Uncertainty Considerations for Development Planning Type Curves

Session 1: Production Type Curve Construction – Best Practices and Pitfalls

SPE Workshop: Sept. 26th, 2017

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Introduction

- Resource play development is often characterized by the “Type Well” (also called a Type Curve or Type-well Curve) which is the average (expected) well in a program of wells.
- There are no guidelines or standards.
- There are complexities (see Understanding Type Curve Complexities and Analytic Techniques and associated blogs).
- There are many uncertainties.

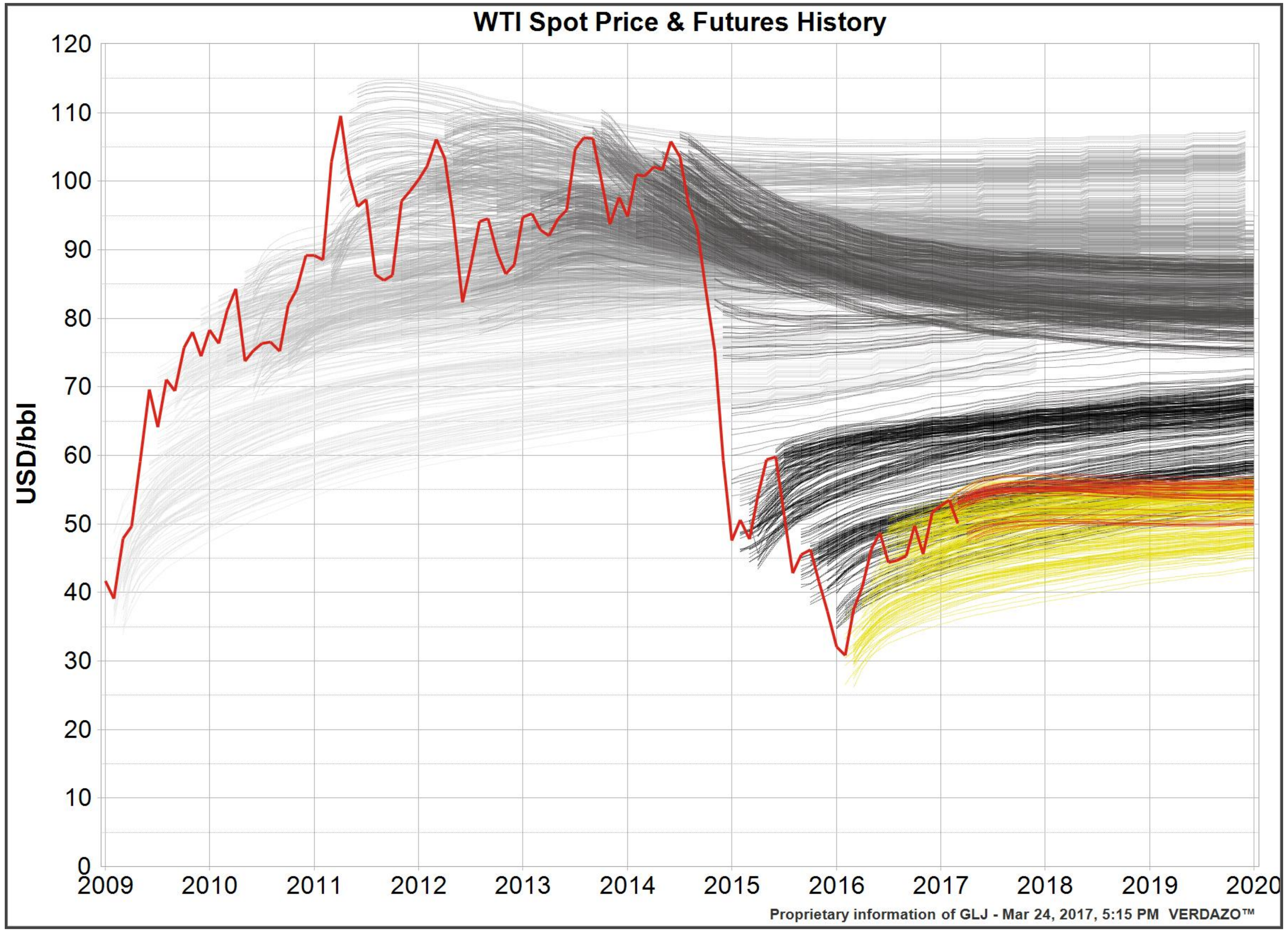
Type Well Uncertainties

- **Reservoir** → managed with analogue selection
- **Completion Design** → managed with analogue selection, dimensional normalization, modelling, AI/Machine Learning, Multivariate Analysis, Parallel Coordinate Distributions (to identify thresholds and correlation windows)
- **Sample Size** → Do I have enough data points to adequately represent the range of possible outcomes? Can I deliver the mean with a small drilling program?
- **Data History** → Do I have enough production history to be confident in my forecast?
- **Operational Design** → rate restrictions, artificial lift & EOR further complicate reliability of type-well curves
- **Interference** → spacing, cardinality, & parent-child interactions

Price Uncertainty

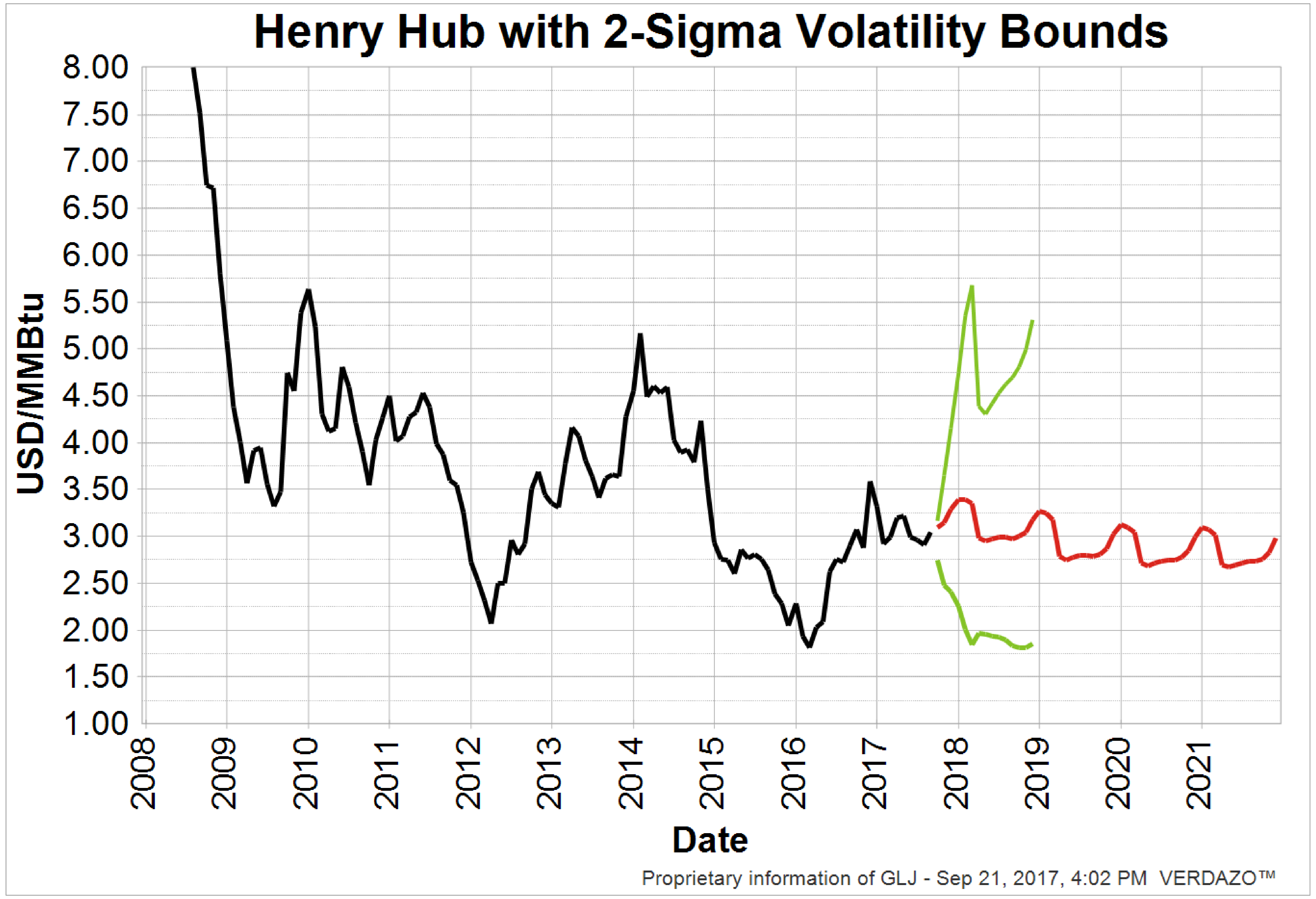
- Market conditions necessitate planning for the “lower for longer” price scenario

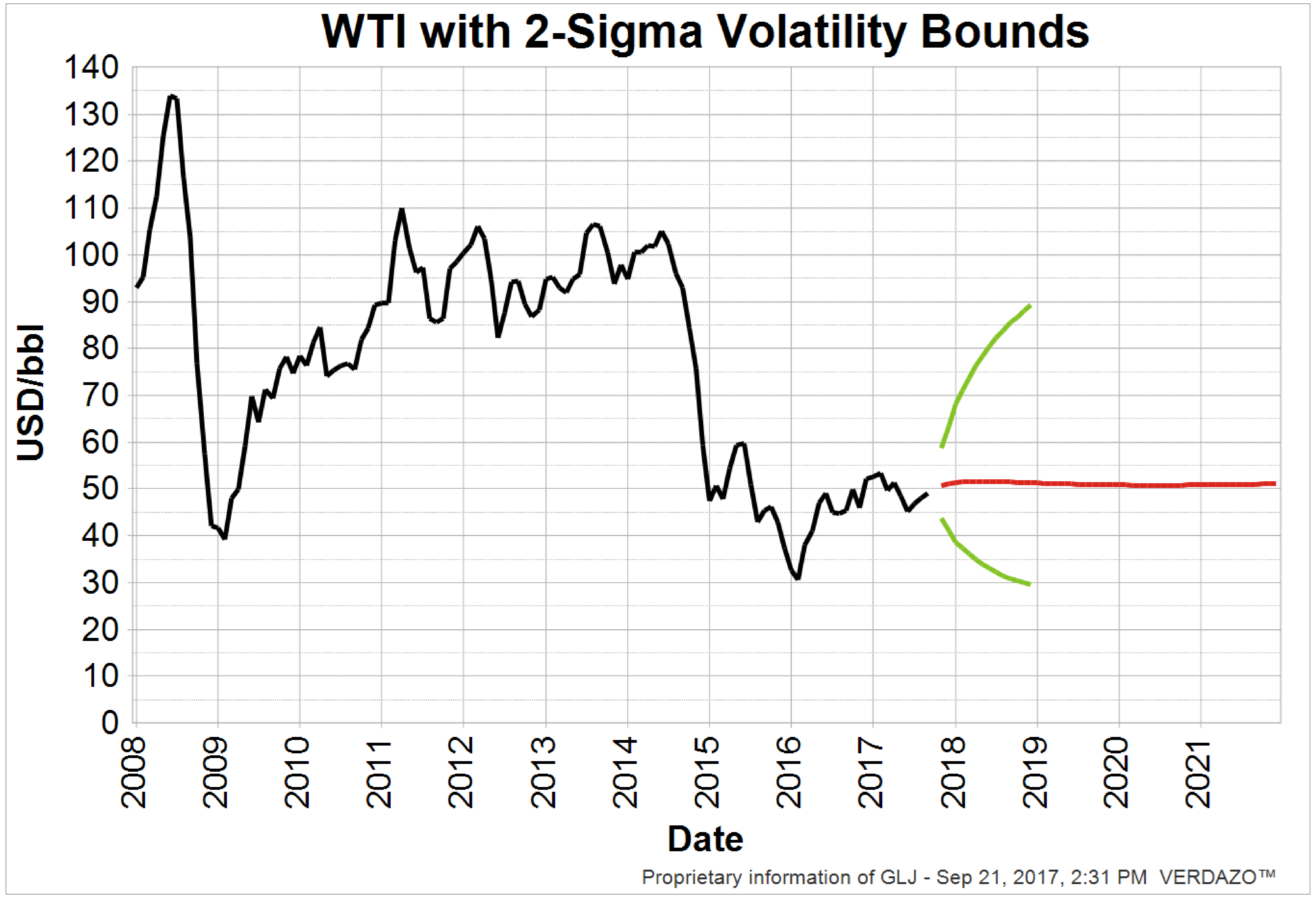
- Horizontal multistage fractured wells are dramatically affected by near term price fluctuations because of the early-life value-weighting



Price Uncertainty

95% confidence interval bounds





Check out Session 8: (Price) Forecasting is Hard, Tyler Schlosser, GLJ Petroleum Consultants

Courtesy of GLJ Petroleum Consultants

One Thing is Certain: Stock Price Impact

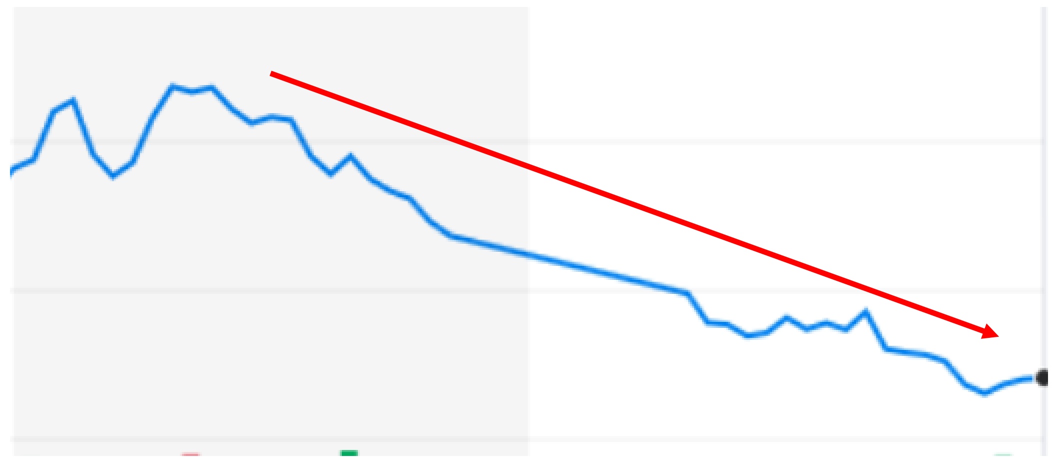
Investors do not react well to production guidance shortfalls

Reduced by 40% in 8 months

Reduced by 50% in 7 months

Reduced by 30% in 2 weeks

Reduced by 40% in 8 months



Reduced by 70% in 8 months

Reduced by 26% in 1 month

Reduced by 40% in 8 months

Reduced by 40% in 8 months

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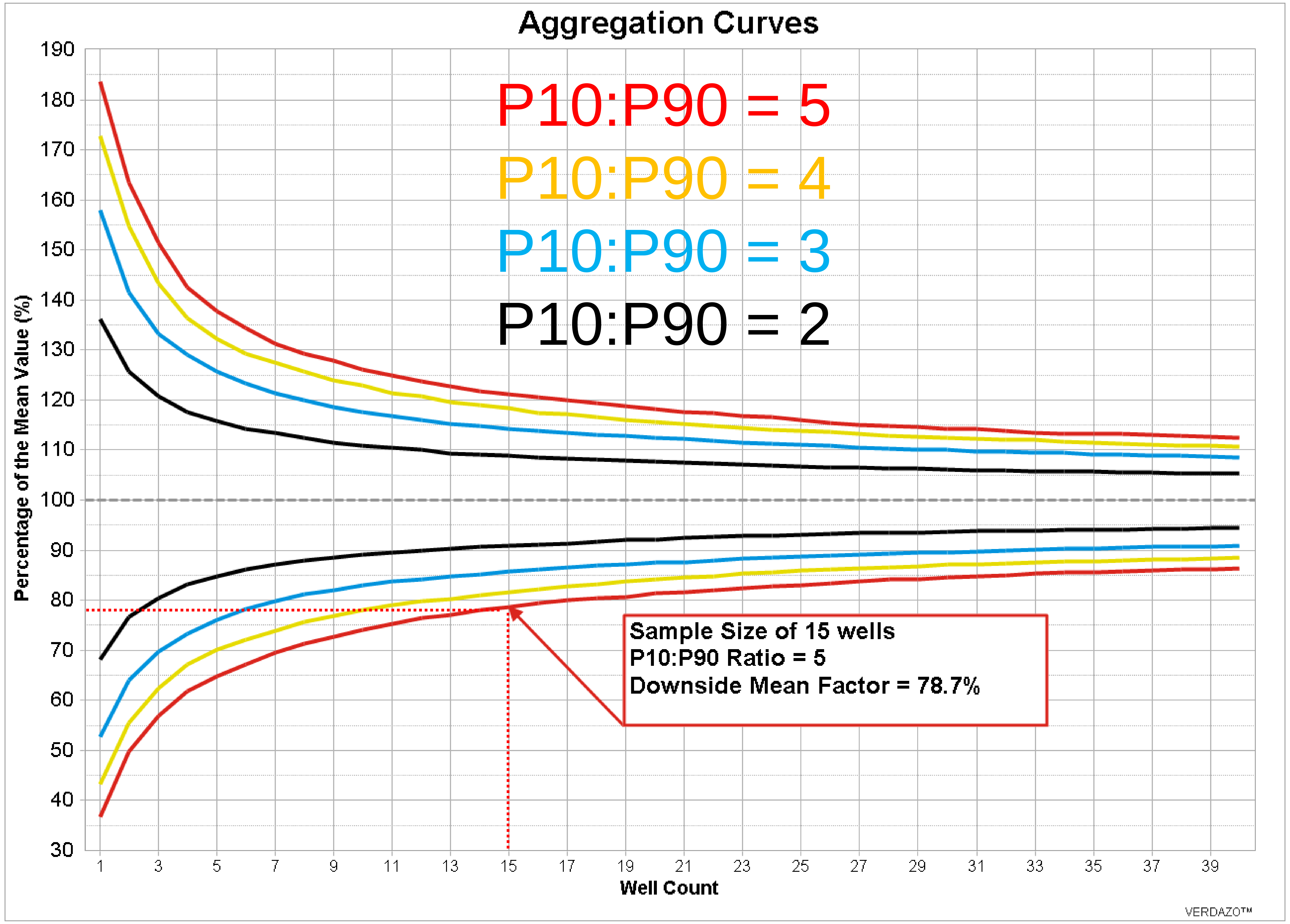
Using a Downside Mean

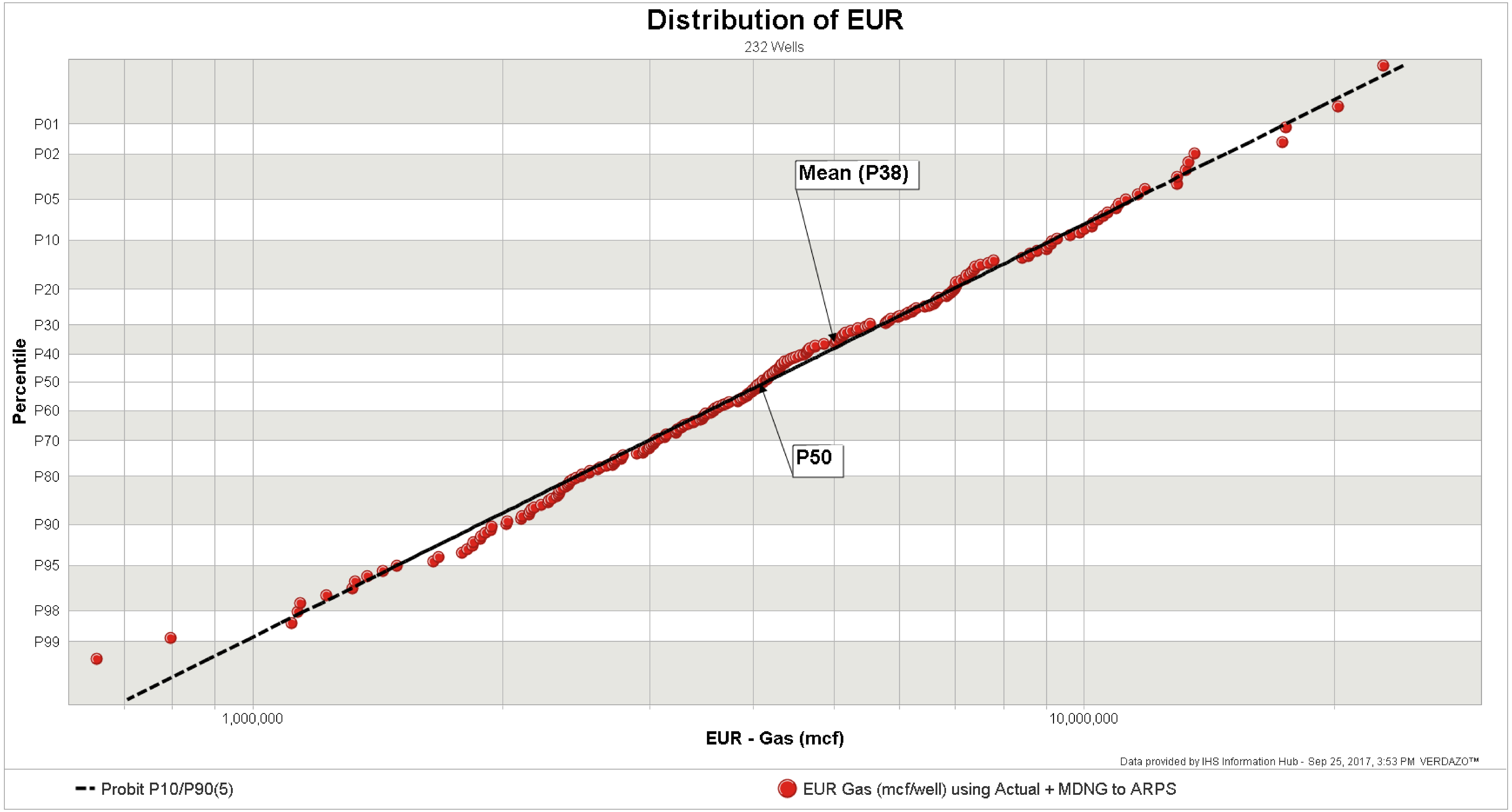
Examining Sample Size, Aggregation & Production History

Uncertainty in Sample Size & Aggregation



- I have a known reliable analogue Mean (based on statistically significant sample set).
- Downside (Program Arithmetic) Mean is the mean that you have a 90% chance of achieving or exceeding given the number of wells you're drilling.
- Find your sample size on the X-axis for the P10:P90 ratio of your sample set.
- Multiply your analogue Mean by the Percentage on the Y-axis.

Example: Uncertainty in Sample Size & Aggregation



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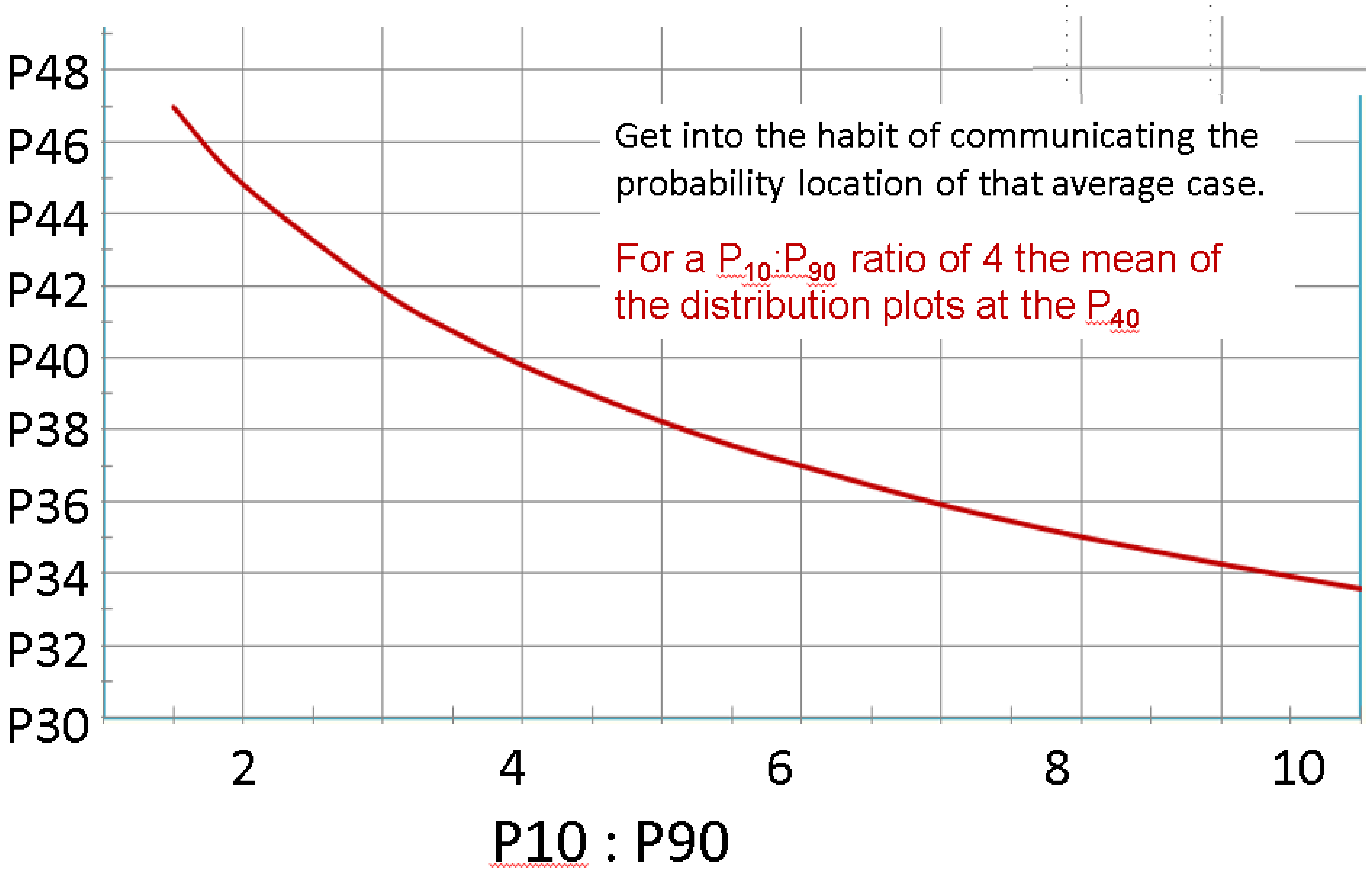
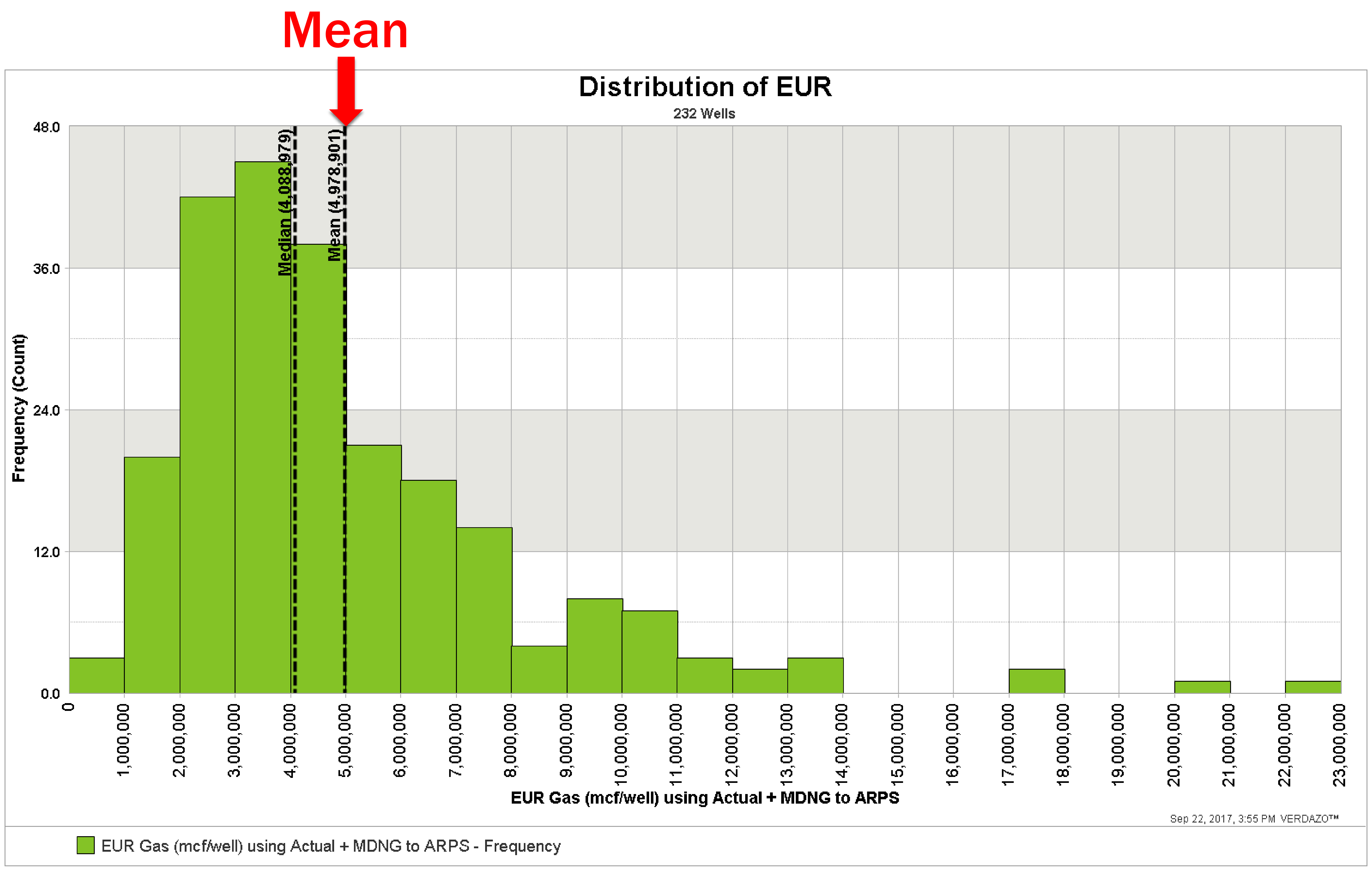
Percentile Location of the Mean vs P10:P90 Ratio



Example 1: Uncertainty in Sample Size & Aggregation



Each well has a 62% chance of being less than the mean.

If I'm only drilling 15 wells…

Mean = 4,979 mmcf
P10:P90 = 5
Downside Mean Factor = 78.7%
Downside Mean = 3,918 mmcf

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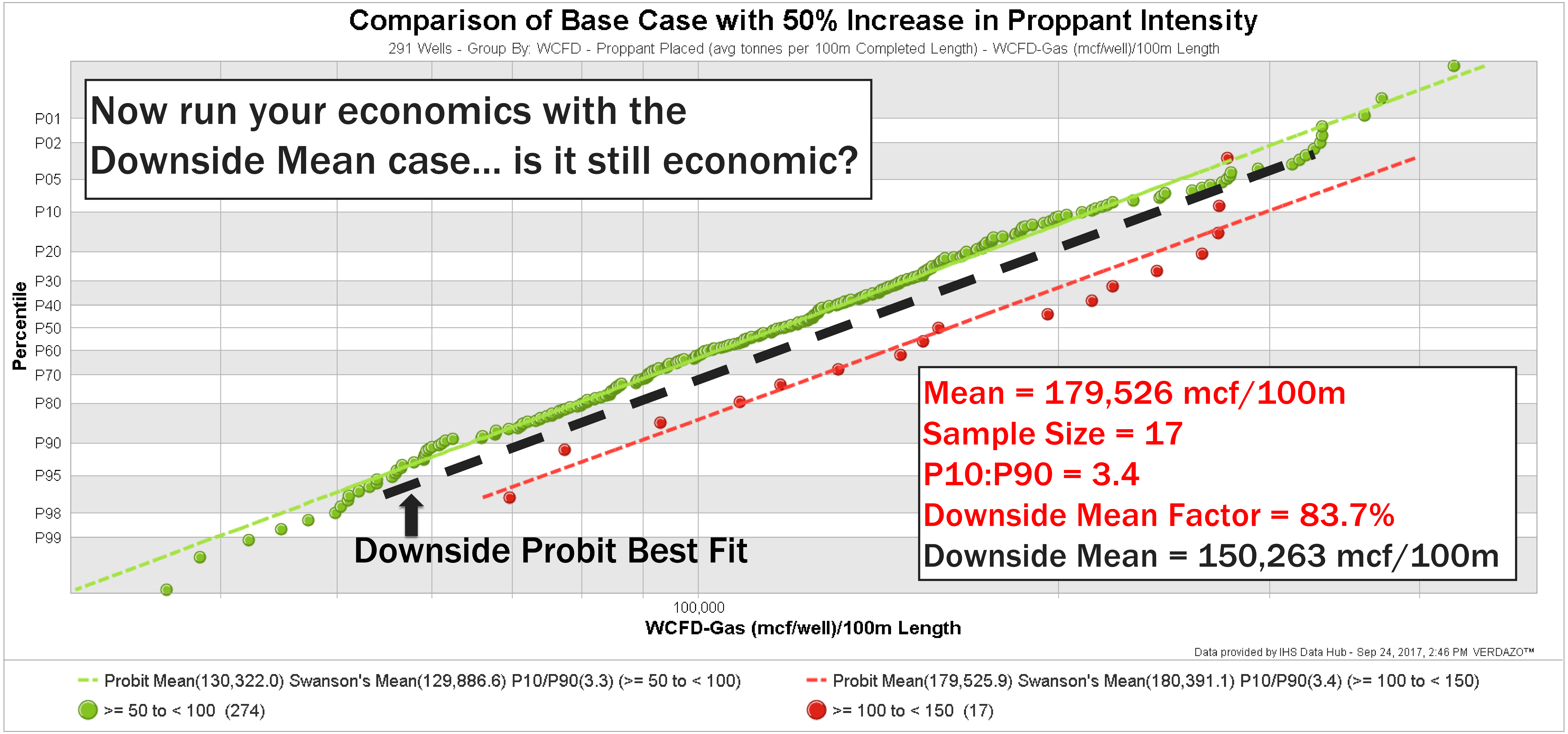
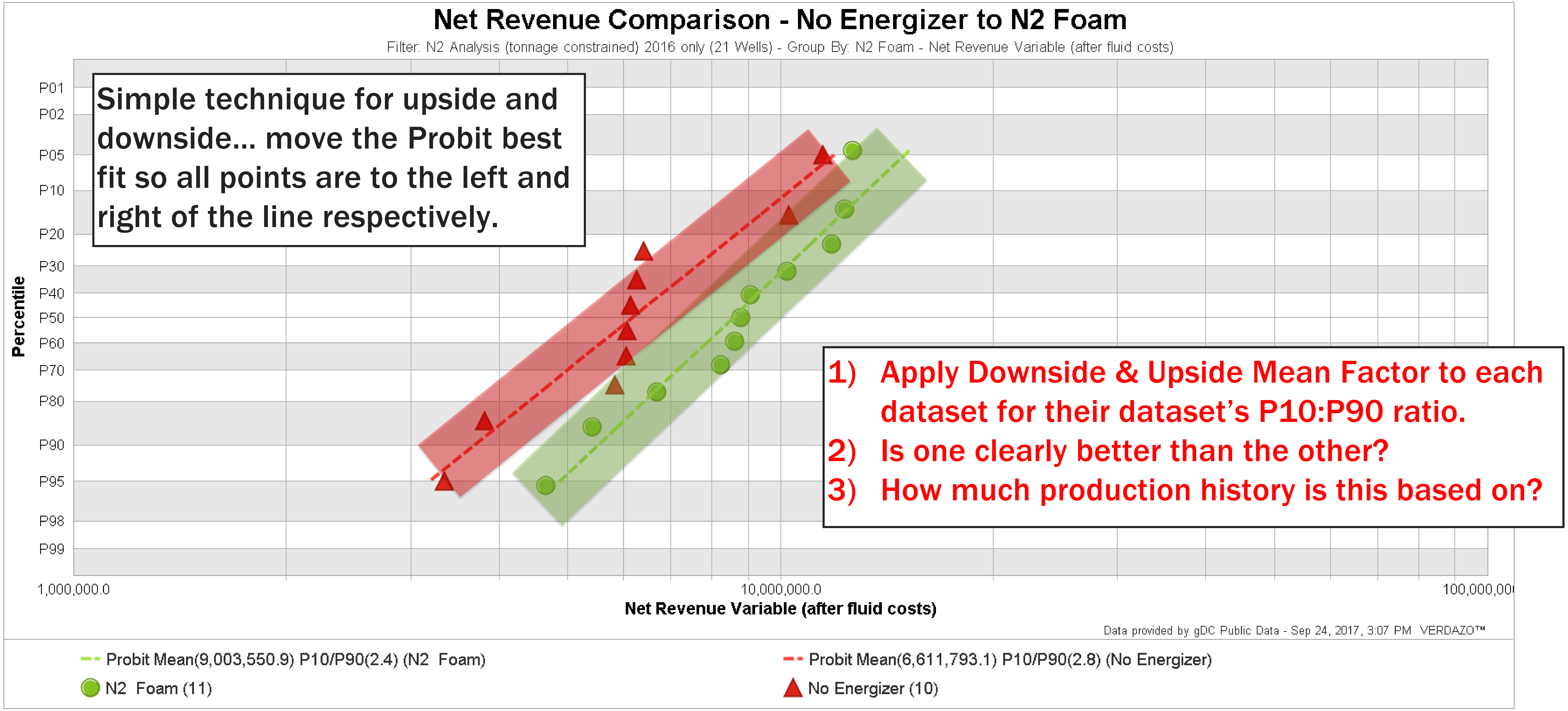
Example 2: Proppant Intensity



Example 2: Energizer Comparison



How much production history do I need?

Analysis of Production Measure Correlations to EUR for 4 Plays

		Montney (Gas)				Cardium (Oil)				Viking (Oil)				Bakken (Oil)			
		Data Set 1		Data Set 2		Data Set 1		Data Set 2		Data Set 1		Data Set 2		Data Set 1		Data Set 2	
		Correlation %	Well Count	Correlation %	Well Count	Correlation %	Well Count	Correlation %	Well Count	Correlation %	Well Count	Correlation %	Well Count	Correlation %	Well Count	Correlation %	Well Count
	PD Rate (month 1)	10.6	585	18.9	227	33.8	1592	37.7	769	21.8	3098	19.5	818	30.1	1387	30.0	991
	PD Rate (month 1-2)	21.0	584	29.9	226	42.3	1592	49.9	769	28.6	3098	35.3	818	39.5	1387	38.9	991
	PD Rate (month 1-3)	31.2	583	36.7	225	48.1	1592	58.0	769	33.4	3098	45.2	818	46.4	1387	45.1	991
	Peak	60.0	585	50.6	227	53.5	1592	67.0	769	40.1	3098	65.1	818	61.3	1387	65.5	991
	IP30	32.6	585	39.3	227	44.4	1574	56.2	769	30.9	2999	52.3	818	44.8	1387	45.7	991
	IP60	42.7	585	45.2	227	54.8	1573	68.6	769	38.5	2999	59.7	818	51.3	1387	51.4	991
	IP90	49.2	585	49.9	227	60.8	1573	74.2	769	43.5	2999	64.0	818	56.5	1387	56.1	991
	IP180	60.8	576	62.0	227	70.0	1561	80.7	769	53.4	2994	71.0	818	66.6	1387	66.8	991
	IP365	72.4	576	74.9	227	79.9	1561	86.1	769	69.1	2994	79.0	818	77.5	1387	78.8	991
Condensed Data	3 Month Cum	23.2	585	19.4	227	46.9	1592	60.2	769	36.4	3098	58.9	818	52.2	1387	52.2	991
Condensed Data	6 Month Cum	49.3	585	45.1	227	65.4	1592	76.6	769	65.4	3098	70.0	818	65.0	1387	64.6	991
Condensed Data	12 Month Cum	67.1	523	67.0	227	77.6	1524	84.8	769	67.8	2563	77.9	818	76.5	1357	77.1	991
Condensed Data	18 Month Cum	75.4	473	76.1	227	82.9	1357	88.7	769	79.4	2002	82.4	818	82.3	1249	84.0	991
Condensed Data	24 Month Cum	79.7	377	81.6	227	86.7	1233	91.1	769	84.2	1551	85.3	818	88.6	1184	88.3	991
Condensed Data	30 Month Cum	83.5	287	85.1	227	90.3	966	92.8	769	87.4	1125	87.5	818	91.1	1067	90.9	991
Condensed Data	36 Month Cum	87.5	227	87.5	227	94.1	769	94.1	769	89.7	818	89.7	818	92.6	991	92.6	991
Non-condensed Data	3 Month Cum	16.4	585	8.9	227	43.8	1592	57.1	769	35.5	3098	56.1	818	51.6	1387	52.0	991
Non-condensed Data	6 Month Cum	40.3	585	30.5	227	63.8	1592	74.0	769	49.1	3098	64.6	818	63.8	1387	63.5	991
Non-condensed Data	12 Month Cum	59.5	523	56.2	227	77.3	1524	84.5	769	67.3	2563	76.9	818	76.2	1357	76.7	991
Non-condensed Data	18 Month Cum	71.5	473	70.5	227	82.9	1357	88.6	769	79.3	2002	82.3	818	82.1	1249	83.7	991
Non-condensed Data	24 Month Cum	77.5	377	78.4	227	86.7	1233	91.0	769	84.2	1551	85.3	818	88.4	1184	88.0	991
Non-condensed Data	30 Month Cum	82.0	287	83.5	227	90.2	966	92.7	769	87.5	1125	87.6	818	90.9	1067	90.7	991
Non-condensed Data	36 Month Cum	86.4	227	86.4	227	94.1	769	94.1	769	89.8	818	89.8	818	92.4	991	92.4	991

Legend

86.4	Green = Correlation between 70% and 100%
59.5	Yellow = Correlation between 50% and 70%
40.3	Red = Correlation between 30% and 50%
16.4	Grey = Correlation between 0% and 30%

Data Set 1 = wells with >80% correlation on Modified Duong fits for both "a" and "m" and >6 months production after peak

Data Set 2 = subset of Data Set 1 where all wells have >=36 months production

Note: Sample sets include only horizontal wells.

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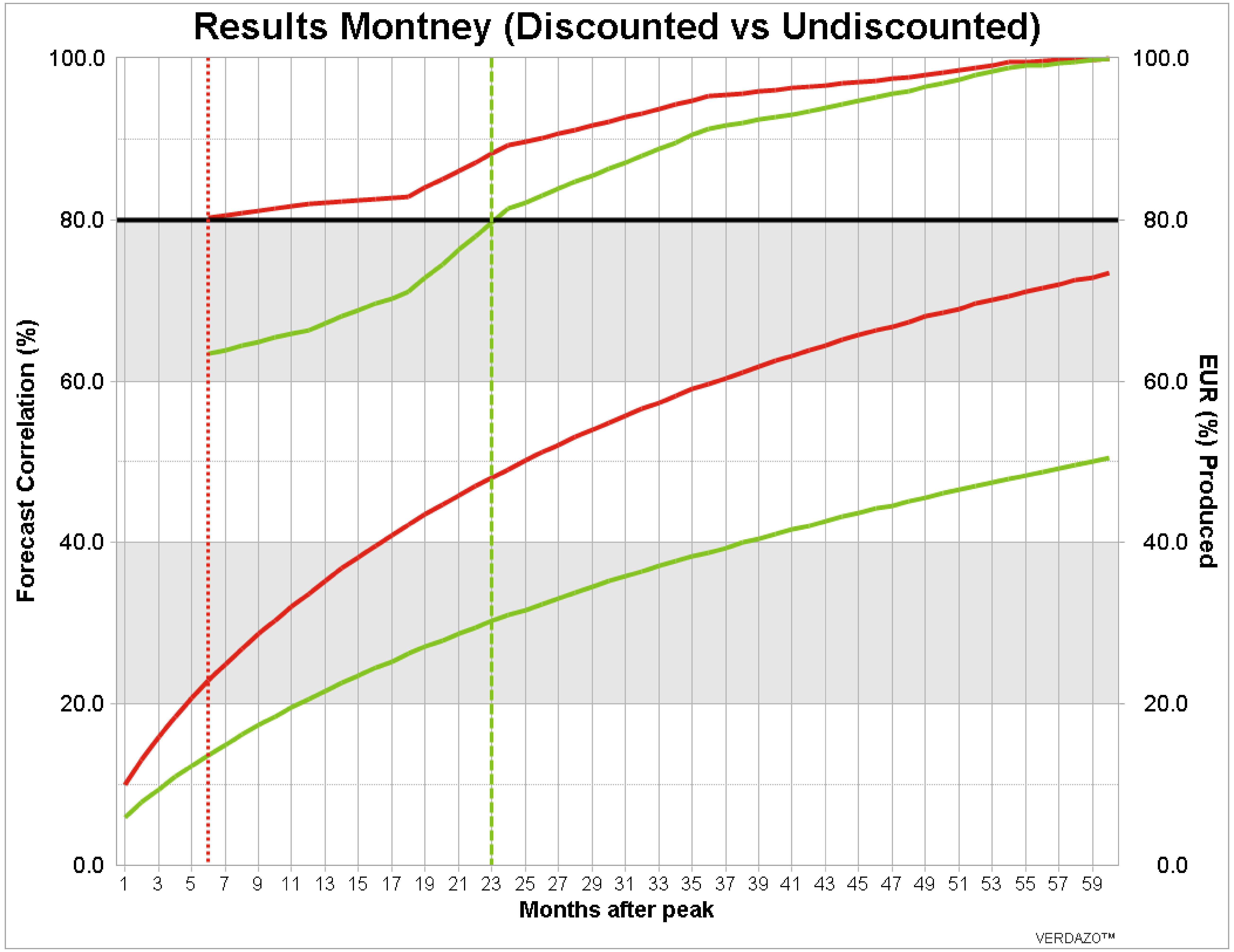
EUR calculation based on 240 month forecast using Modified Duong auto-forecast up to boundary dominated flow BDF), then transitioning to Arps for remainder of forecast.
Gas wells (Montney) used 60 months to BDF and a ***b*** value of 0.5 for Arps
Oil wells (Cardium, Viking and Bakken) used 48 months to BDF and a ***b*** value of 0.5 for Arps

How much production history do I need?



Value vs Volume Perspective

In one study… applying a 10% discount factor to EUR (as a proxy for value) required only ~25% of the production history as a volume (undiscounted) view did to achieve an 80% confidence in a forecast.

Completion Uncertainty

Completion Uncertainty

1) Innovators often have few data points to work with
2) High dimensionality (many variables)
3) Correlations are rarely linear
4) Heteroscedasticity (variability of a variable is unequal across the range of values of a second variable that predicts it)
   - Can manifest itself as thresholds and correlation windows... see SPE 185077 Multivariate Analysis Using Advanced Probabilistic Techniques for Completion Optimization

5) Geological targeting (JPT Article Models Overstate Technology Impact, Understate Location Impact for Unconventional Wells)
6) Completion learning curves

Scaling for Completion Design

1) Use distributions to help you scale (e.g. in slide 11), but take into account sample size and aggregation curve downside/upside considerations.

2) Artificial Intelligence & Machine Learning can help us understand what matters most and establish predictive models.

Any conclusive insight is going to rely on good data and lots of it.

Conclusions

Conclusions

1) Forecasting is hard and requires rigorous analysis.
2) The market consequences of production shortfalls can be drastic.
3) Be aware of uncertainty due to sample size & amount of production history (more data is better).
4) Leverage the Downside Mean (Aggregation Curve) approach to better plan for statistically achievable results.
5) Show your work→ support your conclusions with compelling visual narratives.

"You can better assess the merits of a conclusion/decision if you can see how it was arrived at"

Thanks to Advisors & Trusted Experts

Matt Ockenden (VP Corporate Planning, Paramount)

Jim Gouveia (Rose & Associates)

GLJ Petroleum Consultants

Thank You

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