The valuation and assessment of unconventional or “continuous resource” opportunities is not feasible using traditional probabilistic, volumetric-based methods. While a fully stochastic business, value-chain model is the best way to assess the potential of an unconventional play, we continue to lack a solid definition of Chance elements similar to what we have traditionally applied to conventional accumulations (Container: Reservoir, seal, trap and Contents: source and migration, with subtle variances from company to company).

In Unconventional projects, there are two primary technical risks… That the formation will not produce, and that the production will be inconsequential. As such, Productivity and Materiality become the linchpins for Chance and Uncertainty Management in unconventional plays.

“Productivity” is the probability that a given formation will be able to flow a sustained gas stream. This Chance element is tied to, but not dependent on, completion technology.

“Materiality” is the probability that the sustained production will be large and consistent enough, and extend over a large enough area to constitute a viable play based on local or world analogues. Essentially, Productivity is flow-based $P(G)$ and Materiality is $P(S)$.

Each will have sub-elements which may be tied to technology, local economics, or marketing aspects. The commercially oriented nature of the Materiality Chance is due to the business-decision centered approach required in unconventional plays. Conventional methods tend to hold commerciality and economics separate from technical risking, but this is impractical if not dangerous in unconventional resource plays due to the fact that the majority of the business uncertainty arises from production profile uncertainty.

In an integrated business assessment of unconventional opportunities, we start with an assessment of the potential of the play. We assess the
Expected Ultimate Recovery, the Production Profile, the costs for the pilot facility, pilot wells, early experimental wells, factory phase development wells, facilities costs, learning, price volatility, operating costs, and rig and facility timing. It is a low-margin business and we need to be able to identify where our efforts will have the most reward.

References


Risk Analysis of Unconventional Projects

Bill Haskett
Senior Principal
Decision Strategies Inc.
Risk Occurs in Three basic categories

- **Productivity**
  - The probability that the play will produce sustainable production

- **Materiality**
  - The probability that the sustained production will be large enough and consistent enough to constitute a viable play

- **Above Ground**
  - Access, environmental, water availability and handling, egress, liquids handling, sales, internal capabilities

Unfortunately...
Most technical teams stop with these elements.
Think again…

Access, environmental, water availability and handling, egress, liquids handling, sales, internal capabilities…

If you think, as an Upstream person that this is “not my problem”…

Your project is doomed from the beginning.

Identifying and mitigating these risks gives you leverage, control, **Competitive Advantage**!
Is it There?

**Productivity**

In Conventional, if it is there it is going to produce.

Not so with Unconventional.

Probability of Hydrocarbon presence in a large enough quantity that sustainable flow is achieved.

This is usually 100%, but can be less in frontier areas.
Conventional seemed straight-forward…

...but no longer applies
Unconventional Play Work Flow

**Business Context**

- EUR Envelope
- Production Forecast
- Costing
- Pilot Optimization
- Pilot Threshold
- Economic Viability
- Mid-Program Exit
- Full Factory Phase

**Play Volumetrics**

- Spacing Unit Volume
- Spacing Unit Definition
- Core/L Por & Ads Por (optional)
- Area Definition
- Spacing Unit Correlation
- Full Play Simulation

**Play Opening Volume Assessment (optional)**

**Decision Based Volumes**

- Reasonable?

**Play Potential**

- Calibrated Play Volume Potential
In Unconventional, the area of potential is usually big.

The collection of spacing units forms a “Pseudo-Field”
“Conventional” uses Field Size Distributions

But remember… each field is a collection of wells… or spacing units

See Haskett and Brown (2005), SPE 96879 For a more detailed explanation
Meet the Well Size Distribution

Every field has a family of wells. Good wells… and bad wells

Our quest is to efficiently determine what we have.
The Correct Approach is an Envelope

An unconventional opportunity will have a resource unit distribution someplace in between the bounds.

If there is any uncertainty about what you will find on average… You need an Envelope!
Is it Big Enough to Matter?

Materiality

The probability that the sustained production will be large enough and consistent enough to constitute a viable project

P

Is Rate and Profile based
Resource assessment forms the foundation but there is much more...

Contribution to NPV Uncertainty

- 67% Resource
- 15% Production
- 18% CAPEX

*Typical Gas Shale Play
Work on What Matters
A decision centric approach provides a better assessment

• Create a Learning Plan
  – Pilot objectives
  – Production testing
  – Capital Efficiency

• Recognize what would change your decision

• Ensure Project Management Skills
  – Are in place
  – Are appropriate for Learning and Factory phases
Probabilistic Production Profiles, Not Time Anchored Type Curves

P10-50-90 Pathways

Rate

Time

90th Percentile

50th Percentile

10th Percentile
Presenter's Notes: Traditionally, reserves in shale gas reservoirs have been estimated using decline curve analysis. The reservoirs are very tight; the wells are widely spaced, and the wells remain in transient flow for many many years. As a result the decline exponent, or B factor, as it is called, is quite high.

In the case shown here for 162 wells in Devonian gas shales in eastern U.S., the B factor was 2.367.
Presenter's Notes: Now, the concern is, if you start drilling these wells closer together, they're not going to remain in transient flow over their entire life. They eventually sense the nearby wells and the decline steepens.

So in the case of the Devonian wells in the eastern U.S., if the B factor drops to 1, which is harmonic decline, you'll only have 57% of the reserves you originally had. And if the B factor drops to 0, which is exponential decline, you'll have 23% of the reserves you originally had.

So some people, particularly Tom Blasingame at Texas A&M, are quite concerned that we may be overestimating reserves by using this technique to extrapolate early time data in closely spaced wells.
Ultimately we must make our decisions based on a Full Value-Chain approach.
Jonah Field Wyoming – (Majority vertical wells)

One Mile

~20 Acre Spacing

One Square Mile

One Mile
Jonah Well Density Superimposed on Pittsburgh

Intelligent Horizontals will significantly reduce pad density
Above Ground Risk Matters

Access, environmental, water availability and handling, egress, liquids handling, sales, internal capabilities...

Identifying the Business Pinch Points is critical.

A Business Pinch Point is any element along the value chain that is scarce or could become scarce if the competition was involved.
Competition and Business Pinch-points

IDENTIFY
• Competitors
• Positioning and Strategies
• Business Pinch-Points
• Value of Control

Client Focus Area
Geological and Production Uncertainty allow you to Manage Above Ground Risk... And Optimize

How much land and when?

How large a pilot program?

How many rigs and when?

It enables you to create an efficient *Learning Plan*
How many pilot wells do you drill?

<table>
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<tr>
<th>1 well</th>
<th>2 wells</th>
<th>3 wells</th>
<th>4 wells</th>
<th>5 wells</th>
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</table>

Pilot Effectiveness

- Diminishing learning with additional drilling
- "Optimal" Wells

*True Positives*
*True Negatives*
PA Horizontal Dry Gas

- 10,000 acre Pseudo-Field
- First assess what the reservoir will do
- Determine critical thresholds
- Program is stopped if Pilot fails to show sufficient EUR
- Optimize pilot program and land given strategy and objectives

### RESULTS OF SIMULATION

<table>
<thead>
<tr>
<th>Probability</th>
<th>P90</th>
<th>P50</th>
<th>P10</th>
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<tr>
<td>Full Project</td>
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<td>Pilot Success</td>
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### Success Case Discounted Investment, $MM

<table>
<thead>
<tr>
<th>Probability</th>
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<td>Net</td>
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<td>Post Learning Well Cost ($MM)</td>
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How much land do you secure before the pilot result is known?

- High early purchase risks stranding capital or direct loss from pilot failure
- Both Risk and Cost based optimization
- Potential competition reduces land availability for late acquisition
- Increased competition elevates price for late acquisition
Entry and development decisions

- Exploration Success
- Pilot Success
- Mid-Program Check
- Development Success

Decision Paths:
- Does there exist Resource? (P_g)
- Is it recoverable? (P_p)
- Was the Pilot Truthful? (P_c)
- Is it profitable? (P_c)
Risk Analysis of Unconventional Projects

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