Abstract

Over the last decade, oil and gas well productivities were estimated using decline-curve analysis for thousands of wells as part of U.S. Geological Survey (USGS) studies of continuous (unconventional) oil and gas resources in the United States. The estimated ultimate recoveries (EURs) of these wells show great variability by assessment unit (AU), among AUs of similar reservoir types, and among groups of AUs with different reservoir types. Within a particular oil or gas AU (such as the Barnett Shale), EURs vary by about two orders of magnitude between the most productive wells and the least productive ones (excluding those that are dry and abandoned). The distributions of EURs are highly skewed, with most of the wells in the lower part of the range.

Continuous AUs were divided into four categories based on reservoir type and major commodity (oil or gas), eroded gas shale, shale gas, other low-permeability gas AUs (such as tight sands), and low-permeability oil AUs. Within each of these categories, there is great variability from AU to AU, as shown by plots of multiple EUR distributions. Comparing the means of each distribution within a category shows that the means themselves have a skewed distribution, with a range of approximately two to three orders of magnitude.

A comparison of the three gas categories (coalbed gas, shale gas, and other low-permeability gas AUs) shows large overlap in the ranges of EUR distributions. Generally, coalbed gas AUs have lower EUR distributions, shale gas AUs have intermediate sizes, and the other low-permeability gas AUs have higher EUR distributions.

The plot of EUR distributions for each category shows the range of variation among-developed AUs in an appropriate context for viewing the historical development within a particular AU. The Barnett Shale is used as an example to demonstrate that dividing wells into groups by time allows one to see the changes in EUR distribution. Subdivision into groups can also be done by vertical versus horizontal wells, or by any other variable for which one has or can calculate values for each well. The resulting plots show how one can subdivide the total range of productivity in shale-gas wells into smaller subranges that are more appropriate for use as analogs.

Estimated Ultimate Recovery (EUR)

For each AU, tens to thousands of hand-fit decline curves to individual wells were used to create a distribution of EURs (Cook and Charpentier, 2019). The use of automation and probabilistic expression to create probabilistic type curves may allow similar well-level results for more wells with a smaller time investment (Cook and Charpentier, 2019).

Clouds: Distribution of Distributions

The variability of oil and gas well productivities for continuous (unconventional) petroleum accumulations: U.S. Geological Survey

Are clouds built from different data sources comparable?

Figures 1, 2, and 3 present examples of clouds for Barnett shale horizontal wells. The distributions of EURs are highly skewed, with most of the wells in the lower part of the range. The distributions are of various types, not necessarily lognormal. The data from previously drilled wells give a similar range of variability as from the estimates for undrilled wells.

Figure 4. This cloud plot presents the EURs for all Barnett Shale wells drilled through October of 2009. The distributions of EURs are highly skewed, with most of the wells in the lower part of the range. The distributions are of various types, not necessarily lognormal. The data from previously drilled wells give a similar range of variability as from the estimates for undrilled wells.

Data Sources

IHS ENERGY, INC., MONTHLY PRODUCTION DATA FOR U.S. WELLS

50,000+ wells in continuous deposits studied

Estimated ultimate recovery (EUR) by decline-curve analysis

Decline-curve analysis done by hand or by automated procedures

USGS ASSESSMENTS OF CONTINUOUS RESOURCES IN THE UNITED STATES

132 assessments conducted from 2009 to 2013

Input forms give the estimated EUR distribution for the undrilled part of each assessment unit (AU)

EUR given as a bullet, triangular or lognormal distribution

For most AUs, the EUR distribution for the undrilled portion of the AU is shown as that for the drilled portion of the AU

EUR distribution estimated from the input forms takes into account geologic differences of undrilled versus drilled portions

Estimated ultimate recovery (EUR) by decline-curve analysis

Decline-curve analysis done by hand or by automated procedures

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Figure 5. The EUR distribution for the undrilled portion of the Barnett Shale (red) is shown as that for the drilled portion of the Barnett Shale (blue). The EUR distribution estimated from the input form takes into account geologic differences of undrilled versus drilled portions.