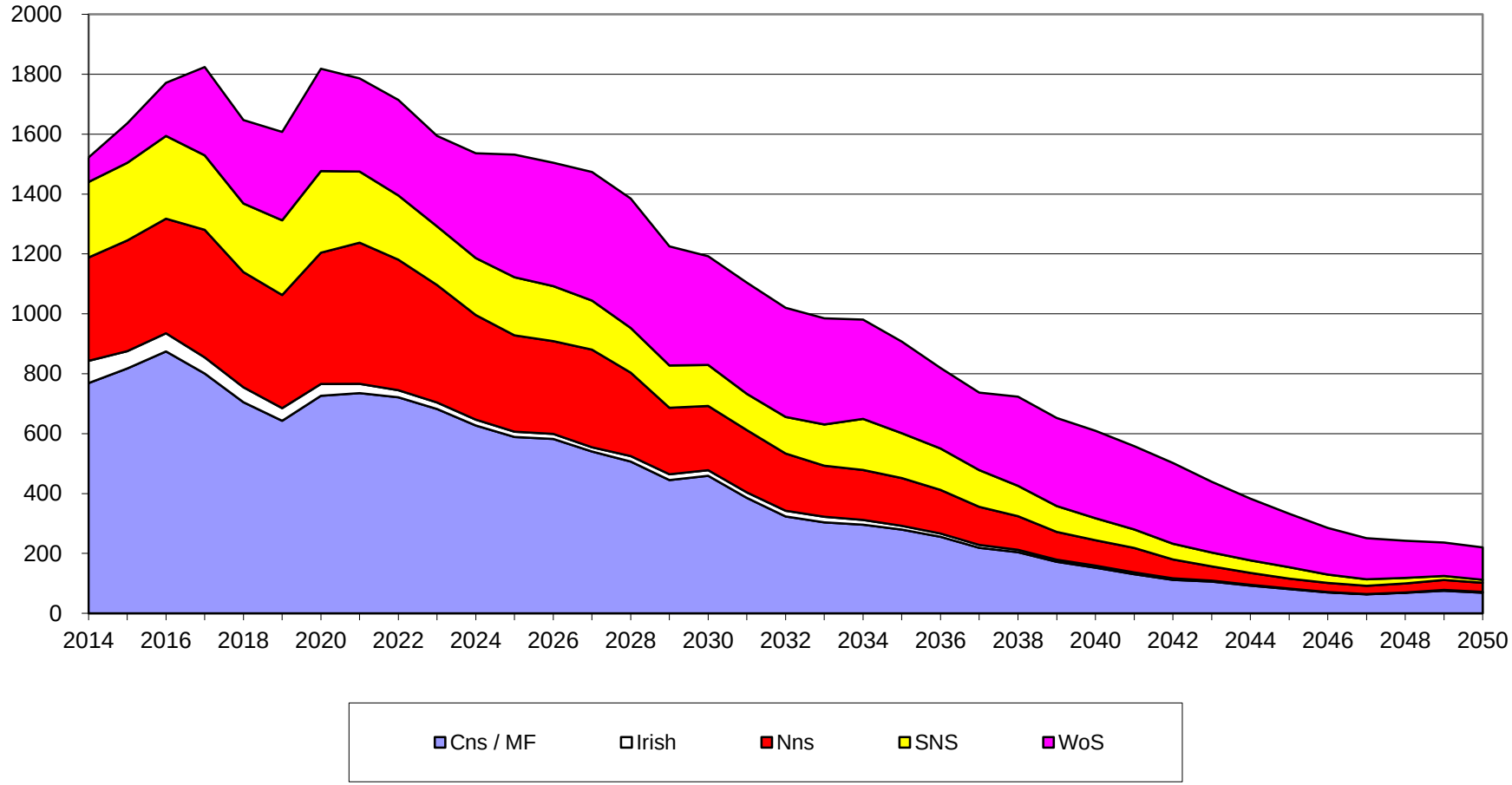

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Number of New Fields/Projects Passing Hurdles by 2050

Probables	16	(out of 23)
Possibles	9	(out of 20)
Incremental (current)	132	(out of 171)
Technical Reserves	147	(out of 254)
New Discoveries	99	(out of 157)

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Cumulative Expenditures (£bn.2014)

Development	122.2
Operating	174.9
Decommissioning	45.0
TOTAL	**342.1**

Cumulative Hydrocarbon Production (UKCS)

Real Price	2014-2050, bn boe	
$90, 58 pence	NPV/I > 0.3	NPV/I > 0.5
Production Efficiency Problem Resolved	15.0	12.6
Production Efficiency Problem Unresolved	14.1	11.6

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Estimates of Remaining Potential (Bn Boe (rounded)

	Low	Central	High
Reserves (p + p + p)	4.5	8.3	12.1
PAR	1.4	3.4	6.4
Yet-to-Find	2.2	6.1	9.2

DECC's best estimate of remaining recoverable potential in range 11.1-21 bn boe

Total depletion to date: 42 bn boe

Source: DECC

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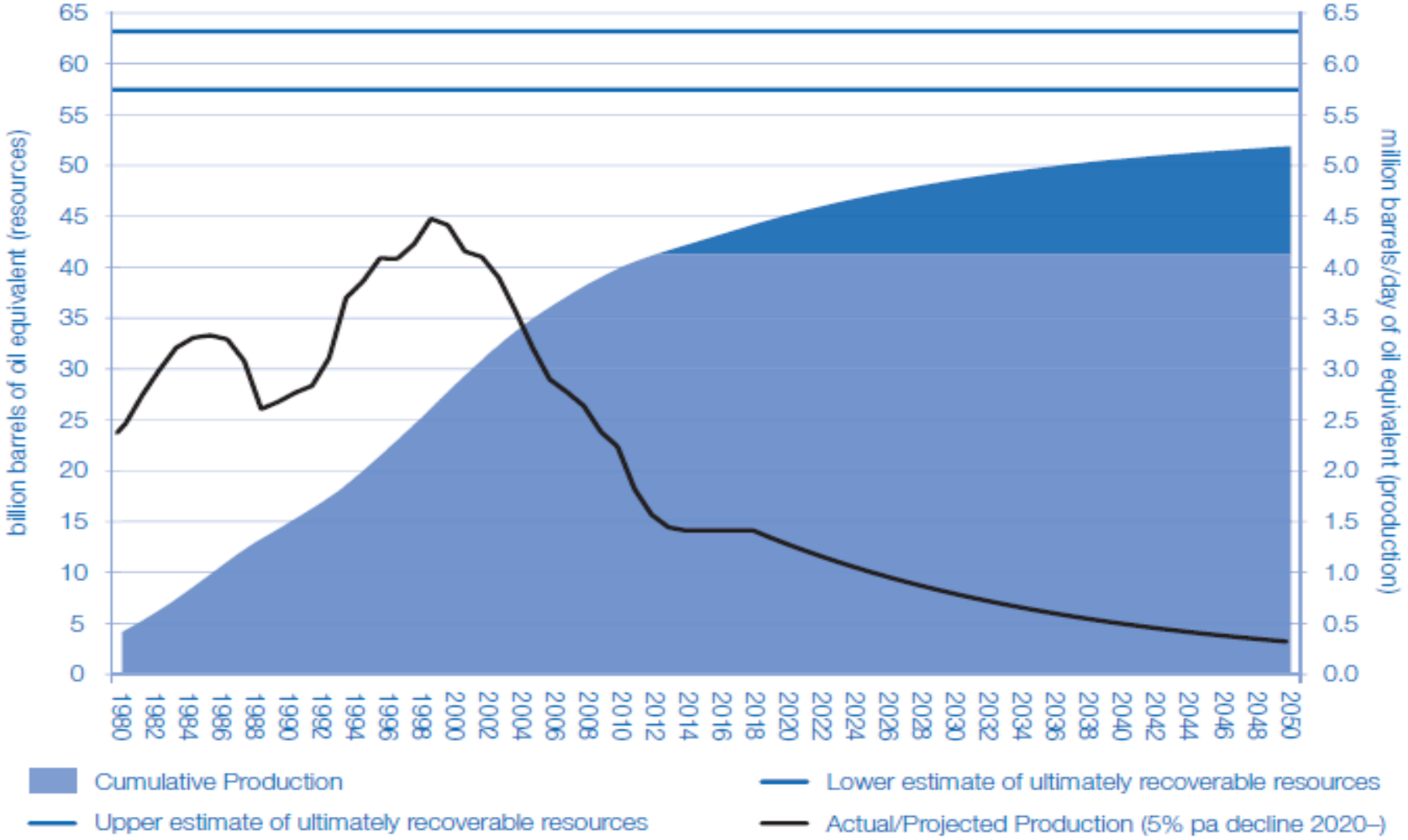
Chart 3A: Chart showing UK oil and gas reserves and production[14]



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Source: DECC

Effects of Tax Concessions for SC on unsanctioned fields:

1) BFA for SC employed for new fields at £75/tonne maximum with no cap
2) Investment uplift for SC at 62.5%
3) SC at 20% with existing field allowances

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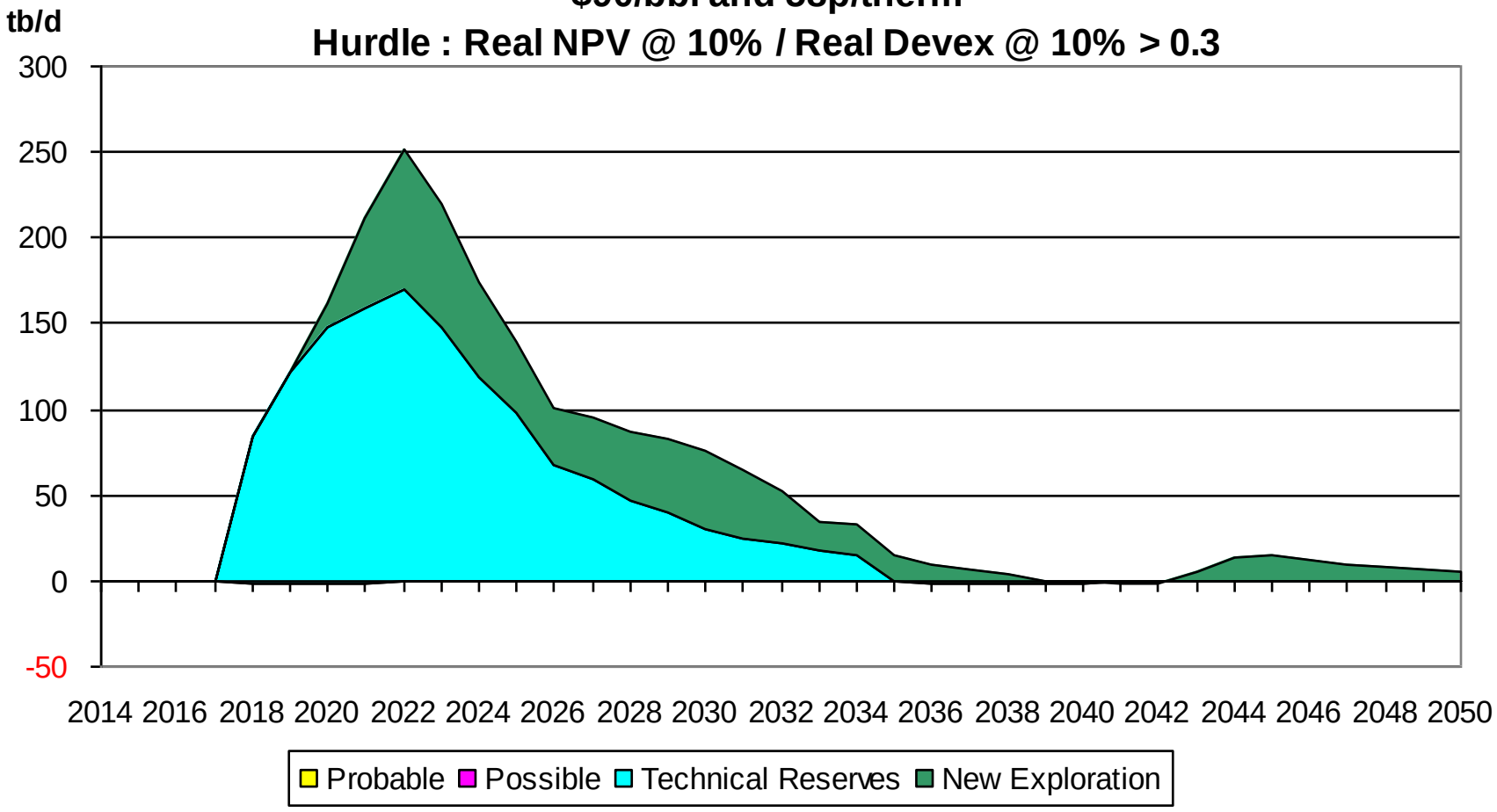
Change in Potential Oil Production
with Brown Field £75 no cap allowance
$90/bbl and 58p/therm
Hurdle : Real NPV @ 10% / Real Devex @ 10% > 0.3



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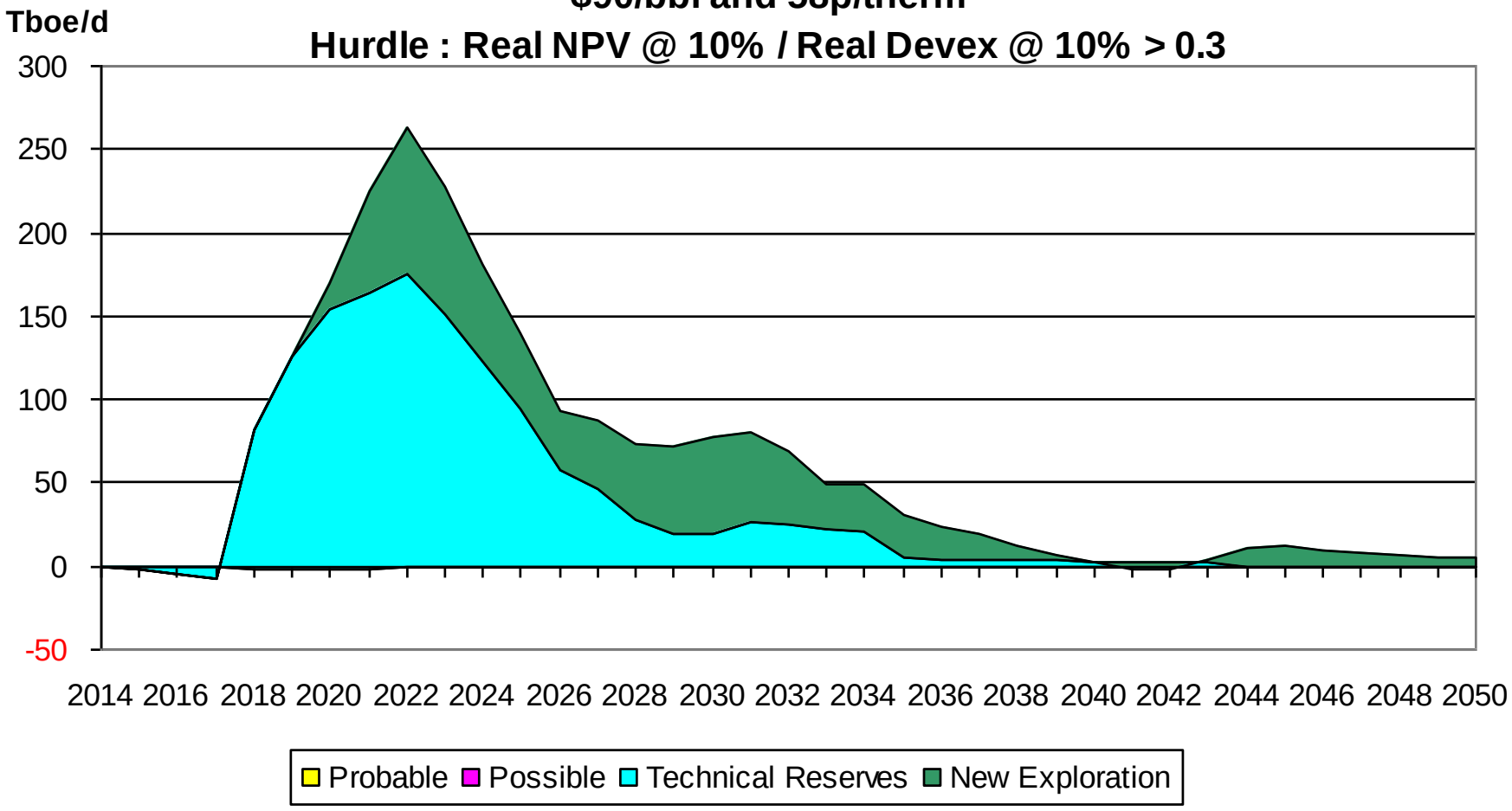
Change in Potential Total Hydrocarbon Production with Brown Field £75 no cap allowance $90/bbl and 58p/therm Hurdle : Real NPV @ 10% / Real Devex @ 10% > 0.3



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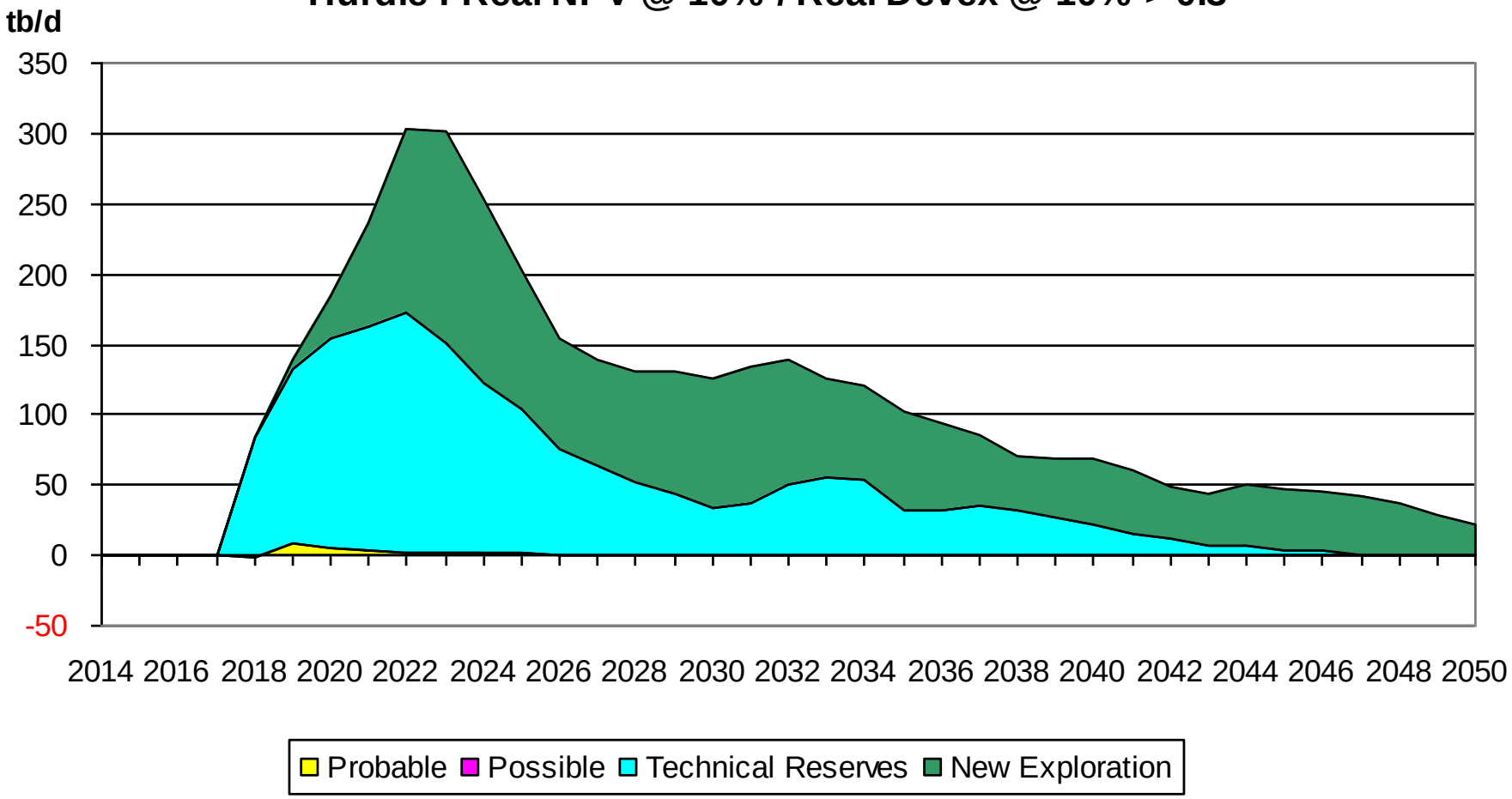
Change in Potential Oil Production
$90/bbl and 58p/therm
Hurdle : Real NPV @ 10% / Real Devex @ 10% > 0.3



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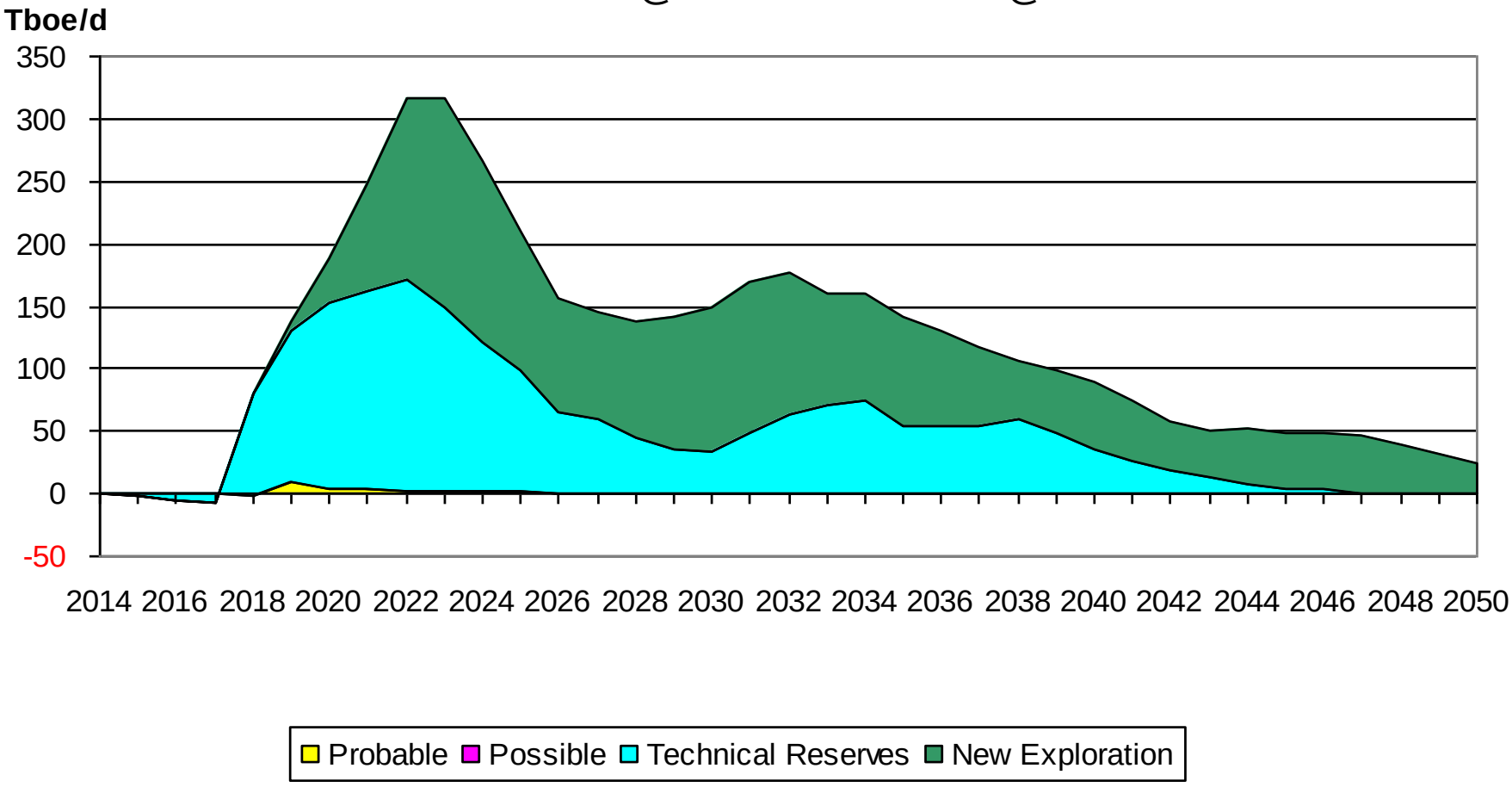
Change in Potential Total Hydrocarbon Production
$90/bbl and 58p/therm
Hurdle : Real NPV @ 10% / Real Devex @ 10% > 0.3



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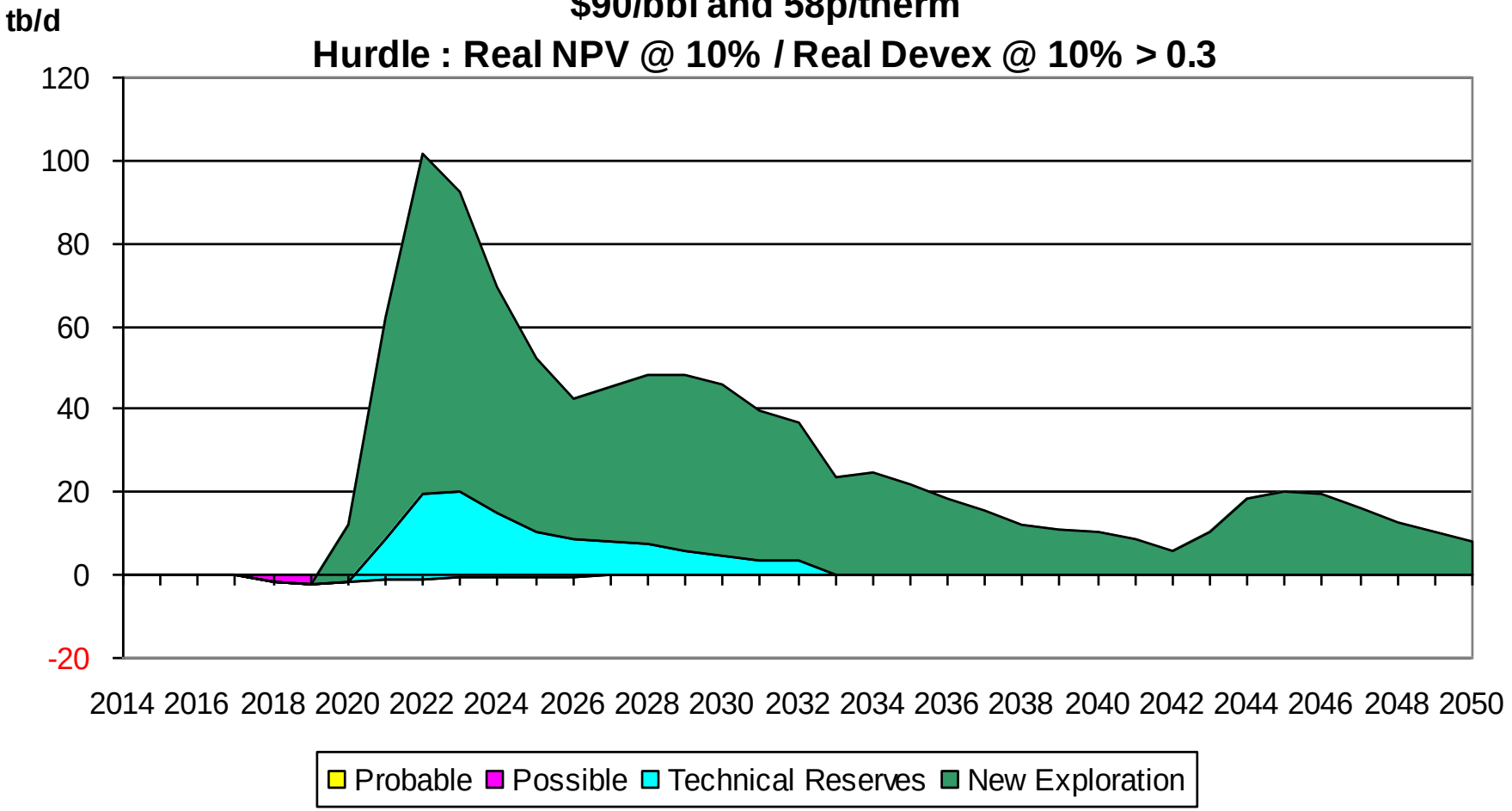
Change in Potential Oil Production
SCT 20%
$90/bbl and 58p/therm
Hurdle : Real NPV @ 10% / Real Devex @ 10% > 0.3



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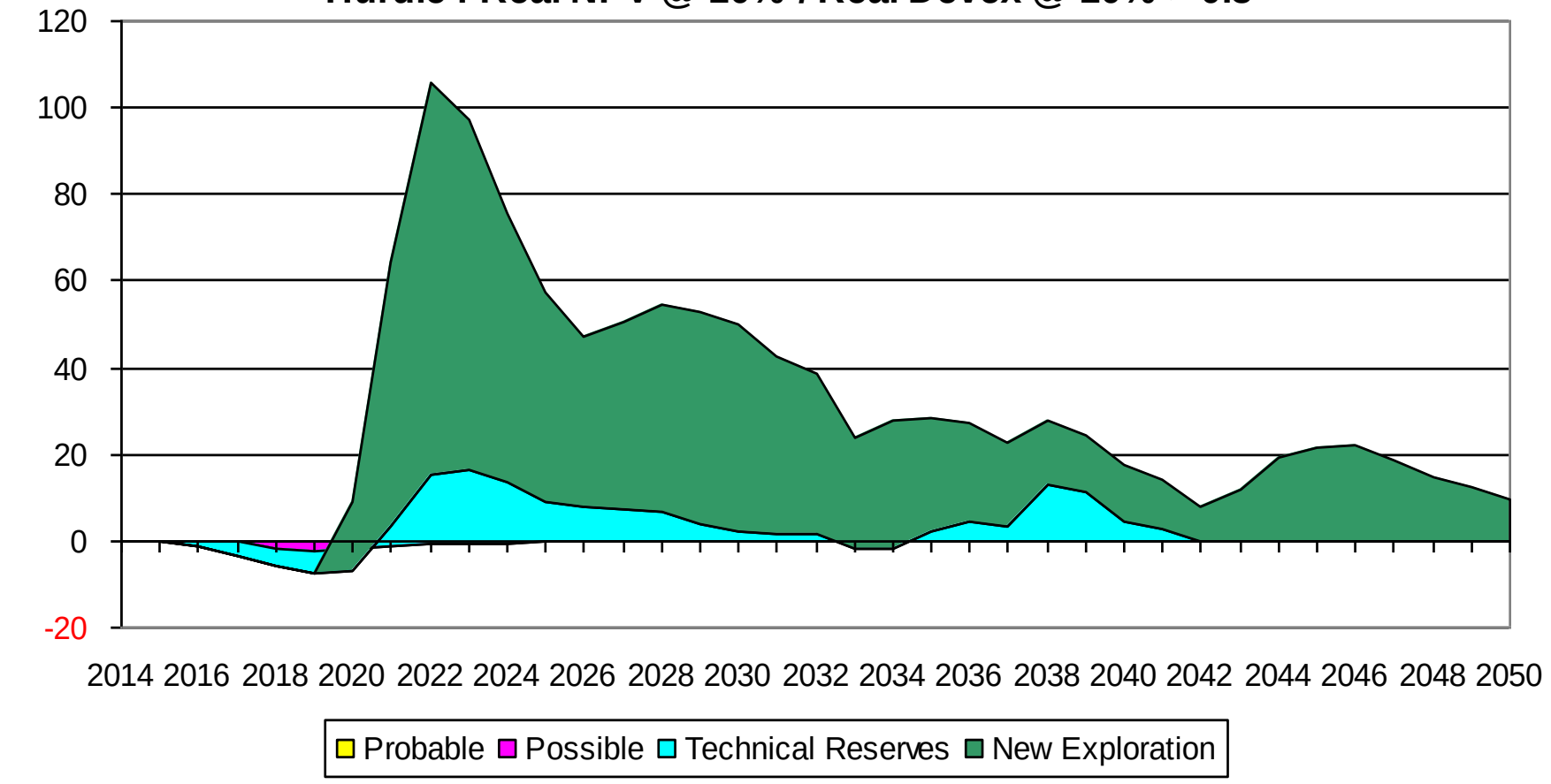
Change in Potential Total Hydrocarbon Production
SCT 20%
$90/bbl and 58p/therm
Hurdle : Real NPV @ 10% / Real Devex @ 10% > 0.3



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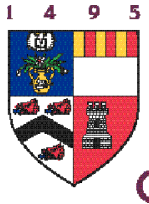
Extra Production from Tax Reliefs 2014-2050

1) BFA for SC at £75/tonne for unsanctioned fields = 804 mmboe
2) Investment uplift for SC at 62.5% = 1,572 mmboe
1) SC at 20% = 505 mmboe

Conclusions

1. In period 2014-2050 partial success in implementing Wood Review proposals could result in cumulative production of 14-15 bnboe
2. Targeted tax reliefs could result in a further 1-1.5 bnboe
3. Further incentives could produce considerable EOR
4. Technological progress should produce further production
5. Higher prices/cost reductions will incentivise further projects



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