# Importance of Probability Distributions on Volumetric Characterizations in Resource Assessment

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## Abstract

Before making investment decisions for hydrocarbon opportunities, explorationists need to realistically evaluate chance of geologic and commercial success. Proper characterization of volume uncertainty, typically using statistical methods to evaluate parameters required for a hydrocarbon accumulation (porosity, net-to-gross, etc.), is essential. Use of past venture analysis has documented the tendency of industry to systematically overestimate the expected mean accumulation size and underestimate the volume range for undrilled prospects. Often such optimistic expectations result from improper characterization of the range and variance of volumetric input parameters.

The preferred choice of probability types used has long been a topic of debate and typically include Lognormal, Normal, Triangular, Beta, Uniform, and Gamma. When assigning distribution type and range, one must consider what each distribution represents. For parameters such as reservoir thickness or porosity, which have spatial or stratigraphic variations in measured values, the distribution represents uncertainty in the mean value for the evaluation unit. Generally, the distribution should be narrower than the range of individual measurements, but if biased, the range could be wider than or offset to measurements. For parameters such as closure area and height that will ultimately be a single measured value, the input distribution represents the range and probability of potential values. The granularity of the volumetric equation can vary, such as gross rock volume as a single aggregate parameter or as multiple input components. Use of multiple components is preferable to enable better control over the uncertainty distribution. Fluid contacts are complex and may be poorly represented by a simple distribution.

In this presentation, we discuss strengths and weaknesses of various options and argue that the Beta distribution is well suited for most symmetrical and asymmetrical volumetric inputs. By using modified inputs, the Beta distribution can be defined using minimum, maximum, mode, and dispersion (λ) parameters. Increasing parameter variance within the defined range is crucial, as the range may be limited by low-end cutoffs (e.g., minimum porosity cutoff) and high-end physical limits (e.g., net-to-gross less than 1). Because naturally unbounded distributions (e.g., Lognormal) must be truncated, the bounded Beta distribution is more intuitive and can reasonably represent the appropriate level of skewness. We discourage using intermediate input values (e.g., P90 and P10 rather than min and max) and allowing software to extend the range, as this approach can result in unforced errors (extending ranges outside of allowable range) and obscure the ability to learn as prospects are drilled. It is preferable to follow a well-defined workflow to ensure that the range is sufficient rather than depending on software to correct for user underestimation of the range.

Assessment of Energy Resources Wednesday, July 27 9:50 AM