[EA]Managing Uncertainty for Better Decision Making*

Mark Schneider[1]

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[1]Rose and Associates LLP, Jakarta, Indonesia (MarkSchneider@roseassoc.com)

Abstract

The very nature of the oil and gas industry requires us to explore many kilometers beneath the Earth's surface in search of hydrocarbons from accumulations that we will never see with our eyes. For the discoveries that we make, the industry must approve large sums of money to be spent now to develop an unknown volume of hydrocarbons that will be produced in the future and sold at an unknown price. The uncertainties in our industry invade every aspect of the full life cycle of every project. We try to eliminate uncertainty by acquiring new data while we continue to analyze the old data. Sometimes we pretend we have eliminated uncertainty by running economics on deterministic estimates. Reality is that there will always be an irreducible level of uncertainty and the best we can hope to do is to understand and properly characterize uncertainty.

Only after properly characterizing uncertainty and incorporating it into our resources and economic evaluations can we expect to optimize our business decision making. Managing uncertainty starts with the technical aspects of the subsurface geological elements and continues with estimation of resource volumes, development costs and timing, and through the full producing life of the asset. However, effective estimating under uncertainty is a different skill set than the formal education that geoscientists and engineers earn in the university and they rarely get formal training after entering the workforce.

Many years of providing training courses and consulting has made it evident that as humans collectively, we are not inherently good at estimating ranges with proper confidence intervals to questions when the answers are unknown. This presentation will include an interactive section of five questions for the participants to estimate the answer by providing a range that they have 80% confidence the true answer is within their defined range. If the participants in the symposium follow the trend noticed by the author in similar surveys over many years, the ranges provided will include the answer less than 40% of the time, which is less than half of what was requested.

Prospect Evaluation

The feedback that is learned from this is that everyone needs to be vigilant about checking the reasonableness of all distributions that are prepared in prospect evaluation. This includes reality checks on the extreme endpoints of all distributions to make sure they are reasonable and geologically possible before the activity begins (e.g. drilling a well) and performance tracking after completion of the activity (e.g. post-drill appraisal of all inputs). Estimates with ranges that are too narrow are examples of overconfidence bias. Another common bias in prospect evaluations is optimism bias where the distribution percentiles and the mean are consistently too large. Figure 1 is an illustrative example of how these two common biases look as distributions when compared to the true unbiased distribution.

Without formal training in effective estimating, there often are some common pitfalls and mistakes that are made during the preparation of a prospect's resource distribution. So, in addition to the previously mentioned challenges in assigning the correct range for the distribution of a parameter, we also are challenged with identifying biased datasets, recognizing what scale should be used (e.g. distribution of core plug porosities or reservoir average porosity?) and using the correct distribution type.

Figure 2 is an image showing scales varying from thin sections to field level average values of a parameter (e.g. porosity). Upscaling from small to large scales tends to average out extreme values and reduces the P10/P90 ratio. A fine grid 3D geologic static model should use a distribution based on a small scale. But, for estimating resource volumes for an exploration prospect, we need to know the "Field Level" average (e.g. porosity) and thus we want to build the distribution of the range of the average at the field level.

Another surprising challenge is to ensure that the correct parameter to build the desired distribution is always used. Gross reservoir thickness is an example of a parameter that is sometimes mistakenly used. When resources volumes are estimated using the Area x Average Net Pay Method, the reservoir thickness is a separate distribution and not spatially defined relative to the productive area. So, to ensure that only the reservoir above the water contact at the crest of the structure is included, the gross pay thickness is the parameter that the distribution must define. Gross pay thickness is the smaller of the gross reservoir thickness and hydrocarbon column height. Figure 3 visually compares these two gross thicknesses.

Calculating Probabilities

Reality checks of the reasonableness of inputs to all distributions is one of the easiest and simplest ways to eliminate common mistakes and to improve the quality of the evaluation. Several cases will be discussed during the presentation. All parameter distributions must be built for the success case. The implication of this is that distributions should not include values below a cutoff value that are not part of a success case. For example, the entire porosity distribution must be above the cutoff porosity that correlates to the effective minimum permeability for flow of hydrocarbons. If porosity is less than the petrophysically defined cutoff value, the prospect will be a dry hole due to reservoir failure and this needs to be handled in assessing the chance of geologic success.

Another issue that happens too often is not reality checking P99 and P1 productive areas by plotting them on the map. In this presentation, all percentiles, such as P99 and P1, are based on the greater than or equal percentile convention. So P99 means there is a 99% chance that the actual value will be equal to or greater than the estimated P99; and there is only a 1% chance that the actual value will be equal to or greater than the estimated P1. Plotting P1 productive areas on the map can sometimes quickly show that it is not geologically reasonable. Reasons include closure is downdip of known dry holes, an implied hydrocarbon column height larger than geologically possible, or the P1 area goes well beyond the most optimistic structural closure that could be interpreted.

With the challenges in preparing unbiased evaluations, a common question is how one improves and builds appropriate distributions. The best way to get calibrated is performance tracking of actual results versus pre-drill estimates. Meaningful trends cannot be made based on a small sample size. So, another challenge is having enough wells drilled to allow for statistically significant conclusions.

Small sample size is also an issue in building appropriate distributions for the pre-drill evaluation. One of the best analysis techniques to understand if estimated ranges are appropriate is using percentile histogram charts. The concept is simple, regardless of the actual estimated value, only 10% of all outcomes should be less than the P90, another 10% should be between P90 and P80, and likewise for all 10% increments of the distribution. Figure 4 shows how percentile histograms can be used as a diagnostic tool. The most common results in estimating resource volumes is being too optimistic by not recognizing the downside. As a result, significantly more outcomes than expected are below P90.

The holistic view taken to this point of the challenges, pitfalls and mistakes that are often made have been focused on building the geologic distribution. But in the search for better decision making, should geologic distributions be used for commercial decisions? The answer is no. Geologic discoveries that are too small to economically develop are abandoned. Only discoveries large enough to make a profit on look-forward investment basis are developed. Should economic evaluations be made on the same basis as the decisions are made? The answer is yes.

If real decisions are made based on commerciality, then better decisions will be made if the economic evaluation is based on the commercial resource distribution and the chance of commercial success. The corresponding geologic resource distributions and chance of geologic discovery are important in performance tracking to improve future subsurface evaluations, but they should not be used as the basis of the economic evaluation.

Examples

Figure 5 includes information that is helpful in making an investment decision. The table and log-probit chart are two different displays of the geologic and commercial distributions. For this gas prospect, the chance of geologic success is 30%. The minimum commercial field size (MCFS) required to get approval to develop is 120 BCF (P90 of geologic distribution). Geologically, the prospect can be summarized as having a 30% chance of making a discovery with geologic mean of 549 BCF. Commercially, the prospect if a discovery has a 90% chance of being large enough to develop with a commercial mean of 600 BCF. So, there is a 27% chance (i.e. 30% x 90%) that the prospect will be a commercial discovery of 120 BCF or more.

A common misunderstanding of some decision makers is believing that there is 27% of achieving the commercial mean of 600 BCF. This is wrong, there is a 27% chance of finding an accumulation that is greater than or equal to 120 BCF with a mean of 600 BCF. The chance of making a discovery of 600 BCF or more is only 9% as shown in the bar chart. The difference between 9% and 27% could easily influence the decision maker to make a different decision.

Most companies have good exploration guidelines on preparing exploration prospect evaluations. But there are often no guidelines on how to develop commercial discoveries. Figure 6 is an example of two very different ways to develop the same resource volume with major economic consequences.

Conclusions

In conclusion, it is the author's hope that this presentation created awareness among the readers for the many pitfalls and mistakes that need to be avoided and the importance of reality checking distributions in managing uncertainty for better decision making.

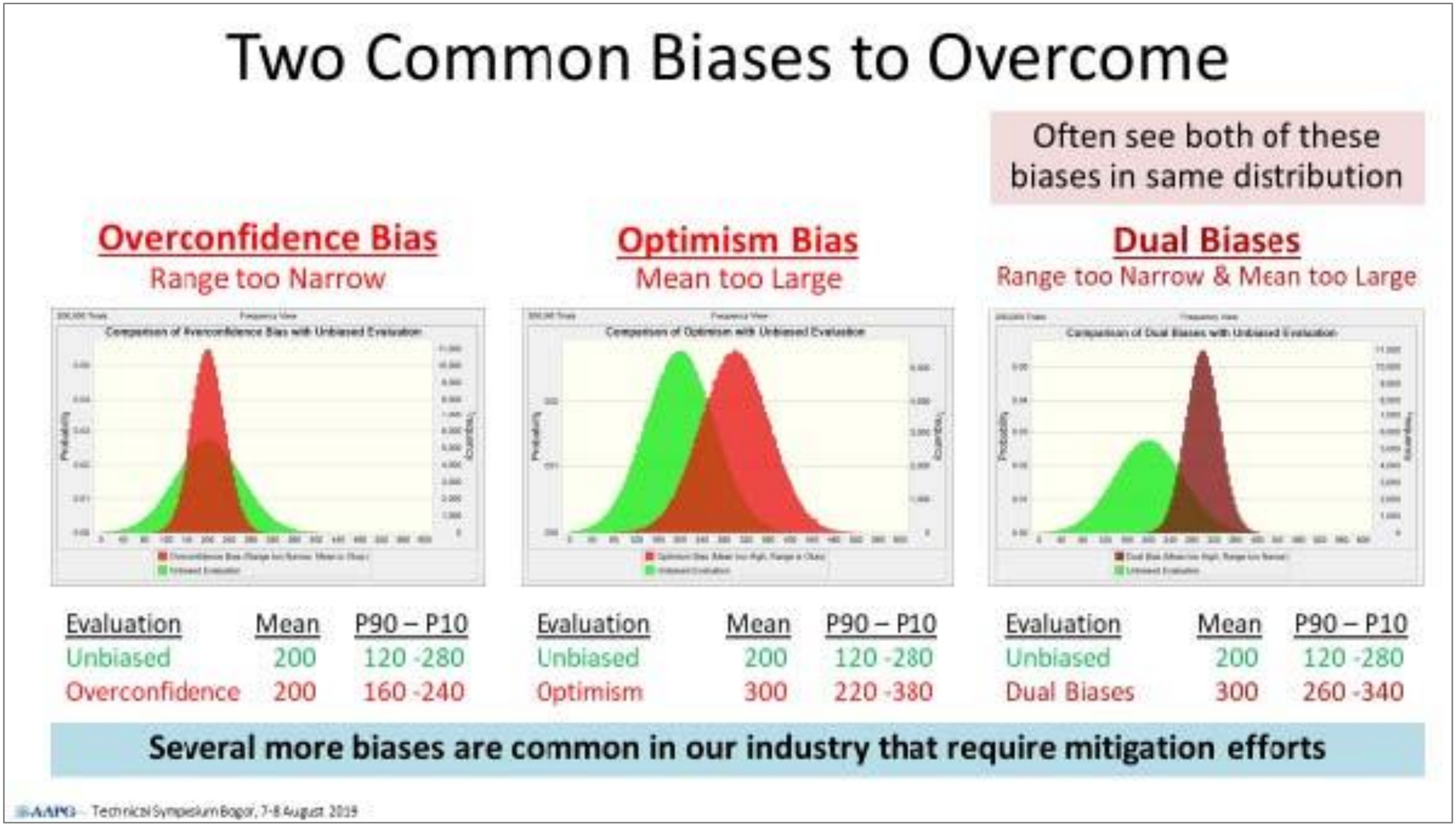

Figure 1. Example of two common biases in estimating under uncertainty.

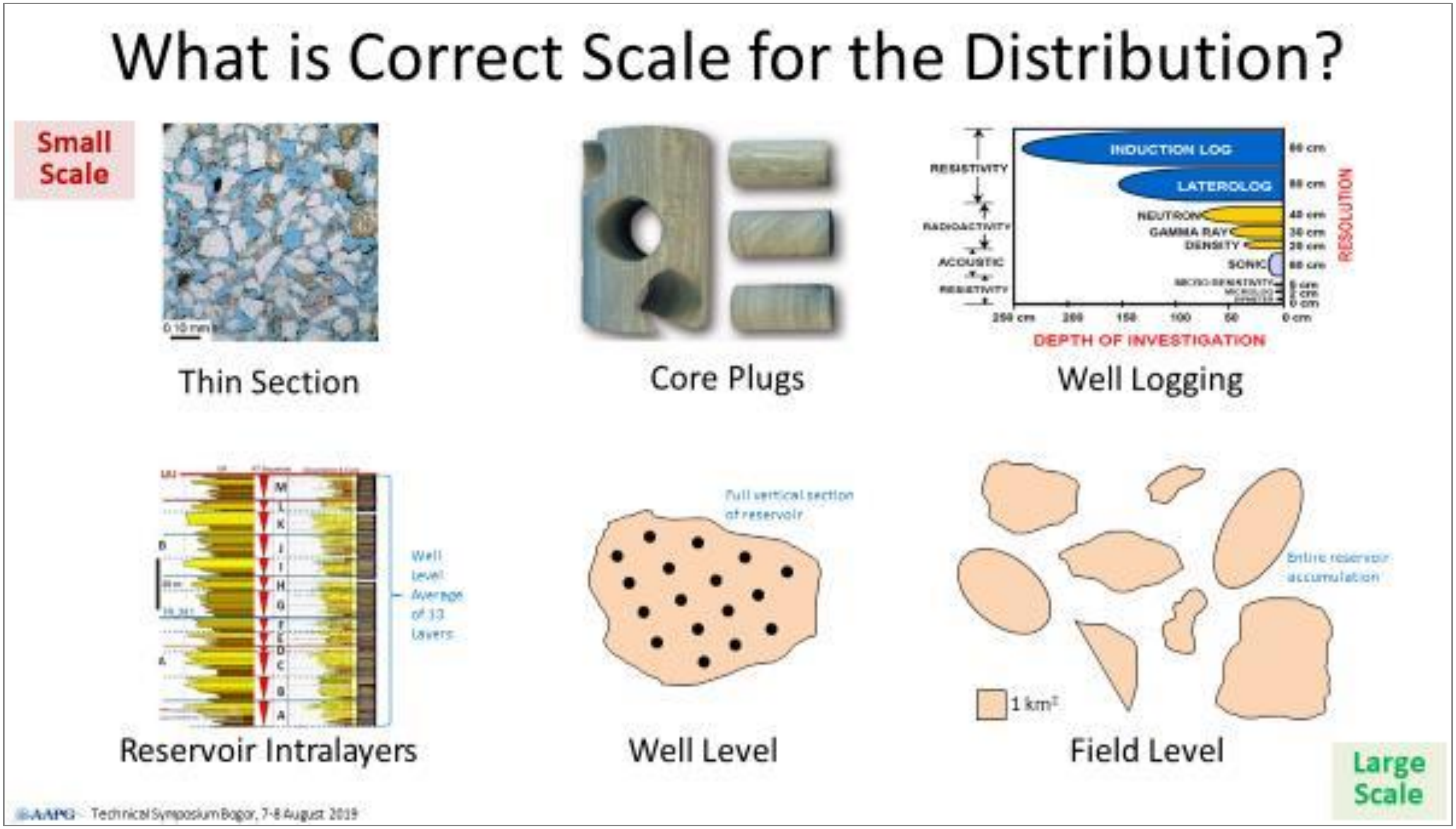

Figure 2. Using the correct scale is important for building distributions.

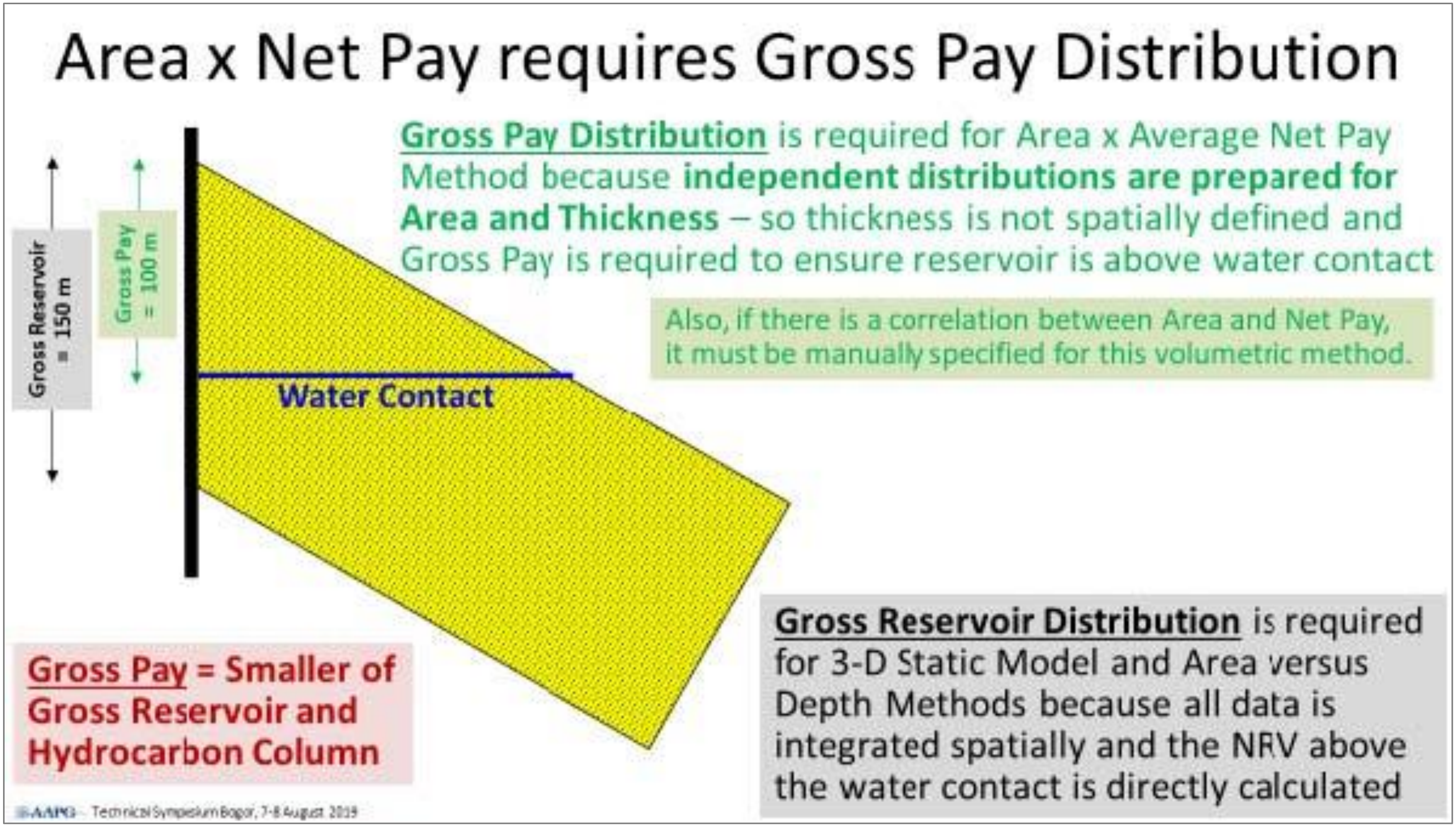

Figure 3. Gross Pay Distribution required for Area x Average Net Pay Method.

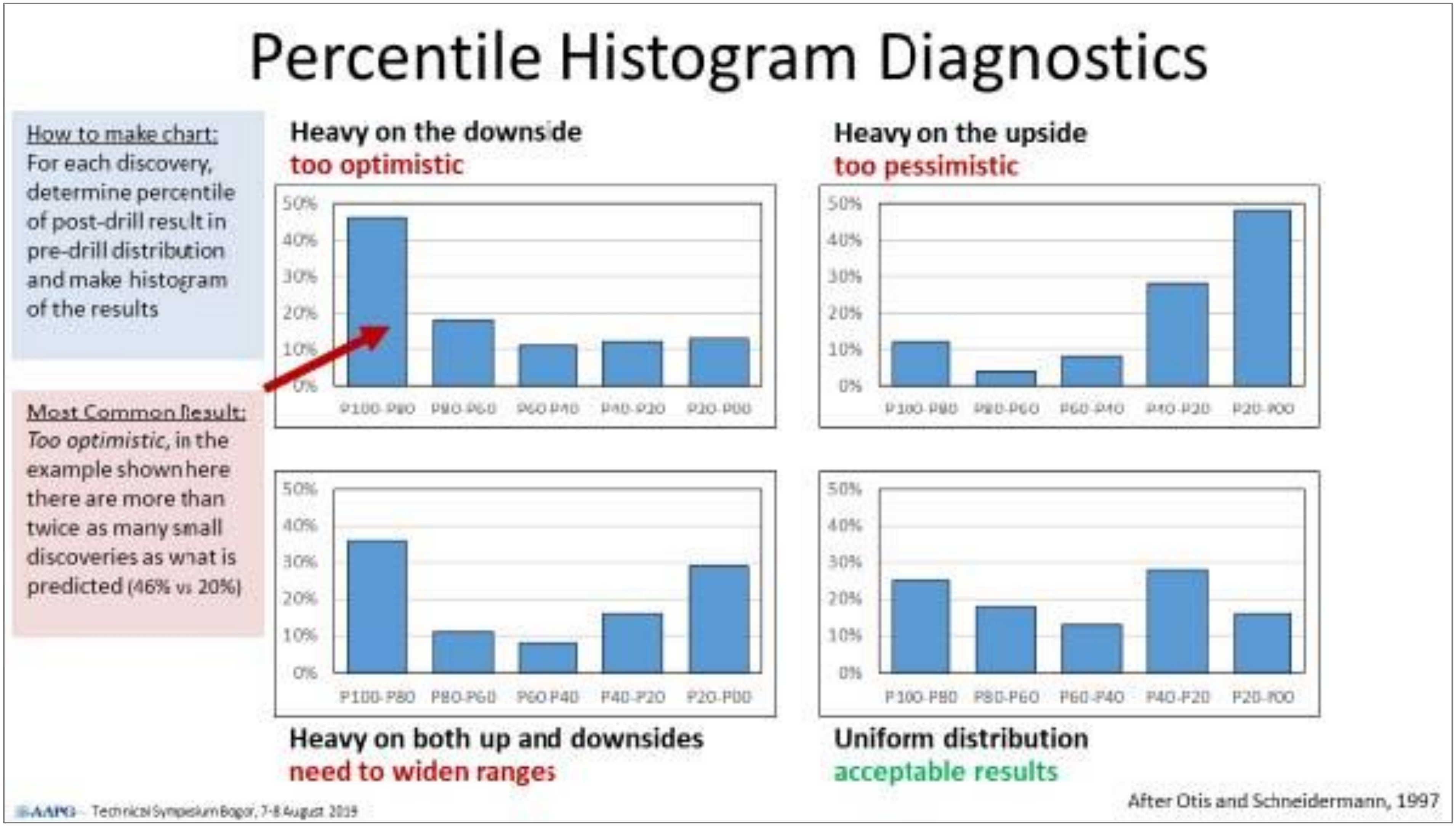

Figure 4. Diagnostic plots to evaluate reasonableness of pre-drill distributions.

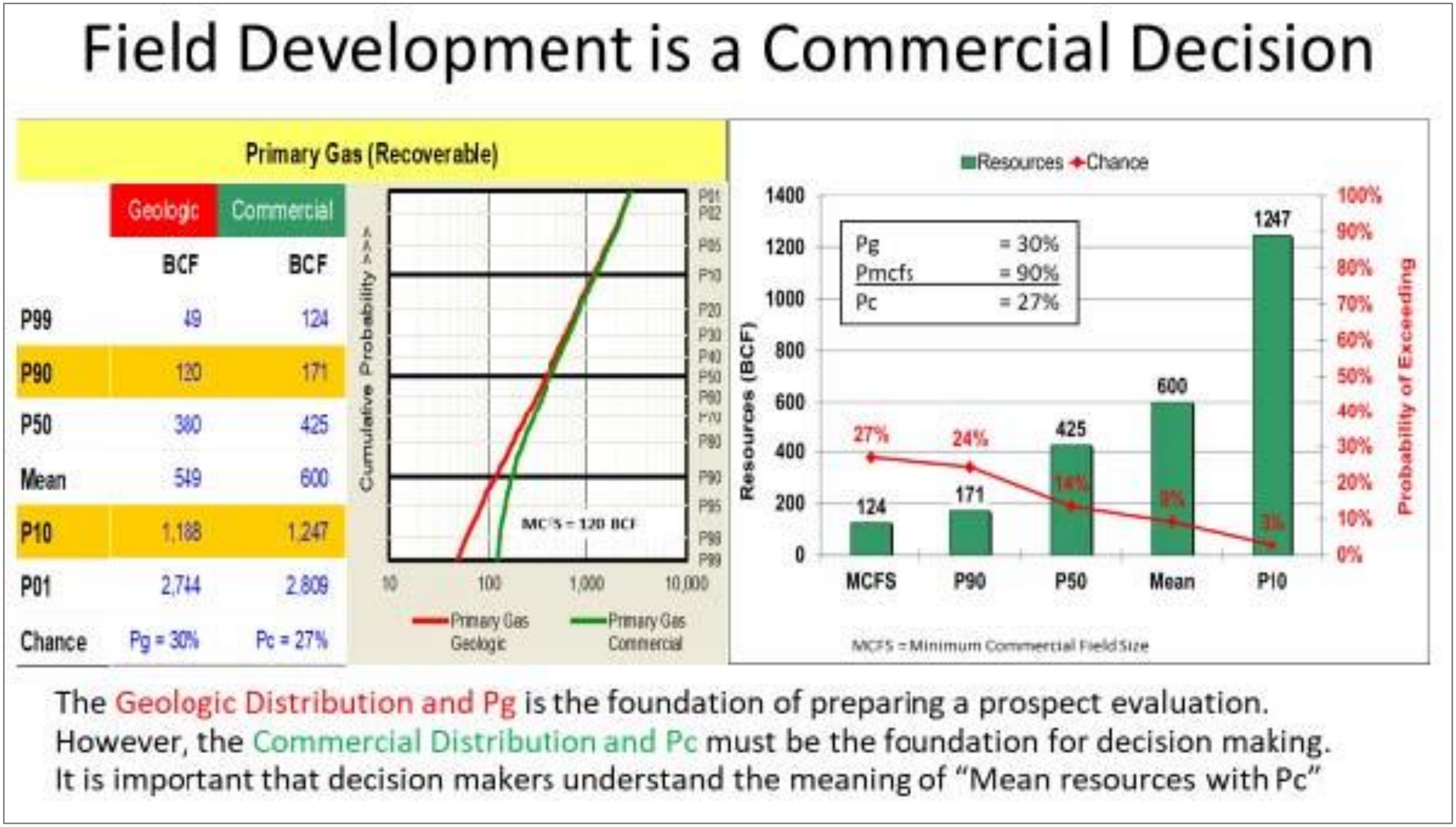

Figure 5. Key information to help make decision on commerciality.

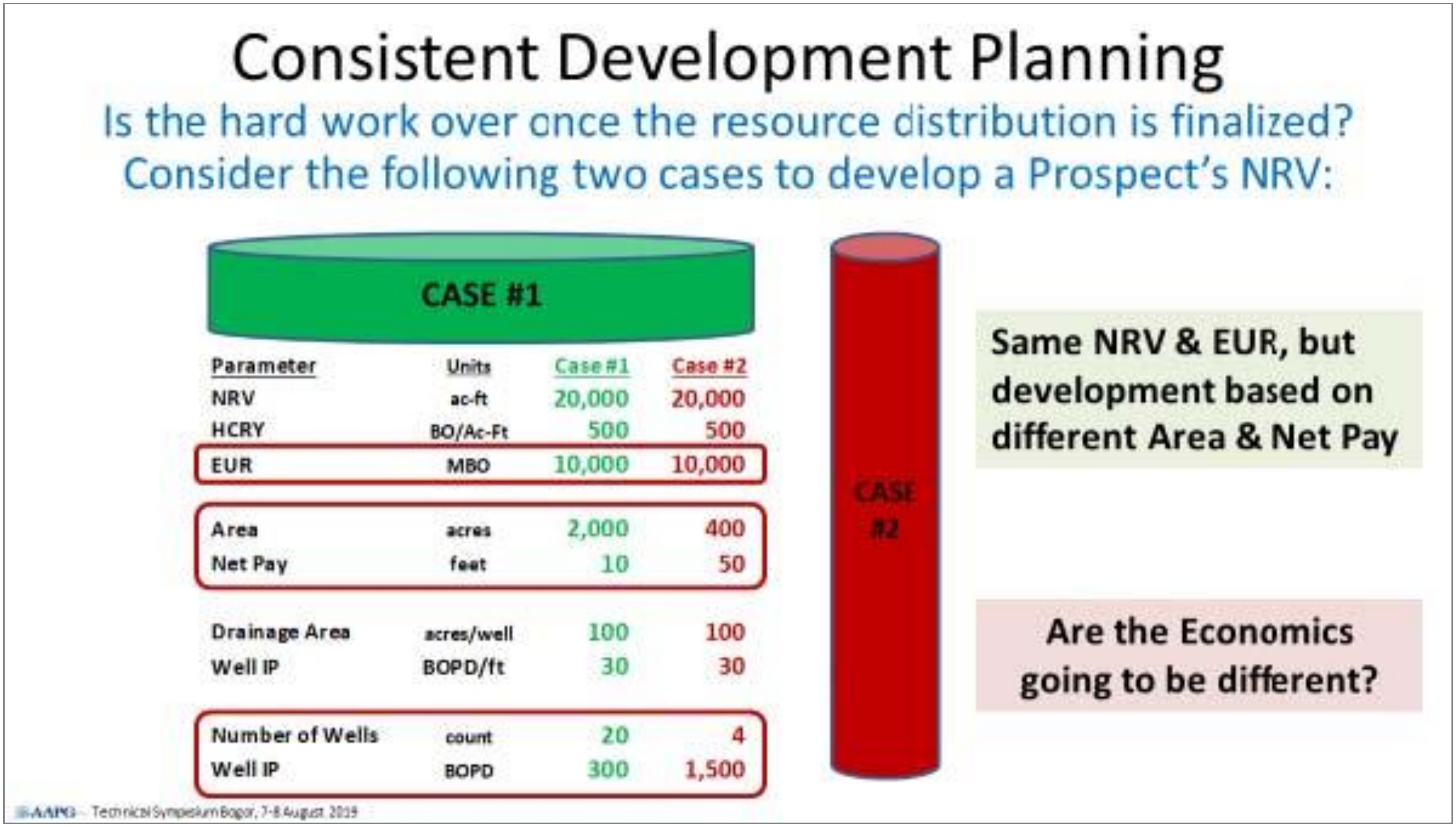

Figure 6. Development plan has major consequences on decision.