Oil and Gas Reserves Evaluations

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Issues in Oil and Gas Reserves Estimations

- Techniques proved in conventional resources not necessarily appropriate in unconventional resources

- Uncertainty levels moderate in conventional resources, higher in unconventional resources

- Resources (hydrocarbons in place) are not necessarily reserves
What Methods Do We Use to Estimate Reserves?

- Volumetric analysis
- Analogy
- Extrapolation of production history
- Reservoir simulation (models)
Reserves Estimation: Volumetric Method

- Areal Extent (productive limits of reservoir)
  - Structure map
  - Seismic
  - Analogy
- Net pay thickness
  - Well logs
- Porosity
  - Well log or cores
- Water saturation
  - Well logs or cores
- Recovery efficiency
  - Analogy
  - Drive mechanism
  - Reservoir characteristics
Reserve Estimation: Analogy

- Average reserves from offset wells or fields with similar reservoir characteristics
- May not work in unconventionals
  - Poor wells may offset good wells
- No shale resource is an analog for any other shale
Decline Curves – Plots of production rate vs. time, usually on semi-log scale

- Exponential decline
  - Decline rate constant
- Hyperbolic decline
  - Decline rate changes with time
Illustration of Problems with Decline Curve Projection (Jenkins and Ilk)

Haynesville Performance Possibilities

Shale Gas Decline Curve Forecast Using 1.5 years of Production

- $b = 1.0$ (Harmonic) 5.7 Bcf
- $b = 1.5$ (Super-harmonic) 7.0 Bcf
- $b = 0.0$ (Exponential) 3.7 Bcf
- $b = 0.5$ (Hyperbolic) 4.2 Bcf

Reserves Estimation: Numerical Simulation

- Rigorous mathematical model
  - Breaks reservoir into thousands of ‘cells’
  - Calculates fluid flow between cells
  - Requires accurate reservoir data
  - Expensive, requires high level of expertise
  - Quality of forecast limited by quality of data input
Unconventional Reservoir Development
(Shales)

Typical steps in development

- Drill exploratory well, discover reservoir
- Test areas of interest with pilot program(s)
  - Determine effective stimulation practices
  - Determine appropriate well length
  - Determine appropriate well spacing
- Drill wells to hold acreage as in lease agreements (e.g., one well per section)
- Develop acreage with technology, well spacing ‘proved’ in pilot program
- No proof of concept in pilots, no reserves
Shale Reservoir Completion

- Horizontal wellbores
- Multi-stage hydraulic fractures
- Fracture spacing 2-5 stages/1000 lateral feet
- Lateral length x frac length = drainage area

75-100 bpm
1.8-3.5 lb/gal
250-330 M lb/stage
Shale Reservoir Completion (Cont’d)
Reserves in Shale Reservoirs

How does industry currently estimate reserves in shale reservoirs?
- Answer: Decline curves/type wells (analogy)

Are reserves predictions reasonably accurate?
- Answer: Perhaps, but not with this methodology alone

Decline Curve Analysis
- Uncertain for wells in ‘transient flow’ (early time production – months or years)
- Can be as much ART as science
- Reserves estimates can vary greatly depending on historical production data

Industry standard is decline curves—but what happened to the other methods?
Uncertainty in Shale Reserves Estimates

- **Least uncertainty**
  - Longer well histories, providing better documented decline trends, type wells for analogy, established drilling and completion technologies
  - Pressure-independent reservoir properties
  - Dry gas rather than gas condensate or light oil (phase changes in future)
  - Examples: Barnett, dry gas Eagle Ford and Marcellus, Woodford, Fayetteville

- **Greater uncertainty**
  - Newer shale plays, shorter histories, as in Permian Basin, Utica
  - Gas condensate, light oils as in Eagle Ford, Marcellus, Bakken
  - Complex reservoir properties, as in Haynesville

- **Wild card:** human tendency of undue optimism in any reservoir
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