Applying Probabilistic Well-Performance Parameters to Assessments of Shale-Gas Resources

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Applying Probabilistic Well-Performance Parameters to Assessments of Shale-Gas Resources

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USGS Assessments Before 1995

- In-place estimate plus estimate of recovery factor
- Volumetric calculations of rock volumes and resource densities
 - In pore space
 - Sorbed
- Recovery factors poorly known

USGS Assessments 1995 to Present

- Well production data used to derive a distribution of estimated ultimate recoveries (EURs)
 - Divide assessed area into cells
 - Calculate numbers of untested cells
 - Apply EURs to cells

Methodology Needs

- Digest larger volumes of production data
- Better include geologic understanding of spatial and temporal trends
- Apply analog information to hypothetical or very immature assessment units

Present Calculation Method

- Present USGS method calculates as if you were sampling from the EUR distribution thousands of times independently
 - Calculates as if mean EUR were known exactly
 - Underestimates uncertainty

Improved USGS Methodology

- Directly estimates uncertainty of EUR
 - Affected by temporal and spatial trends
 - Depends on geology, not just data
- Based on wells, not cells
- Assesses sweet spots and nonsweet spots

Temporal Trends

- Historical success ratios and EUR distributions may not be appropriate for future drilling
- Look at temporal changes in EUR distribution
 - Changes in technological practice
 - Changes related to geology

This diagram shows distribution of production for four groups of vertical Barnett Shale wells of roughly equal size, with group 1 containing the earliest wells and group 4 the most recent. The data show a decrease in first full month well production over time.

This figure compares trends in Bossier Formation well characteristics over time. Around 1990, there was an increase in drilling accompanied by a decrease in average well spacing and an increase in average first full month production. Data for 2008 are incomplete.

Spatial Trends

- Look at spatial changes in EUR distribution
 - Define sweet spots
- Compare to known geology
 - Thickness
 - Total organic carbon (TOC)
 - Thermal maturity

This map shows estimated ultimate recoveries (EURs) of Fayetteville Shale gas wells and how they cluster into sweet spots.

This map compares the well EURs of the previous map to the thickness of radioactive shale (as contoured by David Houseknecht, USGS). Note the moderate level of correlation between EUR and shale thickness.

Risk

- Divide the assessment unit into a quantitatively assessed area and an area that has no significant resource potential
- How much of the shale is a self-sourced reservoir?
 - >2% total organic carbon, and
 - Adequate maturity (thermal or biogenic)

Quantitatively Assessed Area

- Option to divide the assessment area geologically into sweet spots and nonsweet spots
 - Not necessarily mappable at this time
- Each part has its own success ratio and its own EUR distribution

Application to Data-Poor Environment

- Risk becomes much more important
- Uncertainty of mean EUR is large source of overall uncertainty
- Analog datasets

Comparison of several groups of shale-gas wells that could be used as analogs for assessments of data-poor areas. The box-and-whisker plots summarize the distributions of the first full month of production, which is commonly the highest monthly rate of production. Note the contrast between distributions of vertical and horizontal well productivities within the same formation. F90 denotes a 90 percent chance of at least the amount tabulated. Other fractiles are defined similarly.

This is another way of comparing EUR distributions for analog groups of shale-gas wells. Squares represent the mean of each distribution. Note the large variation among groups. For example, the means for vertical well groups differ by greater than an order-of-magnitude. MMCF = millions of cubic feet.

For more information go to:

[http://energy.cr.usgs.gov/oilgas/
noga/methodology.html](http://energy.cr.usgs.gov/oilgas/noga/methodology.html)