Valuation Utilising Real Options Techniques in the Oil & Gas Industry

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Abstract

Oil and gas assets have unique characteristics which challenge the applicability of commonly used valuation techniques (e.g. NPV, Decision Tree Analysis). These commonly used techniques neglect the high uncertainty levels that surround oil and gas assets and the flexibilities that field development engineers have to tailor their exposure to this uncertainty. A Real Options methodology is developed for discoveries to include the value of uncertainty and flexibility to ensure a closer alignment of valuation with the 'real' project environment. Initial results indicate that a Real Options approach to valuation has the potential to significantly impact the oil and gas industry in a wide range of areas.

1.0 Introduction

Oil and gas assets have unique characteristics which challenge the applicability of commonly used valuation techniques (e.g. NPV, Decision Tree Analysis). Some of the main drivers of asset value are highly volatile and include commodity price, reserves quantity and development costs (Faecke 1982). The valuation life of oil and gas assets typically spans several decades and this exacerbates the uncertainty fundamental to all oil and gas assets. Furthermore, the magnitude of investment required to develop prospective assets is often a significant proportion of company value.

The size, duration and uncertainty of valuation drivers expose oil and gas companies to high levels of risk. As a response to this, many projects are developed in stages. This enables overall asset uncertainty to be reduced as key decisions are made in the future where the context of the asset is better defined and understood. At this future time the asset development is progressed if favorable conditions are encountered. Alternatively most oil and gas developments can be abandoned or deferred to minimize losses in unfavorable conditions. Thus, flexibility implicit within oil and gas assets is highly valuable in risk reduction.

To date, most valuation techniques have failed to adequately include the flexibility implicit within the development of oil and gas discoveries. They often neglect the ability of field development engineers to in build flexibility in operations when designing, enabling the project to adapt to the future uncertain conditions. An example of this flexibility is the commitment to build additional capacity into a new platform such that additional production wells can be included in the future. In the event of upward revised reserves estimation this additional capacity can be utilised to accelerate production and revenue realisation, increasing the present value of the project.

1.1 Field Development

Field development is the process that oil and gas companies undertake with the intention of generating value for their shareholders, from oil and gas prospects. Field development encompasses a wide range of issues and begins with exploration and can end in production of hydrocarbons. Each stage in field development is generally conditional on the success of all prior stages. The broad stages of field development are presented below in Figure 1.0:

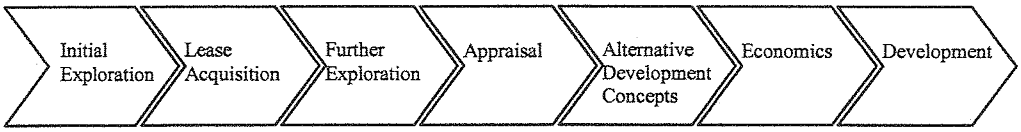

Figure 1.0: Development chain for field development.

At each stage the discipline and detail of the engineering differs substantially. In the initial stages up to appraisal, reservoir engineers and petroleum engineers primarily aim to reduce the uncertainty surrounding the quantity and quality of the given discovery. Hence seismic, drilling and lab testing are used extensively and conducted until the uncertainty surrounding the project is reduced significantly. Appraisal activities should be concluded at the point at which the marginal benefit from the expected uncertainty reduction exceeds the marginal cost from doing so.

According to Woodside OPREP (Woodside 2004), at the alternative development concepts stage (presented in Figure 1.0) given the uncertainty that remains regarding the prospect, facilities development engineers determine feasible development alternatives to produce the hydrocarbons. Following this, economics are conducted and each development alternative is valued. The best development concept is then selected to maximise the expected return to the company's shareholders for a given level of risk. Hence the difficulty of valuing a discovery, considering it will have merely passed the first stage in the development cycle, is apparent.

1.2 Valuation Techniques

The fundamental motivation for companies is to undertake investments which maximise shareholder wealth. Thus all technical, engineering and economic data which can affect a project must be translated into the impact the specific piece of data will have on the project value.

The Net Present Value (NPV) approach to valuation developed by Sharpe (1964) and Lintner (1965) has been the dominant asset valuation tool used in recent times. It has been used by practitioners across most industries, including the oil and gas industry. The approach calculates the value implication for the company of existing projects or prospective projects. Its implementation requires the forecasting of future free cash flows (FCF) and the risk associated with those cash flows. Free cash flows are forecasted based on expected future outcomes and are net of all expenses, taxes and royalties.

This approach is limited in its applicability to oil and gas assets given their unique characteristics of flexibility and uncertainty. The limitation results from the assumption that underlies the NPV method that investments are irreversible and that the development plan determined at the commencement of the project will be followed until completion. Furthermore, the inputs required for the model are difficult to determine as commodity prices and reserves quantities can fluctuate dramatically throughout the life of the project and the risk of the project can vary.

To avoid the limitations and inaccuracies of the rigid NPV model, Myers (1977) proposed the use of financial options theory to assist in the valuation of 'real' assets. At the time this had intuitive appeal as Black and Scholes (1973) and Merton (1973) had developed a method to value the flexibility that was implicit within financial options. The flexibility is generated as a call option holder has the right but not the obligation to buy an asset at a specified price in the future. Hence their exposure to future events is asymmetric, as in the event of an unfavourable outcome, the option is simply discarded, limiting downside exposure.

Considering the characteristics of financial options it is easily understood that many projects contain valuable 'real' options. A 'real' option is identical in nature to a financial option with the only difference being the environment in which each is based. Kulatilaka and Marcus (1992) have identified the presence of real options in company operations. They provide examples of flexibility implicit within company operations which provide valuable asymmetries. These include the option of deferring projects in times of unfavourable economic circumstances to minimise losses. In the extreme, the company has the option to abandon the project. In the event that the project has already commenced the ability to temporarily shutdown operations can be valuable. They also consider growth options where an initial investment may expose the company to the possibility of further expansion.

Given the staged development of an oil and gas discovery and the uncertainty surrounding the future value of the field, it appears that real options are present and that they are valuable. In order to capture the value of the project by including the benefits of flexibility, many previous attempts at applying real options theory to oil and gas assets have been made. Paddock, Siegel and Smith (1988) develop a method which adheres to a closed form solution emphasising financial rigour while sacrificing practical engineering influences. In contrast, Laine's (1997) model develops a numerical procedure focusing on practical considerations while assuming theoretical validity of her financial model.

2.0 Methodology

The fundamental motivation of the Real Options Valuation (ROV) model is to include the value of uncertainty and flexibility implicit within most oil and gas projects. Uncertainty describes the range of possible outcomes that a project is exposed to in its given environment. Considering an oil and gas discovery the main uncertainties include commodity price, reserves quantity and development costs. These uncertainties can have a significant impact on the value of a project and this is determined by the flexibilities that are available to the owner of the project.

In the event of high uncertainty in the drivers of a project, the flexibilities implicit within that project become highly valuable. From the field development engineer's perspective, the presence of flexibilities within the project enables him to tailor his exposure to future uncertain outcomes. Hence, flexibilities can enable an asymmetric exposure to the uncertain future as further commitment to a project would only be undertaken in the event of a likely favourable outcome.

It is clear from the above discussion that a model which aims to capture the value of uncertainty and flexibility implicit within most oil and gas projects must satisfy two requirements. Firstly the model must attempt to model the uncertain future outcomes to which a project can be exposed. Secondly the flexibilities available to the field development engineer to react to these future outcomes must be included.

As previously discussed, static tools (e.g. NPV, Decision Tree Analysis) fail to capture the uncertainty and flexibility implicit within a project and their associated value impact. This results from their inability to model future uncertain outcomes. By omitting the uncertainty present in drivers, the value of flexibility implicit within projects is automatically set to zero as there is no value in having flexibility if the future is known and certain. The ROV methodology improves on the limitations of static techniques by capturing the value of uncertainty and flexibility in a structured manner.

2.1 Overview of the ROV model

The ROV model determines the valuation of a discovery by separating its evolution into two distinct stages. These stages are Exploration & Appraisal (E&A) and Development & Production (D&P). This distinction is necessary due to the different uncertainties present and flexibilities available to the field development engineer at each stage.

2.1.1 Exploration & Appraisal stage

The E&A stage for a discovery is characterised by considerable reserves volume uncertainty. This stage includes all efforts to appraise the potential oil volumes that can ultimately be recovered. Such efforts frequently include drilling appraisal wells to determine reservoir properties. Depending on the potential field size and complexity, gauged from initial results, the number of appraisal wells can vary. The cost per appraisal well is significant and the incremental information gained per additional well is likely to reduce. Hence in the E&A stage, the field development engineer aims to reduce the uncertainty that surrounds the reserves volume estimate given the economic constraints.

At each possible appraisal stage the field development engineer has several key decisions to make which determine the evolution of the project. The options available to the engineer include the choice to abandon the project, progress with further appraisal or commit to production. These choices are made in the context of the remaining reserves volume uncertainty and the oil price at decision point. Hence in the E&A tree, which is used to model the E&A stage, the key uncertainties to be modelled are the reserves volume and the oil price (see Figure 2.1).

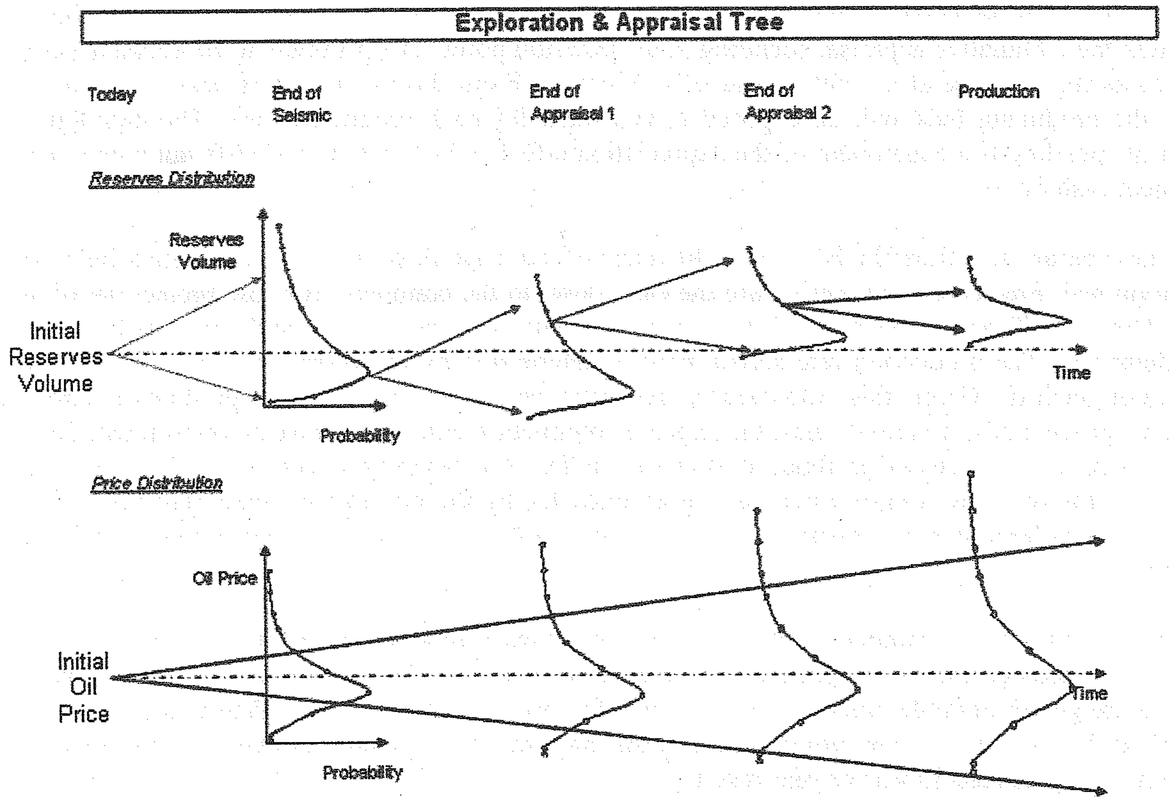

Figure 2.1: This diagram presents a scenario where the field development engineer will conduct three appraisal stages and subsequently commit to production. The reserves distribution scenario present is only one of many that could occur. Note the reduction in the range of reserves values as more information is gained. Below are the associated price ranges that the project is likely to experience. Note that oil price uncertainty increases with time.

2.1.2 Development & Production stage

In committing to the decision to produce, the field development engineer is exposed to a range of decisions which are different from that in the E&A stage. Thus, a second stage of Development & Production is required to model this. The D&P tree, which models the D&P stage, requires several key inputs from the E&A tree to incorporate the context of the project's evolution and environment at the decision point.

From a reserves volume perspective the reserves volume estimate at that point and the uncertainty that remains about the estimate is required. These estimates summarise the reservoir engineering data provided about the field and are the key requirements in terms of facilities selection to produce the field. The reserves volume is used to size the processing facilities to best extract the value of the field. In developing a field there is often a range of feasible scenarios to extract the hydrocarbon. While the least expensive solution may be appealing on face value, often by increasing the capital expenditure committed to the project, production can be accelerated which can add significant value in present value terms.

The two other key parameters to be taken out of the E&A tree for use in the D&P tree include the oil price and the cumulative appraisal spending at the decision point. The oil price at the decision point is taken as the oil price at the initial year of production. From this the range of possible prices to which the producing field will be exposed is generated for each producing year. The cumulative appraisal spending is a component of the depreciation effects which can be a significant component of project cash flows.

With these parameters from the E&A tree, the range of free cash flows from the developed field can be determined. Free cash flows (FCF) are the cash flows to the company from the project net of all costs. Hence FCF are a function of the production rate, oil price, costs and taxes and royalty considerations. The production rate across time is determined by the reservoir properties and the production facility. Given this information, reservoir engineers can produce production curves through a process of simulation. Thus, the expected production volume per year is determined, given the full extraction of reservoir fluid. It is assumed that the reserves uncertainty which may be implicit in the reserves volume estimate is accounted for by the possible development restriction. The reserves volume is hence assumed to be constant once the development commitment has been undertaken.

The prices which will eventuate to pair with a given year's production are highly uncertain. As previously discussed the initial price is extracted from the E&A stage. To model the subsequent prices a range of possible prices is determined for each producing year. When each price is multiplied by the production volume and costs and tax and royalty effects are included, a distribution of free cash flows per year results.

It is at this stage of modelling that the flexibility available to the field development engineer once the D&P stage has been committed to can be included. At any year of the projected production profile, the option to abandon is present. This provides a valuable asymmetry as the project will only produce in the event of a year of positive free cash flow and hence only when company value is increased. Once this flexibility has been included the range of free cash flows is collapsed to a single value per year by probabilistic weighting (see Figure 2.2).

The resulting weight production cash flows are then discounted by a discount factor and summed to determine the present value of free cash flows at the time of first oil, commonly called the ready for start-up (RFSU). Additionally the capital expenditures (CAPEX) to develop the field are also appreciated to their present value at the time of first oil. The CAPEX is then subtracted from the project free cash flows. The net value of proceeding with development is hence determined.

The net value using this discounting method is the value at the time of first oil. However, in order to determine the project value at the decision point where development was first committed to, the net project value at the time of first oil must be discounted by the development lag time period. The development lag time period encompasses the time from the decision point to the time of first oil. Hence, this is the time of construction for the facility.

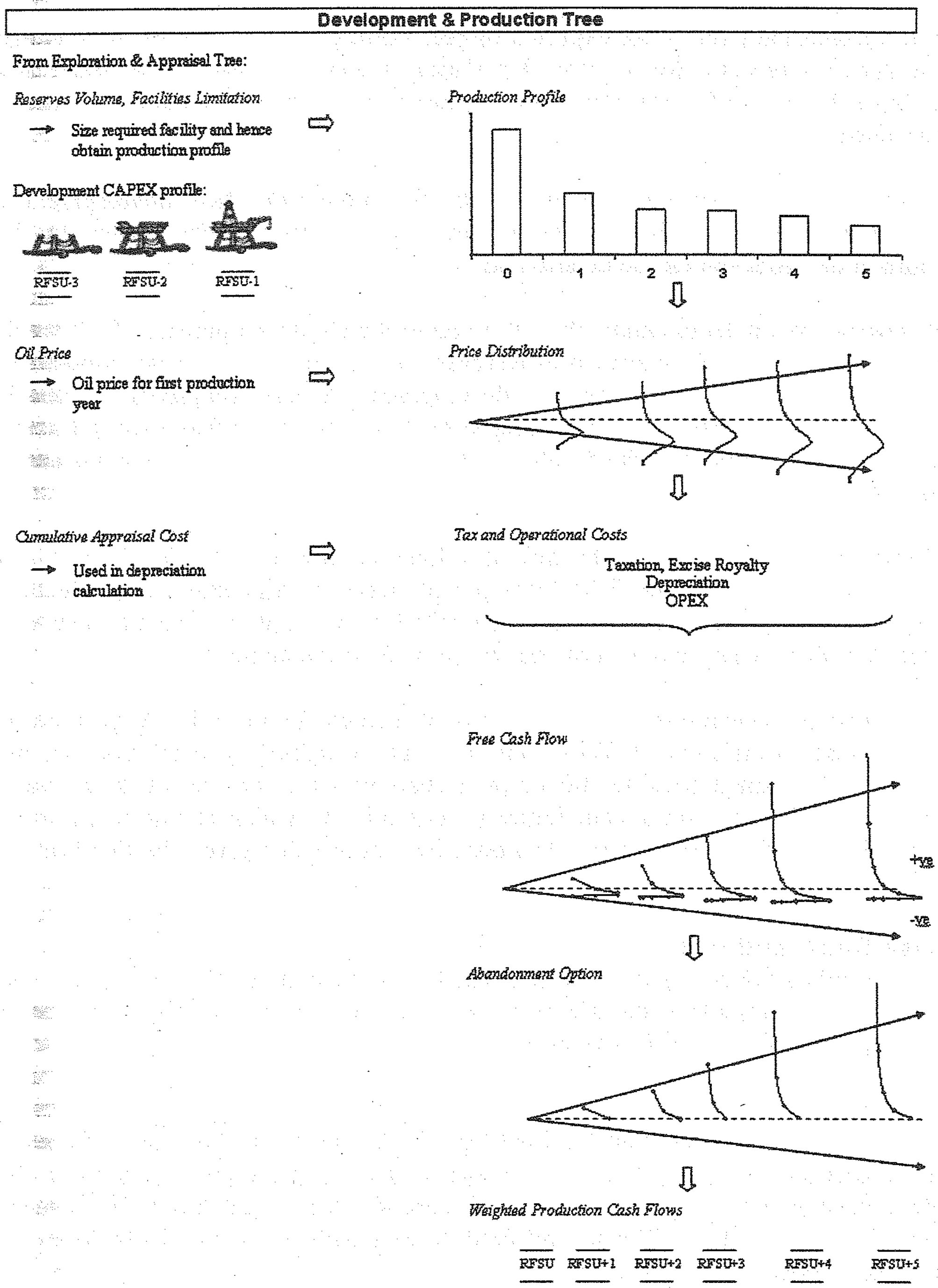

Figure 2.2: Diagram detailing the calculation of project values given the decision to commit to production. Commences with the introduction of values from the E&A tree to the D&P tree (top left). These values are used to determine the initial inputs from which the final weighted production cash flows for each producing year are calculated.

2.1.3 Overall Value Determination

The value at the decision point is the expected project value given that development is undertaken. The method above is repeated for all other E&A stage scenarios at each given stage in appraisal evolution. Hence for each E&A stage the value of proceeding with development for each scenario can be determined.

With these values we can commence including the flexibilities that field development engineers have to best manage the uncertainty of future outcomes. At each decision point the options to undertake further development can be determined.

For a single decision point, let us denote the value committing to development as D. If we follow the above procedure for all possible scenarios of reserves volume and price, we can populate the whole E&A tree with the value of committing to development. At the completion of this it can be determine for example, the value of committing to development given that a second appraisal was undertaken. Let us denote the weighted value of the outcomes given that a second appraisal was undertaken as A.

With the values of D and A known, the field development engineer can decide on his course of action. In the event that $D>A>0$ the field development engineer will commit to production and not undertake any further appraisal. In the event that $A>D>0$, he will opt to undertake further appraisal. Should D and A both have negative values, the project will be abandoned.

This optimal decision procedure is continued across all scenarios in the E&A stage to determine the optimal action at each decision point. These values are then weighted by their associated probability of occurring and discounted back to the initial valuation point. The result is the value of the discovery which includes the significant future uncertainties to which it will be exposed and the actions of the field development engineer to maximise future value given the flexibilities implicit within the project.

3.0 Case Study and Results

The scenario described below is part of an ongoing field development plan and hence is subject to the strictest confidence. Details of the discovery or the specifics of the results are not provided and the results of the case study are indicative only.

3.1 Case Study

In order to determine the insights that the Real Options Valuation methodology offers to industry practitioners, a case study was undertaken. The case study focussed on a discovery which had two potential field development options. The first of these was to be undertaken by integrating the discovery with existing facilities. The second field development option was to build a new facility with a customised capacity for the discovery.

By performing a Real Options Valuation of the discovery under the two field development scenarios several insights could be gained. Firstly, given the performance of standard NPV analysis for each scenario, a comparison between the NPV and the ROV values could be undertaken. This would enable the value of flexibility to be determined. Secondly, by undertaking a ROV analysis of both development options, the value impact of the new facility with respect to the discovery could be quantified. This is calculated by the difference in the value of the discovery under the two different scenarios.

3.2 Results

The accuracy of the developed ROV model was tested by setting the value of all flexibilities to zero. By definition the Real Options Value should have collapsed to the Net Present Value upon the removal of all flexibilities. This was in fact the case in all scenarios and provided a solid foundation from which the uncertainties and flexibilities implicit within the discovery could be introduced.

To determine the impact of the uncertainties and flexibilities on the value of the discovery, each variable was gradually included. From the figure below (see Figure 3.0) it can be observed that the value of uncertainty and flexibility has a large impact on the value of a project. This follows observations of the value of projects in the wider oil and gas industry as a result of recent uncertain and high oil prices.

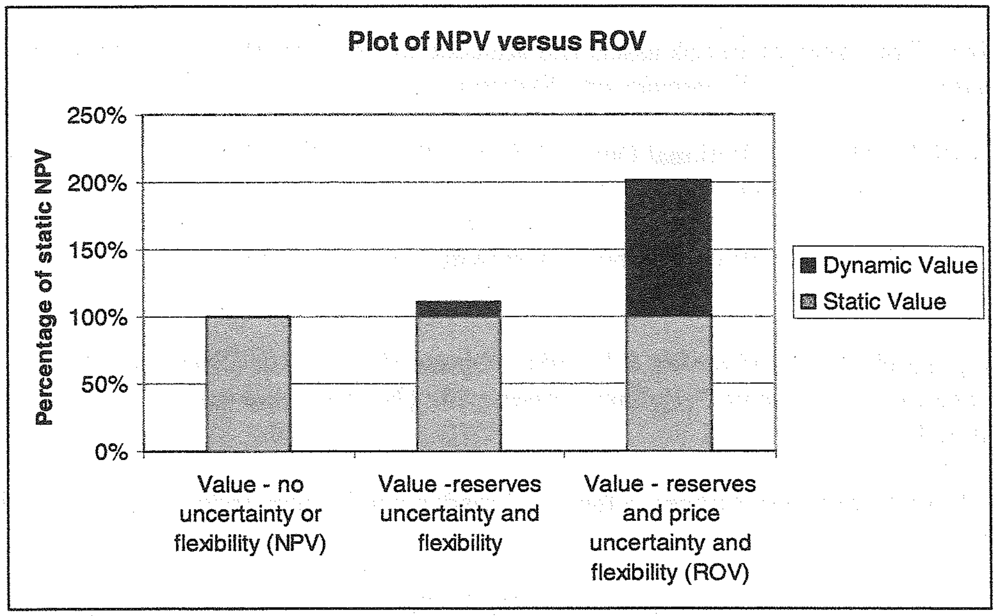

Figure 3.0: Plot of the value impact of uncertainty and flexibility for a given discovery.

The impact of the new facility on the value of the discovery was also significant. The value of the discovery in the environment of the existing infrastructure was close to zero, while it had significant value in the event of the new infrastructure development. Thus it is apparent that field development engineers can positively impact on the value of discoveries by committing to additional producing facilities in their vicinity.

4.0 Conclusion

The Real Options Valuation model developed offers significant improvements over static techniques that are most commonly used (e.g. NPV). By modelling the future uncertainties that a project may experience and including the flexibilities implicit within most projects in a structure method, a valuation that is more closely aligned with the 'real' project environment results. Through correct application, Real Options techniques promise to have a significant future impact on the oil and gas industry in a wide range of areas.

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