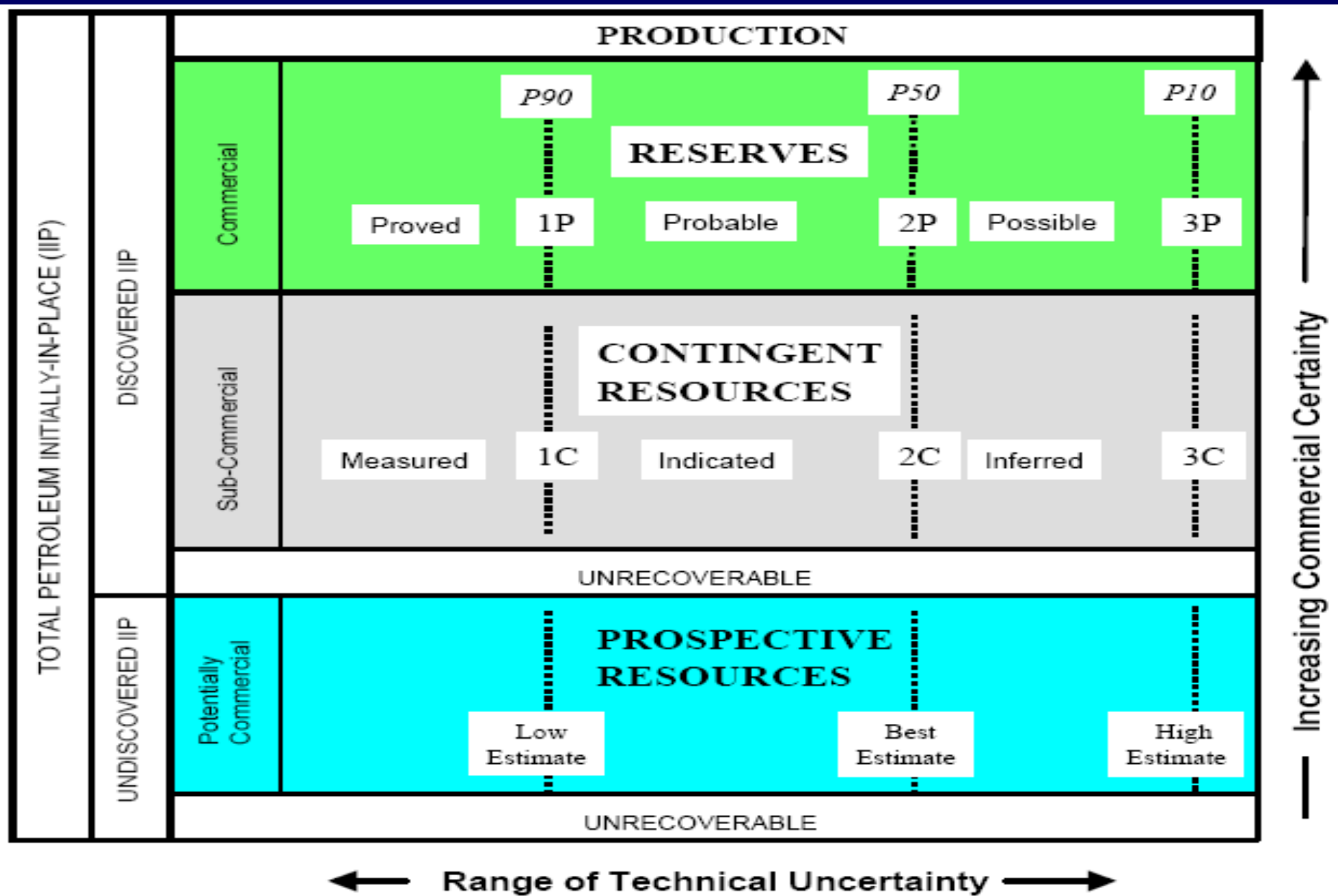


**Regional Section SPE – SEAPEX
Bangkok June 17, 2010**

**Booking Probabilistic
Reserves Within PRMS**

**Jim Gouveia P. Eng.
Rose & Associates LLP**

SPE, AAPG, WPC, SPEE Resources Classification Framework



The Petroleum Resource Management System

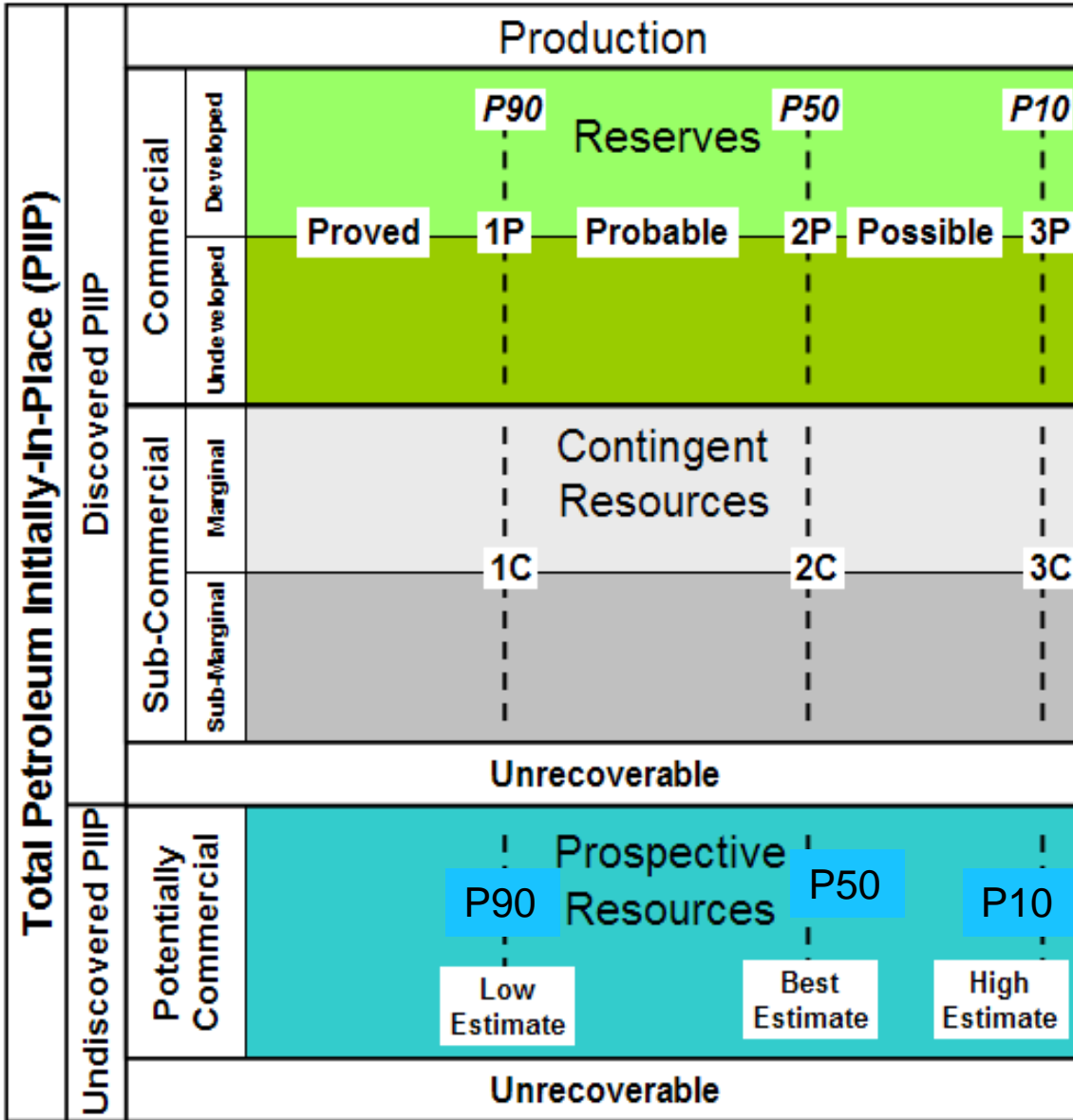
- **The PRMS is Principle-based and Project-focused.**
- **Commerciality has to be confirmed before classification of the recoverable resources as reserves can be undertaken.**
- **Reserves represent the part of resources which are commercially recoverable and are either on production or have been sanctioned for development.**
- **Reserves Categories signify Risk (Prospective Resources) and Uncertainty (the range of outcomes of success) but not Commerciality.**

The Petroleum Resource Management System

- We use Risk to describe the Threat of Loss. Resources which are at significant Risk should be categorized as Prospective Resources.**
- The terms: Low, Best and High should be avoided.**
- Low should be defined as the P90, Best as the P50 and High as the P10 to drive consistent interpretations within your firm.**

Petroleum Resources Management System (PRMS) SPE, AAPG, WPC, SPEE 2007

← Certainty Increases →



↑ Increasing Chance of Commerciality ↓

On Production
Approved for Development
Justified for Development
Development Pending
Development On Hold Development Unclearified
Development not Viable

Prospect	↑ Risk ↓
Lead	
Play	

← Range of Uncertainty → Not to scale

Petroleum Resource Management System

Proved:

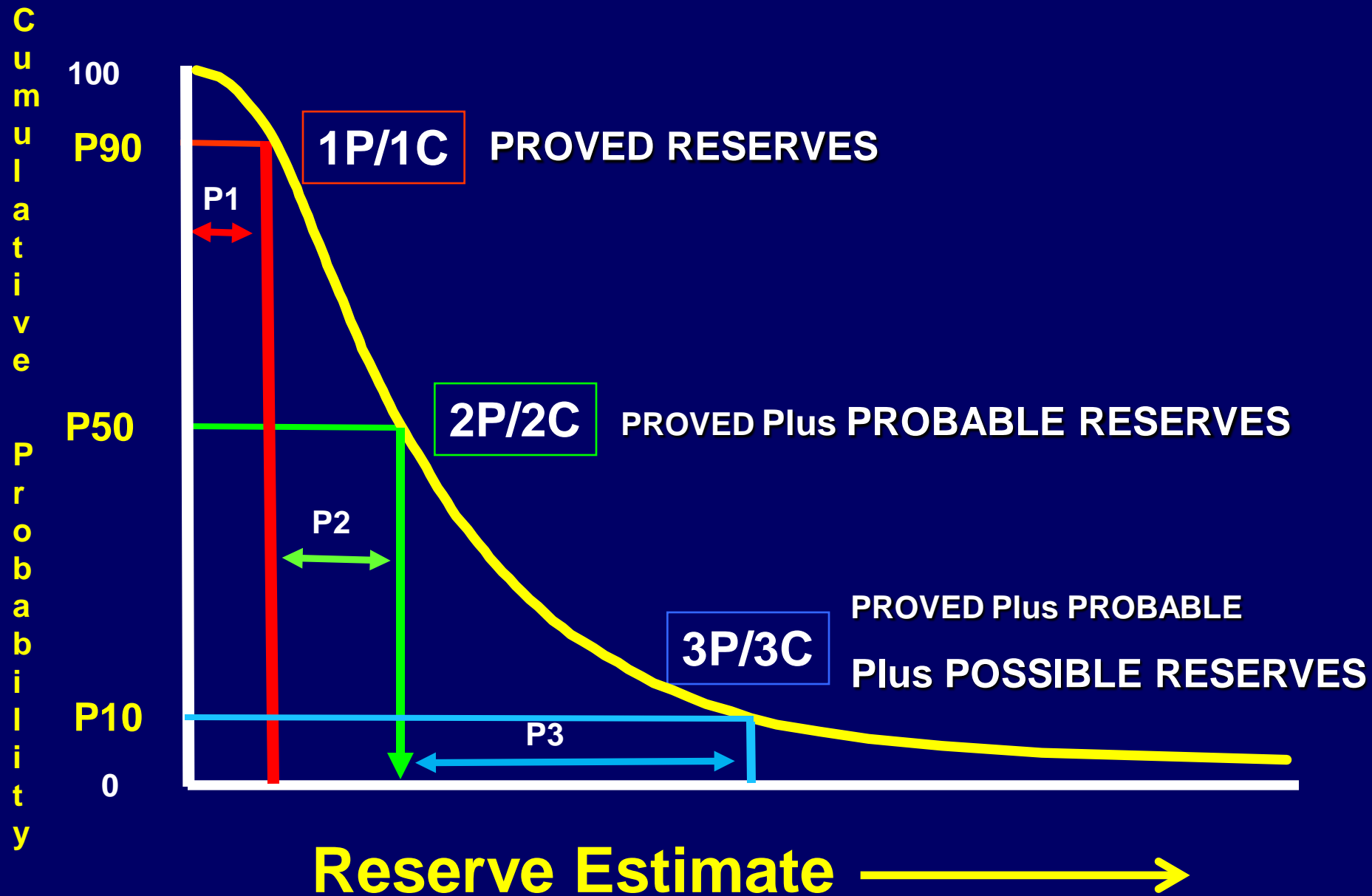
If **Probabilistic methods** are used there should be at least a 90% probability that the quantities actually recovered will equal or exceed the Proved estimate.

If Deterministic methods are used then we must be “Reasonably Certain” that these reserves will be recovered

Reasonably Certain was clarified by the SEC’s new rules as follows: “Reasonable certainty means much more likely to be achieved than not.”

How many professionals and managers will view this as equivalent to a P90?

RESERVE BOOKING CATEGORIES



The Petroleum Resource Management System

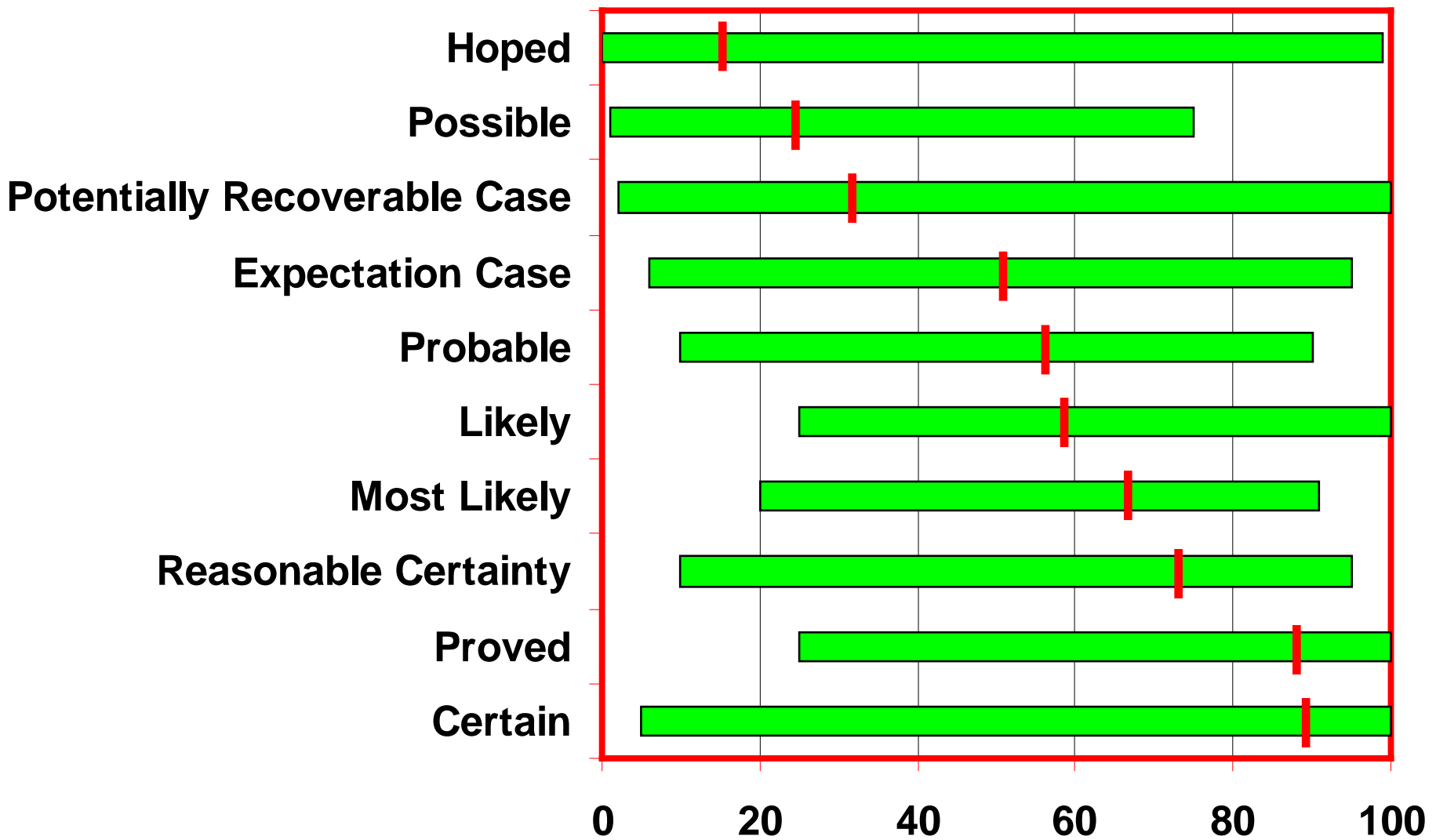
When using Deterministic Systems qualitative words are used. For example for Proved Reserves we define Proved as : **“Reasonable Certainty”**

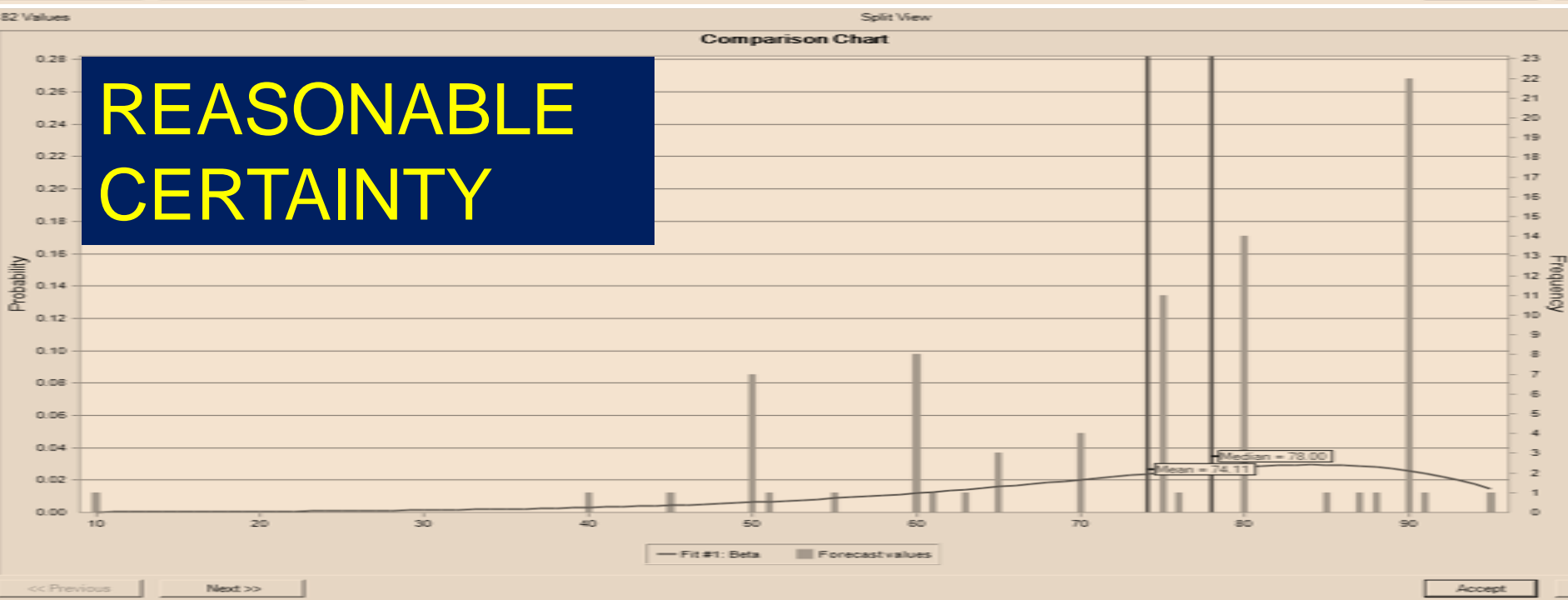
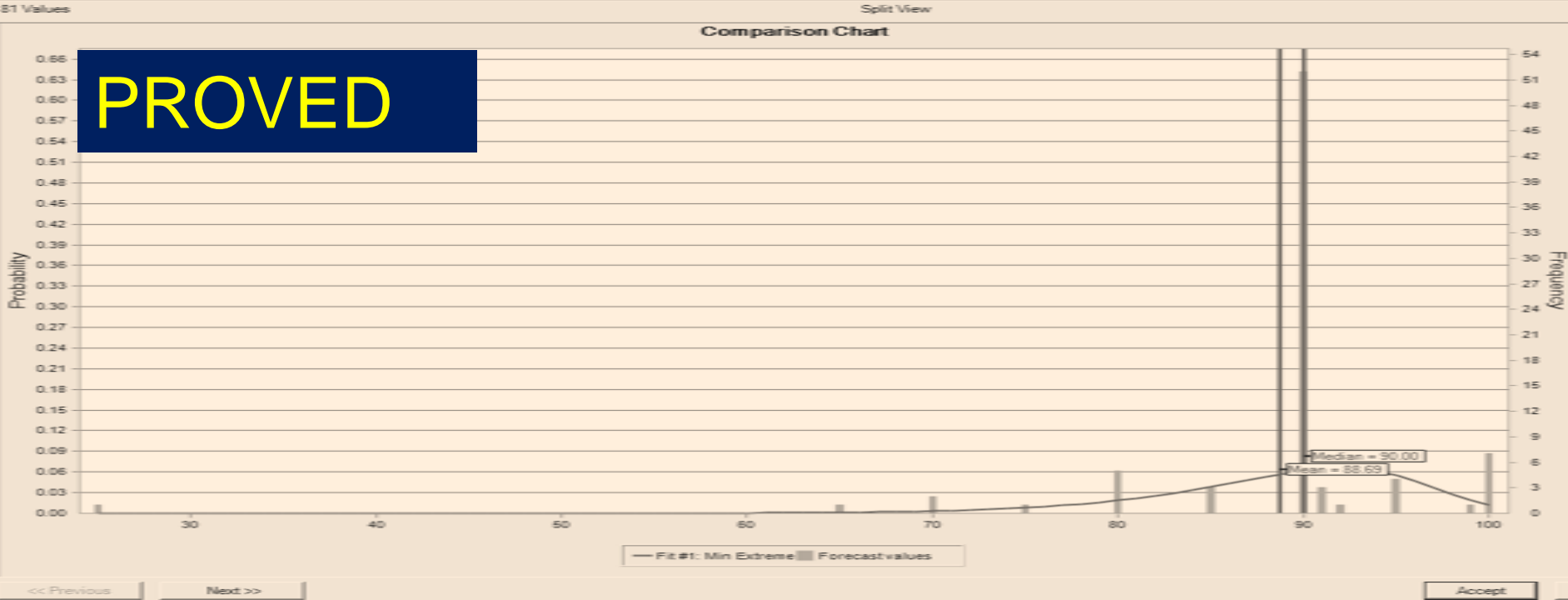
BUT

Words are NOT effective Communication terms if we are seeking consistent professional booking of Reserves.

Lets look at an example:

Word Meaning Survey Results





Petroleum Resource Management System

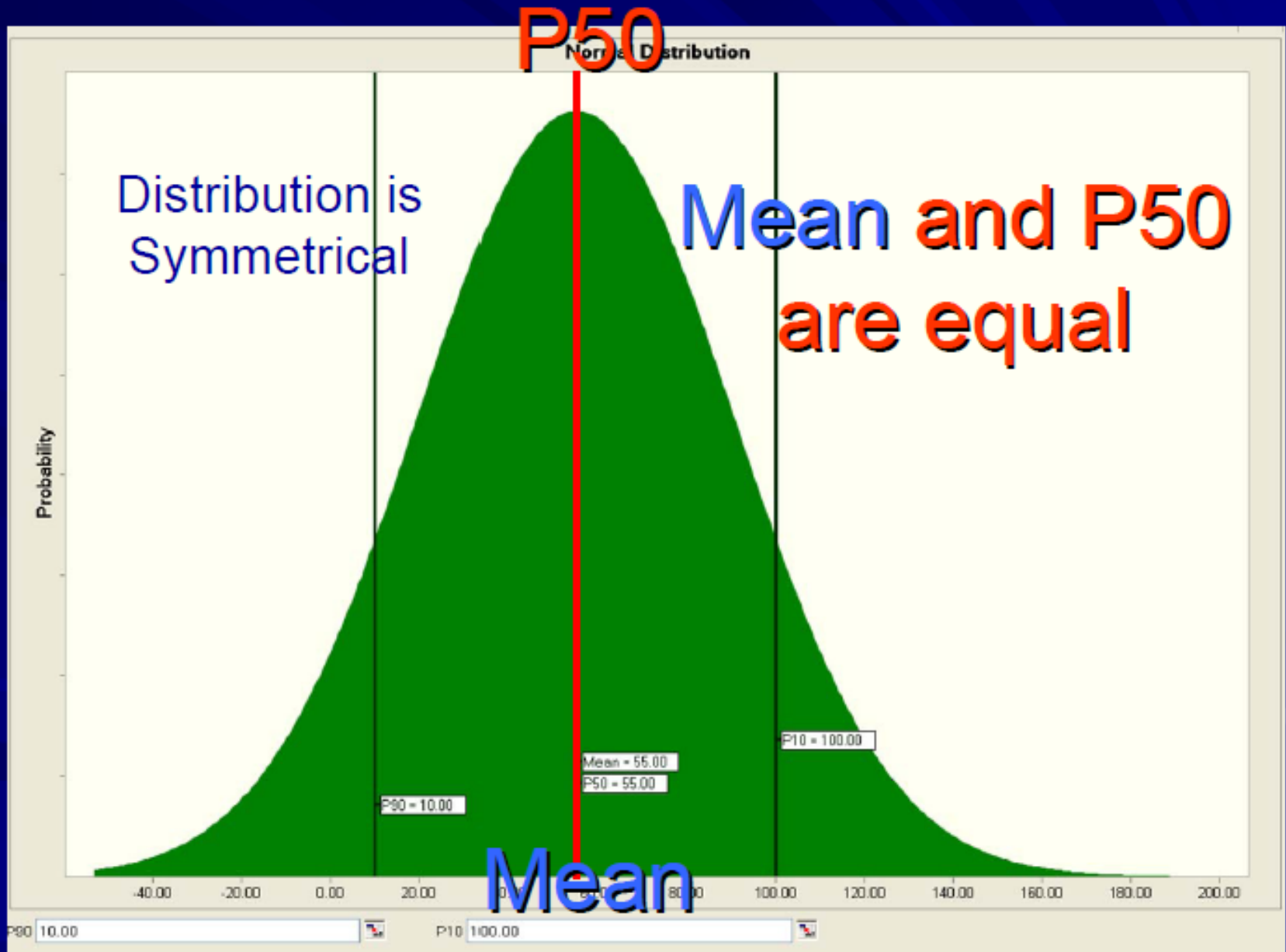
Proved Plus Probable:

It is equally likely that actual remaining quantities will be greater than or less than the sum of the Proved plus Probable Reserves (2P).

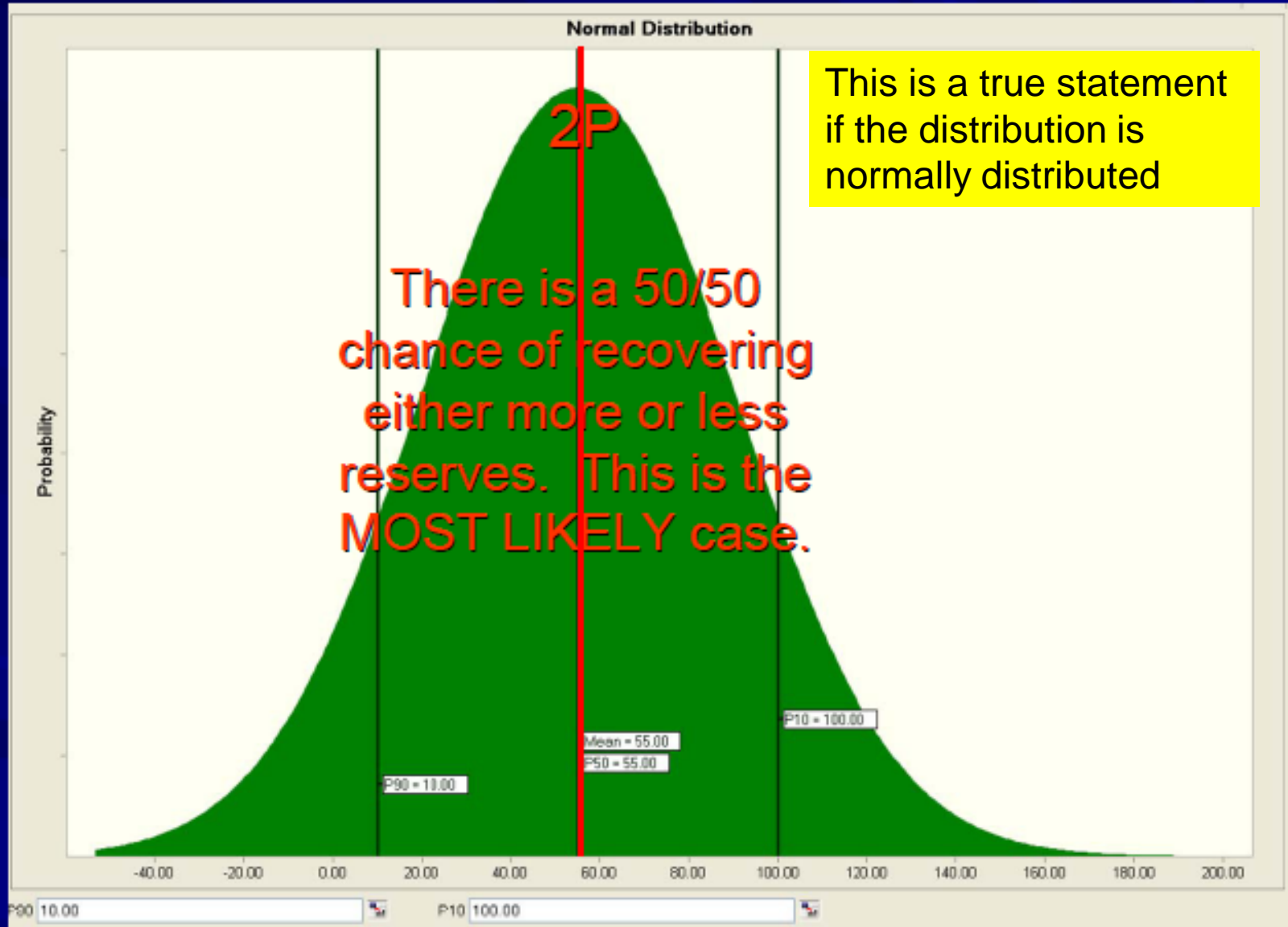
When Probabilistic methods are used, there should be at least a 50% probability that the actual quantities recovered will equal or exceed the 2P estimate.

“Is this the elusive **“Most Likely”** Value?”

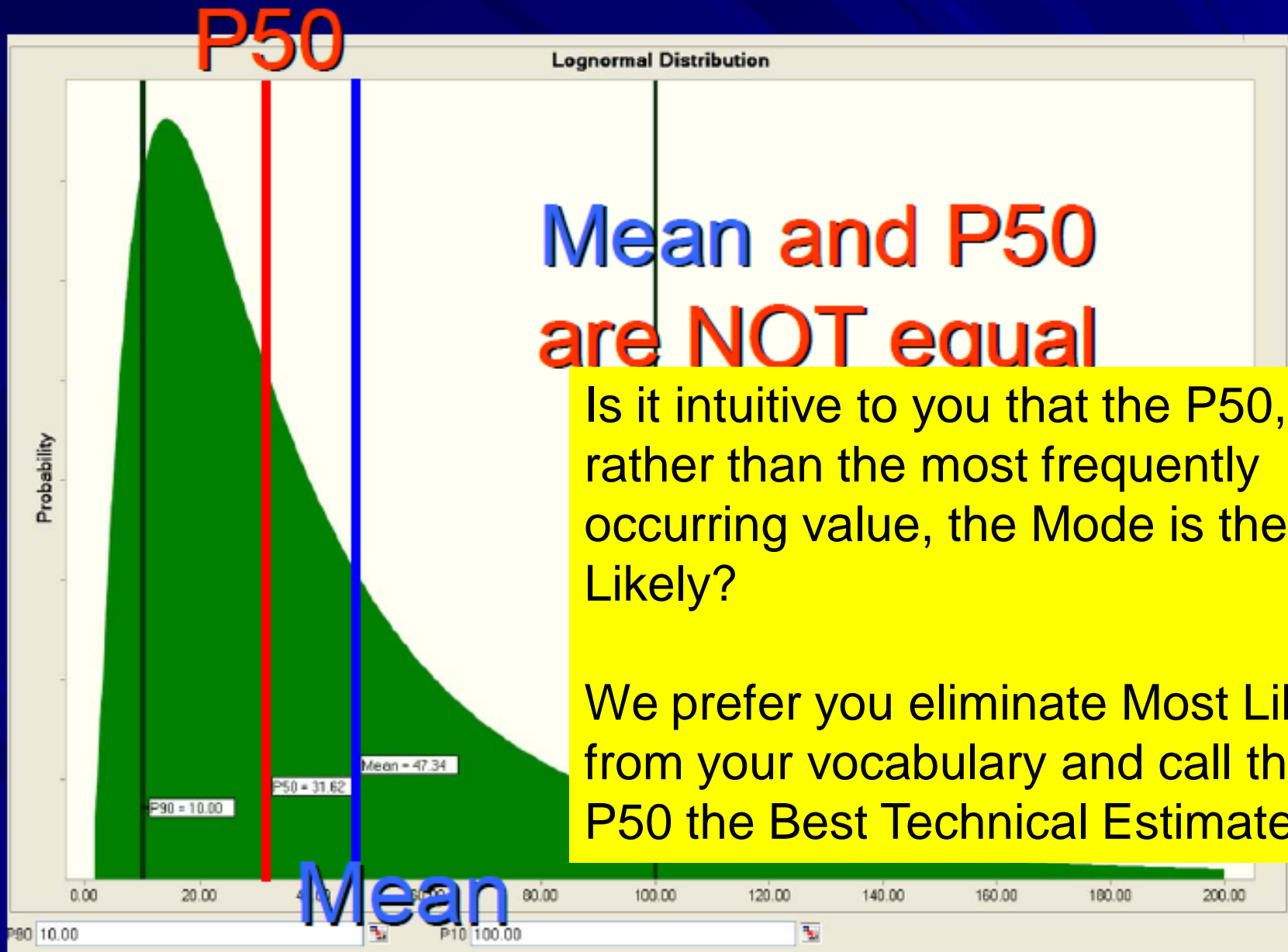
Statistical Distribution - Normal



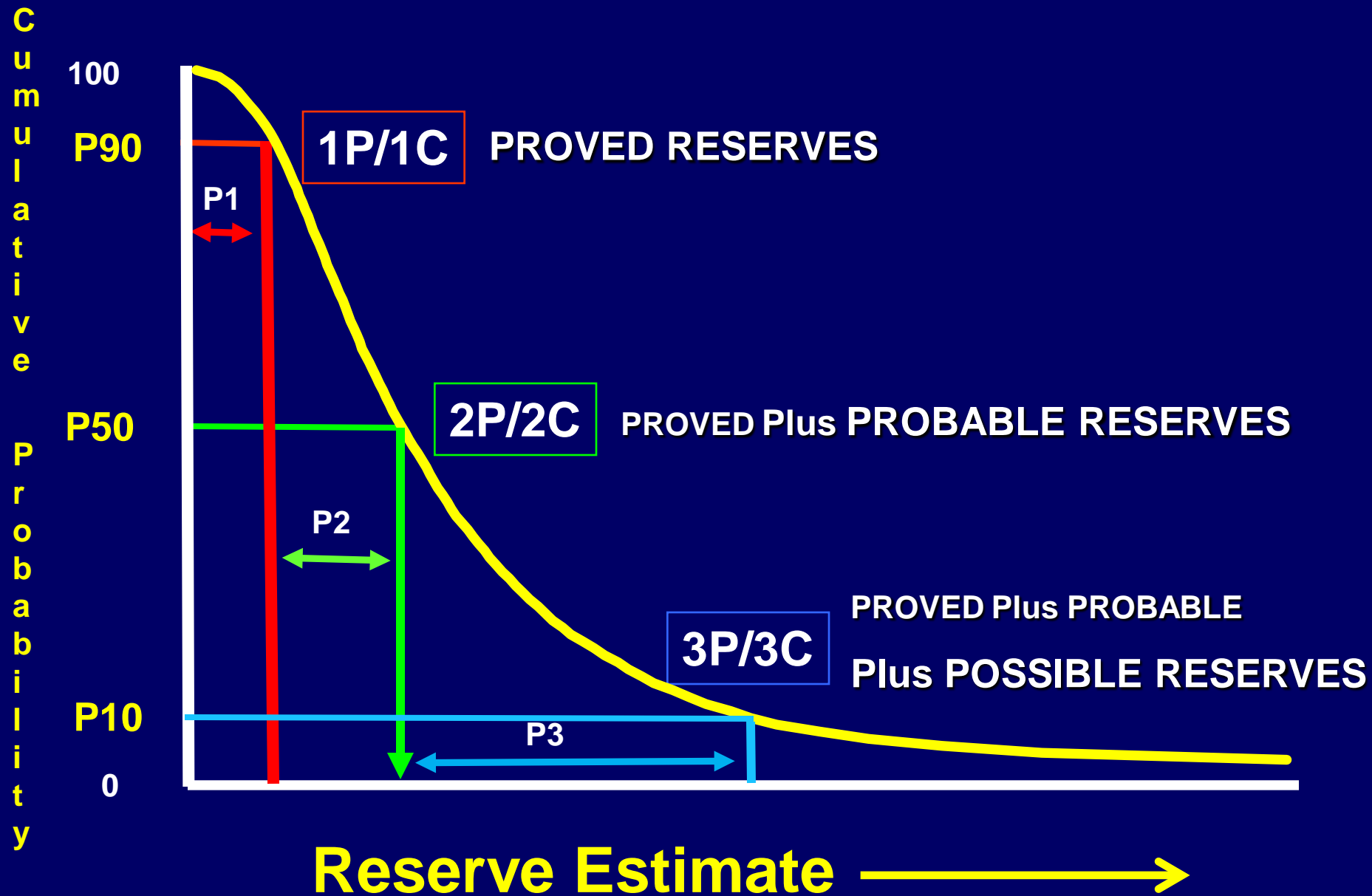
Statistics to Define Categories



Statistical Distributions - Lognormal



RESERVE BOOKING CATEGORIES



WHY IT IS TIME FOR PROBABILISTIC RESERVES?

Qualitative Words, such as “**Reasonable Certainty**” are not effective Communication tools.

Testing has consistently proven that without calibration it is not possible to consistently directly estimate P_{90} 's and P_{50} 's.

Lets look test the theory and then look at some testing results:

Practice



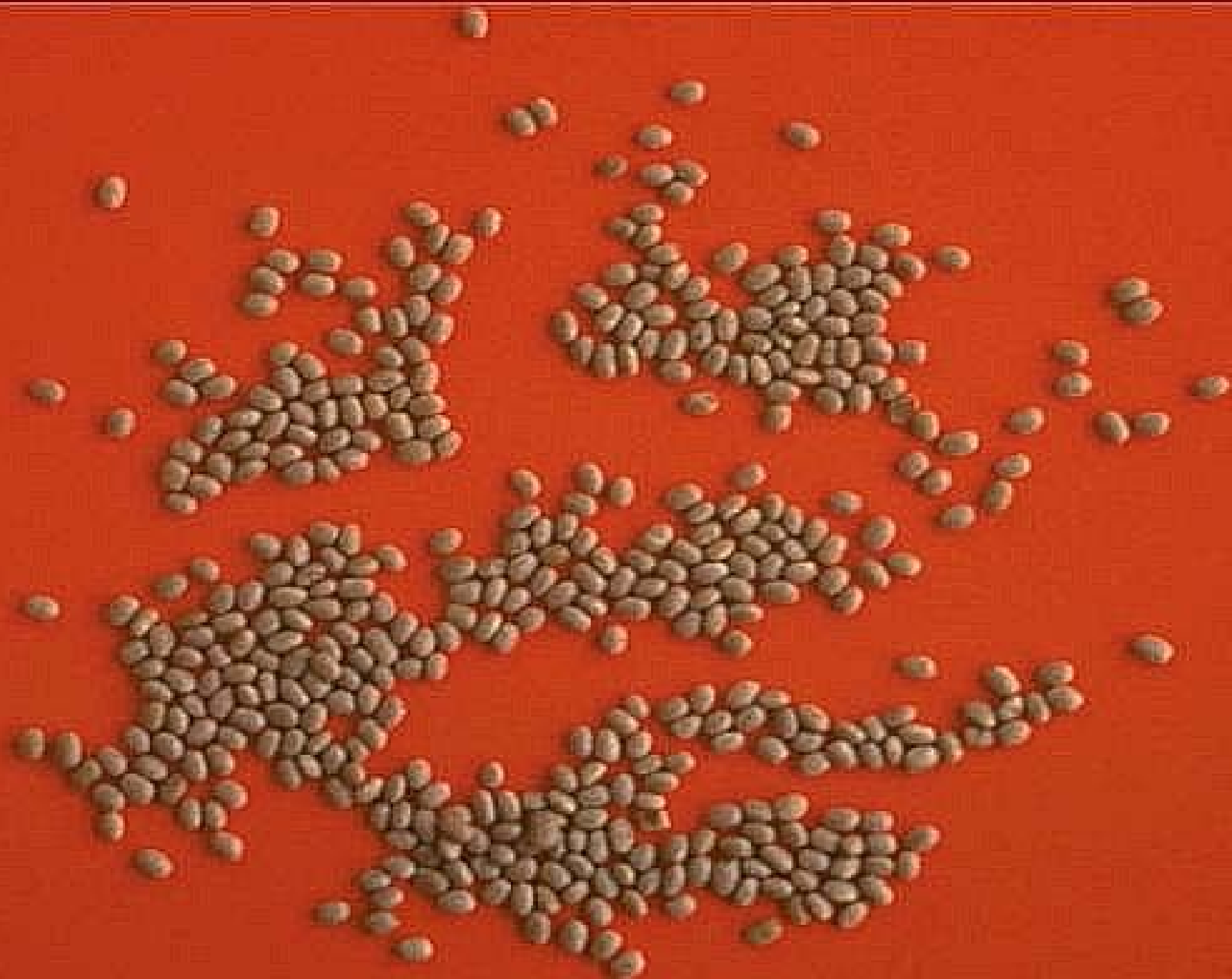
Uncertainty

$n = 175$

What Lesson Are We Learning?

WIDEN OUR RANGES!

Slide A



Uncertainty

n = 446

**If We Plotted The Class Estimates
They Would Be **Lognormal****

WHY?

Estimating in Ranges Requires Confidence Levels

Probabilistic estimating requires estimation based on confidence levels.

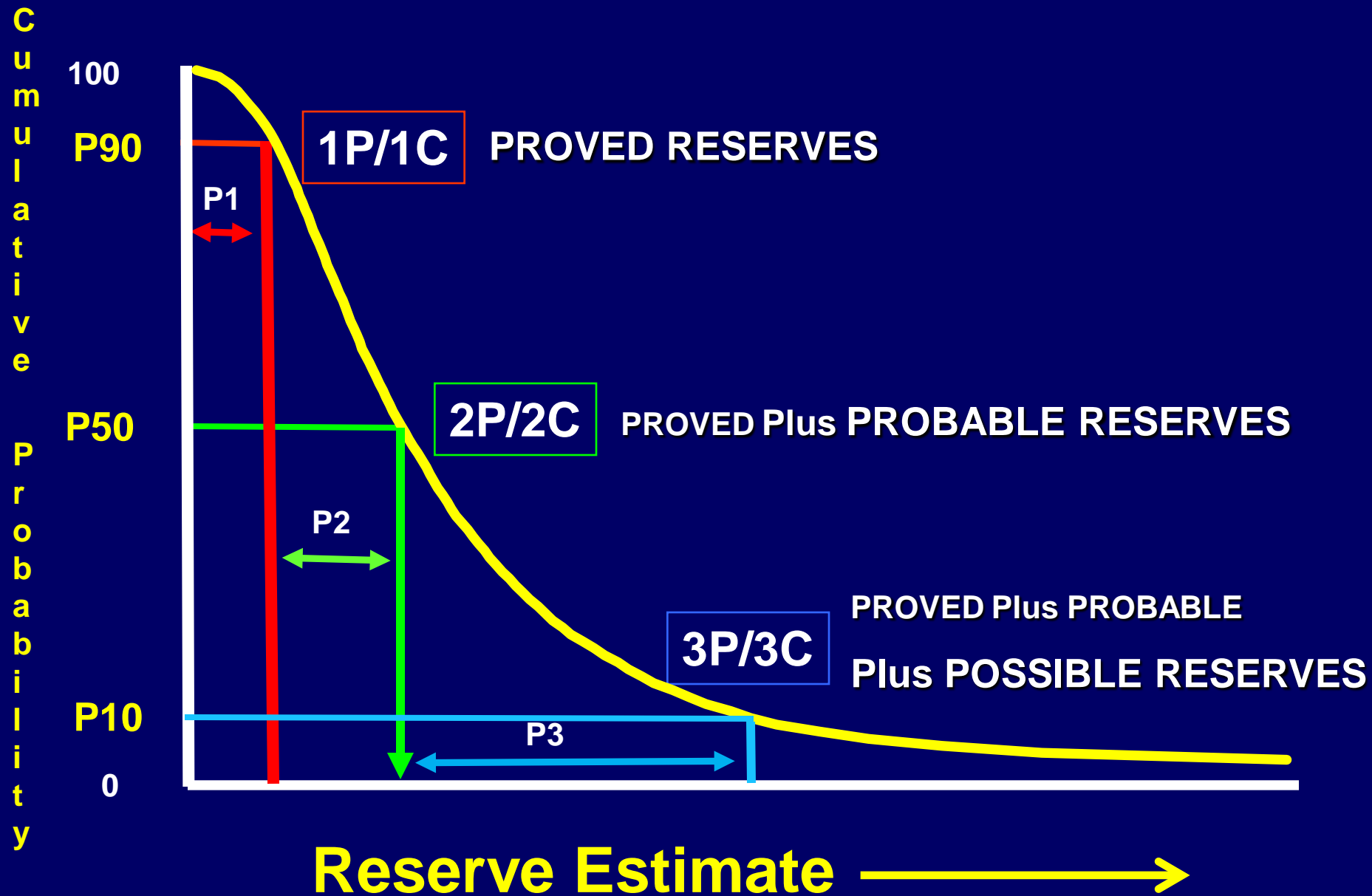
Can we directly estimate these Confidence Levels?

Or

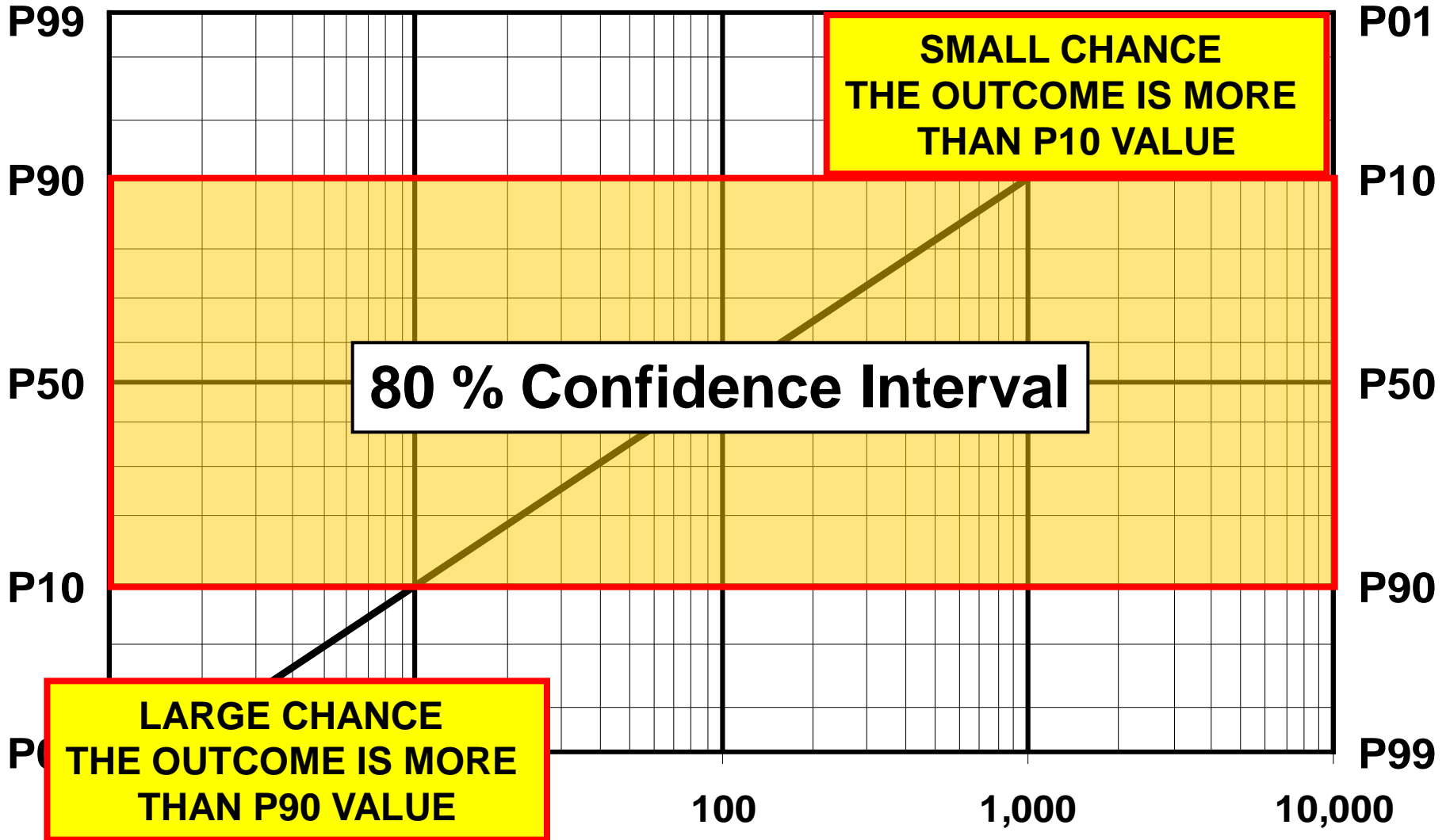
Is the determination of the range of outcomes with reality checking of the range required?

Lets try an estimation exercise to determine how accurate we are at directly estimating our confidence levels

RESERVE BOOKING CATEGORIES



Estimating With Probabilistic Ranges



Estimating P10 - P90 Ranges

Provide your ranges for
questions 1- 5 .



___ to ___ **1) What is the Coastline of Thailand in Kms?**

___ to ___ **2) How many cell phones were in use in Thailand in 2008?**

___ to ___ **3) How many Airports were there in Thailand in 2009?**

___ to ___ **4) What was Thailand's Average Daily Oil Production in BOPD for 2008?**

___ to ___ **5) What was Thailand's Average Daily Gas Production in MMSCFD for 2008?**

3 219 Km 1) **What is the Coastline of Thailand in Kms?**

62 MM 2) **How many cell phones were in use in Thailand in 2008?**

105 3) **How many Airports were there in Thailand in 2009?**

330 000 4) **What was Thailand's Average Daily Oil Production in BOPD for 2008?**

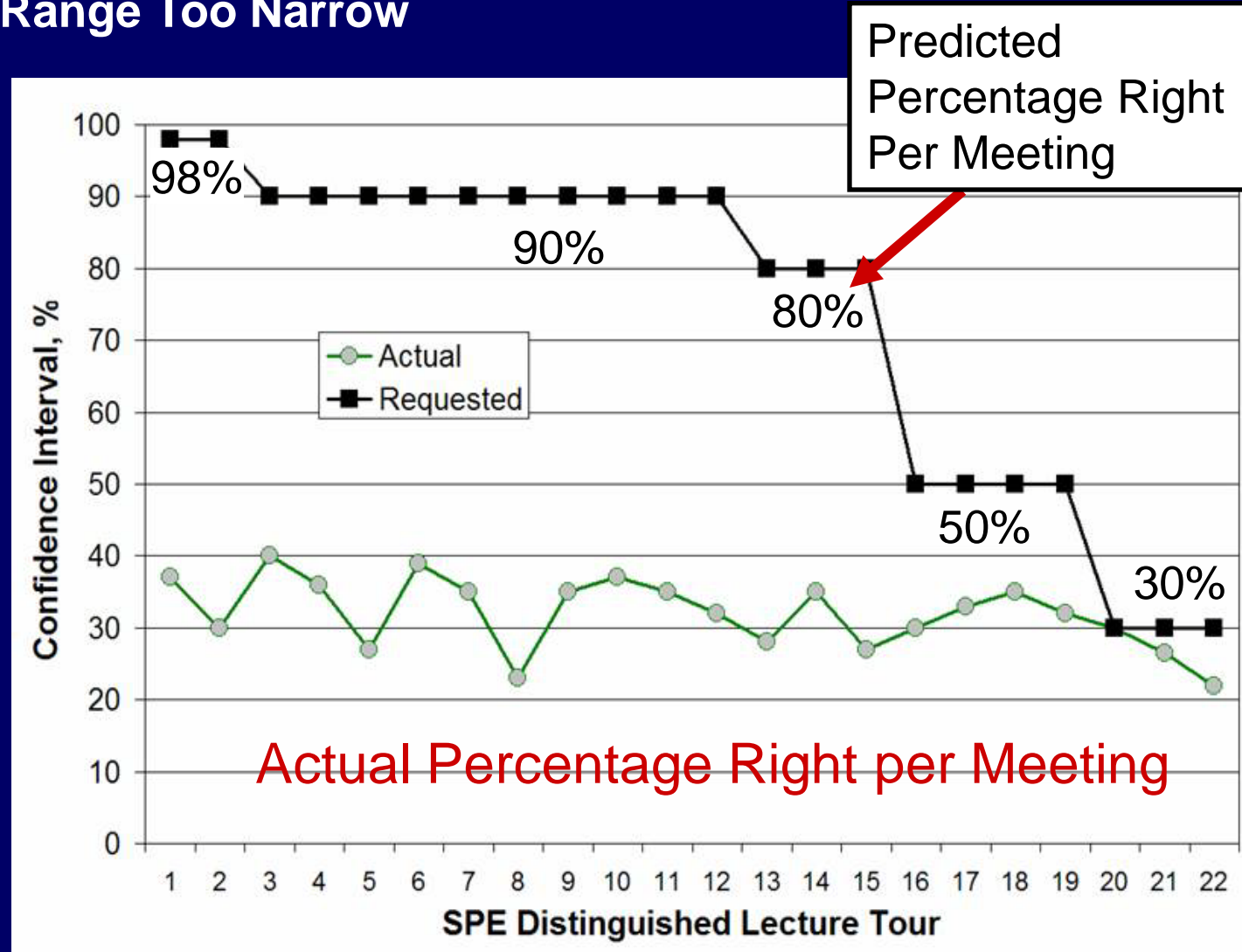
3 000 5) **What was Thailand's Average Daily gas Production in MMSCFD for 2008?**

ESTIMATING WITHIN A CONFIDENCE RANGE

We Think We Are Smarter Than We Actually Are!

Setting Predictive Range Too Narrow

We have little comprehension of comparative levels of confidence



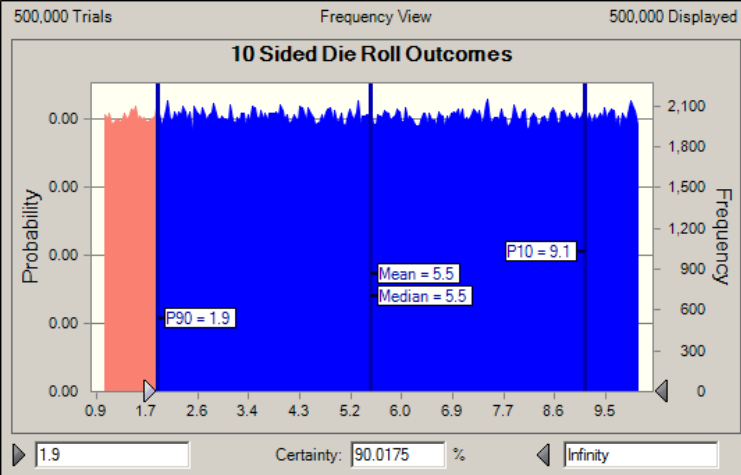
Aggregation Principles 101



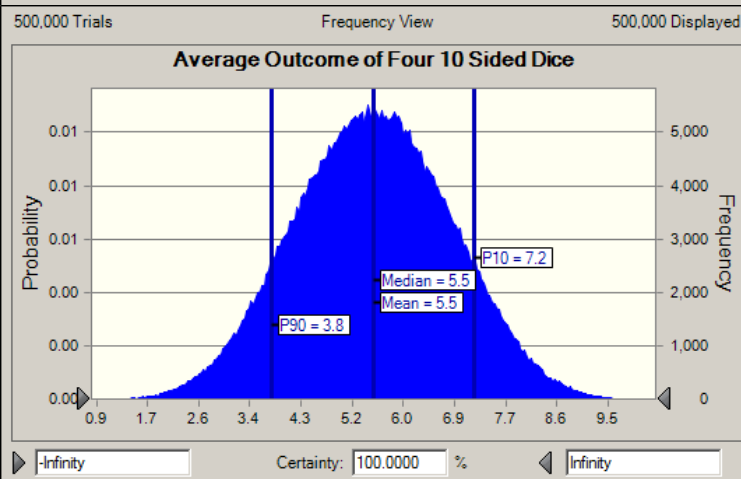
- Roll a 10 sided die. The Probability of achieving a 2 or more approximately a P90 event. We are reasonably certain we will roll a 2 or more 90% of the time.



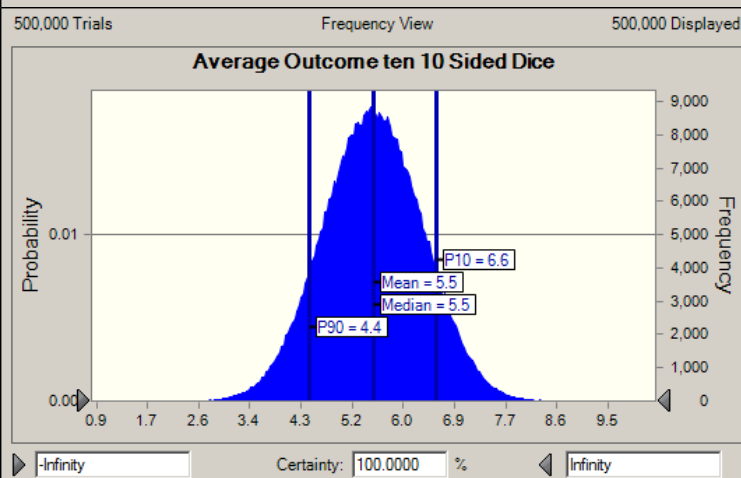
- Roll 10 different 10 sided dice. The Probability of achieving a particular average outcome or more 90% of the time is our P90.
- Is an average outcome of 2 or more a P90 outcome?



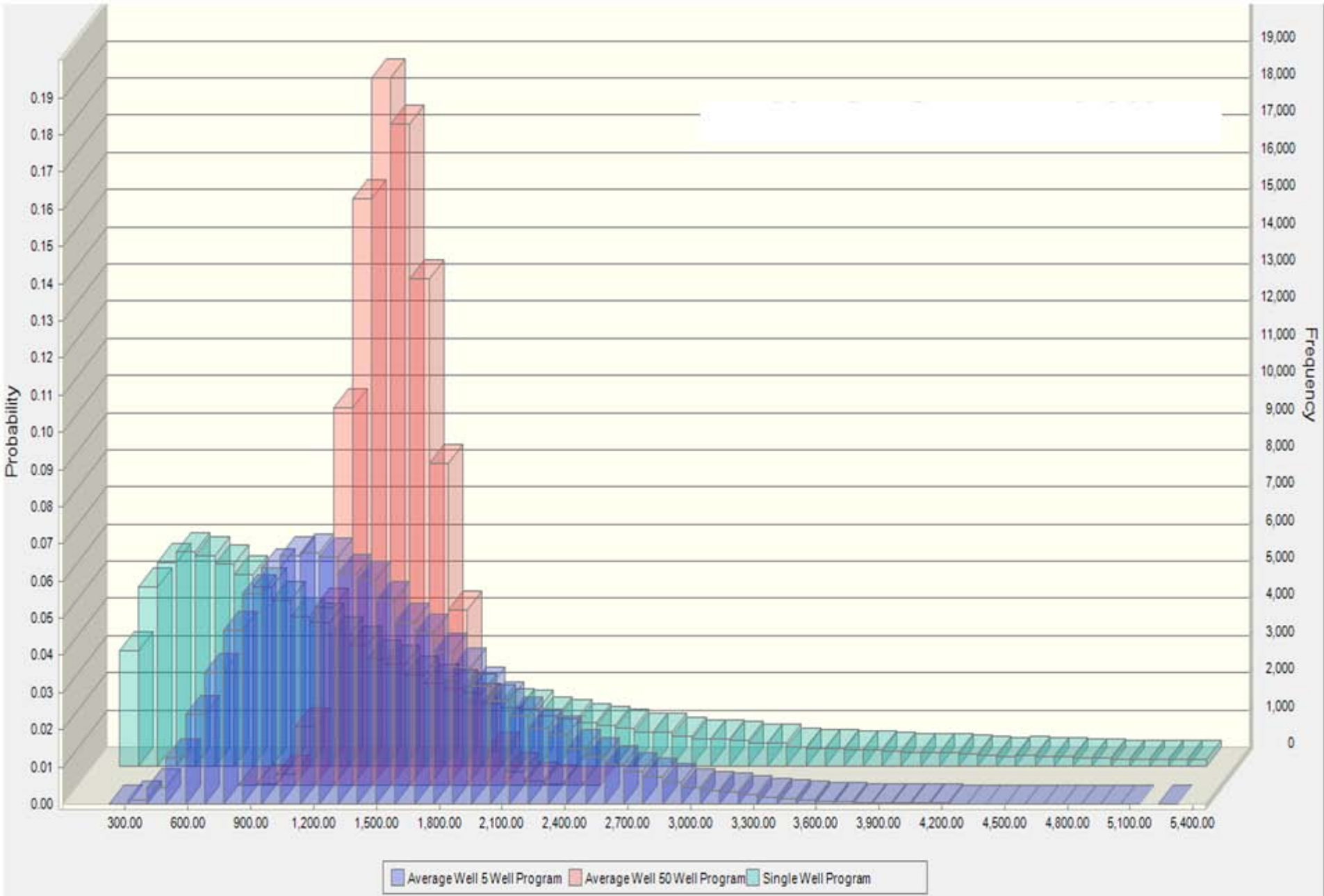
- Roll a 10 sided die. We are reasonably certain we will roll a 2 or more 90% of the time. The P10/P90 ratio is 4.8.



- Roll Four, 10 sided die. We are reasonably certain we will roll a 2 or more 99.8% of the time. The P90 aggregated outcome is 3.8. The P10/P90 ratio is 1.9.

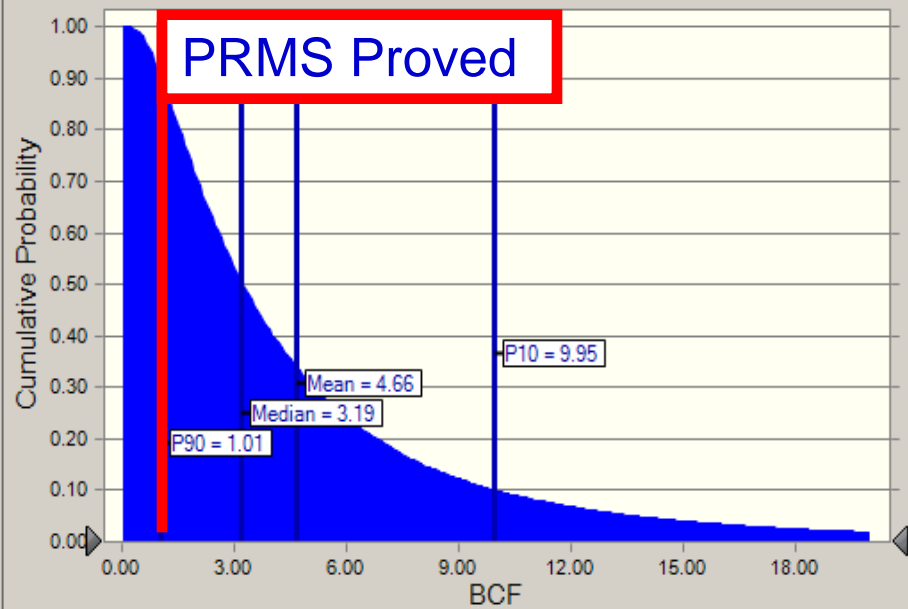


- Roll Ten, 10 sided die. The Probability of achieving a 2 or more is 99.999%. This is not a P90! The P10/P90 ratio is 1.5.

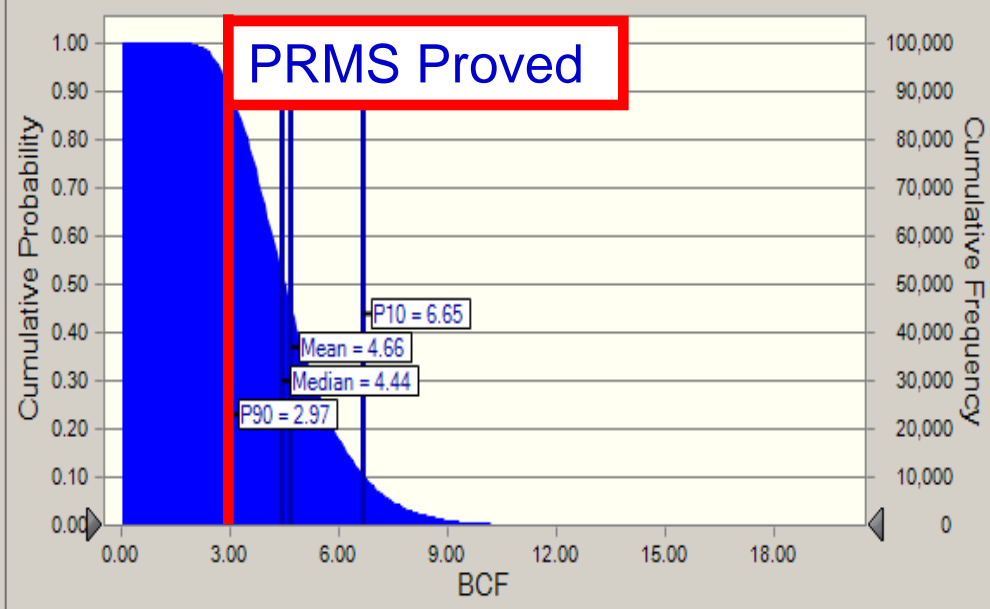


Aggregation impact of 1, 5 and 50 wells on a P_{10}/P_{90} ratio of 10 Type Curve

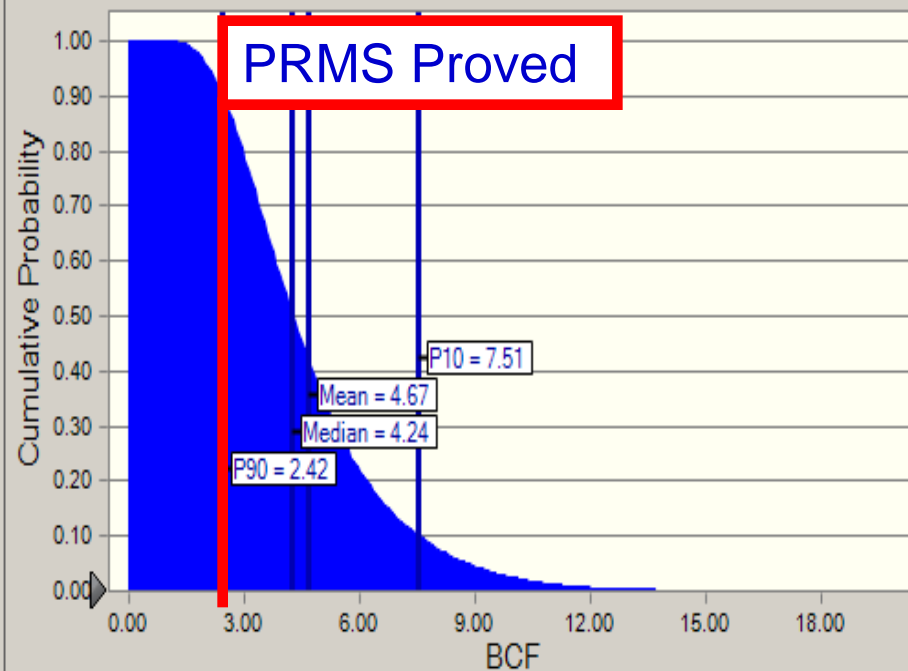
Single well Forecast



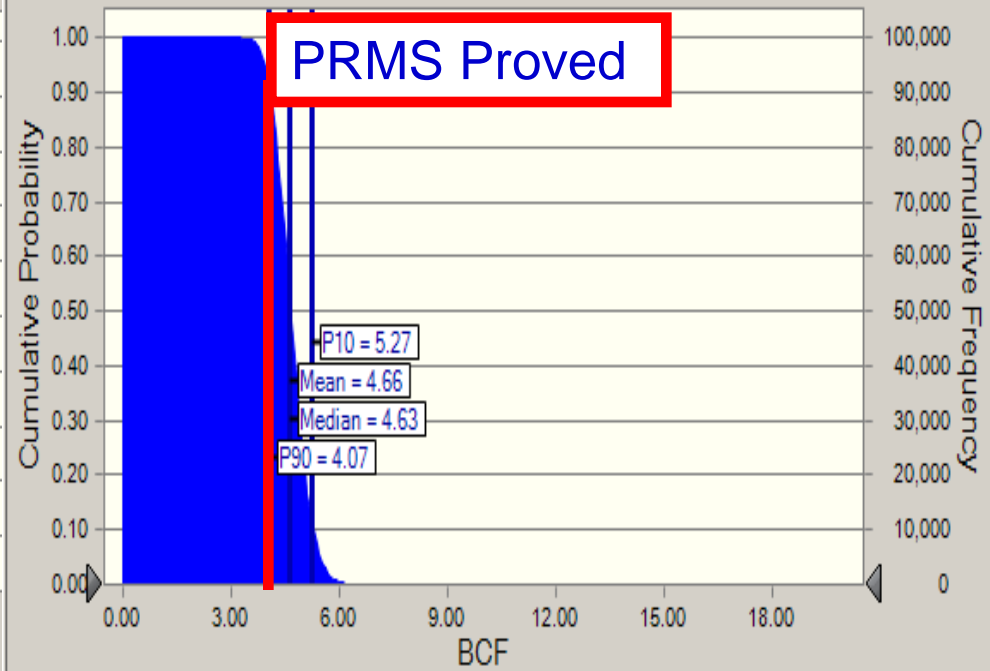
Average Well in a 10 Well Program



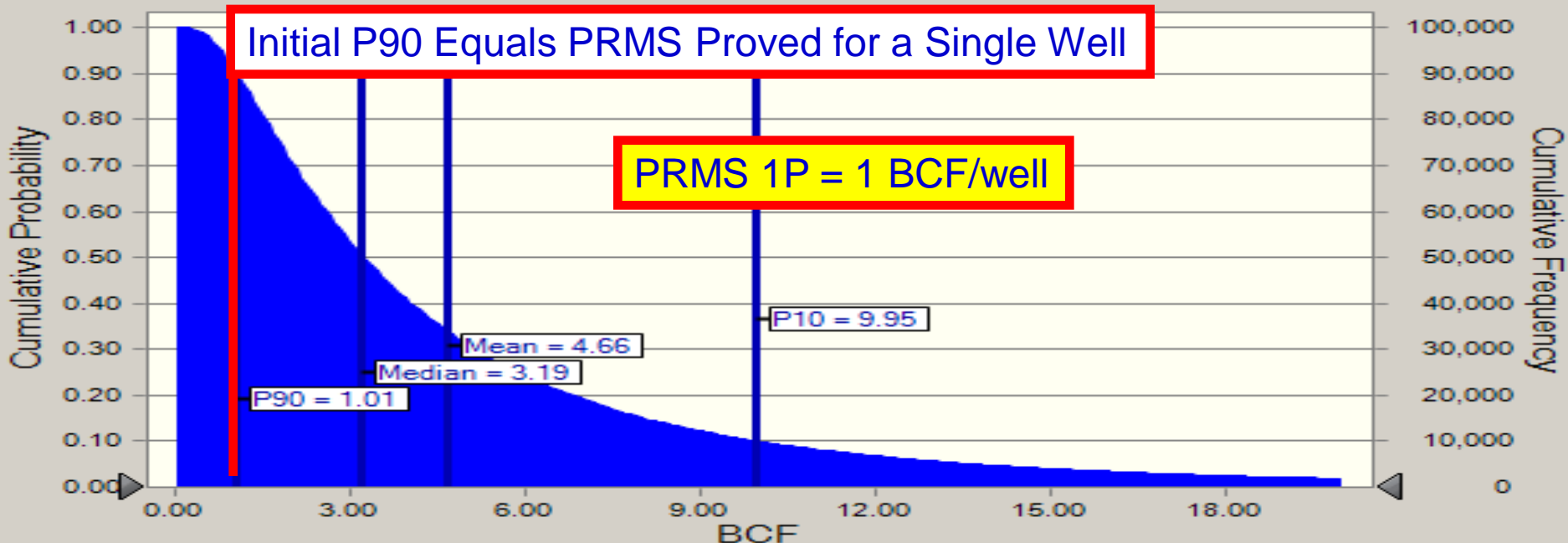
Average Well in a 5 Well Program



Average Well in a 100 well Program



Single well Forecast



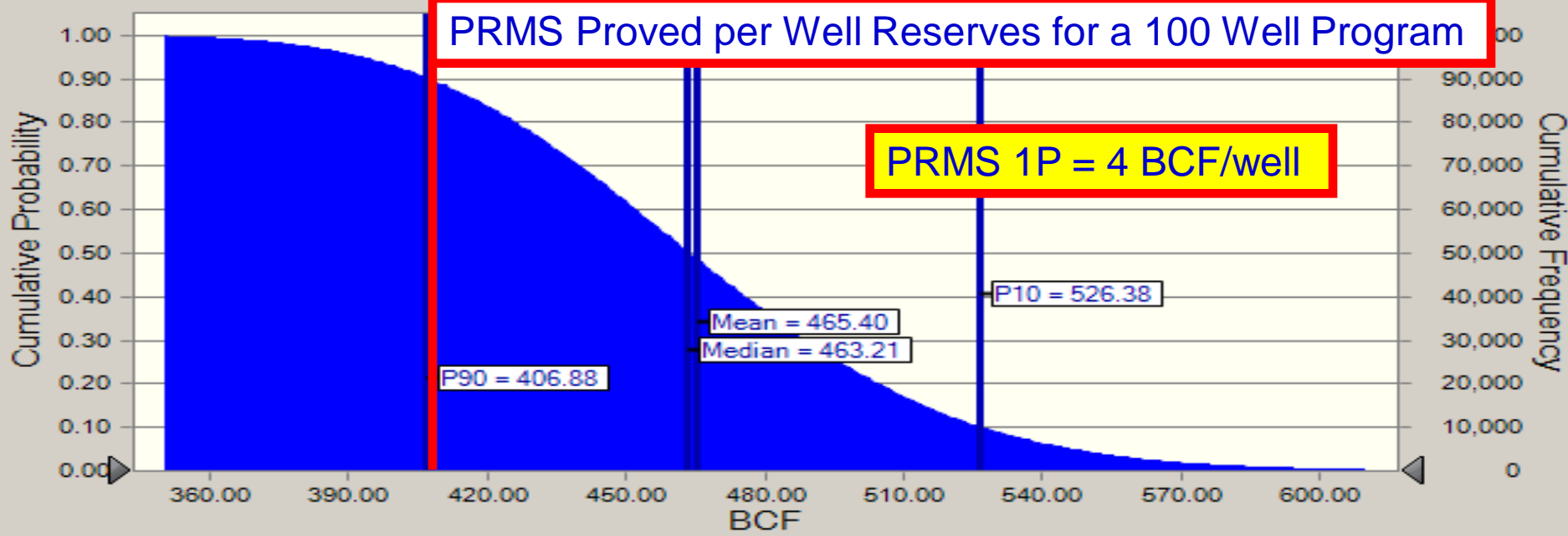
Initial P90 Equals PRMS Proved for a Single Well

PRMS 1P = 1 BCF/well

Cumulative Probability

Cumulative Frequency

100 Well Program



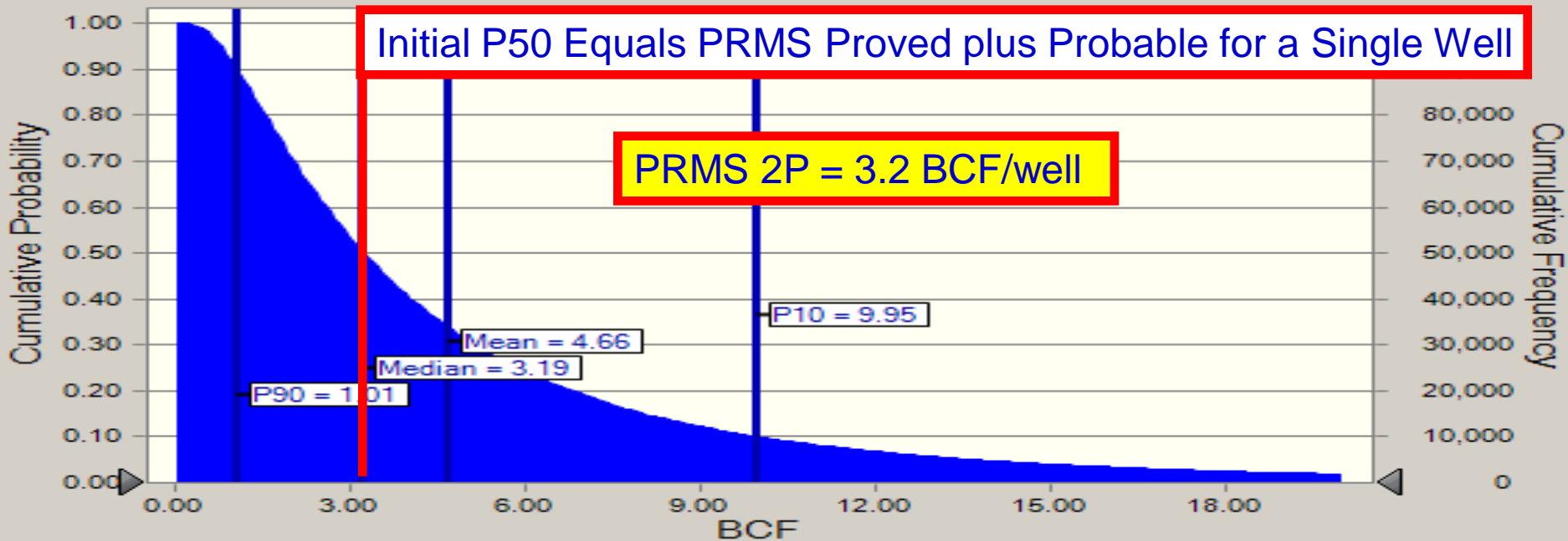
PRMS Proved per Well Reserves for a 100 Well Program

PRMS 1P = 4 BCF/well

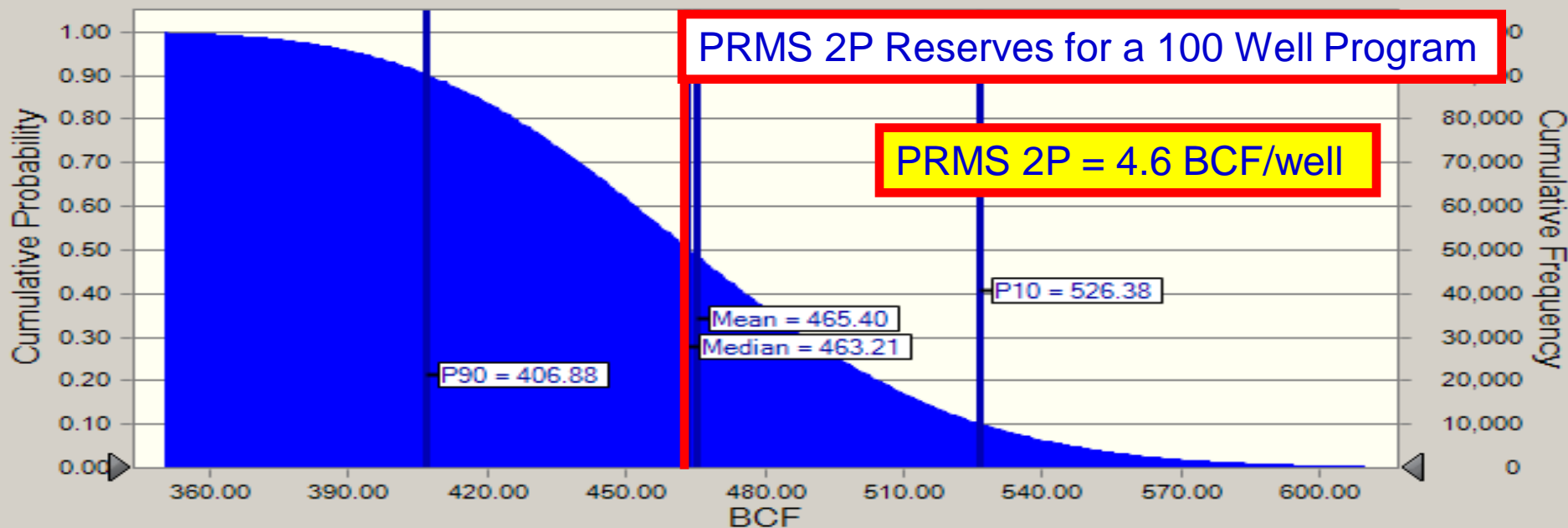
Cumulative Probability

Cumulative Frequency

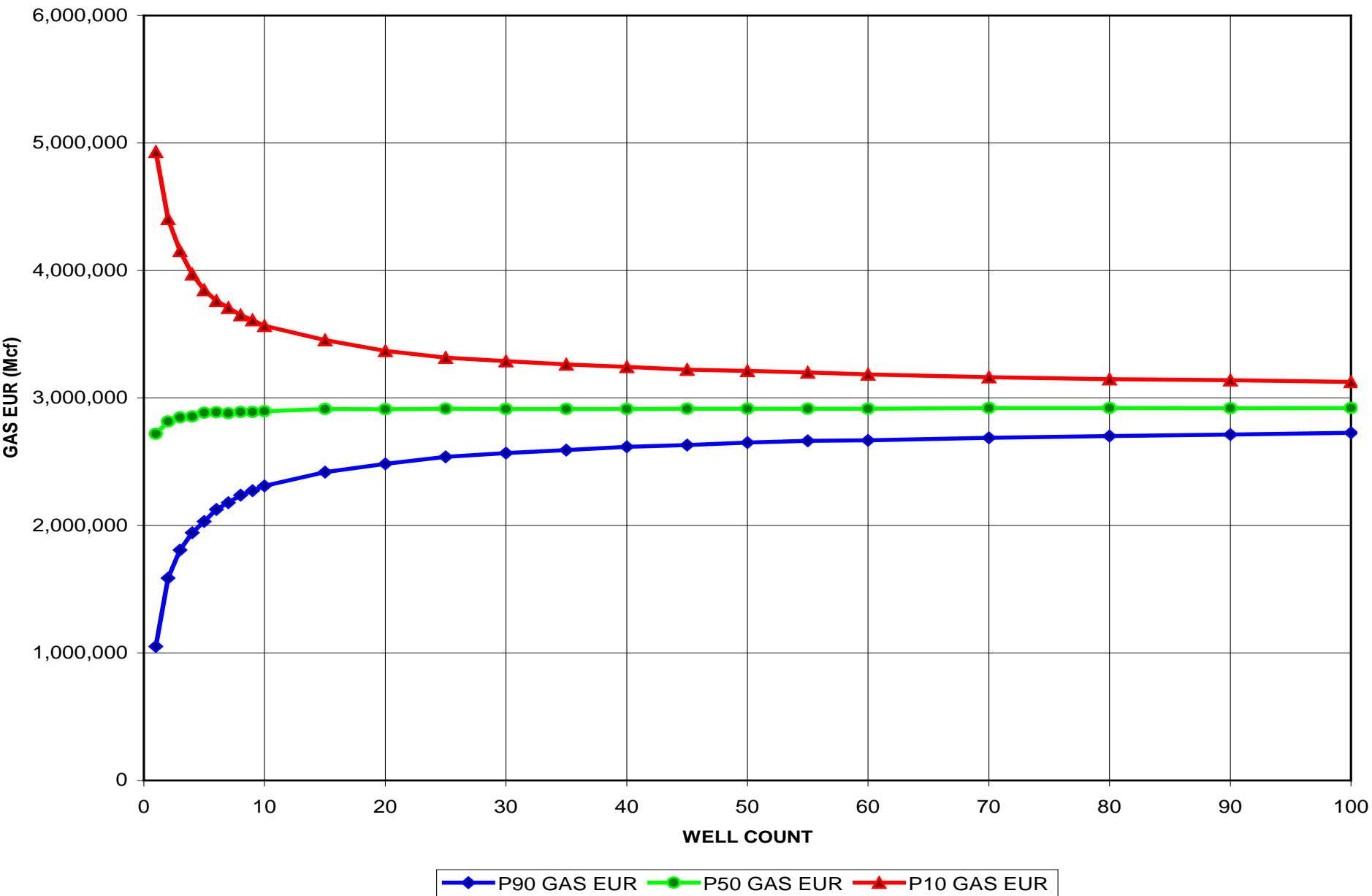
Single well Forecast



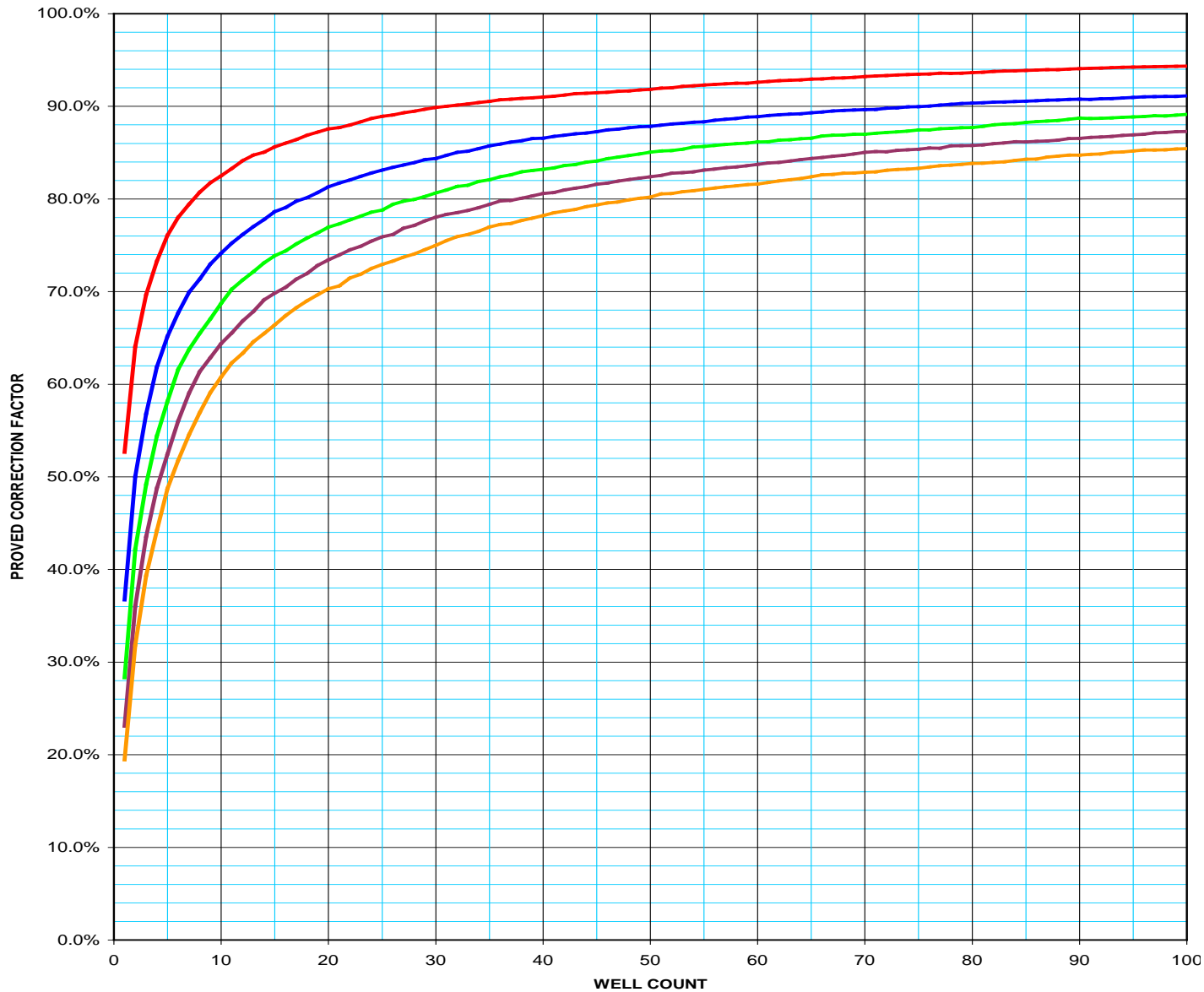
100 Well Program



P10 to P90 Range Vs. Well Count



SPEE Proposed Fudge Factor For Deterministic to Probabilistic Reserves



— P10/P90 = 3 — P10/P90 = 5 — P10/P90 = 7 — P10/P90 = 9 — P10/P90 = 11

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