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Worthless PUDs? We'll buy them all at that price!

Fair Value Impairment Must Consider Option Values

Executive Summary

The issue:

Year-end 2015 reserve reports, referenced in SEC reporting for E&P companies, show a value of zero dollars for many proved undeveloped reserves. This whitepaper addresses how the application of option pricing analyses can provide insight for fair value determination of proved undeveloped well locations.

Misconception:

Many investors believe that the PV10 reserve values (as required by the SEC) are comparable to Fair Value. However, current reserve reports relying on 2015 petroleum prices indicate that the undeveloped properties have no value, even though E&P companies with available cash, private equity groups, and numerous funds are currently acquiring these properties.

Option Pricing Models:

Grounded in financial theory, practice and observable markets, these models and analytical tools capture the effect of pricing volatility on the value of future cash flows. This paper reviews these concepts at a high-level and then presents the results of a redacted case study recently prepared for a client.

ValueScope's has the expertise to develop credible option pricing analyses.

Our team of professionals provide:

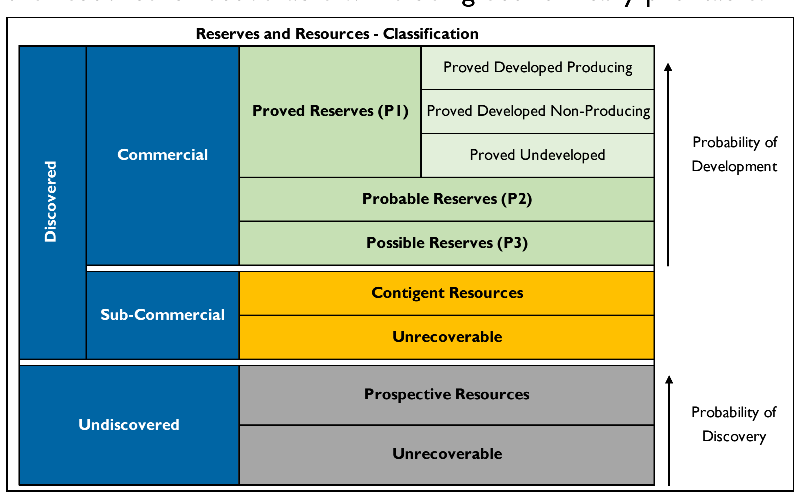
- *Experience: decades of combined valuation experience*
- *Staffing: Petroleum Engineers, Ph.D.'s, CFA's, CPA's, and MBA's*
- *Independence*

The Issue at Hand

2015 year-end reserve reports (PV10) consistently show that many proved undeveloped well locations ("PUDs") are "uneconomic," or worth zero dollars. This fact is driven by the low historical oil and gas prices of 2015 which do not adequately justify the current cost to drill, complete and operate the well over its expected economic life.

In the U.S., the Society of Petroleum Engineers and SEC-reporting guidelines define petroleum resources. Depending on the relative certainty of expected production, marketability, economics and legality, resources can be upgraded to Reserves.

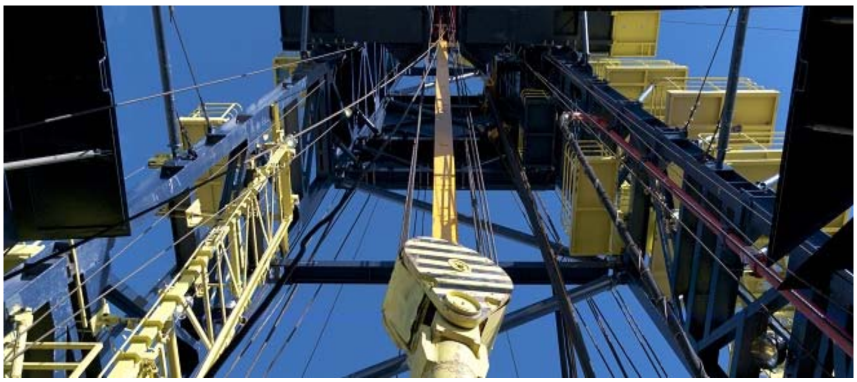
Within the Reserves category, there are three sub-categories that indicate the certainty of a well's volume; of these, Proved Reserves have the highest certainty. Proved Reserves include developed and producing, developed but not producing, and undeveloped properties. A reserve is considered proven if it is probable that 90% or more of the resource is recoverable while being economically profitable.



PUD locations are a major driver of a company's market value. Since a PUD requires a capital investment before production begins, they are sensitive to economic conditions. If the net present value (NPV) of a PUD drops below zero, under the fixed assumptions in an engineer's reserve report, the location is considered to be uneconomic, and no value is attributed to it. In this paper, we demonstrate how to determine the true economic value of these locations.

Real Options Explained

Real Options Valuation, also often termed real options analysis, applies option pricing techniques to capital budgeting decisions (such as investing capital in drilling, completing, and producing a well). A real option is the right — but not the obligation — to undertake certain business initiatives, such as deferring, abandoning, expanding or accelerating a capital investment project such as drilling and completing a well's location.



Real options are generally distinguished from conventional financial options in that they are not traded as securities and do not usually involve decisions on a publicly traded underlying asset. Real option holders, i.e. some investors and management, can directly influence the value of the option's underlying asset (well locations, leases held, etc.)

Real options analysis, as a discipline, extends from corporate finance to decision making under uncertainty, adapting the techniques developed for valuing financial options to "real-life" decisions. Real options analysis force decision makers to be explicit about the assumptions underlying their projections. For this reason, business strategy formulation increasingly employs real options valuations as a tool. The extension of real options to determining the value of PUDs in the current low, but volatile commodity price environment, requires analytical steps beyond traditional discounted cash flow models.

The fundamental difference in a real options framework is its treatment of volatility, or risk, in the expected future cash flows. In traditional discounted cash flow analyses, the risk is typically reflected in higher discount rates, which result in lower expected present values. With real options analyses, the underlying risks present <u>opportunities</u> to investors, as opposed to the only downside.

Option Pricing Models

A widely accepted, albeit simple, model for determining the value of financial options is the Black-Scholes Option Pricing Model, or "BSOPM." The BSOPM is a mathematical model which gives a theoretical estimate of the price of European-style options. The formula led to a boom in the popularity of options trading and scientifically legitimized the Chicago Board Options Exchange and other options markets around the world.

Fischer Black and Myron Scholes first published the Black–Scholes model in their 1973 paper, "The Pricing of Options and Corporate Liabilities," published in the Journal of Political Economy. They derived a partial differential equation, now called the Black–Scholes equation, which estimates the price of the option over time. The key idea behind the model is to hedge the option by buying and selling the underlying asset in just the right way and, as a consequence, eliminate risk. This type of hedging is called delta hedging and is the basis of more complicated hedging strategies such as those engaged in by investment banks and hedge funds.

The BSOPM assumes that:

- the market consists of at least one risky asset (a share of stock) and one riskless asset, usually characterized as a US Treasury security,
- the rate of return on the riskless asset is constant and thus called the risk-free interest rate,
- stock prices are assumed to follow a random walk with drift; more precisely, it is a geometric "Brownian motion," with drift and volatility assumed constant over the life of the option,
- the stock does not pay a dividend,
- there is no arbitrage opportunity (i.e., there is no way to make a riskless profit),
- it is possible to borrow and lend any amount of cash at the riskless rate,
- it is possible to buy and sell any amount of the stock (this includes short selling), and
- transactions do not incur any fees or costs (i.e., frictionless market).

When applied to oil and gas reserves, the following mapping of the BSOPM inputs are frequently used:

Comparative Inputs

Call Option on Share of Stock		Proven Undeveloped Reserves (PUD)
Underlying share price	➡	DCF value of reserves when developed
Strike price	➡	Capex needed to develop
Time to expiration	➡	Time remaining on mineral lease
Dividend yield	➡	Value decay resulting from waiting
Time value of money	➡	Time value of money
Volatility of share price	➡	Volatility of developed reserves value

For more complicated options, simulation or Monte Carlo option valuation models are used as they can account for more than five inputs, substantially increasing their usefulness. It is important to note that given the same assumptions, a Monte Carlo option analysis will result in the same value as the BSOPM. For real options analyses, a Monte Carlo analysis is essentially a discounted future cash flow model that has been modified to account for future volatility in cash flows (typically driven by pricing and production volatility).

A Simplified Example

A lease or an undeveloped well can be thought of as a call option, i.e., the holder has the right but not the obligation to drill and produce. In options terminology, drilling is like paying the strike price of an option to receive the value of the future production (analogous to a stock price).

In this example, we assume that the lease for the PUD has a three-year remaining economic life. The present value of the future cash flows is determined to be $3 million at expected prices, and the cost to drill the well is $4 million. Clearly in a world without volatility, no rational investor would make this decision as the expected net present value would be a loss of $1 million.

However, applying these same inputs in a BSOPM framework with volatility considered, the following graphic shows that real options values are positive (not negative or zero) and that the value of the real options increases with increasing volatility.

Real Option Values		3-Year Option Value Comparison		
	Traditional DCF	**No Volatility**	**25%**	**50%**
PV Cash Flows – Current	$3,000	$3,000	$3,000	$3,000
Average PV CF with Volatility		$3,000	$4,248	$4,759
Capital Cost to Complete	$4,000	$4,000	$4,000	$4,000
Years until expiration		3.0	3.0	3.0
Volatility		0.0%	25.0%	50.0%
Value	**-$1,000**	**$0**	**$248**	**$759**

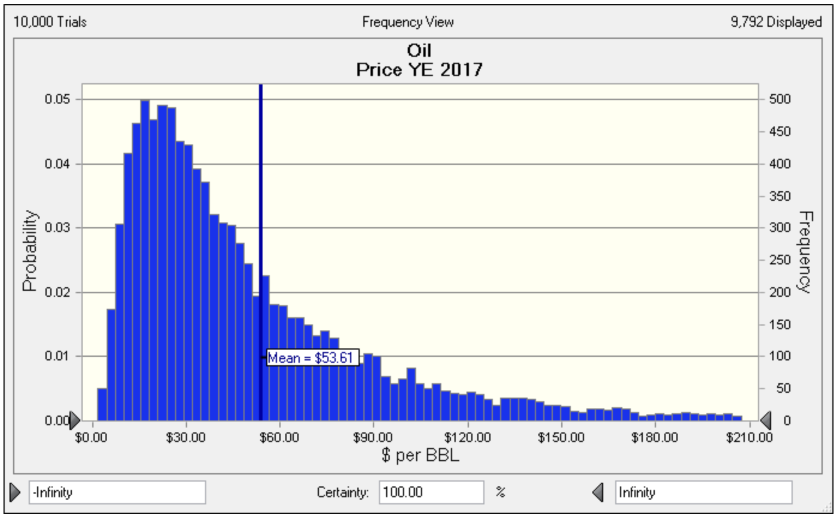
Rather than the PUD's value above being a loss of $1 million, "uneconomic" or effectively zero since no investor would invest, a real options framework demonstrates that under a scenario of 50% annual volatility in cash flows, the PUD has an expected value of $759 thousand, given the assumptions.

Client Case Study

An E&P client recently engaged ValueScope to determine the value of their PUD locations in the Bakken in support of a potential sell-side transaction. Working with this client, we defined two sets of wells with expected similar production, referred to as Tier 1 and Tier 2 wells. Tier 1 wells had higher production and lower costs than Tier 2 wells. Therefore, they were assumed to be drilled first if forecast economics justified. At the time of our analyses, only their Tier 1 wells were expected to be economic under traditional discounted cash flow analyses.

For the Real Option Analyses, we simulated oil and gas prices by using observed market volatilities, a log-normal distribution, and applying a Geometric Brownian Motion with the drift calibrated to the future strip pricing. The drilling program's schedule was determined by testing each well's economics by month under different simulated strip prices. If the well's NPV tested positive, the well was drilled and completed. Then, the next well in inventory was tested for its economic viability. Drilling constraints imposed in our analyses were a maximum of two drilling rigs operating and a timing of one well per rig per month.

The simulation showed that Tier 1 wells were not always economical and less than all of the Tier 1 locations would be expected to be drilled. In a traditional DCF analysis, this risk is typically accounted for by adding risk premia to a discount rate, an exercise which requires a significant amount of judgment.



The simulation analyses also showed that on average, eight of thirty Tier 2 locations were expected to be economical (as opposed to none of them).

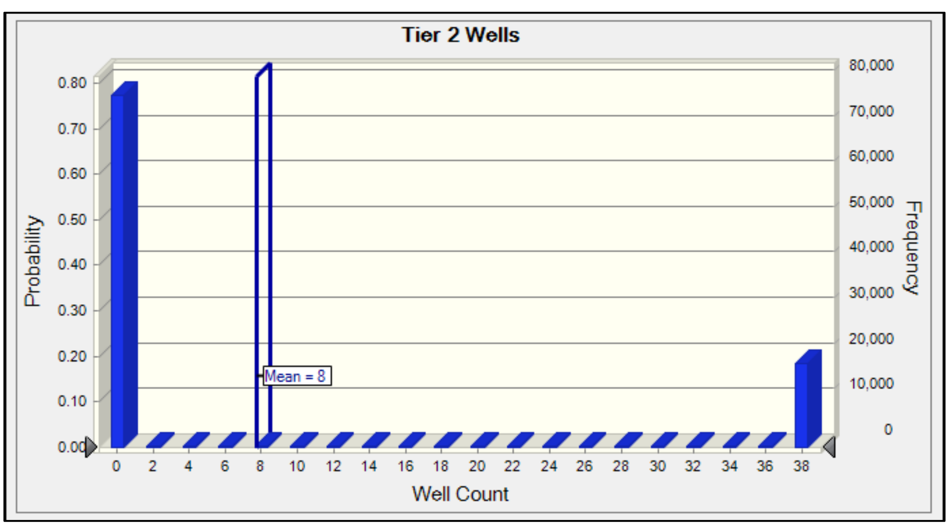
Given their positive economics under certain outcomes, they were included in the pro forma drilling plan and served to increase the total value of the company's reserves.

The following assumptions drove our Monte Carlo simulation to derive the real option value of the PUDs, as opposed to the zero (uneconomic) values reflected in the company's 2015 reserve report.

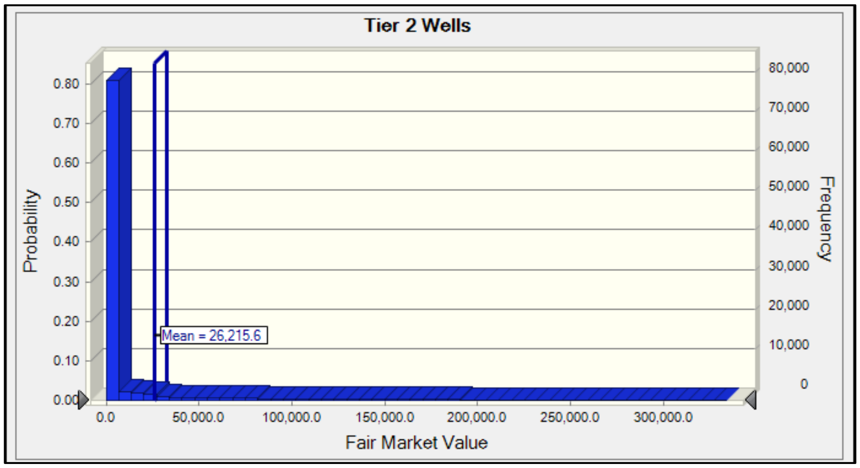
	Tier I Wells	**Tier 2 Wells**
• Drilling / completion costs (M$)	$7,000	$7,500
• Expected quantities (MBbl)	657	357
• Operating expenses, etc. ($/Bbl)	$7.00	$8.00

- Expected pricing
  - Futures strip pricing for oil and natural gas
  - Drift required to calibrate model to strip pricing above
  - Volatility based on underlying commodities implied (not historical) volatilities
- Drilling constraints
  - 2 Rigs
  - 2 wells per month

The results of our analyses showed that on average, 8 of the 30 Tier 2 wells were expected to be economical.

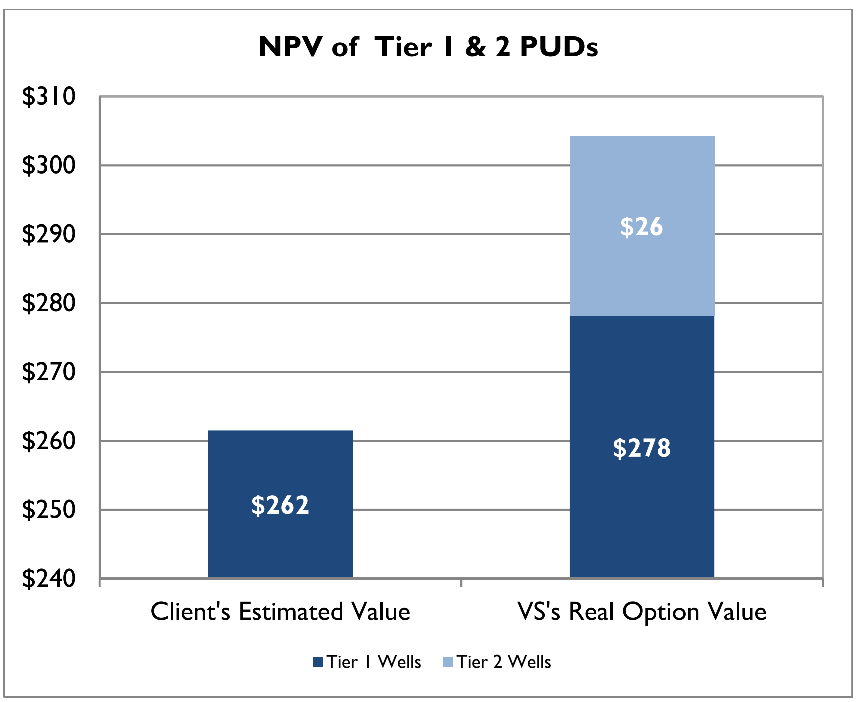


The value of these eight wells added approximately $26 million dollars of fair value to the reserves, as compared to the reserve reports' indicated value of zero dollars.



Key Takeaways

Overall, the analyses showed the client's reserves had a net present value approximately 16% higher than what the operator had booked in their financial statements.



As described above, many PUDs today (mid-2016) are shown to be uneconomic (i.e. zero value) in year-end 2015 reserve reports prepared according to accepted PV10 methodologies. However, individual investors, private equity groups and fund managers are actively seeking to acquire these assets, sometimes at premium prices. Why? Because they understand the underlying option value of these assets and also that volatility, or risk, can present opportunities as opposed to the lower values reflected in traditional discounted cash flow analyses.

How ValueScope Can Help

ValueScope's knowledge of Fair Value concepts and their conceptual application to a petroleum company's common and preferred shares, partnership units and/or reserve values enables us to provide credible and independent analyses, and thoroughly documented fair value reports. ValueScope's team includes experienced petroleum engineers, Ph.D. economists, Chartered Financial Analysts, Certified Valuation Analysts, and Certified Public Accountants that provide rigor and credibility to our analyses and reports.

Clients routinely retain our professionals to:

- Develop independent analyses of the fair value of petroleum reserves,
- Develop independent analyses of the fair value of closely-held E&P shares and limited partnership units, and
- Provide economic damage calculations and valuation support/expert testimony in litigation matters.

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