Recurrent Issues in the Evaluation of Unconventional Resources*

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Abstract

There is significant current commitment within the industry to develop and implement methods to assess the prospectivity of Unconventional Resource opportunities. The purpose of this paper is to identify some of the common recurring errors in both numerical evaluation and operational priorities, with specific examples.

Efficient planning and evaluation of Unconventional opportunities is critical due to the low margin, high capital nature of the business. Converting the Conventional exploration and development mindset over to one that places high value on project management and manufacturing efficiency is difficult. Appropriate evaluation and applied operational learning are critical to evaluating decisions that can mitigate downside risk, including the critical post-pilot go/no-go decision.

Some Specific trouble points are:

● Attempting to model future program results with a single distribution of individual well EUR results – predicting the unpredictable with unwarranted precision.

● Force fitting a lognormal distribution through datasets that are decidedly non-lognormal, particularly in the outer portions of the probability space. The “double whammy” of prediciting an overpopulation of high volume wells (including unrealistically high recovery wells) and underpopulation of low volume wells results in overestimation of results… often significantly so.

● Overemphasizing assessment of chance of geologic success, when the key questions to resolve are the chance that the significant risked (pre-pilot) investment will lead to a “go” decision, how often does a particular pilot design correctly predict viability or non-viability – and what the chance is that the entire venture will be an economic success.

● Failing to recognize the critical success factor - production profile uncertainty - and model this correctly, and develop appropriate prioritized learning objectives for the pilot.

● Ignoring the impact of business pinch-points, the scarce resource items which when controlled provide profit assurance and distinct competitive advantage.

The failure to link the statistical assessment to operational priorities on project assessment or Play entry relegates business sense to an after-thought. The unfettered, unfocused “drill it and see what happens” approach results in sub-optimal pilots that fail to provide appropriate confidence for critical business decisions, destroys value, and risks loss of competitive advantage in an Unconventional Play.

Introduction

In the mad scramble to enter, test, and develop Unconventional opportunities, a significant number of evaluation shortcuts have been taken. These errors range from simple arithmetic problems through to failure to understand the true uncertainty within such opportunities. The collection of rules of thumb, incorrect statistical assessment methods, and inappropriate analogues leads companies to perceive and publically portray incorrect forecasts of success. In addition to the resulting error being too precise, it typically overestimates play volumetric (and value) potential.

All too often the objective of the analytical effort is aimed at the creation of a single expected NPV or reserve calculation. In so doing, any context of what the number means the company has to do to better itself or identify and mitigate downside threat is tossed aside. Most companies are calculation centric, “what is there”. They will dedicate weeks if not months to carry out the implausibly precise calculation of what is in the ground and then make arbitrary and flawed choices of non-variant production profile, otherwise known as a type-curve, and replicate it across the play. The valiant struggle to provide company management with an expected value or expected resource – “the answer” - ignores the fact that the important decisions facing a company do not occur at the mean. Failure to *properly* take into account the range of potential outcomes throws away any opportunity to optimize the pilot, target critical learning, realize a truly competitive land strategy, and hampers the move to true manufacturing efficiency in the factory phase.

Unconventional opportunities are filled with risk and decisions. Unfortunately, there are five significant errors, or failures to take advantage, that are seen to be repeated by many if not most companies across the industry. The companies are not (usually) committing these errors or lapses in judgment intentionally. Much of the problem stems from the relatively immature nature of the unconventional side of the business. Leadership typically has a solid Conventional up-bringing and often fails to recognize the distinctly different business decision context or competitive environment of Unconventional resource exploitation. Reservoir, drilling, and production staff have been thrown into the Unconventional realm without the necessary understanding or skills to properly assess, in a business context, the risk and risk mitigation potential. Schools teach the calculation and forecasting of results, yet they seldom teach what to do with the results, nor do they convey how to prioritize work on the most important elements. Their people have had little if any training or practical experience in uncertainty assessment, decision support, project management, or competitive strategy; four critical skill areas that no company can excel without.

The critical errors/failings we shall focus upon below are material threats to success and commonly seen. They are divided into three primary categories: statistical/arithmetic errors, inappropriate assumptions for and use of production profiles and type-curves, and a lack of business context or recognition of competitive advantage opportunities.

Statistical / Arithmetic Errors

Fundamental Aggregation

Fundamental problems exist in the incorporation of uncertainty into the assessment of opportunities. For example, the upside aggregate is *not* the aggregate of all of the individual variable upsides. It bears repeating that the addition or multiplication of common percentiles of individual variables does not produce an aggregate result of the same percentile. The blind assumption that the upside result is the combination of all the upsides of the component variables creates an unreachable forecasted result and an exaggerated expected result for an opportunity. This simple error is at the root of many companies’ failure to perform to expectation.

Constraining to Lognormality

Unconventional opportunities are comprised of wells with variable results that often form a roughly lognormal pattern. There is deviation from lognormality at the top and at the bottom of the distribution, in both cases diverging above the lognormal regression line. The good wells (above P10) tend to be not as prolific as the underpinning of lognormality would predict, and the poor wells are more represented in the population. This deviation is natural and real.

The Unconventional Gas world is *not* lognormal. Lognormal methods gained popularity in the realm of conventional field size distributions and individual prospect pre-drill reserve estimates, and are used because they are relatively simple and fit the majority of the distribution for such volumes.

When a lognormal fit is used to predict individual gas well recoveries, the fact that the best wells will be poorer than the lognormal fit will impact the results more than the under-population of poor well results. As a consequence, the expected (mean) well result is increased, often significantly.

The appropriate way to manage the upper ends of the component distributions is to impose a limit on the input distribution. Placing a limit differs from truncation in that the relative percentiles of the forecast distribution are preserved. On stochastic sampling, values chosen higher than the limit are brought back to the limit. While this creates a small error, it preserves the initial interpretation (10% of the distribution remains above the interpreted P10) with managing the upside forecast for validity. As a proxy for limit imposition, some companies and software products make use of a "Stretched Beta" distribution to achieve roughly the same effect.

Distributions of Well Families

Companies delude themselves due to false uncertainty assessments. They fail to recognize a basic sampling scale error. Schmoker et al. (2001) proposed the use of a cell based method for estimating GIP. In the field we drill collections of wells. When we approach an opportunity, and before many wells are drilled, we have uncertainty in the general quality of the family of wells that will ultimately result. We do not know if the collection will be generally good or generally poor. When we evaluate opportunity potential, it is most useful to assess resource and value through the simulation of the uncertain well collection as opposed to the aggregated mean. Our evaluations must help us make decisions as opposed to simply calculating an expected result (Savage, 2009).

It is critical to understand the sampling level. We get our information at the well level. We require a critical number of wells to provide us with relative certainty of our results for an area. Yet we predict economic success at the opportunity or development program level. When forecasting outcomes for projects, the distribution of well families must be recognized as opposed to a single distribution of well outcomes.

Consider the Figure 2, which shows a cumulative probability distribution for per-well recovery (the straight line and implied probit scale imply this is supposed to be lognormal). A tremendous amount of uncertainty is expressed in a well size distribution. Consider an algorithm where you sample this distribution hundreds or even thousands of times and then sum the result (e.g., you are calculating "Yet to Find" volumes).

Suppose that the mean outcome for the distribution shown to be sampled is 1 BCFG. Now, for sake of argument, let's say that you are modeling no uncertainty in the number of wells drilled…. 1000 wells in each iteration. You sample that distribution randomly 1,000 times and sum the results. You repeat this 5,000 times and order the results. Using this single distribution for well outcome, the answer you get will invariably be about 1,000 BCFG. Despite the fact that you have modeled a huge uncertainty in what the NEXT WELL will deliver, with a reasonably large sample, you converge on the mean solution.

Therefore, one is assuming the ability to predict with uncanny accuracy the future aggregate size characteristics of the undrilled family of locations – the answer will always hover right around the mean of that individual well distribution. The uncertainty that is expressed in the YTF calculations will almost entirely be due to uncertainty in play extent (number of wells) and does not reasonably capture the range of uncertainty in aggregate well outcomes:

The use of a single distribution for well outcome implies that there is absolutely no uncertainty in the interpreted field potential.

This is obviously incorrect. It precludes making any reasonable assessment for pilot success thresholds, pilot well optimization, pilot and program learning priorities, or downside risk identification and mitigation. It provides no information on the true uncertainty of the play and eliminates any confidence in the assessment of the chance for a go-forward or exit decision. Assessing a project with a single distribution for well outcomes, be it a new play or new production technology, is useless biased, deterministic number-crunching.

We recommend entering either a range for AVERAGE per well recovery (by its nature much narrower than the range of individual well recovery) or enter an ENVELOPE of individual well distributions defined by an absolute upper and lower bound for these inputs, and then randomly sampling a hybrid distribution on each iteration. The method was adapted by Haskett and Brown (2005) as a means to incorporate uncertainty based GIP and recoverable across an area of potential. The adapted method uses bounding analogues to create, at the well level, a distribution of well families.

Production Profile Uncertainty

Recognizing the True Source of Uncertainty

The primary uncertainty in the value of an opportunity is derived from the uncertainty of the production profile. Fully two-thirds of the contribution to uncertainty of a typical gas shale play's NPV is production profile related. Approximately 18% is Capex and operating uncertainty, leaving only 15% of the total uncertainty in value to be associated with resource volumes (Haskett, 2009). Spending an inordinate amount of time creating detailed volumetric assessments and then defaulting to deterministic production profiles (type-curves) leads to overestimation of production potential and value – and is an inefficient use of analysis.

The Uncertain Profile

Deterministic type-curve use provides only a single point assessment. Typically the type-curve has been created from expected IP, expected decline (hyperbolic/exponential/harmonic), expected B (hyperbolic exponent, sometimes referred to as the decline curve shape factor), with an expected EUR that will be produced over 30 to 50 years. Production time is fixed, and the curve is fit.

Rarely are there analogues for production performance, and rarely is there the inclusion of even the simplest of uncertainty distributions… P10-P50-P90 type-curves. When the simple probabilistic method of P10-P50-P90 curves are applied, they are usually applied across the entire area of potential. All wells are assigned the P10 curve to deliver the P10 opportunity aggregate profile. This is simply unacceptable.

This is not to say that the use of a type-curve is universally flawed. It is the naive construction of the type-curve set (10-50-90) that destroys the validity. All too often attempts at type-curve uncertainty simply factor up and down the expected type-curve to get the high and low cases. The shape of modeled production decline behavior remains the same across the curves as, essentially, only the IP changes between the "probabilistic" cases. This is an invalid assessment method.

In reality, IP is partly dependent on reservoir character and GIIP. Decline is inversely dependent on reservoir quality and GIP. B is dependent upon the reservoir's ability to recharge the near well-bore vicinity. As EUR changes, all three of these elements will vary. Finally, while increased EUR can be expected to produce increased IP, a high IP in and of itself is *not necessarily* indicative of a high EUR. This variability indicates that P10-P50 and P90 type-curves can (and do) have very different shapes.

We recommend that production profiles be created from the base reservoir characteristics and anticipated ranges of behavior. The profiles should be created with correlated inputs of EUR, IP, Decline, and B without regard to time. Time becomes the free variable. We have the least valid and least reliable information on production life and there is no viable reason why this should be an anchored variable. Additionally, the cumulative value curve of most projects asymptotically approaches the NPV after approximately 15-20 years. All critical business and development decisions will be likely to have made by this time. It is important to model as many near-term variables as possible without interference and bias from long-term reservoir behavior assumptions beyond this period. Any set of inputs must be tied to reality and be supported by sound interpretation and application.

These inappropriate methods and applications are seen to cause/create significant false upside potential as well as a false impression of well result stability. They also mask the downside threat as well as the ability to create effective pilot phase decision thresholds.

Business and Competitive Assessment

Have an Exit Plan

The recognition of well, pilot, and mid-program performance thresholds presents an opportunity to unemotionally exit an opportunity that is not likely to be profitable. The assessment of decision confidence, how certain it is that the decision to continue or exit is correct, becomes a vital component of decision support. Such an assessment cannot be carried out if all prior work simply focused on the mean or expected result. The full range of uncertainty, including the recognition of multiple well families, must be included in the assessment. Simple variation of the mean is insufficient.

Competition and Business Pinch-Points

Unless a company has acquired all available land in a play, it will have competition from other business interests. As such, companies must assess the full value-chain of the opportunity. Not only should the Upstream team investigate the potential reservoir and production elements, but it must think about what happens beyond the physical characteristics:

- How do you access the area and gain a material interest?
- What is the product egress plan, is there transport availability?
- What will be the water supply/disposal and is it sufficient to handle all industry activity?

Most importantly, the Upstream team must identify the business pinch-points that exist in the opportunity. A business pinch-point is a bottleneck in the value-chain caused by a limited resource, such as pipeline capacity, skilled labor, or rig availability. Pinch-points are created by a shortage and strong competition for that short supply element. These pinch-points offer an opportunity to add value through early recognition and control. For example, a group of companies striving to explore and develop a gas shale in Northern B.C. were faced with restricted access to the area. One company JV saw the problem early, recognizing that the government was unlikely to approve several all weather roads through the area; they applied earlier than the competition for the ability to build access. They were approved and had, at least for a time, a strong competitive advantage.

Another example occurred in the late 1990's when support vessels were in short supply in the Gulf of Mexico. One major company recognized this pinch-point early and pre-emptively booked as many support vessels as they could. This achieved a stable competitive advantage at a relatively low cost. The value-based assessment of control of scarce resources, pinch-points, or other uncertainties is called Value of Control (VoC).

Competitive success has two contributing components, both of which demand thought and action:

1) Enable your company to do better than the competition, and
2) Ensure your competitors do poorer than your company.

The recognition, creation, and preservation of competitive advantage takes effort. Most Upstream Unconventional teams are siloed to the degree that they fail to see the full value-chain. Thus, they run headlong into project roadblocks, delays, and additional cost. They fail to see the business pinch-points and never get a chance to truly determine their own destiny.

Failure to Recognize Materiality

Materiality occurs in two forms:

1) Opportunities are material when they are sufficiently sized to matter to the organization.
2) Interest is material when it is significant enough in the Play to ensure a company controls its own destiny.

The objective of every medium- to larger-sized operating company should be to hold material interest in material opportunities. But what constitutes materiality for a company? Internally, projects are seen to be material when they consume effort, time, and money to the degree that becomes noticeable within the portfolio. This will depend on the utility value of the scarce resource allocation within the company, so it is subjective. However, material interest in a Play is less subjective. It is the critical interest that is required to hold sway in development and strategic sales decisions for the area of interest. In major Unconventional plays this will rarely be below 3 TCFG recoverable. Larger plays, such as the Marcellus, will have self-determining materiality within the sub-plays.

It is possible to be over-material in a play. Learning is a critical element to an efficient transition to the factory phase and ultimately achieving profitable success in a play. Learning is expensive. As optimal completion practices vary from Play to Play, and internally between sub-plays, Industry learning is more efficient than isolated single-company efforts can provide. If other companies have no opportunity to participate in a Play due to a single company's over-material position, learning becomes slow, inefficient, and very expensive. When teams fail to recognize the business aspects of the opportunity they fail to position their company for optimal success.

Summary

A number of common errors result from the incorrect or misapplication of statistical and arithmetic principles. The omission of production profile uncertainty from the opportunity assessment robs the decision-makers of the necessary information on the full range of economic results that are possible. Failure to recognize the full range of results sets the company up for downside risk without the ability to identify and mitigate it. The drive to provide a single expected result for an opportunity closes the door on sensible value enhancement and leverage opportunity.

The functionally integrated Unconventional team must have a sense of the value-chain and critical business pinch-points from the start. Failure to find solutions to deliver scarce resource solutions starts with their identification. Competitive assessment should be a commonly accepted task in the early phases of a project and supported throughout. To be successful in Unconventional Gas exploitation a company needs Access, Critical Mass (two dimensions of materiality), and Operational Efficiency in a context of competitive awareness and position.

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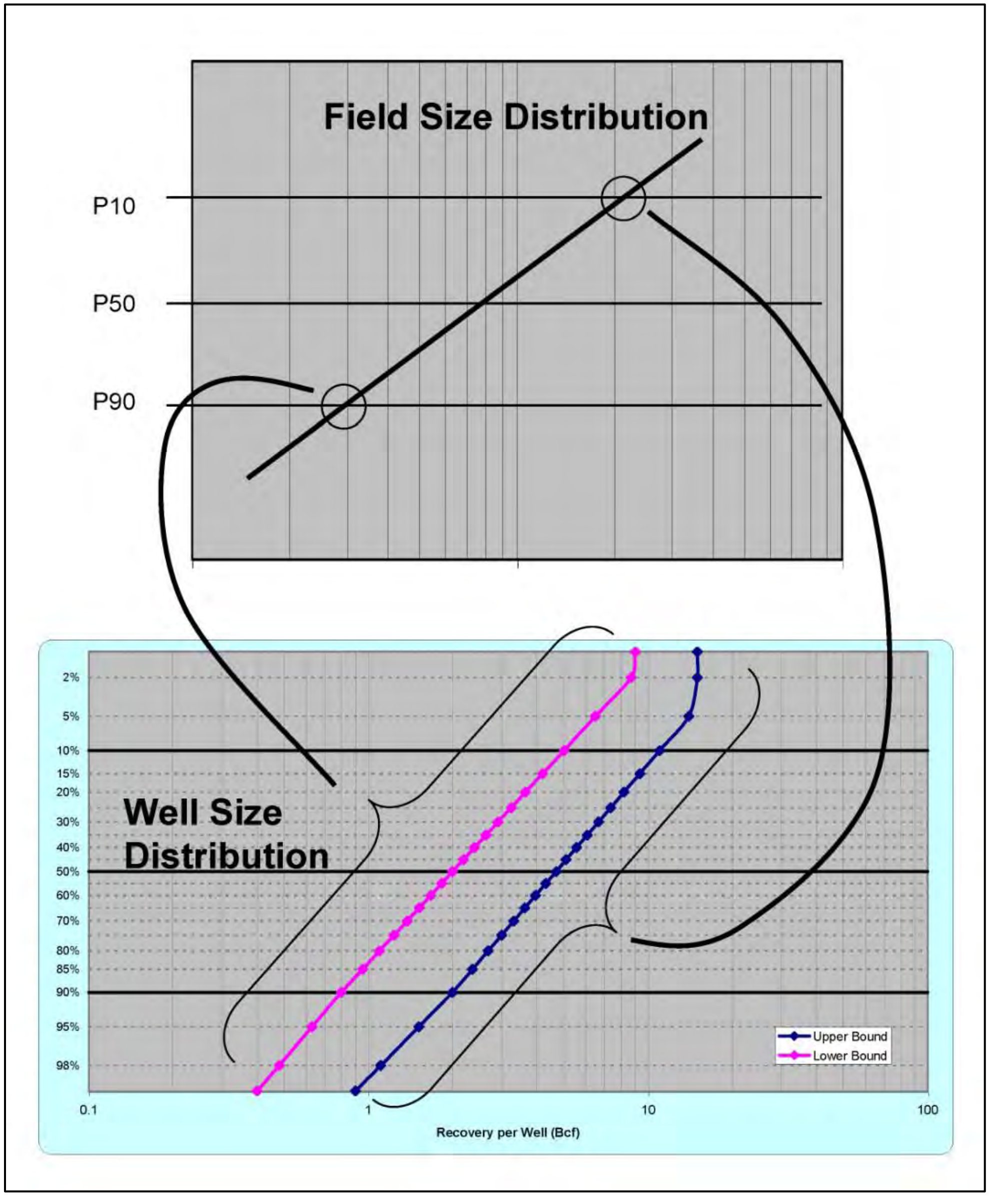

Figure 1. EUR envelope concept (Haskett and Brown, 2005).

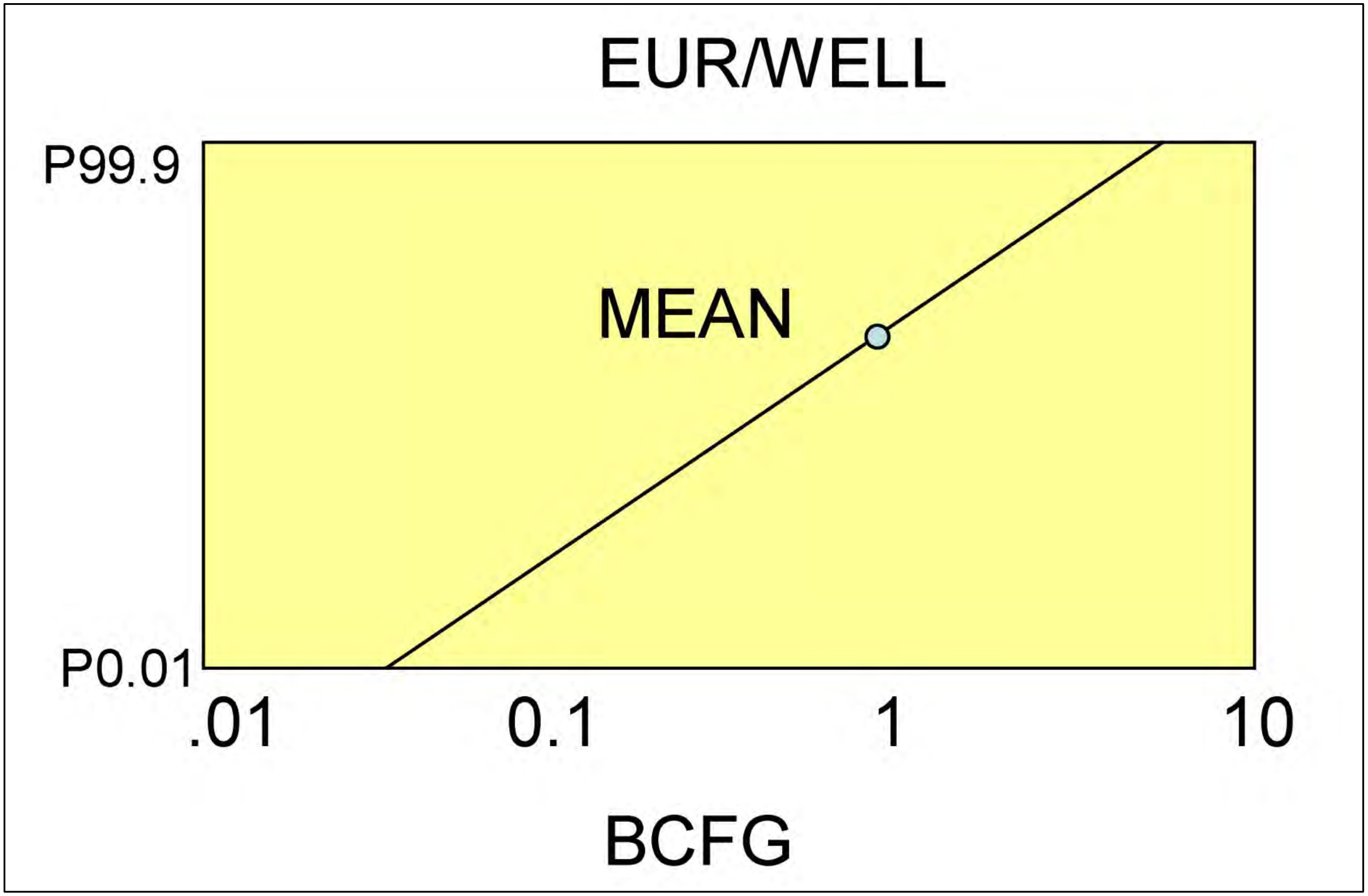

Figure 2. Illustrative distribution of wells.

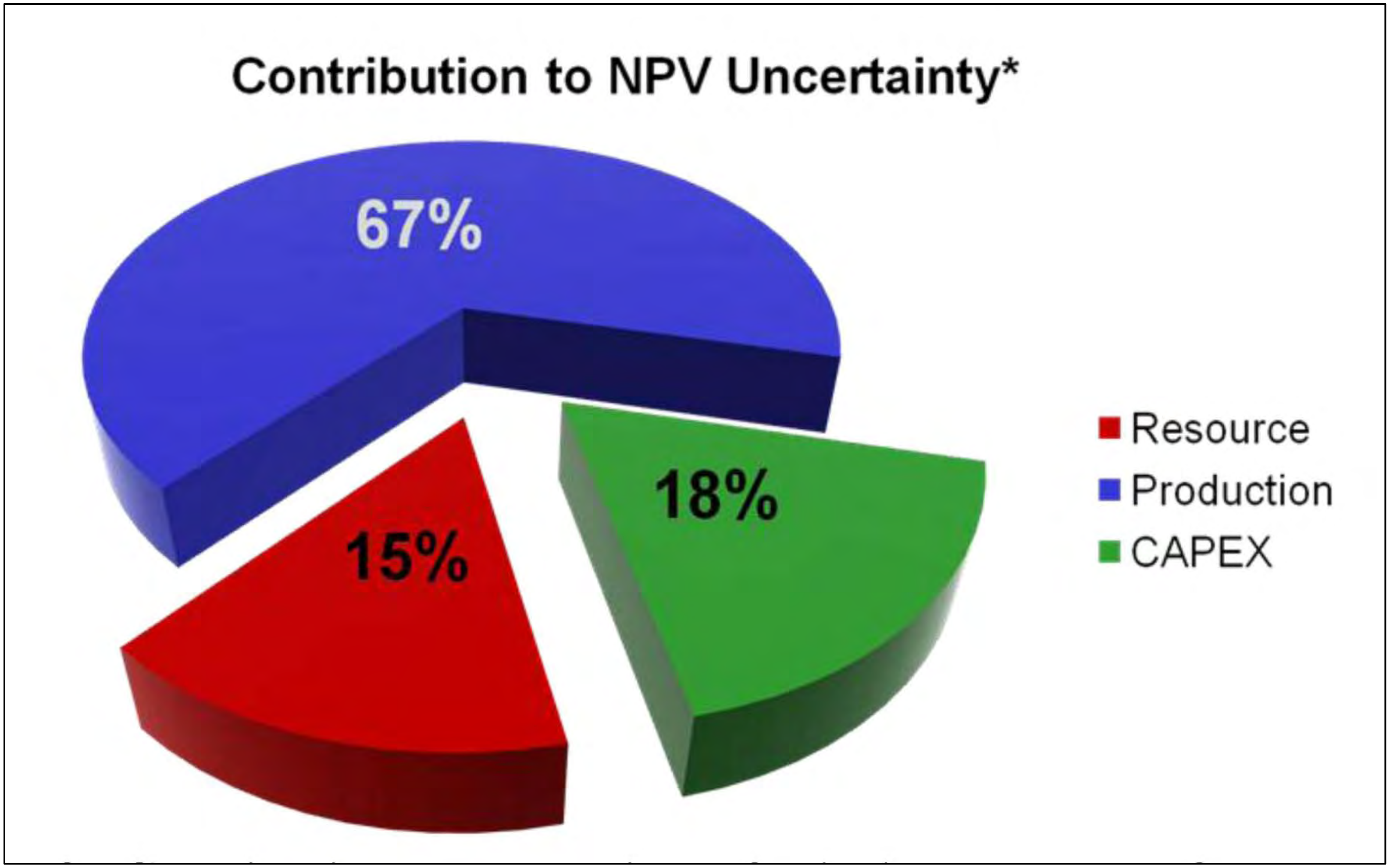

Figure 3. Contribution to Uncertainty of principal elements of a typical Gas Shale Play.

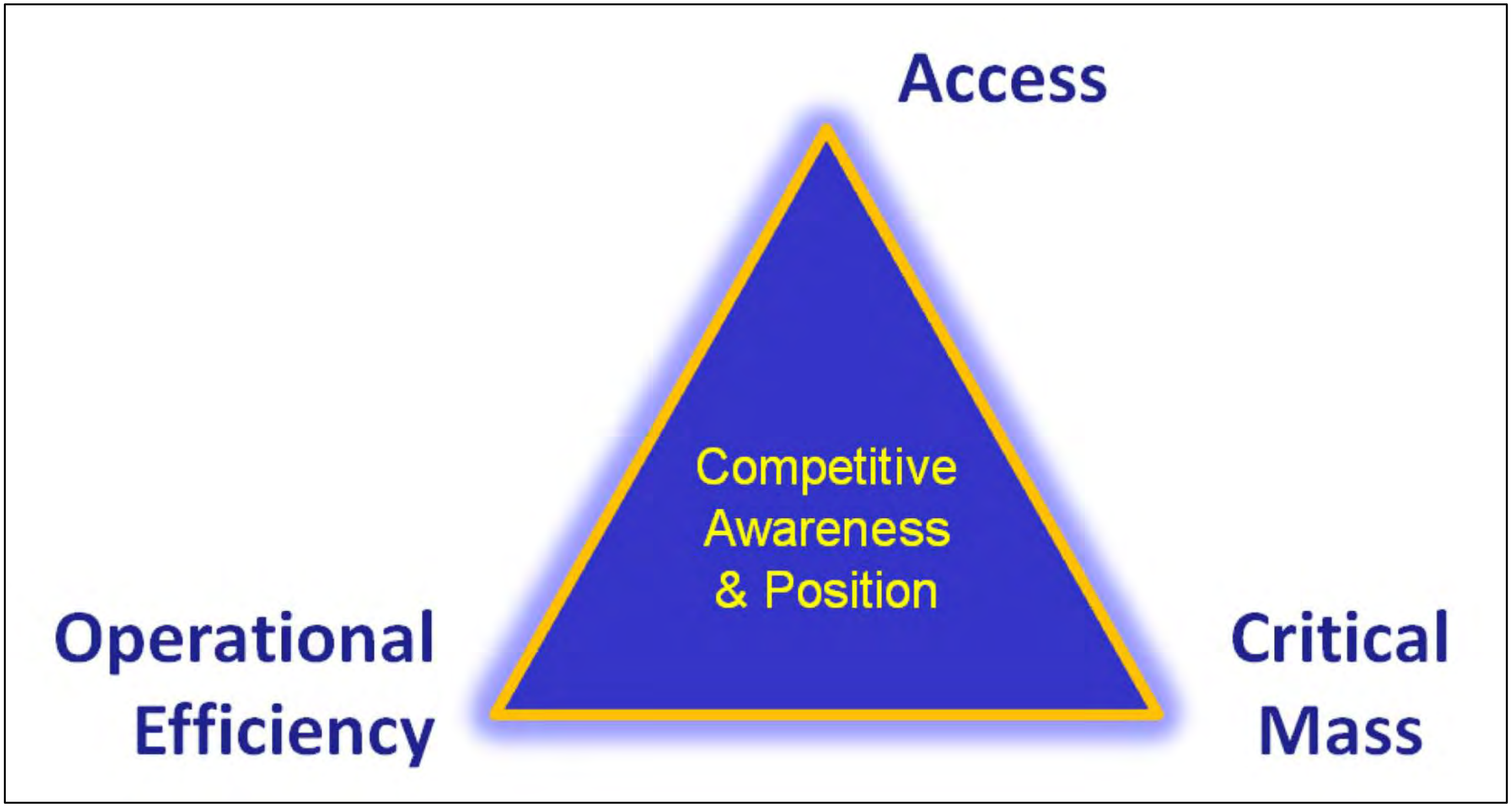

Figure 4. Key Success elements for Unconventional resource opportunities.