MAXIMISING ECONOMIC RECOVERY FROM SMALL POOL DEVELOPMENTS: COMMERCIALISATION MODEL

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ABSTRACT

UKCS Oil and Gas Industry faces existential risks relating to available resource exploitation and severe margin pressures. The average discovery size over the last 10 years has averaged at 25 mmboe with over 200 small pool reservoirs lying undeveloped in the range of 3 mmboe to 15 mmboe. This report considers and determines macro level resource ranges and financial metrics that will allow commercialisation of such pools.

As it becomes increasingly difficult to discover mega oil fields, interest in developing small pools is increasing and there is evidence of successful commercialization of small pools in Nigeria and India.

Deterministic and probabilistic financial modeling was utilised to replicate the economics of small pools while minimum post tax Discounted Profitability Index of 0.3 at 10% discount rate was considered as economic threshold for developing small pools.

Real life data from small pools in the UKCS as modeled under an economic limit test shows a mean output of 7 mmboe and it was determined that under current economic environment, small pools with this output are clearly uneconomic. However, under existing fiscal regime, it is possible to commercialise the same at reserve levels of 11.8 mmboe and above with capital expenditure of USD 213 M; a level that does not fully exploit the small pool potential available in UKCS.

A challenging 25% reduction in capital and operating expenditures will, on the other hand, open up fields with P50 reserves at 9.1 mmboe and above. Game changing technological leadership, which is assumed to deliver a minimum 50% reduction in expenditures, can potentially make individual fields with 5.8 mmboe economic, leading to an overall UKCS prize of 1,060 mmboe. This will require USD 19 B in capital expenditures and USD 16 B in operating expenditures. Implementation of above will require serious collaboration between industry, regulator and academia while ensuring that risk taking in small pools is incentivised.

Further research should consider economic optimization for actual North Sea clusters with small pools and their actual geological and operational possibilities, rationalization of third party tariffs, experience of developing small offshore pools in India and Nigeria for best practices implementation in UKCS and incentivisation of small pool development through fiscal measures.
DECLARATION

This final report is my own composition and has not been submitted previously for any other degree. Where the work of others has been utilized this has been clearly indicated and the sources acknowledged.

Syed Mustafa Amjed

3 August 2015
ACKNOWLEDGEMENTS

Subsequent to publication of Wood Review in February 2014, the UK Government implemented a series of steps to support the oil and gas industry in UKCS, viz. formation of an independent regulator and fiscal changes to name a few.

Moreover, through private public partnerships such as National Subsea Research Initiative (NSRI) and Technology Leadership Board (TLB), focused actions are being taken to increase awareness and develop implementable solutions for issues faced by the UKCS.

This research project was commissioned by NSRI, as one of their initiatives related to development of small pools, and conducted under the supervision and guidance of Dr. Gordon Drummond, Project Director, NSRI. The project was also introduced to the Small Pools Committee working under TLB which has the mandate to develop a range of technology based proposals to enhance recovery from small pools.

For steering the development of financial model, provision of data inputs and general oversight for this project, Dr. Gordon co-opted the support of Graham Whitehead and Nick Sille; who very kindly devoted extensive time and effort to this work and provided all required industry based information on a timely basis.

Peter Blake suggested that project spend be evaluated from a probabilistic perspective and totally changed for the better the dynamics of the work as originally conceived while John Scrimgeour shared his valuable small pool development experience to complement the analytical methodology.

Dr. Alex Brasier was always there to review and offer guidance for the project. Most of all, Professor Alex Kemp took the time out to study the project objectives and provide essential pointers on relationships to study.

And special thanks is due to Dr. Gordon Drummond for conceiving the project and believing in my ability to execute the same.

Thank you all.

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NOMENCLATURE

B : billion  
bbl : barrel  
boe : barrel of oil equivalent  
CAPEX : Capital Expenditure  
DECC : Department of Energy and Climate Change  
DPI : Discounted Profitability Index  
GBP : Great Britain Pound  
GDP : Gross Domestic Product  
IRR : Internal Rate of Return  
KMs : kilometers  
M : million  
mmboe : million barrels of oil equivalent  
NPV : Net Present Value  
NSRI : National Subsea Research Initiative  
OPEX : Operating Expenditure  
RFCT : Ringfence Corporation Tax  
SC : Supplementary Charge  
SPD/s : Small Pool Development/s  
TLB : Technology Leadership Board  
UK : United Kingdom  
UKCS : United Kingdom Continental Shelf  
USD : United States Dollar
1.0 INTRODUCTION

The Oil and Gas Industry operating in the UKCS employs over four hundred thousand personnel across the UK; is UK’s largest industrial investor, having undertaken capital expenditure of GBP 14 billion in 2013; and provided 67% and 53% of UK’s oil and gas demand respectively in 2012 (Wood, 2014). Furthermore, as far as actual corporate business plans are concerned, almost 10 billion boe (barrel oil equivalent) can be produced from the UKCS over the next 40 years (Oil & Gas UK, 2015). However, under the current economic environment of lower crude prices and rising costs, the question is of a very fundamental nature : at what cost?

Given that UKCS is one of the most mature offshore basins in the world, production peaked at 4.6 million boe per day in 1999 and has been in a continuous decline since then. The UKCS produced only 1.42 million boe per day in 2014 which is a far cry from the hey days of the 90s. The increase in capital expenditures and field development over the last few years, though, are expected to boost production levels for a few years. However, there are no significant investment forecasts beyond 2018 (Oil & Gas UK, 2015).

The existential risks that the UKCS faces as an industry in transition can be classified into two major categories; resource related and commercial. Resource related risks relate to the fact that UKCS discovery size has averaged at 25 million boe over the past 10 years, and that 90% of current fields produce less than 15,000 boe per day (Wood, 2014). Commercial risks mainly include production efficiency declines to 60%, reduction in exploration activity, net margin pressures in view of much lower oil prices and rising operating costs, lack of vigorous fiscal reform historically (Samuel, 2015) and consequent lack of commercial interest in marginal & small fields and pre-mature abandonment of mature reservoirs. As Deirdre Michie recently mentioned, the UKCS oil and gas industry now must become sustainable in a USD 60/bbl oil (Michie, 2015).

Furthermore, for the first time since 1978, UKCS cash flows turned negative in 2014. It could be argued that this is due to the GBP 14.8 billion capital investment undertaken in 2014. But the fact remains that investors do not chase negative cash flows. To retain investor interest in the UKCS, cash flows need to become positive as soon as possible.
If the UKCS industry wants to focus on growth, as opposed to mere survival through cost reduction measures, out of box solutions need to be developed for each of the highlighted risks. Given the huge infrastructure and knowledge base that is available to the industry in UK, a renewed entrepreneurial spirit might just be the need of the day to effectively throw off the “sunset industry” label and welcome a new era of growth and industry leadership.

Therefore, it is essential to focus on improving management and cost profiles in all aspects of the industry, including development of small pools, reducing costs and ensuring economic viability and sustainability.
2.0 RESEARCH PROBLEM

In an environment where average discovery size is 25 million boe and likely reducing further, it is essential to plan for commercial production from small pools which are financially challenging but constitute a significant part of UKCS resources. The research project under consideration is focused on determining macro level financial guidelines and metrics that allow commercialization of small pool developments in mature basins and which are expected to produce between and 3 million boe and 15 million boe individually, as highlighted in exhibit given below. This will also support the extraction of the remaining 12 to 24 billion boe resources/reserves in the UKCS by targeting almost 200 of such small pools that are currently undeveloped in UKCS and could potentially contribute 1 to 1.5 billion boe in future production. It can also be assumed that further discoveries will also be made in the same range.

In view of the above, the research question has been framed as follows:

**What changes are required in the financial profile of Small Pool Developments in the UKCS to maximize economic recovery and extract value from the discovered Small Pool Developments (SPDs) and not yet discovered small reservoirs?**

Subsidiary questions that will be addressed include the following:

- What financial limits including Capital Expenditure (CAPEX), Operating Expenditure (OPEX), Net Present Value (NPV) and associated probabilities circumscribe the development of Small Pools?
- What is the pool size threshold in the 3-15 mmboe range that can be made economic under above limits and possible further cost reductions?
- What fiscal regime initiatives / modifications may further improve the financial profile of Small Pool Developments (SPDs)?
- How are the economics of Small Pools impacted by game changing technologies / business models that significantly impact Capital Expenditure (CAPEX) and Operating Expenditure (OPEX)?
- What is the big prize available to the UKCS if Small Pools are made economically viable by game changing technologies / business models?

This project develops targeted metrics that can potentially make SPDs economical and covers tariff based infrastructure usage, development issues encompassing complexity, size and distance amongst others.

Furthermore, development of such targeted metrics could also play a contributory role towards prolonging the life of ageing reservoirs and delaying abandonment, development of niche markets for smaller operators and maintaining UK’s position as an industry innovator in oil and gas sector.
3.0 INTERNATIONAL EXPERIENCE REGARDING SPDs

It is interesting to note that as discovery of mega oil fields becomes more and more difficult both offshore and onshore, oil and gas producing countries are beginning to look at small pools much more aggressively and working towards developing systems and technologies to target them. There is a tacit understanding in the world of oil economics and production that currently marginal and uneconomic small pools will provide a larger share of world oil and gas production going forward (Kaiser, 2010). However, a review of annual financial reports and related disclosures by oil majors does not elicit a significant focus on small pools given that a detailed review of company strategies is beyond scope of this project. On the contrary, there is an impression of cutbacks being applied to marginal projects and a disconnect between actual focus and the idea that marginal and small pools are essential contributors to production.

Nigeria has successfully implemented a marginal field development programme (George Osahon, Director, Petroleum Resources, Ministry of Petroleum Resources, Nigeria, 2013). The Nigerian Petroleum Ministry held that International Oil Companies tend to leave significant resources undeveloped based on their commerciality and internal metrics. The Petroleum (Amendment) Decree No. 23 of 1996 was executed to award such un-developed fields to local and indigenous companies and labeled such field as “marginal”. Further rules and guidelines were developed in 2001 to manage the farm-out and operation of such fields. Subsequently, 24 fields were awarded out of which 9 (38%) were producing as of 2013. 18 operators risk losing their license as they have failed to develop the fields awarded to them by March 2015. It is interesting to see that initial reserves for these 9 producing fields were assessed at 141 mmboe in 2004, averaging 15.67 mmboe per field. However, the same reserves were assessed at 302.62 mmboe in 2013. Development of marginal fields also contributed to generation of additional reserves for the province. It may be noted that in Nigeria, fields which have not been developed for 10 years since discovery can also be classified as “marginal fields”.

Oil and Natural Gas Corporation Limited of India (ONGC), a Global Fortune 500 company, has run a very successful marginal field development programme in Western Offshore blocks. The company views small pools and marginal fields as part of strategy to mitigate production declines from mature fields (ONGC, Annual Report 2013-2014). ONGC has successfully monetised 25 of 58 Western Offshore marginal fields and 5 of 21 Easter Offshore fields mainly through clustering and utilizing near-by facilities. Total current production from such pools is 99,000 boe per day with a simple average of 3,960 boe per day over 25 Western Offshore marginal fields (Adesh Kumar, n.d.).

The “Roadmap for Reduction in Import Dependency in the Hydrocarbon Sector by 2030” published in September 2014 and commissioned by Ministry of Petroleum and Natural

The above may be read in context with the following quote from Wood Review page no. 25:

A significant amount of future production will come from exploiting a large number of small, marginal fields, so the fiscal and regulatory environment must encourage such investment. However, this will also require industry collaboration, use of economies of scale and a regulator that will minimise bureaucracy, facilitate and support developments and help remove obstacles.

It may be mentioned that fiscal, technological and economic situation in above mentioned countries differs significantly from that of UK, however, the problem and dilemma of developing small pools is international in nature and solutions can be found.
4.0 DATA & METHODOLOGY

4.1 FINANCIAL MODELLING
The research question required development of financial models to process the data inputs. Two separate deterministic and probabilistic financial models were developed in Excel and @RISK respectively along with variants. The models replicate the dynamics of SPDs in the UKCS with inputs relating to production, revenue, capital expenditures, operating expenditures, fiscal regime and outputs relating to pre-tax cash flows, taxation, post tax cash flows and valuation metrics with subsea tiebacks to nearest infrastructure as access mode. Capital costs were built up from a base industry figure by adding increments for pipeline and subsea architecture, complexity, geology and composition. Operating costs covered variables such as host tariff, transport tariff and fixed platform costs. Outputs were based on application of an economic limit test and discount rates, and include financial metrics such as Cash Flows, Net Present Values, Internal Rates of Return, Profitability Indices and their probability distributions.

4.2 DATA & METHODOLOGY
Input data to replicate production of SPDs was obtained from DECC. Dead pools within the 3 mmboe to 15 mmboe range were selected as their production profile is completely known. Industry data was collected through face-to-face meetings with industry personnel. Data in public domain was also utilized.

The model logic, including fiscal calculations, were verified in meetings held with representatives from Enquest, Centrica Energy and Subsea 7. The process involved detailed model flowcharting, discussion and validation of results through changing input parameters and observing effect on outputs in view of actual industry experience with small pools and also in view of output from standard industry models used by operators.

Current industry data was used to arrive at a base case profile for a typical SPD in both discrete and probabilistic models. Critical inputs were ranked and then their sensitivities assessed by modifying their distributions to arrive at data points at which SPDs could become probabilistically economic. An approach of arriving at approximate benchmarks through deterministic models and then validating them through Monte Carlo simulation was used to enhance the validity of conclusion drawn. P50 level post tax Discounted Profitability Index at 10% discount rate with a target of 0.3 was used as threshold economic statistic to arrive at targets for inputs to serve as guideposts for industry. It may be noted that probabilistic models give a range of outcomes but deterministic model determines what actually materializes. Both need to work in coordination for robust conclusions.
5.0 RESULTS

A typical small pool under current oil price environment is clearly uneconomic and returns negative discounted valuations even at pre tax level. Expediting development timeframe to two years does not improve the valuations.

5.1 CURRENT ENVIRONMENT

Probabilistic assessment of production under current economic environment shows a 50% chance of 7 mmboe being extracted from a typical small pool development prior to abandonment with 70% chance of nil production in year 6 after first oil. Total CAPEX and OPEX at 50% probability are expected to be within USD 213 M and USD 126 M respectively with negative NPV at 10% discount rate. However, the same are economic at a threshold reserve level of 11.8 mmboe. Deterministically, at an oil price of USD 91/bbl, small pools can start looking attractive, however, combinations of higher mean oil price, a higher reserve level and CAPEX undermine the overall small pool prize.

Tariffs paid to platform owners are a major drain on the financial viability of small pools and need to be rationalized from business and fiscal perspective. This could be attained through increasing utilization of infrastructure, negotiations and fiscal reform. Nevertheless, small pool exploitation requires challenging cost reductions and technological innovations as outlined herein.

5.2 COST REDUCTION OUTCOME

A 25% reduction in CAPEX and OPEX components, not an easy endeavour by any chance, will open up pools with P50 reserves in excess of 9.1 mmboe while returning post tax NPV at 10% of USD 51 M, post tax DPI of 0.31 and post tax IRR of 21% at P50 level. However, CAPEX will have to be limited within USD 174 M which covers infrastructure distance of up to 15 kms while OPEX will have to be maintained within USD 128 M at P50.

5.3 TECHNOLOGICAL BREAKTHROUGH OUTCOME

Technological breakthroughs, significant industry collaboration and effective regulation leading to over 50% reductions in CAPEX and OPEX will release fields up to 5.8 mmboe P50 reserves for development assessed at post tax DPI at 10% of 0.3. CAPEX and OPEX will have to be limited within USD 122 M (USD 21/boe) and USD 74 M (USD 13/boe) respectively at P50 level.
5.4 UKCS SMALL POOL POTENTIAL

Overall small pool development prize for the UKCS, if the above transpires, is a potential production of 1,060 mmboe at P50 level which will require CAPEX of USD 19 B in current terms and OPEX of USD 16 B. Pre tax net cash is a potential USD 26 B with USD 11 B going to the exchequer. However, to promote risk taking in UKCS small pools in view of a plethora of investment options internationally, fiscal incentivisation may also be utilized.
6.0 DISCUSSION - BASE CASE

Discussion starts with a representation of Base Case analyses and major relevant variables to understand the current small pool development scenario; followed by assessment of changes required therein to make them viable. It may be mentioned that the following covers small pools in North Sea from a probabilistic perspective primarily. Individual pools and clusters are always peculiar and have their own specific properties to be dealt with, covering which is beyond the scope of this project.

6.1 DETERMINISTIC ASSESSMENT

An initial deterministic base case for a typical small pool at an oil price of USD 60/bbl with a differential of 7.5% and with reserves of 7 mmboe returns a pre-tax net cash of USD 57.55 M (inclusive of abandonment expenditures) and a NPV of USD (9.85) M at 10% (Table 1). The producing life is 5 years with fixed host platform based operating costs being charged in during the third year of production.

Capital expenditures are based on mean of distance of 17.5kms from nearest infrastructure. Mean values were taken for Composition, Geology and Size increments. Total deterministic capital expenditure in real terms is USD 221 M. With a Discounted Profitability Index (DPI) of (0.05) at 10%, a “typical” small pool based on a mean lifetime production of 7 mmboe is uneconomic even at a pre-tax level. Post-tax NPV at 10% drops to USD (22.88) M.

<table>
<thead>
<tr>
<th>TABLE 1</th>
<th>BASE CASE WITH MEAN VALUES AND 3 YEAR DEVELOPMENT TIMEFRAME</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PRE TAX NET CASHFLOWS</strong></td>
<td></td>
</tr>
<tr>
<td><strong># YEARS FROM FIRST OIL</strong></td>
<td><strong># YEARS FROM FIRST OUTFLOW</strong></td>
</tr>
<tr>
<td>PostEffChange Annual Production</td>
<td>6.07 mmboe</td>
</tr>
<tr>
<td>Gross Revenue</td>
<td>422.47 USD M MOD</td>
</tr>
<tr>
<td>Total CAPEX</td>
<td>222.69 USD M MOD</td>
</tr>
<tr>
<td>Total OPEX</td>
<td>127.07 USD M MOD</td>
</tr>
<tr>
<td>Abandonment Cost</td>
<td>15.16 USD M MOD</td>
</tr>
<tr>
<td>Total Outflows</td>
<td>584.92 USD M MOD</td>
</tr>
<tr>
<td>Pre Tax Net Cashflows</td>
<td>57.55 USD M MOD</td>
</tr>
<tr>
<td>Cumulative PT Net Cashflows</td>
<td>57.55 USD M MOD</td>
</tr>
<tr>
<td>CAPEX</td>
<td>31.85 USD/bboe</td>
</tr>
<tr>
<td>OPEX</td>
<td>18.23 USD/bboe</td>
</tr>
<tr>
<td>Excess OPEX due to Platform - Fixed</td>
<td>60.28 USD M MOD</td>
</tr>
<tr>
<td>Excess OPEX</td>
<td>8.65 USD/bboe</td>
</tr>
<tr>
<td>Total OPEX</td>
<td>120.58 USD M</td>
</tr>
<tr>
<td>PV Excess OPEX due to Platform @ 10%</td>
<td>35.87 USD M</td>
</tr>
</tbody>
</table>

NPV pre tax | 0 | 57.55 USD M |
NPV pre tax | 0.05 | 19.37 USD M |
NPV pre tax | 0.1 | (9.85) USD M |
IRR pre tax | 0.08 |
If the development time is reduced from the expected 3 years taken above to 2 years, pre-tax net cash decreases to USD 51.76 M due to differing revenue and cost inflation factors. However, negative NPV at 10% decreases to USD (3.94) M giving a DPI at 10% of (0.02). Deterministically, it is clear that expediting development would not make a “typical” small pool economic. (Table 2). Pre tax IRRs at 8% and 9% are not attractive in view of industry norms.

<table>
<thead>
<tr>
<th>Pre Tax Net Cashflows</th>
<th>51.76</th>
</tr>
</thead>
</table>

Though the focus of this report is a probabilistic review, which follows, it is interesting to note the deterministic behavior of operating costs, especially, the share that goes to the platform owner as fixed tariff as opposed to variable tariff.

The model assumes that initially OPEX for a small pool is based on variable costs covering transportation and host infrastructure, both charged at a per barrel rate. However, if OPEX (platform’s revenue) going to platform operator drops by more than 40% of peak OPEX, then fixed platform fee is charged to the small pool operator. A mean annual platform cost of USD 92.5 M has been assumed with 4 users. Conversion to fixed fee based on platform costs as opposed to continuing to pay a variable rate based on barrels leads to a net increase of USD 60.28 M in OPEX (Table 1) having a present value of USD 33.87 M at 10% discount rate; an amount which appears excessive and is currently taxed at lower levels. Had the field continued to produce at variable OPEX, this amount would be added back to cash flows and result in an increase in pre-tax DPI at 10% discount rate to 0.11 in base case scenario.
It is understandable that given the huge outlays involved in running offshore platforms, providing host facilities to a small field continuously on variable rates may not be practical for the platform owner but this component takes away a significant amount of cash from the small field and is a factor which needs serious consideration.

6.2 LIFETIME PRODUCTION
We will begin our discussion of base case probabilistic results by assessing Lifetime Production / reserves limited by an economic limit test to the point where revenue meets operating expenses. A typical small pool crude resource potential at P10 and P50 levels is 5.512 mmboe and 8.461 mmboe respectively which transpires into 4.141 mmboe and 7.026 mmboe of potential production / reserves at P10 and P50 levels subsequent to application of an economic limit test (Figure 3). Due to the size and current economic constraints a significant amount of resources will not be extractable.

![Figure 3 – Lifetime Production mmboe](image)

Since lifetime cumulative production from a small pool is subject to an economic limit test, and is primarily dependent on production in individual years, international oil price and OPEX, it is interesting to note that a component of OPEX viz. “Users of Platform” as an
input variable is ranked second on the tornado chart ahead of “International Oil Price”. International oil price is an uncontrollable variable but “Users of Platform” is a variable which can be optimised for a cluster through managerial intervention (Figure 4). However, first year’s production has the most impact as the overall small pool production is modeled based on factors obtained from DECC small pool data which are then applied to first year’s production generated through Monte Carlo simulation.

![Tornado Lifetime Production mmboe](image)

**Figure 4 – Tornado Lifetime Production mmboe**

From a deterministic perspective, the Base Case scenario shows that a typical pool can produce for a maximum of 5 years and that production declines significantly from year 2 of production to year 3 onwards (Table 1). However, probabilistic analysis shows that there is a 1% chance of nil production in year 3 of production with P10 and P50 levels being 0.99 mmboe and 1.54 mmboe respectively. This shows the risky nature of small pools as evident from the actual production profiles from North Sea.

2021 or fourth year of production is interesting in the sense that there is a 20% chance that production will be nil (Figure 5). However, a look at the resource based production profile for the same year reveals a P20 production potential of 0.619 mmboe (Figure 6). This means that there is a significant chance that year four of production will be the abandonment year in which abandonment expenses will be incurred. Furthermore, “Users of Platform” is the second ranked factor affecting production in this year after “Annual Production 2018” which is the first year’s production. This factor relates directly to fixed
OPEX which is a significant drain on small pool cash (Figure 7). Deterministic analysis show abandonment in year six of first oil. As per Monte Carlo analysis, probability of nil production in year 6 is 70%, whereas significantly there is 20% and 45% probability of nil production in years 4 and 5 respectively. This signifies that abandonment can transpire much earlier in pool life as well emphasizing the riskiness of small pools. This also raises the question as to whether 10% is appropriate as a discount rate for small pools, which some operators justify through life extension discussions, an argument which is beyond the scope of this report.

![Figure 5 - Lifetime Production 2021 mmboe](image)
Figure 6 – Annual Production 2021 mmboe

Figure 7 – Tornado Lifetime Production 2021 mmboe
6.3 REVENUE
Revenue is based on a simulated initial international crude price with a 7.5% local differential and a 2% annual inflation rate based on global central bank inflation targets. It could be argued that 2% annual inflation rate may be optimistic given current negative yields on a number of sovereign European debt securities. It is also possible to do a simulation of oil prices for each year gradually increasing the standard deviation to account for increasing uncertainty which will negate the need to have an inflation target for oil prices. However, for consistency over the life of pool, a 2% inflation factor has been used. Initial prices as per Monte Carlo analysis range from USD 46/bbl at P10 to USD 59/bbl at P50 with USD 76/bbl being the P90 level (Figure 8).

Lifetime revenue at P10 and P50 levels is USD 230 M and USD 424 M respectively with the mode being USD 251 M (Figure 9), which is approximately 40% lower than the deterministic revenue of USD 422 M. However, the mean revenue at USD 507 M is higher but this is primarily due to the long tail of the distribution and may not be a realistic statistic in this case to consider. The significantly lower P10 revenue is inline with the fact that chances of abandonment increase significantly from fourth year of production onwards where there is a 20% chance of nil revenue.
6.4 CAPITAL EXPENDITURE

Since small pools are spread throughout the North Sea with some close to existing facilities and others being stranded reservoirs, such as in Northern North Sea, and considering that all pools are different in their physical and compositional properties, Capital Expenditure for this project has been developed probabilistically taking into account Pipeline & Subsea Architecture, Composition uncertainty, Geological uncertainty and Size variability as applicable to subsea tiebacks and loading them on to baseline CAPEX covering one well and platform modifications. Lognormal and triangular distributions were used for modeling additional increments to baseline capital expenditures. Development of pool for base case was assumed over three years.

Deterministically, capital expenditure was assessed at USD 221 M per typical small pool based on mean values for factors identified above (Table 3). Probabilistic distribution provides a better outlook though, with the full range of CAPEX running from a minimum of USD 132 M to a maximum of USD 311 M depicting an analogue field; given that CAPEX is peculiar to each reservoir. USD 214 M is the mean CAPEX which is quite close to the deterministic value (Figure 10).
### Table 3: Capital Expenditure Breakup

#### Outflows

<table>
<thead>
<tr>
<th></th>
<th>2015</th>
<th>2016</th>
<th>2017</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Baseline CAPEX</strong></td>
<td>70.00</td>
<td>23.80</td>
<td>23.10</td>
</tr>
<tr>
<td><strong>Pipeline &amp; subsea architecture</strong></td>
<td>70.00</td>
<td>23.80</td>
<td>23.10</td>
</tr>
<tr>
<td><strong>Composition Increment</strong></td>
<td>17.50</td>
<td>5.95</td>
<td>5.78</td>
</tr>
<tr>
<td><strong>Geology Increment</strong></td>
<td>10.50</td>
<td>3.57</td>
<td>3.47</td>
</tr>
<tr>
<td><strong>Size</strong></td>
<td>52.50</td>
<td>17.85</td>
<td>17.33</td>
</tr>
</tbody>
</table>

**Total CAPEX**

<table>
<thead>
<tr>
<th></th>
<th>220.50</th>
<th>74.97</th>
<th>72.77</th>
<th>72.77</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Baseline CAPEX</strong></td>
<td>70.70</td>
<td>23.80</td>
<td>23.33</td>
<td>23.56</td>
</tr>
<tr>
<td><strong>Pipeline &amp; subsea architecture</strong></td>
<td>70.70</td>
<td>23.80</td>
<td>23.33</td>
<td>23.56</td>
</tr>
<tr>
<td><strong>Composition Increment</strong></td>
<td>17.67</td>
<td>5.95</td>
<td>5.83</td>
<td>5.89</td>
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<tr>
<td><strong>Geology Increment</strong></td>
<td>10.60</td>
<td>3.57</td>
<td>3.50</td>
<td>3.53</td>
</tr>
<tr>
<td><strong>Size</strong></td>
<td>53.02</td>
<td>17.85</td>
<td>17.50</td>
<td>17.67</td>
</tr>
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</table>

**Total CAPEX**

<table>
<thead>
<tr>
<th></th>
<th>222.69</th>
<th>74.97</th>
<th>73.49</th>
<th>74.23</th>
</tr>
</thead>
</table>

#### Figure 10 - Total CAPEX USD M

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However, given that CAPEX is always susceptible to exceeding budgeted expenditures, it may be prudent to consider the P50 to P90 range for expected levels. Critical factors for overall CAPEX turn out to be primarily Size of pool and Pipeline and Subsea Architecture & distance from infrastructure. Triangular distributions were assumed for these variables within a range of 5 kms to 30 kms under the assumption that a tieback within 5 kms would already have been done and there is possibly a perceived limit of 30 kms to tiebacks, though there may be existing outliers. As per simulation, there is a 90% probability of the distance to nearest infrastructure being in excess of 9 kms (Figure 11).

![Pipeline & Subsea Architecture KMs](image)

**Figure 11 – Pipeline & Subsea Architecture Kms**

However, the distance to cover is between 9 kms and 23 kms at 80% confidence level and the overall cost of laying the pipelines and architecture will be USD 61 M and USD 94 M at P50 and P90 levels respectively (Figure 12).
It may be noted that the above distribution to cover Northern North Sea and West of Shetland may require different simulation assumptions to account for stranded pools.

Size increments were further added to the so far calculated CAPEX to cover the additional costs and additional wells that would be incurred to develop incrementally larger pools ranging from 3 mmboe to 15 mmboe with a maximum factor of 1.5x applicable to largest of the pools. The broad assumption underlying this is that one well will be drilled per 5 mmboe of reserves which could either be a production or injector well for larger pools. Size increment was assessed at USD 23 M to USD 52 M at P10 and P50 levels respectively.

Composition and geological uncertainty of the pool was also simulated to account for complexity of the reservoir. CAPEX increment for composition was assessed at USD 22 M and geology at USD 13 even at P90 levels.

Base case CAPEX/boe comes out at USD 30/boe at P50 and USD 54/boe at P90 levels (Figure 13). CAPEX/boe is primarily affected by lifetime reservoir production followed by resource range between approximately 3 mmboe to 15 mmboe and distance to nearest infrastructure (Figure 14).
Figure 13 – CAPEX USD/boe

Figure 14 – Tornado CAPEX USD/boe
6.5 OPERATING EXPENDITURE

Operating costs are based on the assumption of subsea tiebacks to nearest infrastructure and classified into variable and fixed. To model general practice in UKCS, OPEX is initially based on variable transport per barrel and variable host tariff per barrel with the assumption that in the year in which variable costs decrease by more than 40% of peak OPEX (i.e. revenue to the infrastructure owner decreases by 40% because of production decline), variable host tariffs are replaced by fixed platform costs (commonly known as cost-share). Fixed platform costs applicable to small pools is a function of overall annual platform costs divided by the number of users already accessing the infrastructure. As a result OPEX/boe is fairly low in the first 2 years and when fixed platform costs hit, OPEX/boe rises significantly as production declines.

Deterministically, OPEX is USD 127 M over 5 years of producing life (Table 1), with average OPEX/boe increasing from USD 9/boe in first 2 years of production to USD 21/boe, USD 37/boe and USD 55 in years 3, 4 and 5 respectively. The increase is mainly due to fixed platform costs being charged to a declining production from the pool from year 3 of production onwards as opposed to continuing to pay variable costs charged on a per barrel basis. Number of users accessing the platform plays a pivotal role in cost charges. For deterministic assessment, 4 users including the small pool operator have been considered, whereas, the probabilistic distribution covers 2 to 5 users, albeit with a discrete distribution of equal probabilities; as a platform cannot have 2.5 or 4.2 users.

Probabilistic distribution of OPEX takes into account variable tariffs and fixed platform tariffs substituted as per the 40%-revenue-decline-to-platform-owner argument. P50 level operating expenses are USD 126 M while the range between P10 and P90 levels signifying 80% confidence is from USD 76 M to USD 222 M (Figure 15).

Since OPEX/boe charged in individual years deterministically varies significantly due to production decline and ranges from USD 9/boe to USD 55/boe, this merits a study of individual years to understand the dynamics fully.
OPEX/boe in year 2018 or first year of production has a mean and P50 value of USD 10/boe with a P90 level of USD 11/boe which is fairly close to the deterministic values. This is the year in which all operating costs are charged at a variable rate. In the second year of production, where production is expected to be maximum, the mean OPEX/boe declines to approximately USD 9/boe with P50 and P90 levels at USD 9/boe and USD 10.5/boe. However, in the third year of production, where there is a 1% minute possibility of nil production, the mean OPEX/boe shoots up to USD 24/boe with a P90 level of USD 40/boe (Figure 16). It is interesting to note that apart from well production, Users of Platform and consequently platform costs are major variables affecting OPEX in the third year as it shoots up (Figure 17).
Figure 16 – 2020 OPEX/boe USD

Figure 17 – Tornado 2020 OPEX/boe USD
In year four of production, there is a 20% chance that OPEX will be nil confirmed by a mode of zero. This shows that there is a significant chance of the third year being final year of production (Figure 18). P50 level OPEX at USD 30/boe is lower than the deterministic figure of USD 37/boe for the same year due to the reason that the deterministic figure does not take into account the chance of abandonment in fourth year. However, P90 level OPEX at USD 52/boe indicates that production is becoming increasingly costly as time progresses.

In the fifth year of production the probability of nil OPEX increases to 45% with P90 level at USD 57/boe. However, the model shows that under very peculiar circumstances of high oil prices, production may be possible till the 10th year of production.

During the lifetime of the small pool, OPEX is expected to shift from a variable rate to a fixed rate as the platform owner tries both to maintain or increase his revenue and also cover his expenses. This shift in tariff rates is a matter of negotiation between the operator and the platform owner. However, the present value of additional payments to platform owner through the life of a pool could range from a P10 level of USD 18 M to a P90 level of USD 49 M with P50 level at USD 31 M which is fairly close to the deterministic assessment at USD 34 M (Figure 19).
However, it is essential to reiterate here that the above range is purely theoretical as the actual value is subject to negotiation and business conditions and it should not be assumed that a pool can continue to produce at variable rates. The cost of the platform has to be met in its own right and the platform owner will always try to maximize revenue. If platform costs are not met, the whole business model will fail.

6.6 PRE TAX NET CASH FLOWS & VALUATION

Under base case assumptions, there is a 30% probability that pre tax net cash flows will be negative with P50 level at USD 67 M. The probability distribution is quite skewed to the right which is leading to a relatively high mean of USD 137 M which should be disregarded, however, the mode is at USD 3.48 M and P10 value is USD (89) M (Figure 20). As expected, production and international crude prices are the major factors that influence pre tax net cash flows (Figure 21).
Figure 20 – NPV pre tax @ 0% USD M

Figure 21 – Tornado NPV pre tax @ 0% USD M
NPV at 10% discount rate gives a very unattractive investment profile with a negative NPV at P50 level and a 25% chance of negative IRR (Figure 22 & 23).

**Figure 22 – NPV pre tax @ 10% USD M**

**Figure 23 – IRR pre tax**

<table>
<thead>
<tr>
<th>Statistics</th>
<th>NPV pre tax USD M</th>
</tr>
</thead>
<tbody>
<tr>
<td>1%</td>
<td>-$163.07</td>
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<tr>
<td>5%</td>
<td>-$129.90</td>
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<tr>
<td>10%</td>
<td>-$100.78</td>
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<tr>
<td>15%</td>
<td>-$83.03</td>
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<table>
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<th>Statistics</th>
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<td>90%</td>
<td>45.72%</td>
</tr>
<tr>
<td>95%</td>
<td>54.81%</td>
</tr>
<tr>
<td>99%</td>
<td>73.44%</td>
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</tbody>
</table>
With a base case mean cash exposure of USD (216) M and a Discounted Profitability Index (DPI) at 10% coming out negative at P50 level, it can be established that small pools are certainly not economic in current business environment. Post tax figures show an even worse picture with chance of negative NPV at 10% increasing to 55%.
7.0 DISCUSSION – INCREMENTAL CHANGES TO BASE CASE

In this section, we will discuss the changes that need to be made to the profile of a typical small pool reservoir to make it economic and attractive for niche investors if not oil majors. The threshold economic target will be post tax Discounted Profitability Index at 10% of 0.3 to serve as a benchmark against which changes will be evaluated.

7.1 POSSIBILITY OF INCREASE IN RESOURCES

Current production profile developed on the basis of UKCS small pools with resources between 3 mmboe to 15 mmboe deterministically gives a lifetime production / reserve of 6.97 mmboe and a P50 level of 7.06 mmboe. Given that all other factors stay the same, an increase in threshold lifetime production to 11.49 mmboe increases the life of pool by one year (Table 4). Net cash flows increase to USD 281 M while pre tax NPV at 10% increases to USD 136 M from a USD (10) M. Post tax NPV at 10% come out at USD 62 M with a post tax IRR of 21%. Post tax DPI at 10% come out at exactly 0.30 which is a figure that is normally acceptable to small pool operators.

Deterministically, it appears as if a small pool with reserves of 11.5 mmboe may be economic for operators given everything else stays constant.
Before looking at probabilistic results, it makes sense to clarify, that there is a precedence, as in Nigerian and Indian experience with small pools, where reserves have been reassessed post development (refer Section 3.0). Which means that initially lower reserve assessment could also potentially prove economic later on and initiating development from a lower reserve assessment becomes a managerial judgment call.

Probabilistic results show a P50 reserve level at 11.8 mmboe and P90 at 23.5 mmboe. The chance of negative net cash flows decreases to about 5% as compared to 30% in base case with 75% chance that pre tax net cash flows will be greater than USD 100 M (Figure 24).

The above is a significant improvement over base case but probably still not attractive enough for risk aware operators as pre tax NPV at 10% has P10 and P50 levels at USD (26) M and USD 145 M. Pre tax DPI at 10% is still negative at P15 and increases to 0.73 at P50 while post tax DPI at 10% is (0.16) at P10 and 0.34 at P50 (Figure 25).
Given that all financial variables stay constant, an increase in resources from base case by 0.57x to a P50 level of 11.8 mmboe is arguably a very high threshold and leaves lot of resource underground, however, provides a marker for further analysis. It could be argued that there are organizations which based on their tax management may find the above attractive but those would be specific cases. As far as a company which pays tax is concerned, the above mentioned profile of a small pool looks risky even at P50 levels, excluding high risk appetite organisations.
An interesting aspect from a tax perspective is that in the above profile, even after improvement, there is a 20% chance that Supplementary Charge payable will be nil (Figure 26).

### 7.2 OIL PRICE INCREASE

The cases so far discussed have involved simulation of oil prices for the first year of development and then application of a stable price inflation rate yearly. We will now evaluate the realistically deterministic price that can make SPDs economic and the related reserve level threshold.

An international crude price of USD 91/bbl applicable to the base case returns a deterministic post tax DPI at 10% of 0.3, i.e. to say that a USD 91/bbl international price will make SPDs economic. However, this is a high price under current circumstances. Assuming a more realistic price at USD 70/bbl combined with a resource increase factor of 0.33x returns a post tax DPI at 10% of 0.3 at lifetime production of 9.8 mmboe (Table 5).

<table>
<thead>
<tr>
<th>TABLE 5</th>
<th>USD 70/BBL PRODUCTION INCREASED BY 33% AND 3 YEAR DEVELOPMENT TIMEFRAME</th>
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</thead>
<tbody>
<tr>
<td><strong>POST TAX NET CASHFLOWS</strong></td>
<td></td>
</tr>
<tr>
<td><strong># YEARS FROM FIRST OIL</strong></td>
<td><strong>1</strong></td>
</tr>
<tr>
<td><strong>POST YEARS FROM FIRST OUTFLOW</strong></td>
<td><strong>2015</strong></td>
</tr>
<tr>
<td>Total Cash Inflow</td>
<td>9.74 mmboe</td>
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<tr>
<td>Gross Revenue</td>
<td>690.99 USD M MOD</td>
</tr>
<tr>
<td>Royalty</td>
<td>- USD M MOD</td>
</tr>
<tr>
<td>Net Revenue</td>
<td>690.99 USD M MOD</td>
</tr>
<tr>
<td>Total CAPEX</td>
<td>223.69 USD M MOD</td>
</tr>
<tr>
<td>Total OPEX</td>
<td>163.75 USD M MOD</td>
</tr>
<tr>
<td>Abandonment Cost</td>
<td>15.21 USD M MOD</td>
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<tr>
<td>Total CAPEX, OPEX &amp; AIDN</td>
<td>407.75 USD M MOD</td>
</tr>
<tr>
<td>Pre tax Net Cashflow</td>
<td>283.24 USD M MOD</td>
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<tr>
<td>Royalties</td>
<td>89.58 USD M MOD</td>
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<tr>
<td>Post uplift SC Payable</td>
<td>31.87 USD M MOD</td>
</tr>
<tr>
<td>Post tax Net Cashflow</td>
<td>101.80 USD M MOD</td>
</tr>
<tr>
<td>Cumulative Post tax NCF</td>
<td>161.80 USD M MOD</td>
</tr>
</tbody>
</table>

| | | | | | | | | | | |
| | | | | | | | | | | |

Simulating the above conditions with a mean oil price of USD 70/bbl returns a P50 reserve level of 10 mmboe, albeit with still a 5% chance of negative pre tax cash flows. Net cash flows are USD 34 M and USD 293 M at P10 and P50 levels respectively (Figure 27). This simulation also leads to a 20% chance of nil Supplementary Charge payable while post tax net cash flows are USD 19 M at P10 and USD 166 M at P50 level.

Post tax NPV at 10% is interesting in the sense that even at an elevated mean oil price and higher production, which deterministically returns an acceptable project, Monte Carlo analysis still shows a 20% chance of negative NPV with P50 level at USD 70 M (Figure 28).
Post tax DPI at 10% discount rate returns a negative figure at P20 level and 0.35 at P50 level (Figure 29). It is apparent from this analysis that assuming an optimistic oil price mean at USD 70/bbl which returns P50 reserves at 10 mmboe still does not adequately
target UKCS small pool resource due to a high threshold reserve level and that too assessed at a higher mean oil price.

Therefore, further analysis will look at possible reductions in CAPEX and OPEX combined with simulated oil price with mean of USD 60/bbl with a view to arrive at a reserve threshold that accesses a significant number of undeveloped small pools in UKCS.
7.3 COST REDUCTIONS
In this section we look at the effect of realistic but challenging cost reductions, a maximum of 25%, that can be implemented within a timeframe of 1-2 years in the field covering both CAPEX and OPEX.

A reduction in base line CAPEX, which covers the cost of well and platform modification, by 25% and assuming a mean infrastructure distance of 13.5 kms reduces overall CAPEX by 25% down to USD 165 M deterministically from USD 220 M. This reduction in itself has no impact on pool economics and has to be complemented by a reduction in OPEX as well.

A maximum reduction of 25% in all OPEX constituents including annual platform costs that are apportioned to the pool in later years, combined with CAPEX reductions leads to a deterministic pre tax DPI at 10% of 0.40 and post tax figure of 0.17 (Table 6). This cost reduction extends the life of the pool to 6 years, however, does not make marginal pools economic except for perhaps investors with high risk appetite and very effective tax management.

Since a maximum possible 25% reduction in CAPEX and OPEX, which in itself is not an easy endeavour over the next 1-2 years is not sufficient for improving the economics of small pools, therefore, it has to be determined if there is a level of resources within the range of 3 mmboe to 15 mmboe that can serve as a reserve threshold before we check the probabilistic results based on these benchmarks. This confirms that under current situation, only a certain level of resource may be accessible from small pools and our modeling experiment with increasing threshold resource level in sections 7.1 and 7.2 will have a bearing on the analysis.
We can conclude from the analysis so far, that mere cost reductions may open up pools only at higher reserve levels while leaving significant resources underground. Hence, significant technological changes will be required to properly access the small pool prize in UKCS.
8.0 OPTIMISATION CASE 1 – A CHALLENGE

Continuing from the scenario developed in Section 7.3, increasing resources by a factor of 0.21x gives us a threshold deterministic reserve level of 8.9 mmboe. To summarise, a reduction of 25% in base case CAPEX (base line) and OPEX limited by a distance to infrastructure of 13.5 kms evaluated at a mean oil price of USD 60/bbl returns lifetime production level of approximately 8.9 mmboe, a pre tax NPV at 10% of USD 119 M, an after tax NPV of USD 56 M along with a post tax DPI of 0.35 (Table 7 and Table 8).

<table>
<thead>
<tr>
<th>TABLE 7</th>
<th>OPTIMISATION CASE 1</th>
<th>USD 60/BBL, CAPEX/OPEX REDUCED BY 25%, PRODUCTION INCREASED BY 21X</th>
</tr>
</thead>
<tbody>
<tr>
<td># YEARS FROM FIRST OIL</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>* YEARS FROM FIRST OUTFLOW</td>
<td>15</td>
<td>16</td>
</tr>
<tr>
<td>PostEffChange Annual Production</td>
<td>8.86 mmboe</td>
<td>-</td>
</tr>
<tr>
<td>Gross Revenue</td>
<td>538.84 USD M MOD</td>
<td>116.42</td>
</tr>
<tr>
<td>Total CAPEX</td>
<td>167.47 USD M MOD</td>
<td>50.38</td>
</tr>
<tr>
<td>Total OPEX</td>
<td>123.50 USD M MOD</td>
<td>-</td>
</tr>
<tr>
<td>Abandonment Cost</td>
<td>11.38 USD M MOD</td>
<td>-</td>
</tr>
<tr>
<td>Total Outflows</td>
<td>802.34 USD M MOD</td>
<td>16.38</td>
</tr>
<tr>
<td>Pre Tax Net Cashflows</td>
<td>236.40 USD M MOD</td>
<td>(55.38)</td>
</tr>
<tr>
<td>Cumulative PT Net Cashflows</td>
<td>220.20 USD M MOD</td>
<td>(103.38)</td>
</tr>
<tr>
<td>CAPEX</td>
<td>18.90 USD/bbl</td>
<td>-</td>
</tr>
<tr>
<td>OPEX</td>
<td>13.94 USD/bbl</td>
<td>-</td>
</tr>
<tr>
<td>NVP pre tax</td>
<td>0.1</td>
<td>118.81 USD M</td>
</tr>
<tr>
<td>IRR pre tax</td>
<td>0.32</td>
<td>-</td>
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<tr>
<td>Discounted PI</td>
<td>0.1</td>
<td>0.75</td>
</tr>
</tbody>
</table>

Monte Carlo assessment based on above assumptions, however, gives us a 15% chance of pre tax DPI at 10% being negative, 20% chance of post tax DPI at 10% being negative and a P50 figure of 0.31 (Figure 30). The same also shows a life time production of 9.1 mmboe
at P50 level (Figure 31). This implies that under current business conditions a cost reduction of 25% in CAPEX and OPEX can potentially make pools with 9.1 mmboe P50 reserves economic for operators willing to take a 20% chance with negative post tax DPI.

Considering operators who work with pre tax figures, it is arguable if a 15% chance of negative valuation would make sense for them and overcome the enticement of net cash flow of USD 225 M at P50 (Figure 32). This is obviously a managerial call but it is apparent that with 25% cost reductions, some of the larger pools within the 3 mmboe to 15
mmboe range may start looking worthwhile risks. However, a question that could be researched in this context is, whether, when costs were lower by 25%, say 5 years ago, and at better oil prices, were operators investing in small pools? And if not, they why?

A post tax IRR at P50 of 21% (Figure 34) as compared to a pre tax IRR of 30.5% at same probability indicates that fiscal regime plays a significant role in valuation in UKCS. And this is one of the reasons of calling this set of optimization as high risk as it may not be applicable to mature risk averse operators, who may want a better return in view of riskiness of small pools.
Since this case involves a reduction of 25% in base line CAPEX and OPEX components as compared to base case, therefore, it is essential to understand the overall implications.

A 25% reduction in baseline CAPEX (covering one well plus modifications) leads overall to a P50 level CAPEX of 174 M (Figure 35) which is much lower than base case P50 level of USD 213 M. This includes a Pipeline and Subsea architecture component of USD 61 M (Figure 36) which translates into a workable distance of 15 kms for tiebacks to stay within the valuation given above. Distances lesser than 15 kms will add to the valuation of the pool without saying that 15 kms is the absolute limit considering the number of variables involved.

A pool which gives high quality product could add a further USD 10 M to USD 13 M saving to CAPEX charged on account of Composition based modifications while a further USD 6 M to USD 8 M could be saved on account of reservoir geology.
As far as size is concerned, CAPEX has a component of USD 39 M to cover additional development which may be based on the size of the pool and which has to do with additional drilling if required as per pool size.
Given the way CAPEX is practically constituted, small pools with favourable geology, compositions and location could possibly have better valuation profiles ranging between the P50 and P65 levels (Figures 32,33,34).

CAPEX/boe shows significant improvement as it benefits from cost reductions (Figure 38). P50 level CAPEX cost is USD 19/boe as compared to USD 30/boe in base case at same probability. P90 levels reduce from USD 54/boe to USD 32/boe due to cost reductions and also due to the fact that reserve threshold is 9.1 mmboe as compared to 7 mmboe in uneconomic base case.
OPEX behavior is interesting in the sense that despite cost reductions in OPEX components of 25% there is no effect on overall OPEX of the pool. The base case OPEX at P50 is USD 126 M (Figure 15) while the current case, Optimisation 1, has an OPEX of USD 128 M (Figure 39) at P50. The reason for this is that reduction in per unit OPEX components is combined with a threshold reserve level of 9.1 mmboe.

The overall effect is clearly visible in OPEX/boe cost which reduces from base case USD 17/boe (Figure 40) to USD 14/boe (Figure 41) at P50 levels.
Figure 40 – OPEX USD/boe Base Case

Figure 41 – OPEX USD/boe
Everything considered, Optimisation Case 1, discussed above would tend to be considered as high risk due to a 20% chance of negative of post tax valuations. Specifics of pools may be different based on location, geology and tax circumstance, however, we can conclude that at prevailing oil prices; a 25% cost reduction in both CAPEX and OPEX starts opening up small pools at and above 9 mmboe reserves at P50 level.

To assess results at lower prices, a stress test was run with oil prices between P10 to P50 (USD 45/bbl to USD 59/bbl), where median post tax DPI at 10% reduced to 0.19 from 0.33, indicating that small pool project initiation with cost reductions is probably uneconomic at oil prices below USD 59/bbl.

To assess infrastructure distance at greater than 20 kms, it was found that post tax DPI at 10% reduces to 0.19 at P50 as compared to 0.3. Therefore, distances in excess of 15 kms need to be assessed specifically for being economic.
9.0 OPTIMISATION CASE 2 – GAME CHANGERS

The 25% reduction in both CAPEX and OPEX discussed above is itself a challenging task. However, it sets a threshold of fields at 9.1 mmboe for economic development. A game changer in this context would be a significant, say 50% reduction from base case CAPEX and OPEX, which could potentially open up a much larger range of small pools available in the UKCS within a field development timeframe of 2 years rather than 3.

Such a reduction, modeled at post tax DPI at 10% of 0.3 would open up pools with reserves of 5.8 mmboe at P50 level (Figure 42).

![Figure 42 – Lifetime Production mmboe](image)

Total CAPEX in this scenario would have to be limited at USD 122 M at P50 level (Figure 43) which would lead to a CAPEX/boe of USD 21/boe. CAPEX/boe does not reduce as compared to case Optimisation 1 because the threshold level of economic pools has also reduced.
However, this will require OPEX to be contained within USD 74 million (Figure 44) with OPEX/boe at USD 13/boe (Figure 45).
With a post tax IRR at 25% at P50, this case translates into an NPV at 10% of USD 38 M with a 20% chance of negative valuations (Figure 46).
This scenario which is based on a 50% reduction in CAPEX and OPEX components including platform costs and pipeline and infrastructure costs, would not be possible without technological breakthrough and serious collaboration on the part of whole value chain including regulators.
10.0 UKCS BIG SMALL POOL PRIZE

Assuming that above mentioned game changing reductions materialise and UKCS maintains its subsea technological leadership, it would make sense to comprehend the overall potential prize that can be obtained through exploitation of approximately 200 discovered small pools. There are various ways of approaching this calculation including individual simulation of reservoirs and probabilistic summation. However, due to the constraints inherent in this project, basic small pool assumptions were enhanced to represent inputs and outputs into 150 small reservoirs. The factor of 150 was used as there are 157 pools in excess of 5 mmboe and it is assumed that reserve reassessment will come into play at development stage.

From a practical perspective, all pools would be developed at different time frames, however, for this analysis of calculating overall prize, the assumption has to be that all are developed simultaneously and only cash valuations are assessed.

The modeling shows overall small pool resource at 1,270 mmboe at P50 which could potentially translate into reserves / production of 1,060 mmboe at P50 level (Figure 47).

**Figure 47 – UKCS Lifetime Small Pool Production mmboe**
This will require an overall CAPEX of approximately USD 19 Billion based on simulation of distances to infrastructure, composition, geology and variability of reservoirs (Figure 48), translating into USD 18/boe at P50 level.

Overall OPEX is dependent on the life of the pools and production, however, a benchmark of USD 14/boe at P50 level will have to be established leading to a total OPEX of USD 16 Billion to achieve an overall pre tax net cash of USD 26 Billion (Figure 49).
The exchequer gains approximately USD 8 Billion under Ringfence Corporation Tax (Figure 50) and another USD 3 Billion under Supplementary Charge. However, there will be significant regulatory and Governmental role before any of this can transpire in terms of developing a conducive collaborative environment within the UKCS and among competing businesses.

Figure 50 – UKCS RFCT Small Pools USD M
10.1 TAX OPTIMISATION

The big prize for UKCS from small pools can potentially deliver post tax returns of USD 14.8 Billion at P50 levels under the current fiscal regime. The assumptions based on which the above profile is derived are extremely challenging both in terms of cost reduction and technology. Managerial issues of risk leadership and appetite will also come into play as will the fiscal regime.

As it is, small pools are not being developed, and if they were, then the Exchequer stands to gain a significant amount of tax revenue along with employment and GDP growth for the economy. However, this will only happen if the whole supply chain including regulatory bodies work together. Small pool development would need to be incentivised so that an optimum amount of tax revenue becomes highly probable as opposed to nil revenues from small pools currently.

Though this topic would require in depth analysis, however, it was seen in the analysis that under any circumstances, the tax revenue generated under Supplementary Charge is nil at P20 and negligible at P25 due to CAPEX uplift.

To incentivize development of small pools, the exchequer could look at reducing or totally abolishing SC for small pools with P50 reserves up to 15 mmboe. This would send a strong signal to the market that the fiscal regime is supportive of small pool developments; and incentivize players with appropriate risk appetite to ensure generation of USD 8 B tax revenues.
11.0 CONCLUSIONS & RECOMMENDATIONS – OPPORTUNITY IN THE PROBLEM

Small pools in UKCS with reserves in excess of 11.8 mmboe can be exploited under current business and fiscal environment. However, this does not fully address the range of small pools from 3 mmboe to 15 mmboe. A cost reduction of 25% will open up fields with 9.1 mmboe reserves at P50 level. Technological breakthroughs leading to cost savings of up to 50% will open up fields with 5.8 mmboe. Overall this can lead to production of 1,060 mmboe from small pools in UKCS.

Oil majors, throughout the world, with their structural constraints of size and costs in project evaluation, may not have actively pursued small pools so far, however, the combination of declining reserves, mean reverting crude prices, small discovery sizes coupled with cost inflation and decommissioning on the horizon provide the right business environment to focus on technological and managerial breakthroughs for exploiting the small pool niche. This constitutes an opportunity for both oil majors, as well as, niche players to move forward with collaboration, knowledge sharing, academia involvement and technological & risk leadership, especially so for the UKCS which has a chance to rediscover the entrepreneurial spirit of yester years.

There is opportunity in the problem - provided proper stewardship is sustained.

This report has touched upon the subject of small pools from a macro level without differentiating as per location, geology and nearby infrastructure. Further research needs to consider the following:

- Economic model optimization to consider specific North Sea clusters taking into account actual geological and operational conditions
- Research on risk incentivisation and fiscal regime in view of pool economics and international opportunities
- Maturing reservoirs with declining production for discovering parallels with small pools
- Economics of small pools and operators in India and Nigeria for understanding best practices
- Third party cost models and platform economics in view of small pool development
- Lack of interest in small pools previously in greater than USD 100/bbl price environment to discover possible managerial obstacles
12.0 BIBLIOGRAPHY


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