Accurate Asset Level Production Forecasts
Be Sure with BetaZi™

b BetaZi™

Accurate & Fast EUR Forecasts

- Data Used
- Blind Test Data
- Standard Fit

MBBL/Month

Spread of Uncertainty

p10

p50

p90

2009 2011 2013 2015 2017 2019 2023 2021
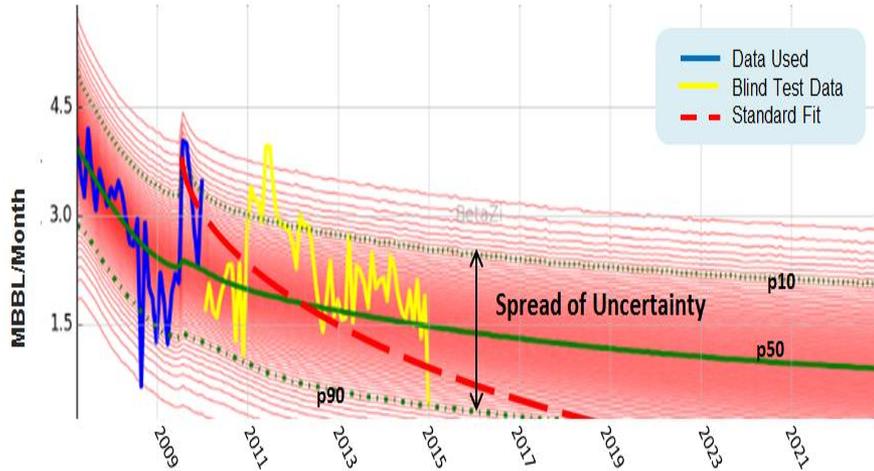
BetaZi Statistical & Verified Type Curve

MBBL/Month

Months

Company TC
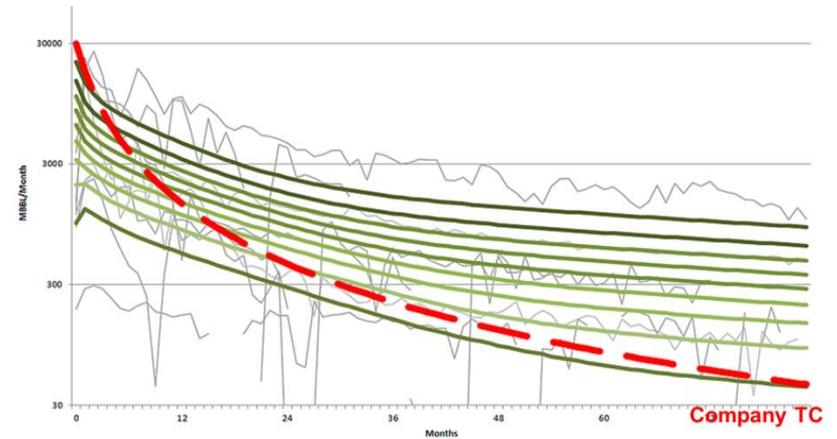
BetaZi Type Curve Validation

BBL/mo

MCF/mo

Count %

P-Value
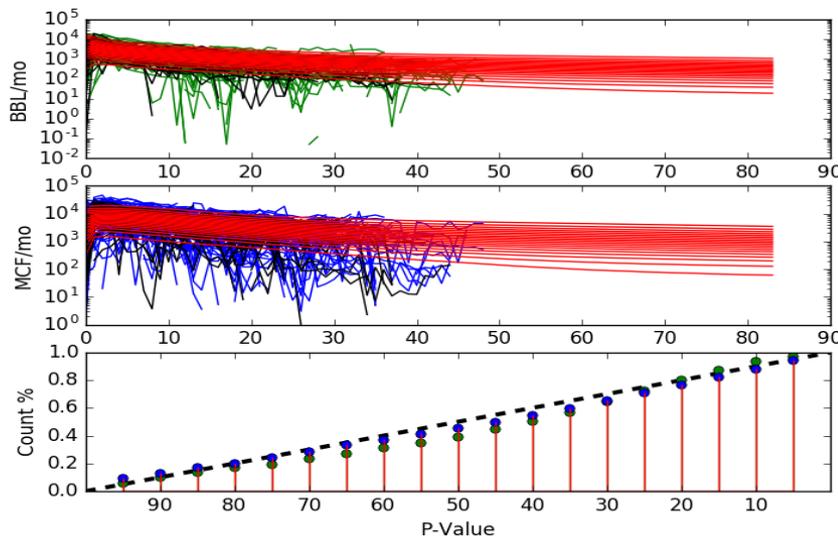
Statistically Correct Production Rollups

Pampa

BBL

Accurate Asset Level Production Forecasts
Be Sure with BetaZi™ BetaZi™

OIL

Proved UnDeveloped (PUD)

PDNP

Producing Developed Producing (PDP)

GAS
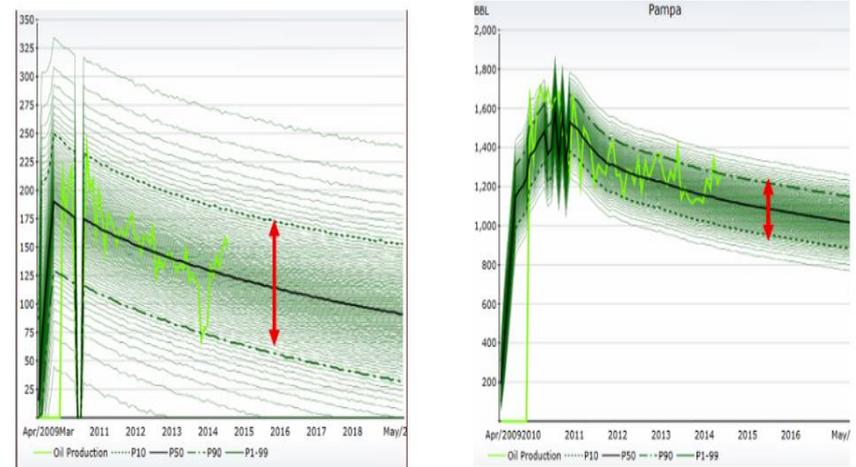
BetaZi™
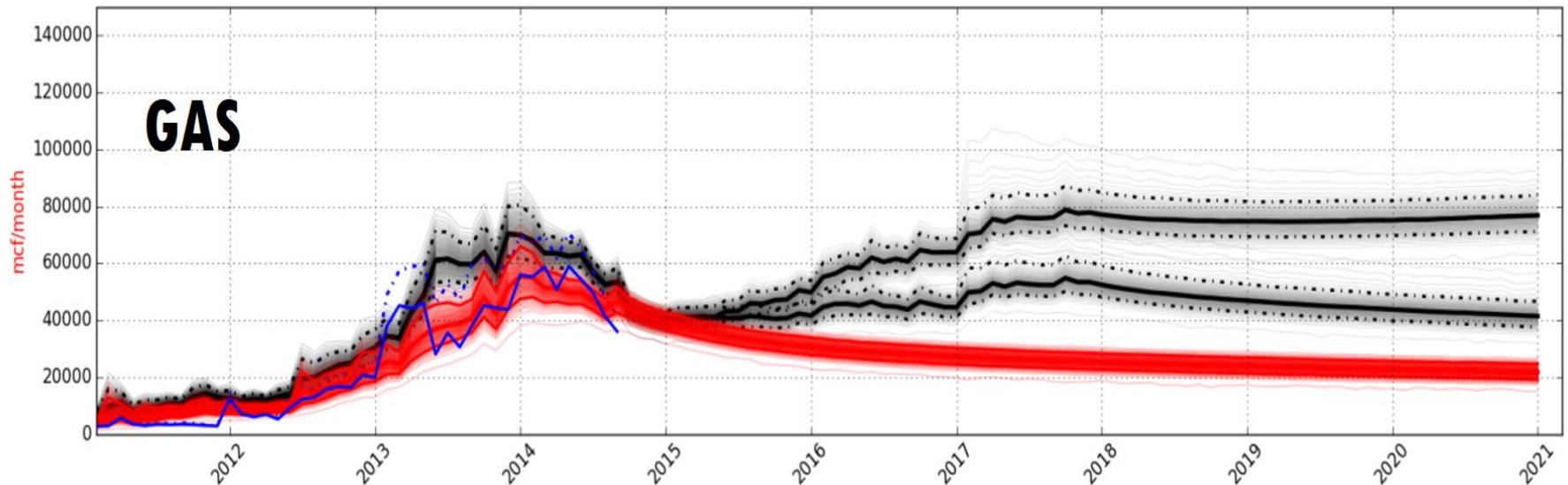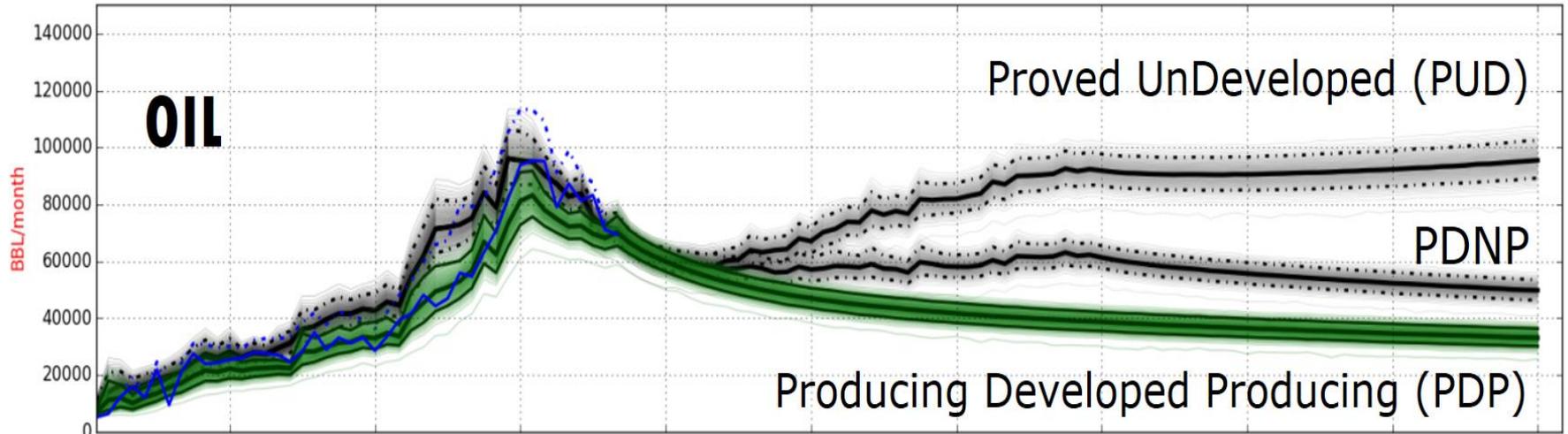
Presents *'THE NEW STANDARD'*

PREDICTIVE ANALYTICS SOLUTIONS FOR QUANTIFYING WELL PERFORMANCE AND FORECASTING FULL FIELD PRODUCTION OF OIL & GAS ASSETS

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Discussion Outline

- The Issues
- The Science
- The Solution
  - Decline, Forecasting and EUR
  - BetaZi Statistical Type Curve
  - BetaZi pScore™
- Applying the Knowledge Learned
- How to get it

The Issue

PRODUCTION FORECASTING: predicting the next 7 years of proved production from existing wells and fields

THE BULK OF OIL AND GAS ASSET ECONOMIC EVALUATION IS BASED ON PRODUCTION FORECAST NUMBERS.

— NOT RESERVES: number can never be tested
— NOT EXPLORATION

**BUT** >90% of production forecasts are currently made or adjusted **by hand.** This makes them:

- Slow
- Expensive
- Subject to bias

During Due Diligence it is prohibitively expensive and time- consuming to recreate a production forecast from first principles. Instead, all you usually do is spot check an Aries or PhdWin database. **In fact, you have no idea how accurate your forecast is and no way of knowing how far off it could be.**

**BetaZi**™

Production Forecasting 101

- Production forecasting is made very difficult by noisy, complicated data.
- Human tendency is to overthink the problem.
- Decide which data is relevant.
- Pick a decline curve (exponential, Arps, Duong, etc.)
- Find the parameters of a curve that fits.
- Adjust.
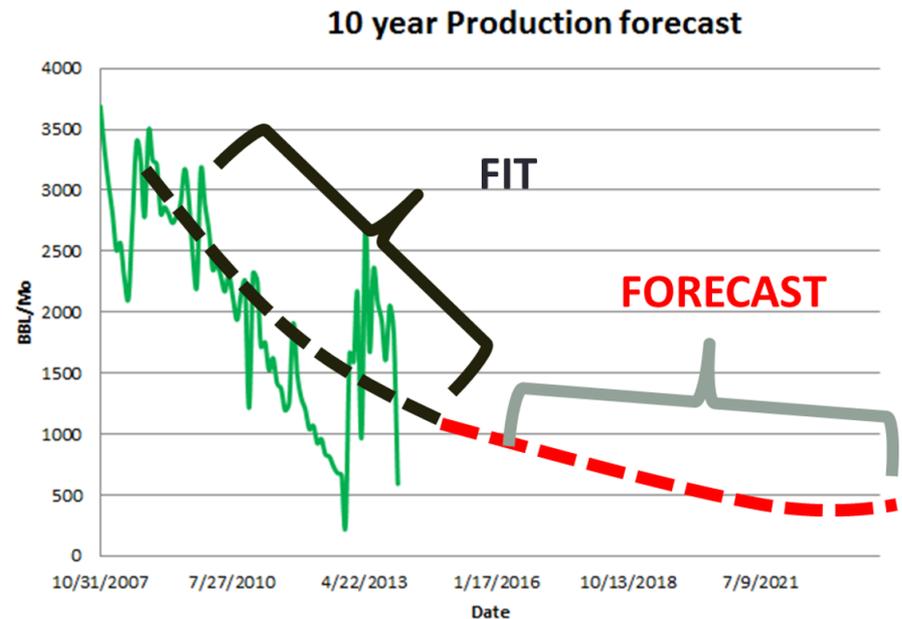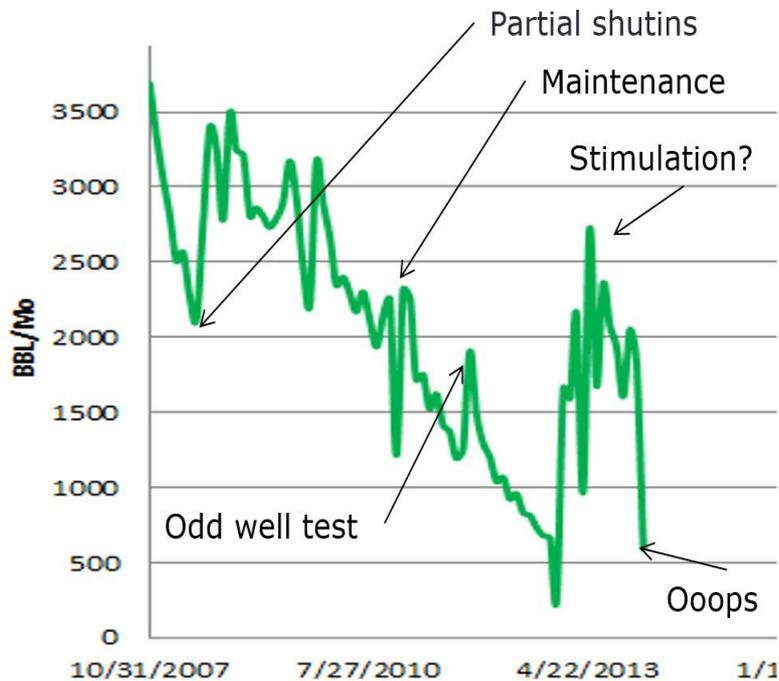
Different Possibilities

- Lots of curves fit the data but…
- Every judgment call introduces potential bias
- It takes a long time (why it's usually only spot checked)
- Forecasts are not consistent
- No rigorous definition of high, medium and low (PRMS)
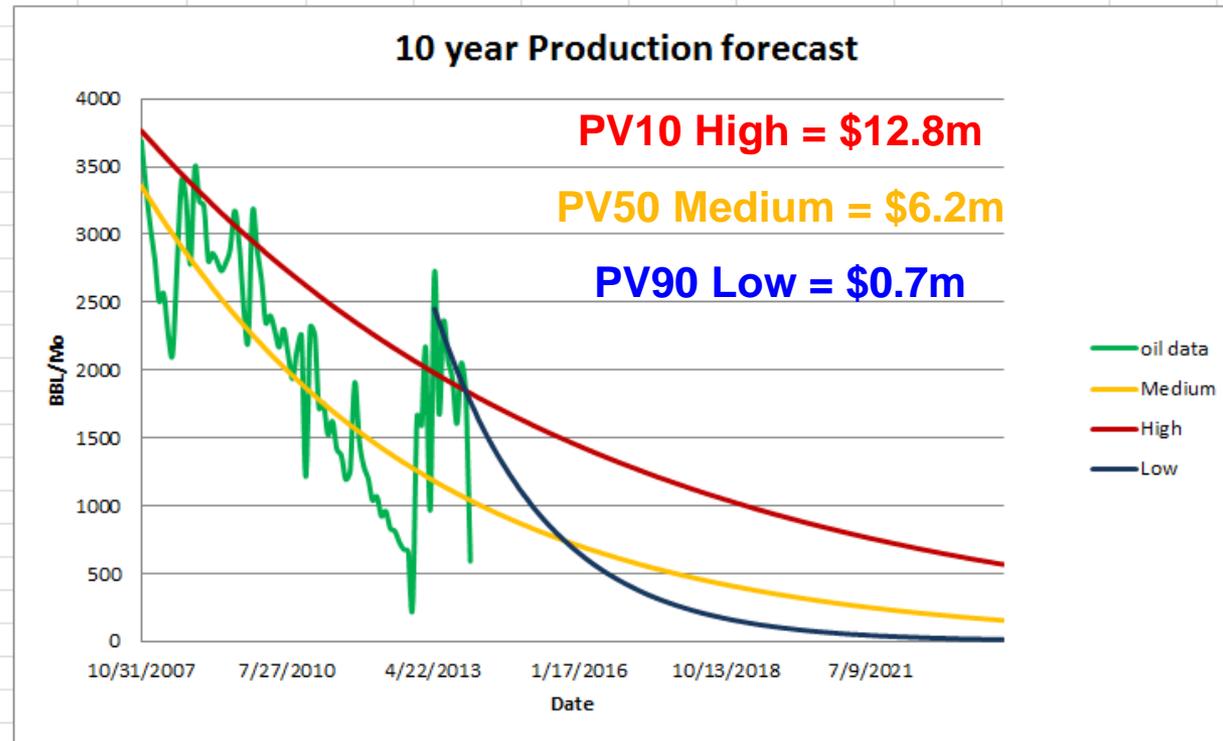
Engineering Bias Provides Choices
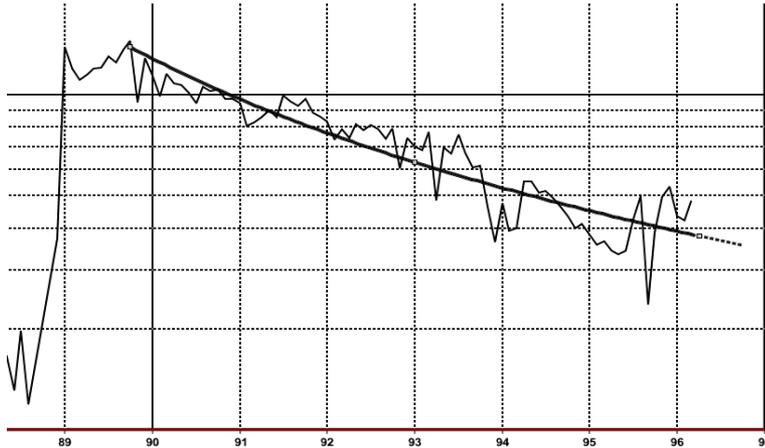
EUR = 112,959 BBL oil
$3.4 m
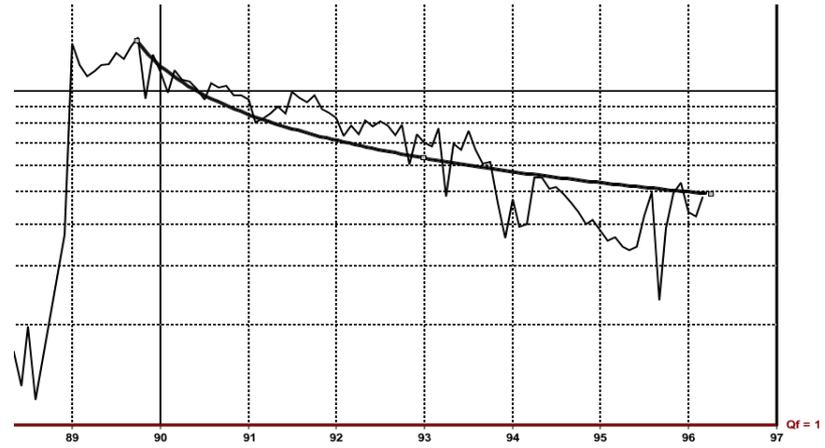
EUR = 787,822 BBL oil
$23.6 m

Multiply by 100 wells -> $2b choice

The Science

The Science – 'The New Standard'

1. Start from first principles.
2. Insist on independent verification.
3. Use statistics.
4. Back-test.

ANALYTICS:
"Figuring out what's there"
Forecast future production based on what it's done in the past.

ENGINEERING:
"Making it work"
Improve the well.

WE HAVE THE SCIENCE.

➤ Fast enough to meet data room deadlines.
➤ Gives you actionable intelligence.

You don't want to waste your engineers' time doing rote forecasting.
You don't want your forecasts to be engineered.

BetaZi™

Predictive Analytics Methodology

Explain in terms of physics:

- › Flow regime changes
- › Time-dependent permeability
- › Drive mechanisms

Explain in terms of statistics learned over big data:

- › Shut ins
- › Stimulations
- › Bad allocations
- › Bad luck

The Internal BetaZi Model

- Find all possible curves capable of explaining the data
- Let the answers range in complexity
- Let them deviate from purely physical behavior
- Run statistics over them to produce percentiles that have real meaning (90% of the time production will exceed p90)
- Get a comprehensive answer
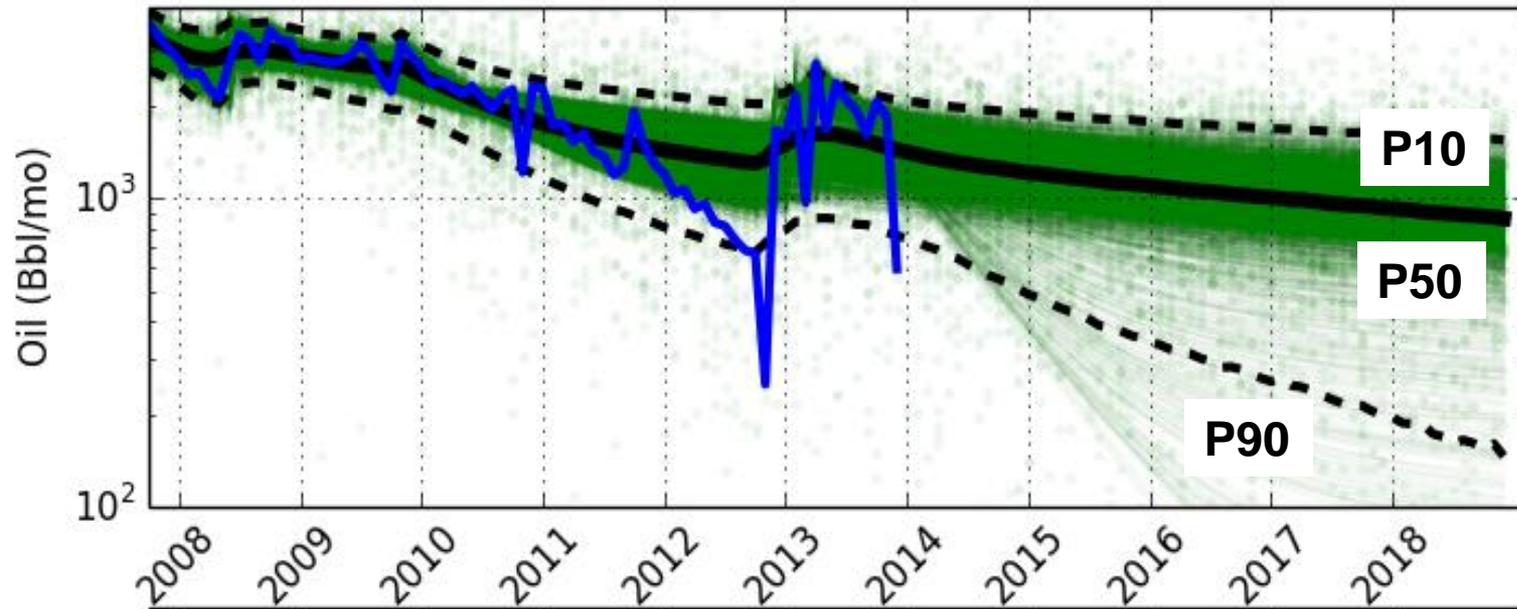
Generates **EVERY** potential decline curve for the data by computing a million samples ranging from simple to complicated, using a sophisticated *physio-statistical model.*

Results = Significant Statistics

Samples are then aggregated into true probabilistic percentiles.
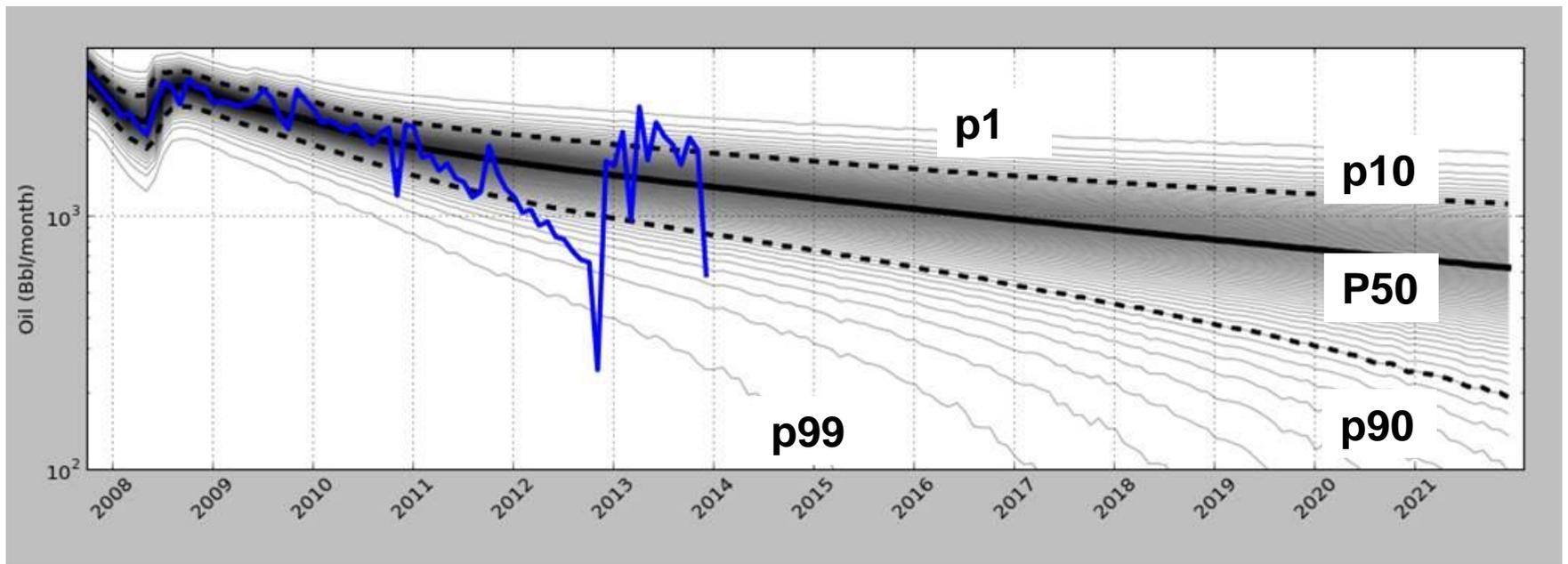
'p90' means that 90% of samples fall above the p90 line

The Solution

BetaZi Forecast – Single Well

INPUTS: oil, gas, water, monthly volumes and working days

OUTPUTS: forecast with calibrated uncertainty

p10

p50

p90
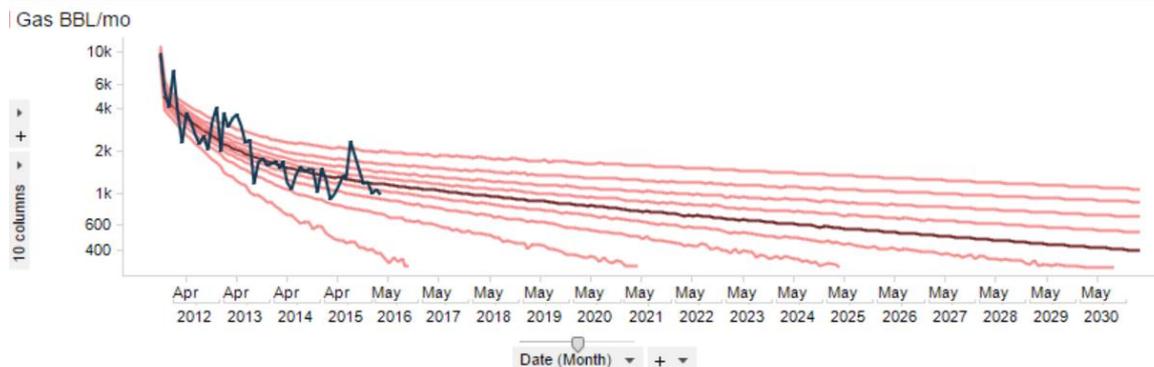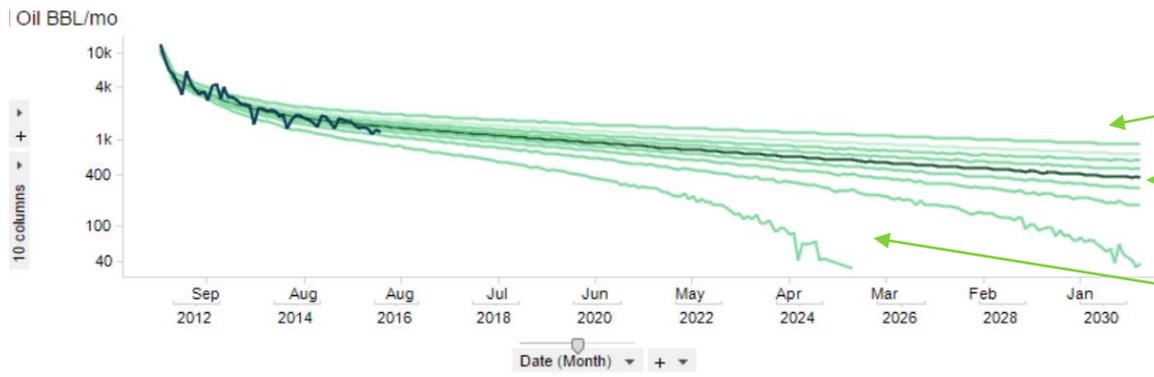
Monthly production is expected to exceed p50 forecast 50% of the time.

Production Forecasts Quality Control
Q-Q Testing Defines Model Performance

QQ EUR 1853 Conventional Oil Wells

QQ EUR 3163 Bakken Oil Wells
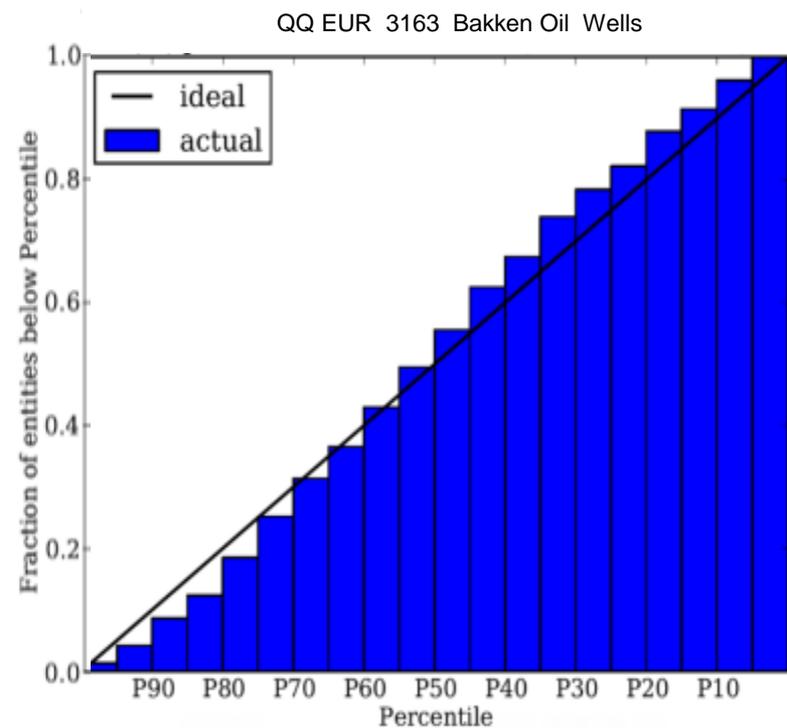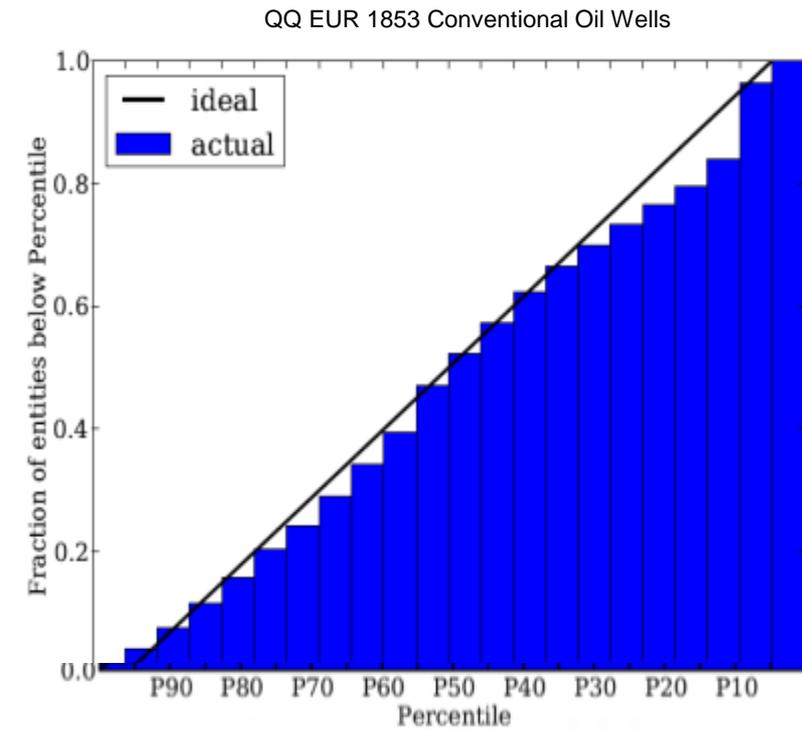
In a Quantile-Quantile (Q-Q) Plot, a straight 45 degree line denotes that 90% of the time holdback data production exceeds the p90, 80% of the time it exceeds the p80, and so forth

BetaZi Statistical Type Curve Verified with Cross Validation

Statistical model computed over 20 – 500 wells. A type curve to rapidly determine that the well population used is based upon truly analogous wells. Results are tested using cross-validation to ensure accuracy.

VALIDATING = PASS
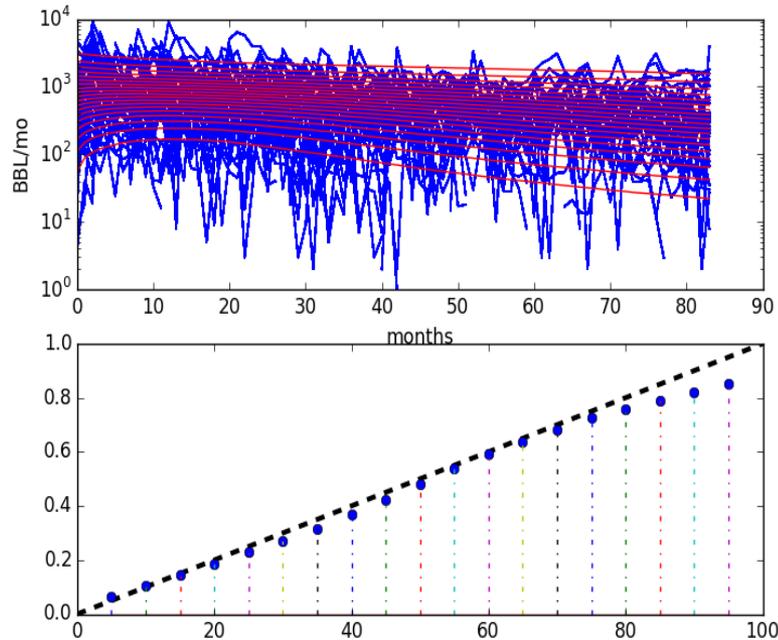
NOT- VALIDATING = FAIL
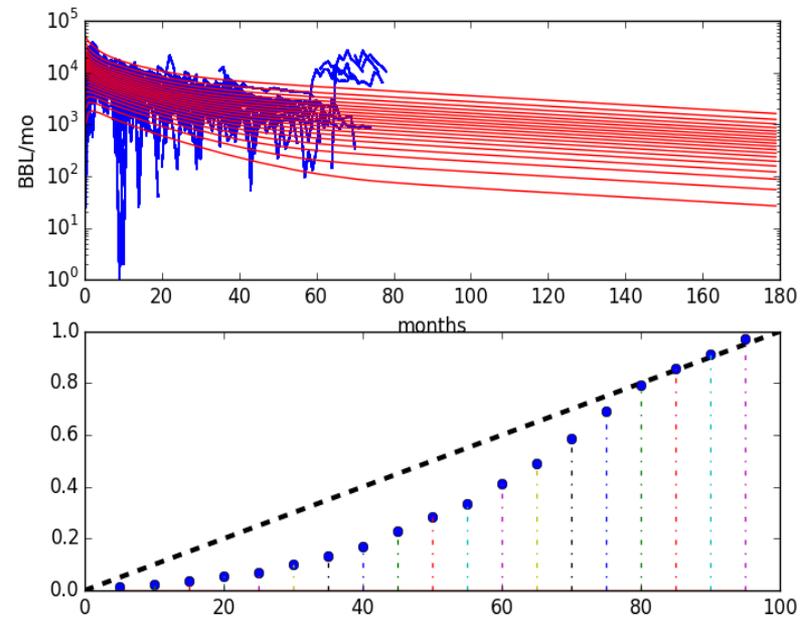
Accurate Forecasts = Accurate Roll-Ups

The p90 of a group of wells is not the sum of the individual well p90s. **Statistics don't add.**
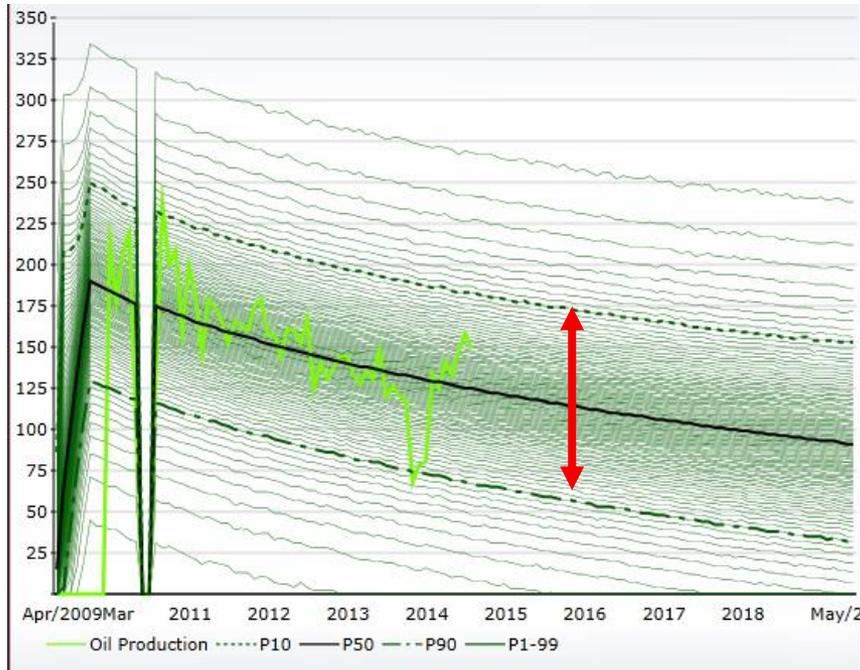
Ratio of uncertainty to production for a single well is 1:1
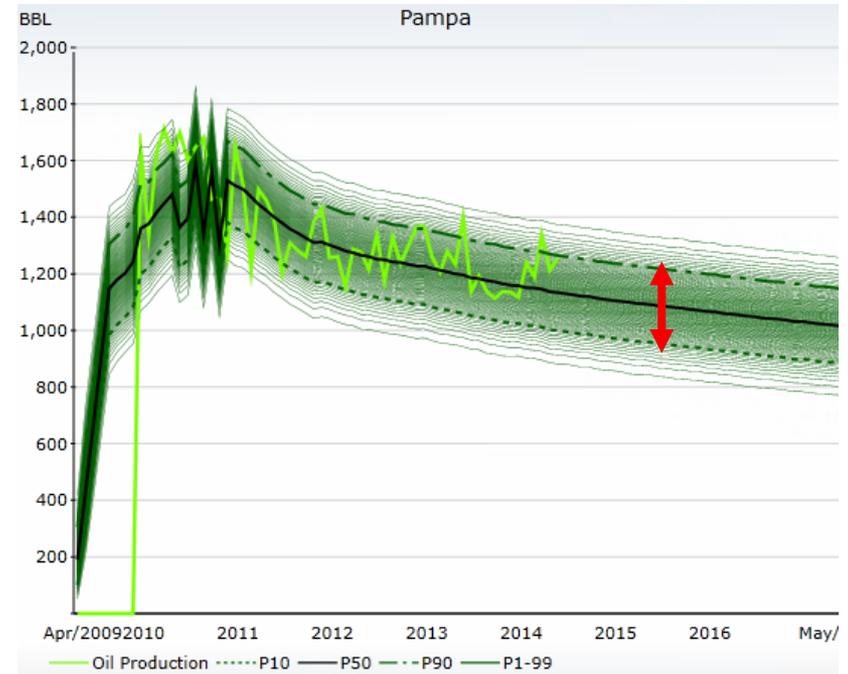
Ratio of uncertainty to production for 20 wells is 1:4

We use roll-ups to determine if company forecasts are outside of reasonable bounds.

Field Level Roll-ups
Proved Reserves: PDP, PDNP, PUD

All reservoir; 185 PDP; 199 PDNP; 162 PUD

OIL

GAS

UnDeveloped (PUD)

Developed, Non Producing (PDNP)
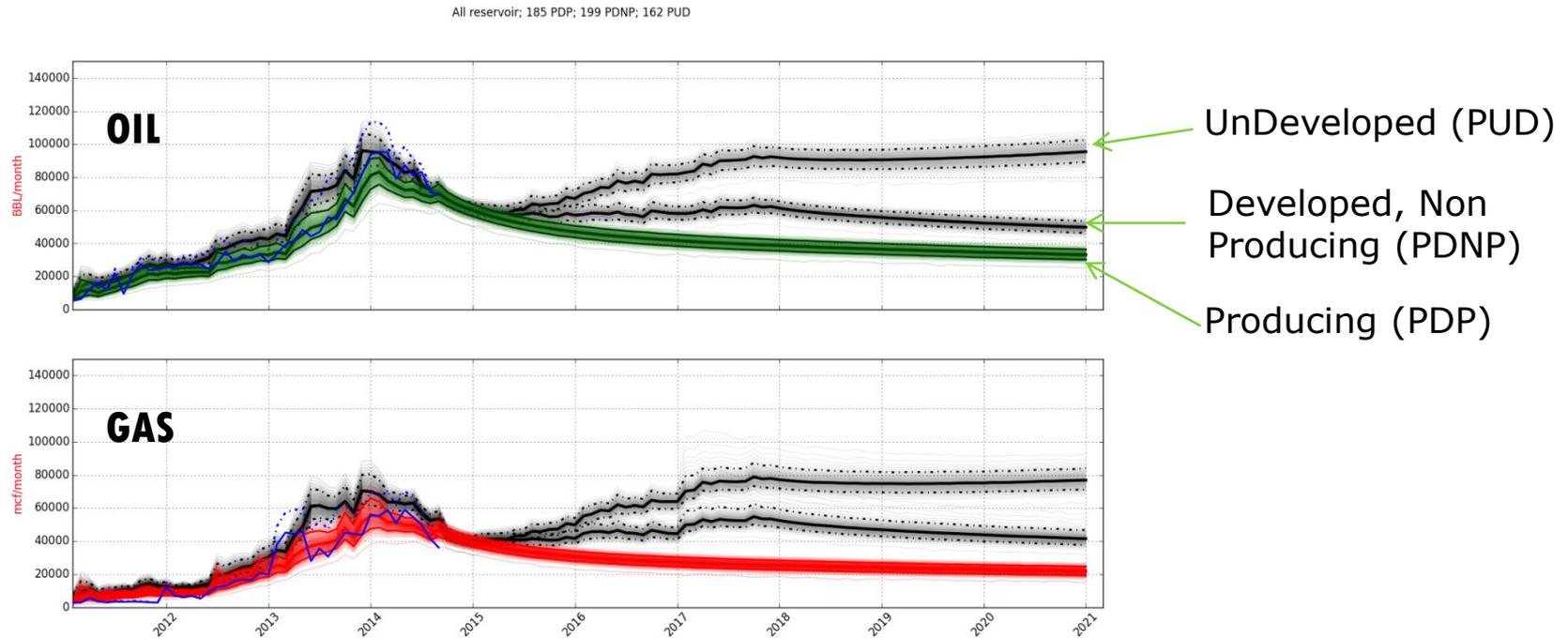
Producing (PDP)

Roll up showing PDP, PDNP and PUD production based on sanctioned drilling program.

BetaZi pScore™ Analysis

pScore is a ranking process assigning a value of 1 to 99 to every well in the population as the well relates to its type curve. This is a very robust way of evaluating the performance of wells that is independent of vintage.
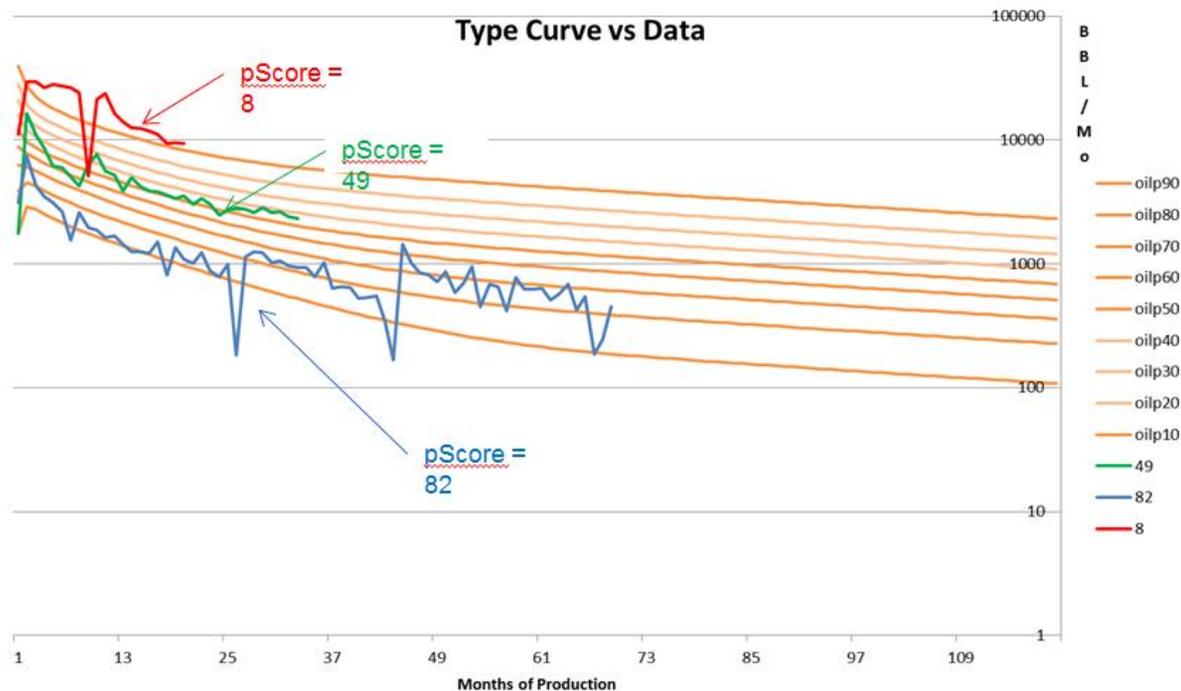
With p-scores you can rapidly plot the relationship of wells to each other.

Reserves vs. half life

Oil and gas fields are usually described in terms of current production and total volume

- Barrels of Oil Equivalent per Day (boepd)
- Reserves or Estimated Ultimate Recovery (EUR)

Reserves and EUR are estimated numbers that are very difficult to test. They constantly change.

Usually the decline rate is embedded in reserve and economic models as hyperbolic parameters but not reported.

Instead, we suggest wells and fields be described in terms of current production and *half life*: the number of years it will take for production to decline by half if no new investment is made.

Exponential decline rates converted to half life

Half life

- 3% = 23 years
- 8% = 9 years
- 18% = 3.3 years
- 50% = 1 year

Y-axis: Years to half production (0, 5, 10, 15, 20, 25, 30)

X-axis: Annual decline rate (90% 85% 80% 75% 70% 65% 60% 55% 50% 45% 40% 35% 30% 25% 20% 15% 10% 5%)
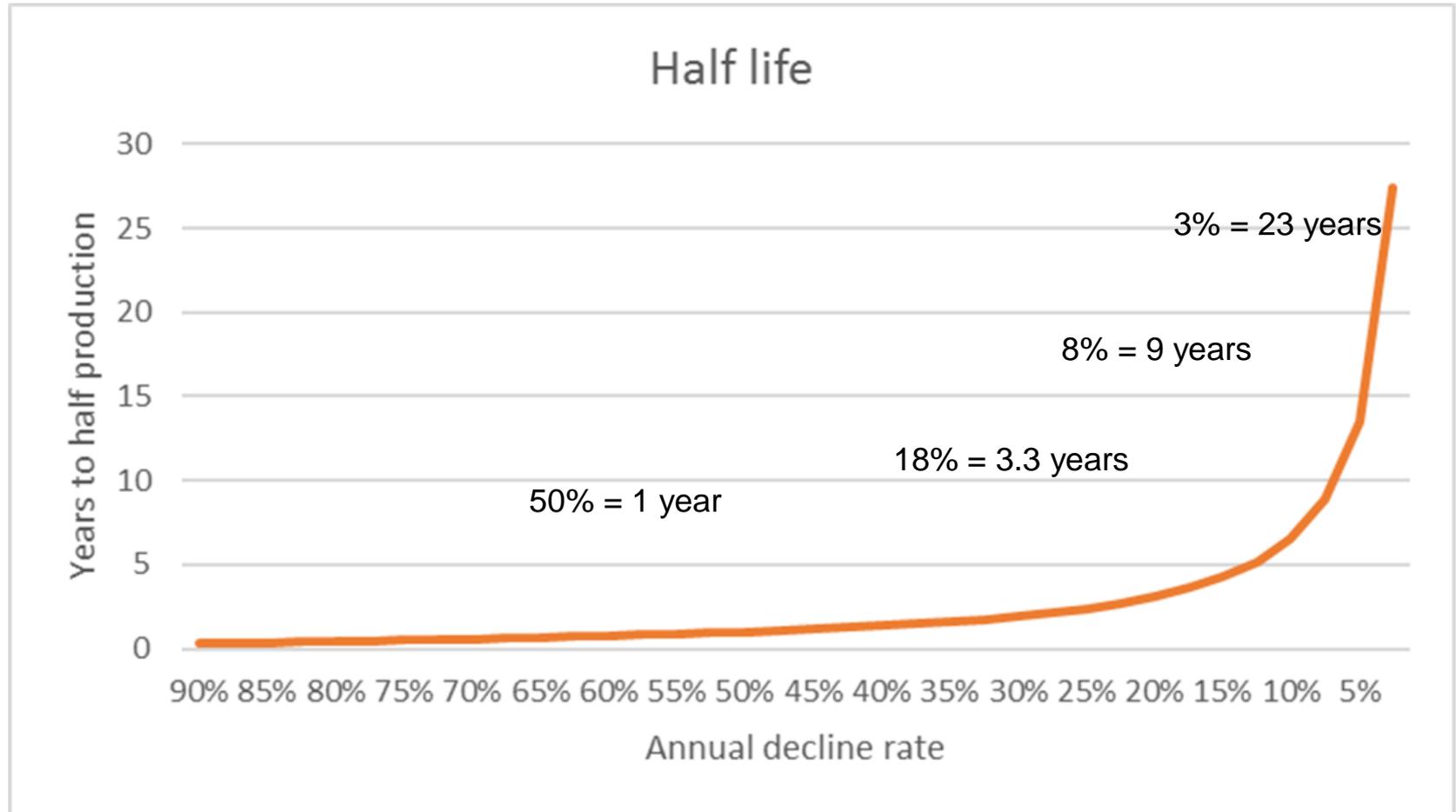
22

$$H = \frac{\ln(2)}{\ln(1 - r)}$$

H = half life (years)

r = annual decline rate (years)

July 4, 2016

Figure 7. U.S. oil proved reserves changes, 2011
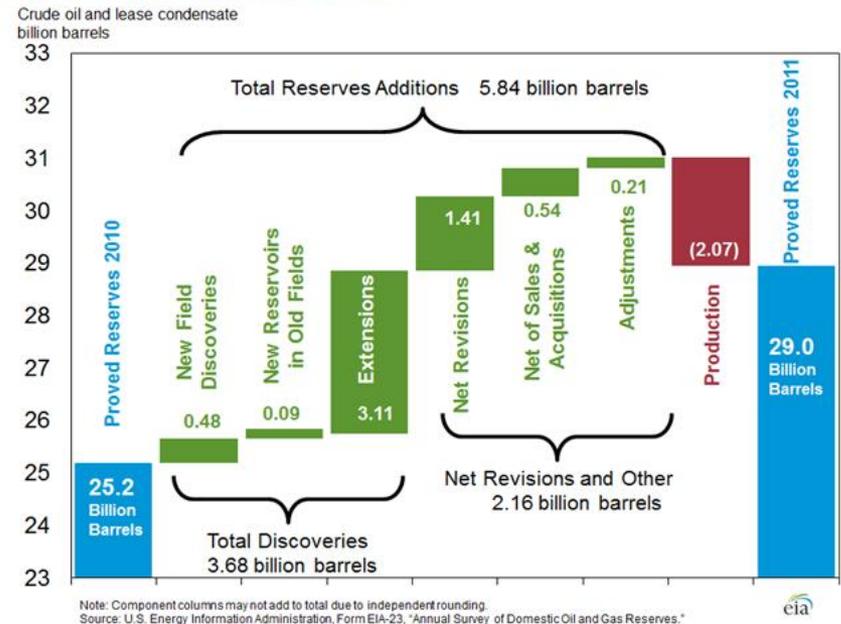
	North Dakota	USA	Saudi Arabia
Production	1.1 M bbl/day	10 M bbl/day	10 Mbbl/day
Reserves	7 – 24 B bbl (Bakken alone)	29 (1p) - 264 (2PCX)	70 (1P) – 212 (2PCX)

1P: Proved Reserves, conservative estimate in existing fields
2PCX: Most likely estimate for existing fields, discoveries and yet undiscovered fields.

http://www.rystadenergy.com/NewsEvents/PressReleases/united-states-now-holds-more-oil-reserves-than-saudi-arabia

Add half life to analysis of production and reserves

	North Dakota	USA	Saudi Arabia
Production	1.1 M bbl/day	10 M bbl/day	10 Mbbl/day
Reserves	7 – 24 B bbl (Bakken alone)	29 (1p) - 264 (2PCX)	70 (1P) – 212 (2PCX)
Well count	13,000 wells	1.1 M wells	4,000 – 5,000
Decline rate	18%	8%	2 – 5%
Half-life	3.3 years	9 years	24 years
Replacement cost (Total)	$26 B	$2.2 T	$10 B
Replacement cost (Annual)	$7.8 B	$244 B	$0.4 B

1P: Proved Reserves, conservative estimate in existing fields
2PCX: Most likely estimate for existing fields, discoveries and yet undiscovered fields.

Back of the envelope analysis

	North Dakota	USA	Saudi Arabia
Production	1.1 M bbl/day	10 M bbl/day	10 Mbbl/day
Reserves	7 – 24 B bbl (Bakken alone)	29 (1p) - 264 (2PCX)	70 (1P) – 212 (2PCX)
Well count	14,300 wells	1.1 M wells	4,000 – 5,000
Decline ra			5%
Half-life			years
Replacement cost (Total)	$29 B	$2.2 T	$10 B
Replacement cost (Annual)	$8.7 B	$244 B	$0.4 B

Not equivalent assets

1P: Proved Reserves, conservative estimate in existing fields
2PCX: Most likely estimate for existing fields, discoveries and yet undiscovered fields.

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Applying the Knowledge Learned

Case: Production Decline Example

Data seen by BetaZi
Holdback test data
Forecast

Oil

Gas

Water
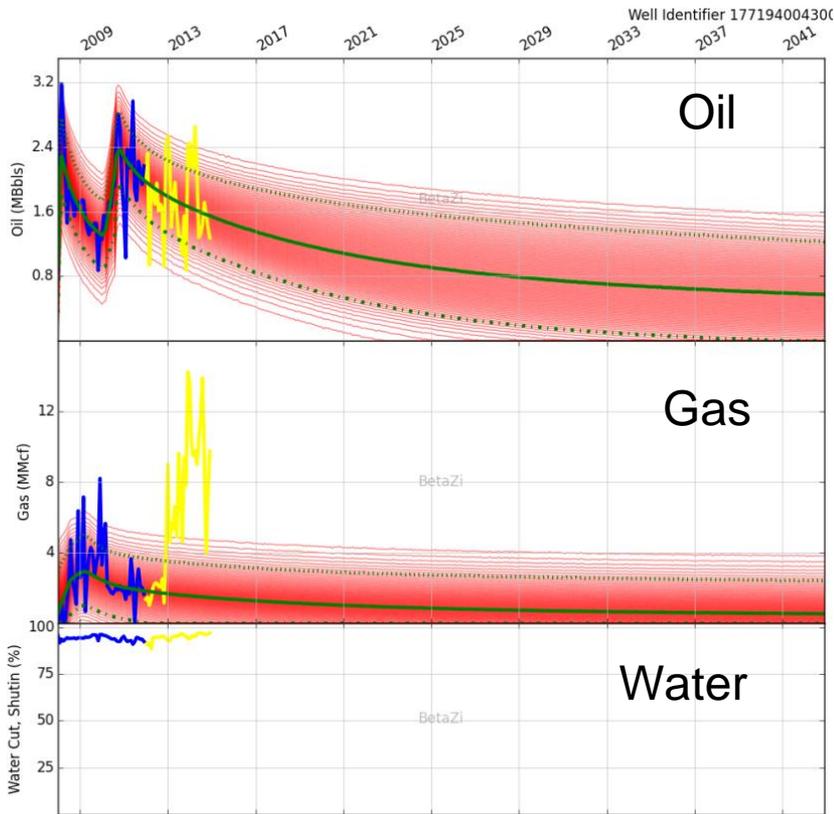
Eagle Ford
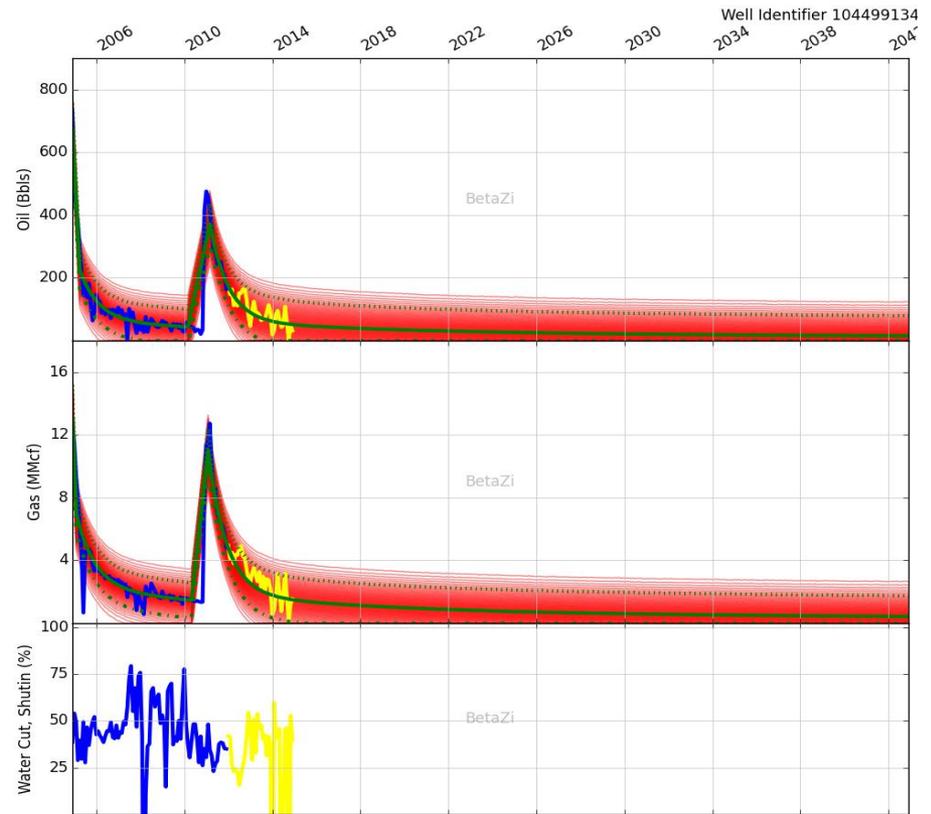
Bakken

Case: Application of pScores

Opening date

Fort Berthold pScore vs. opening date
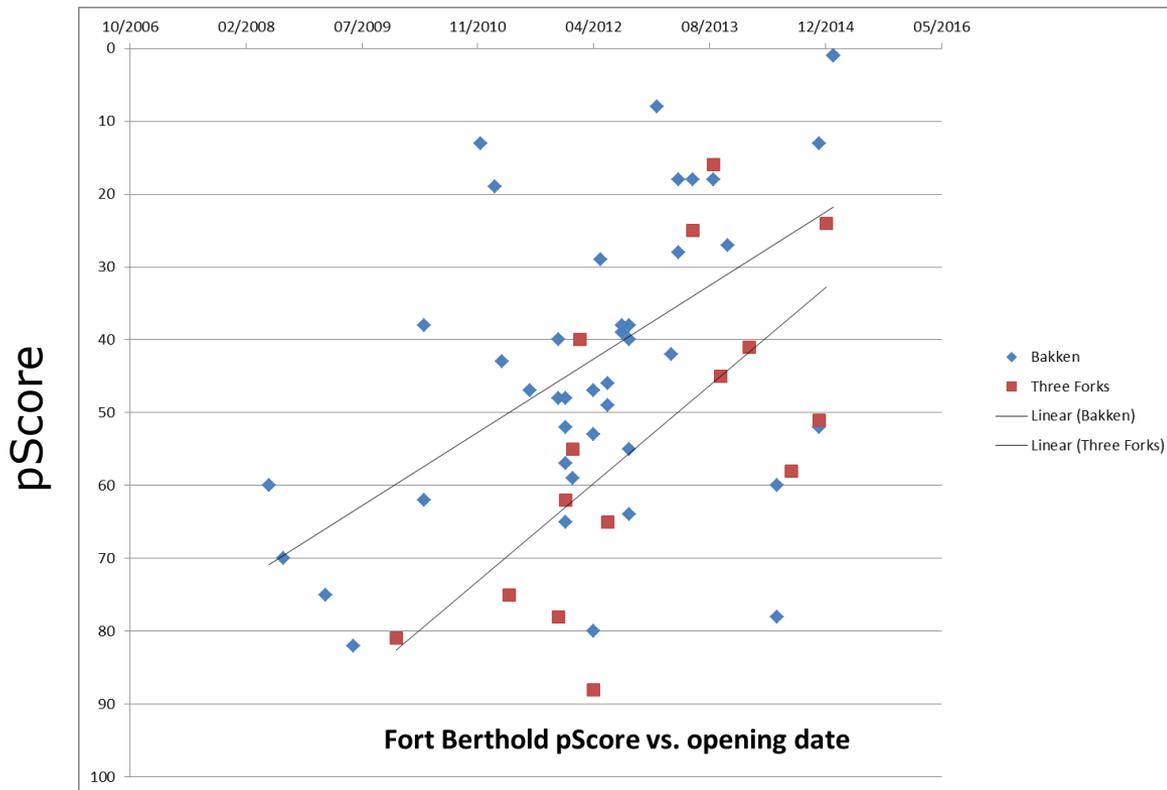
pScore trends clearly indicates that newer wells have higher production.

The scatter could probably be reduced by controlling for lateral length.

pScores provide stable data points for further analysis

Case: pScores New Well performance

Evidence that the field was in severe pressure decline or well spacing was not optimized

Production (low to high)

pscore

length of data record

Vintage of well (old to young)
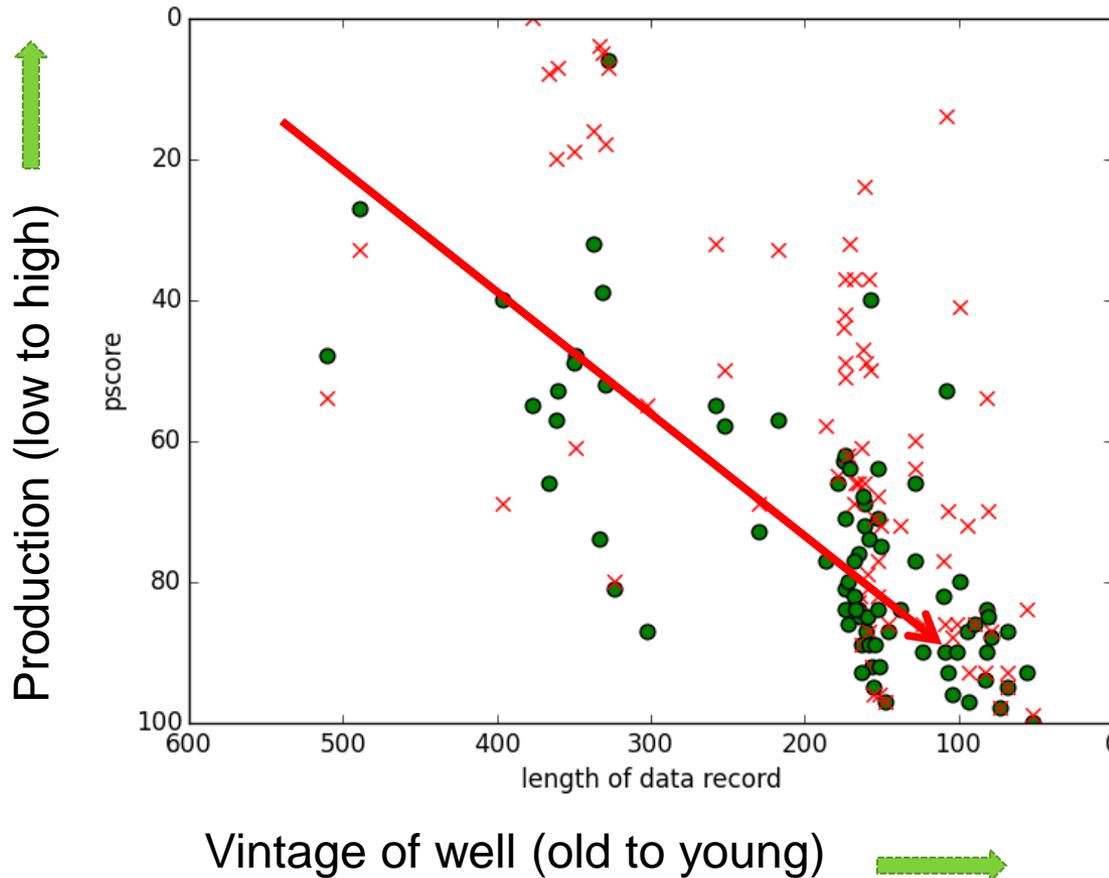
Moral(s) of the story:

➢ Trends indicate reservoir depletion

➢ You need verification tools that start from first principles.

➢ More importantly what wells are used for the type curve?

Green dots are primary fluid (oil); red dots are primary fluid (gas)

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Case: Comparison of Operators

- Operator C has lots of low-producing vertical gas wells.
- They are not getting nearly the returns on their horizontal wells that Operators B and C are seeing.
- We concluded that they are getting hardly any return on laterals!
- Suggested several operators who were getting lateral return.
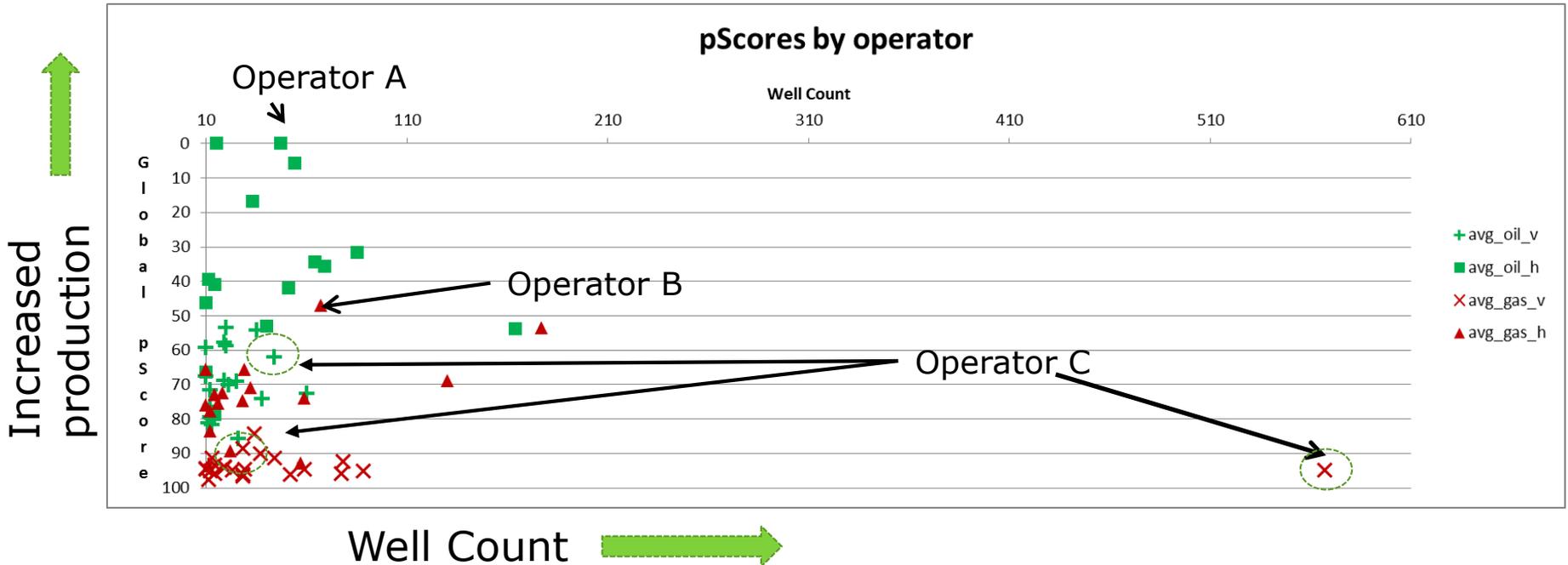
Case: Probabilistic Maps
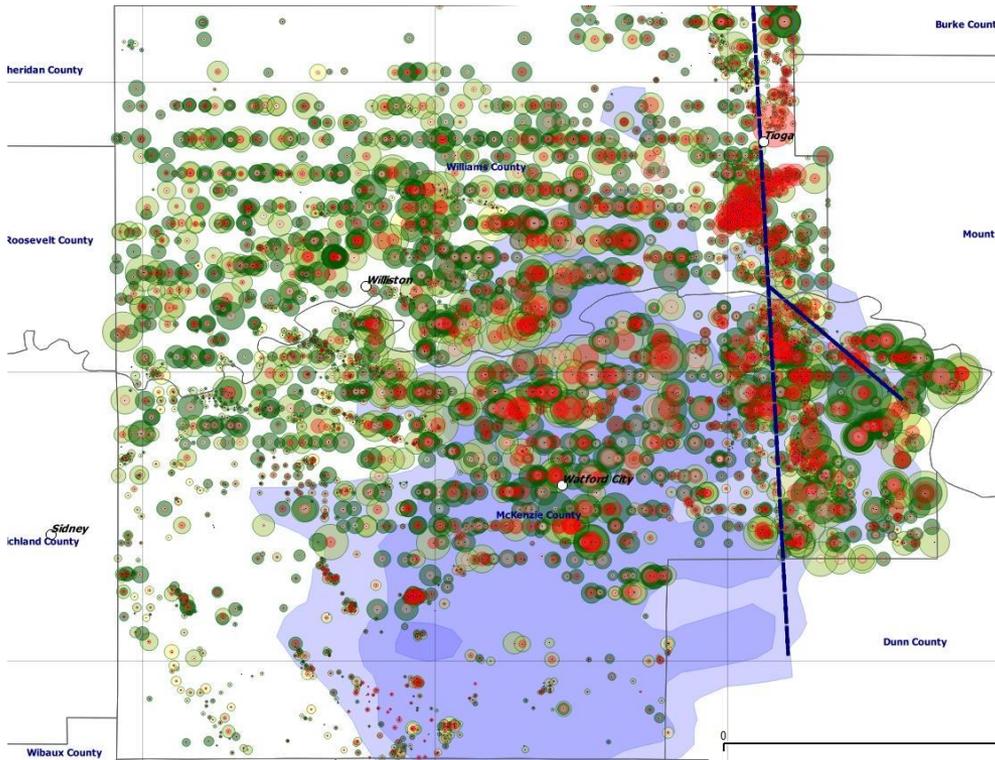
Enables filtering on:

- EUR
- Lateral Length
- Completion Design
- Toe up Toe Down
- Operator
- Vintage
- Other .

Future production map

*(sized according to cumulative prediction for next 5 years, saturation proportional to uncertainty)*

- **BetaZi prediction and uncertainty pre-computed on public data**

Case: Massive Well Studies

Eagle Ford
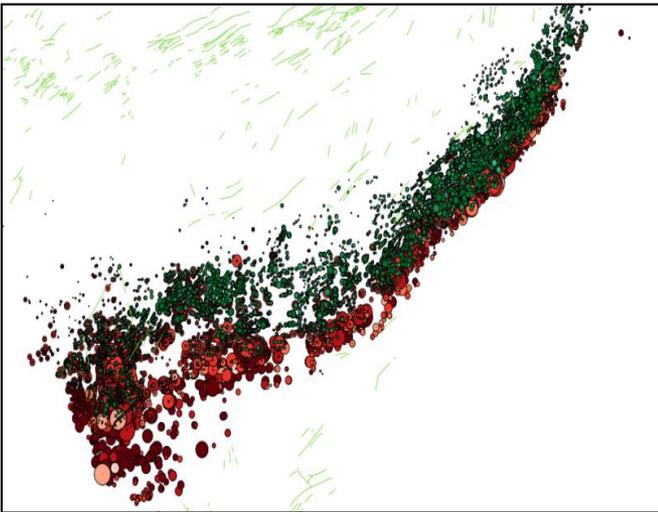
Cleveland
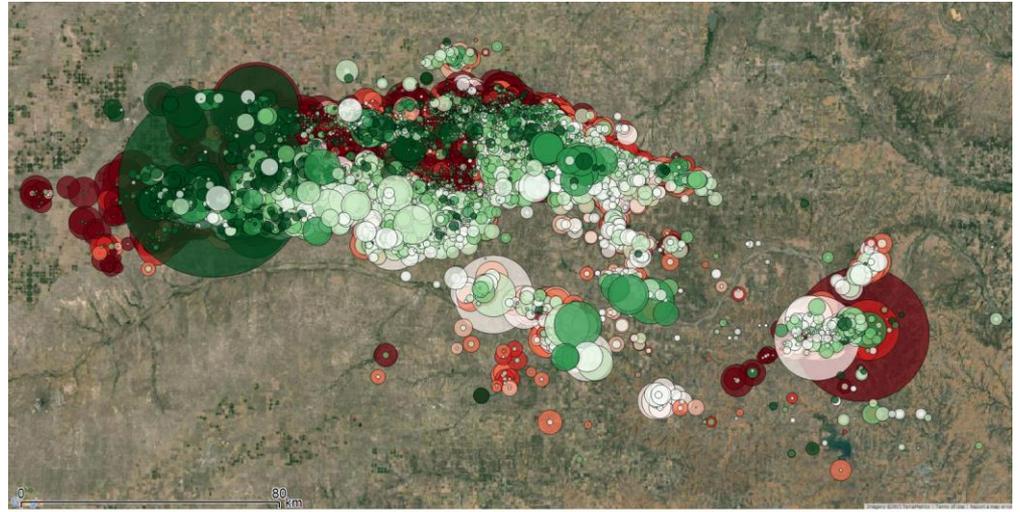
Commissioned by Major producers to compare their production to that of other operators in an area and as an exploration tool.

BZ-Almanac

Yes, it's that easy!

bzAlmanac™ is a play library of every well in the United States and Canada, complete with a full probabilistic BetaZi forecast for each and available for instant download (Browse, Query, Extract).

Product:
• Tobin Insight package: Well production history, Rigs, Allocated production
• Well production forecast 20 years ahead, with percentiles (p10-p90)
• Forecast visualization
• Export capability to all major economic modeling programs
• Roll-up driver tool's (Deal, Company)
• Bubble Maps (Uncertainty by well, EUR's, filter on demand)

Add-Ons:
• PUD PACK: Type Curves, Type Curve Driver Spreadsheet, Development Plan, Relative pScores™, Graphical Selection of Wells, Calibrated testing of Type Curves.
• TOBIN All Access: Leases, Land Grid, Permits based on the 'Gold Standard' of quality data.

Annual subscription based on the price of oil (BOE) on the WTI. Includes well data.   Also available on a per well basis.
No resale or sub-license of results.

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What you can do with it (14,300 active wells)

Without constant drilling,
future production in
North Dakota is a short
term game.

API	127867340
Mbbl Produced	353
Mmcf Produced	59
BOE p10 Mbbl	4326
BOE p50 Mbbl	2197
BOE p90 Mbbl	677
Oil p10 Mbbl	4077
Oil p50 Mbbl	2070
Oil p90 Mbbl	577
Gas p10 Mbbl	1293
Gas p50 Mbbl	498
Gas p90 Mbbl	90
EUR Length (mos)	0

Monthly
production bbl -
boe

Contribution from oil
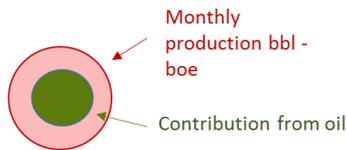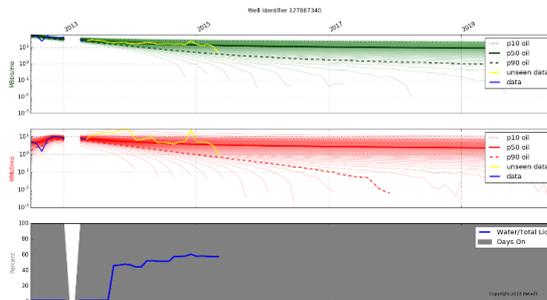
Saturation indicates uncertainty
Low (dark) High (light)

We are waiting on
a new movie here!
Or here!
Or here!

Production for 1/1/2000

BetaZi™

Half Life = 4 years

Peak 36m bbl : Dec 2014

June 2016 30.8 M BBL (exactly as predicted)
July 31.8 BBL (within uncertainty)
Half of current production in Dec 2021

Half 18m bbl: Jan 2019

Quarter 9m bbl: Feb 2030

BetaZi™
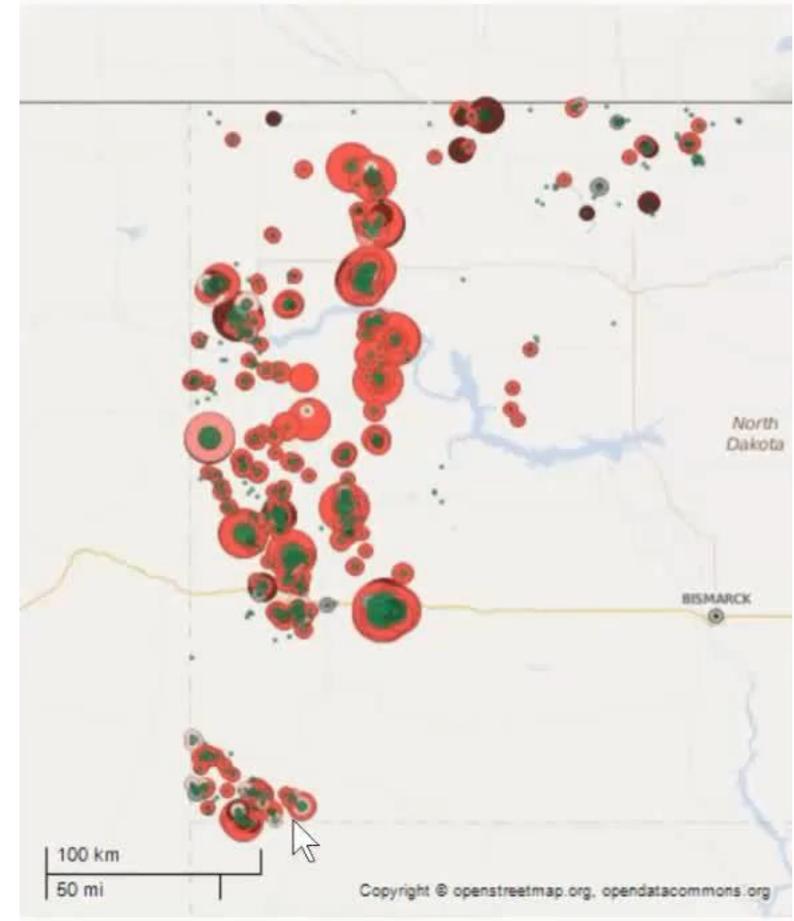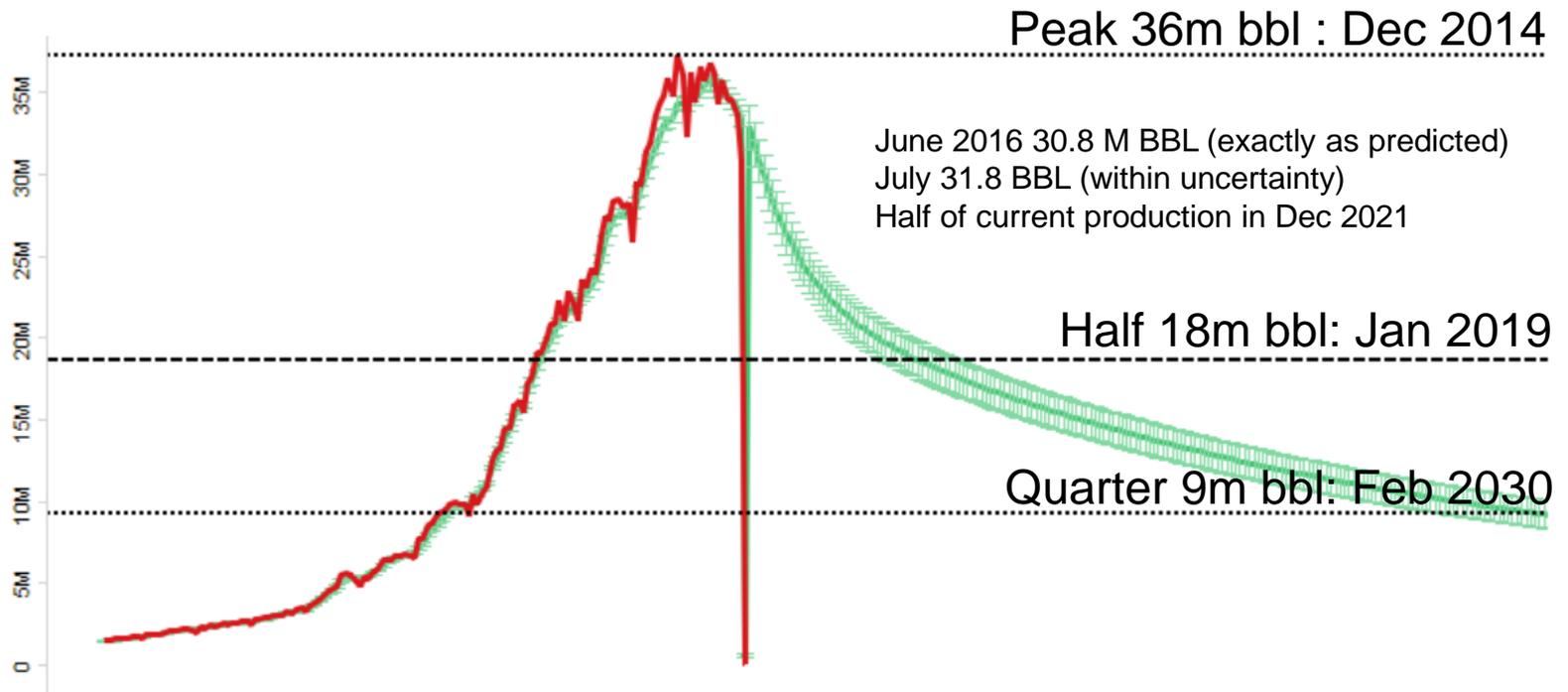
Eagle Ford Basin Study


Eagleford EUR Forecast Map
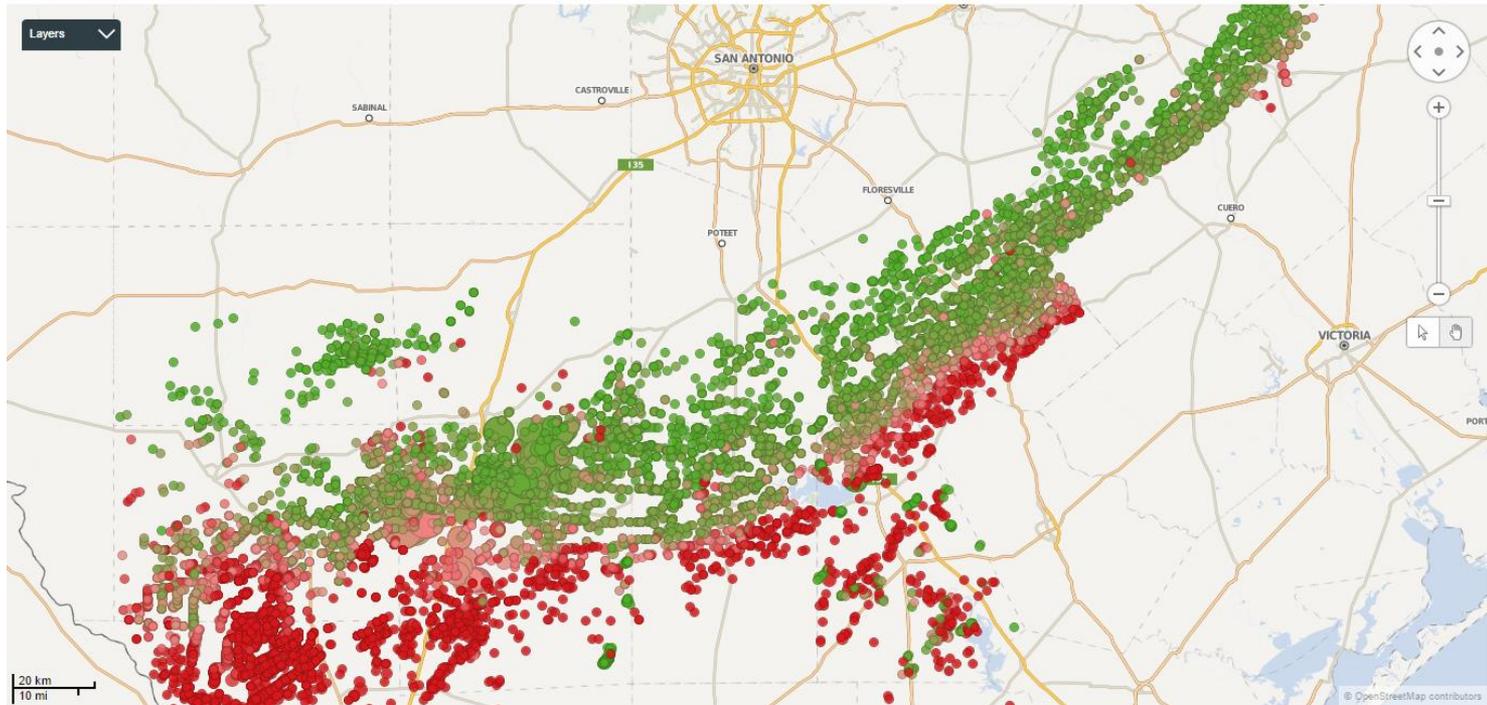
Eagle Ford
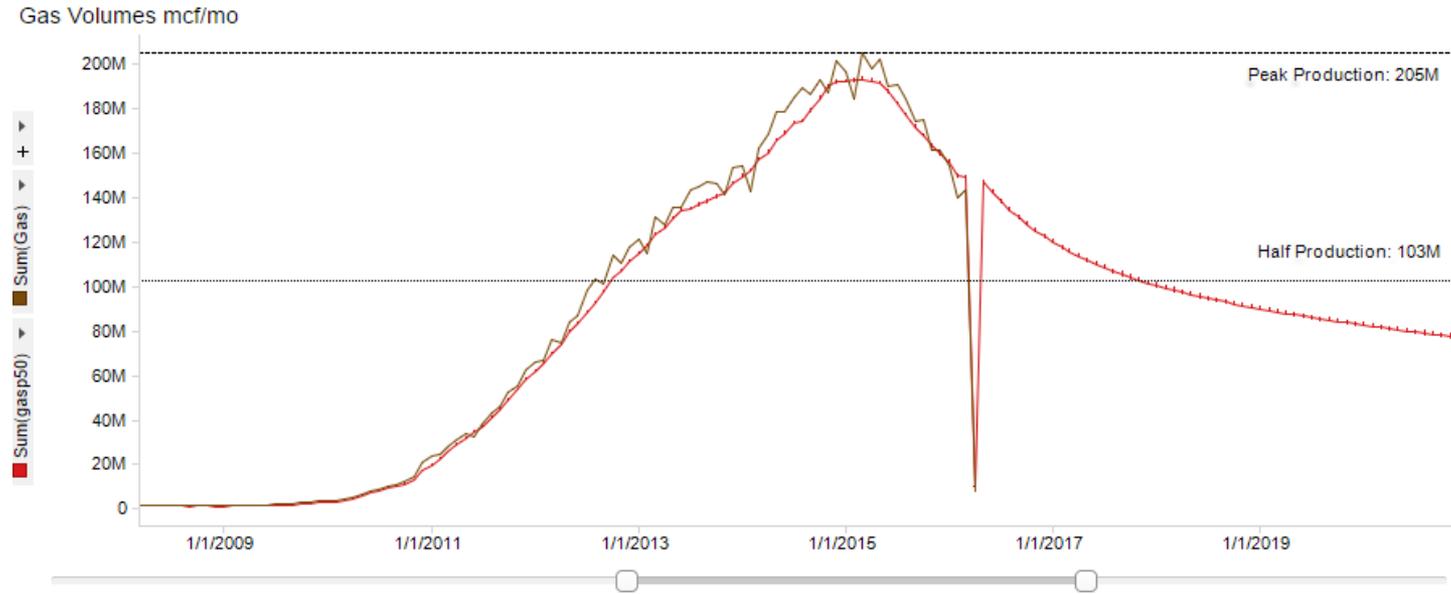
Half Production predicted for 8/2017 (oil and gas)

Company A
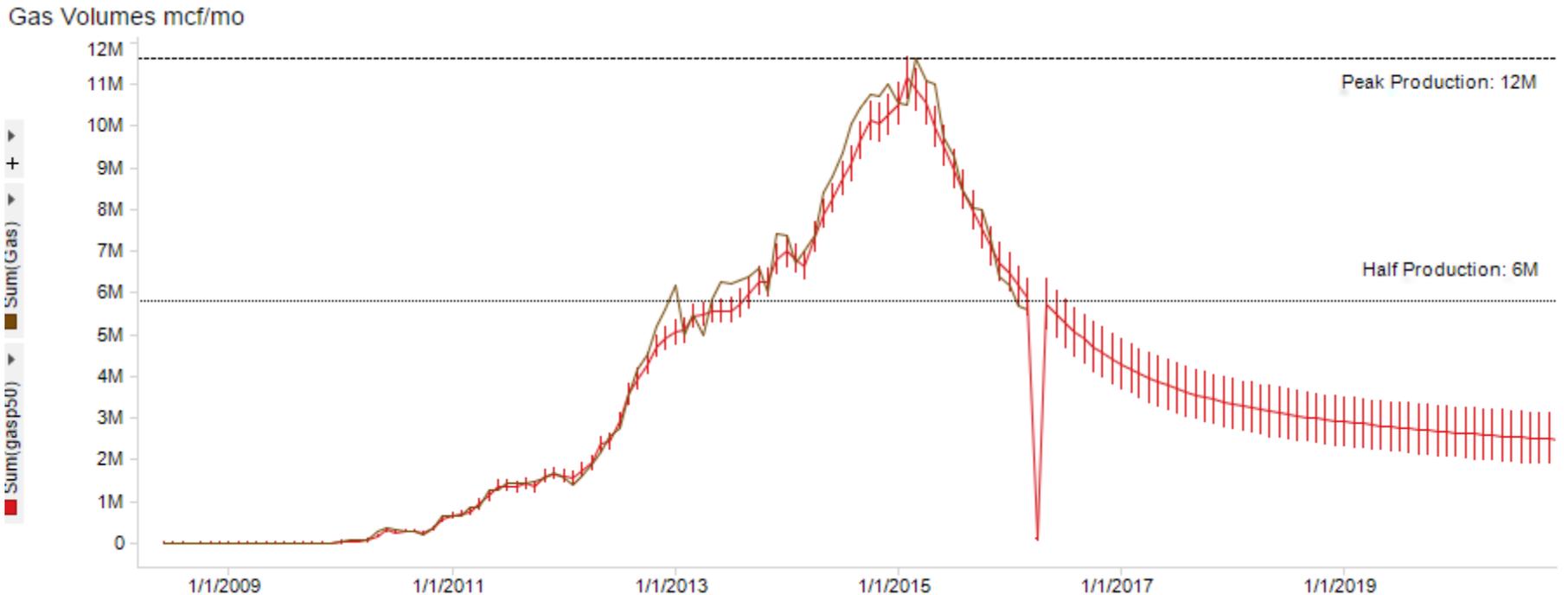
Is already a half production in Eagle Ford (and scheduled for 2018 in North Dakota)

Company B

Gas Volumes mcf/mo

Peak Production: 44M

Half Production: 22M
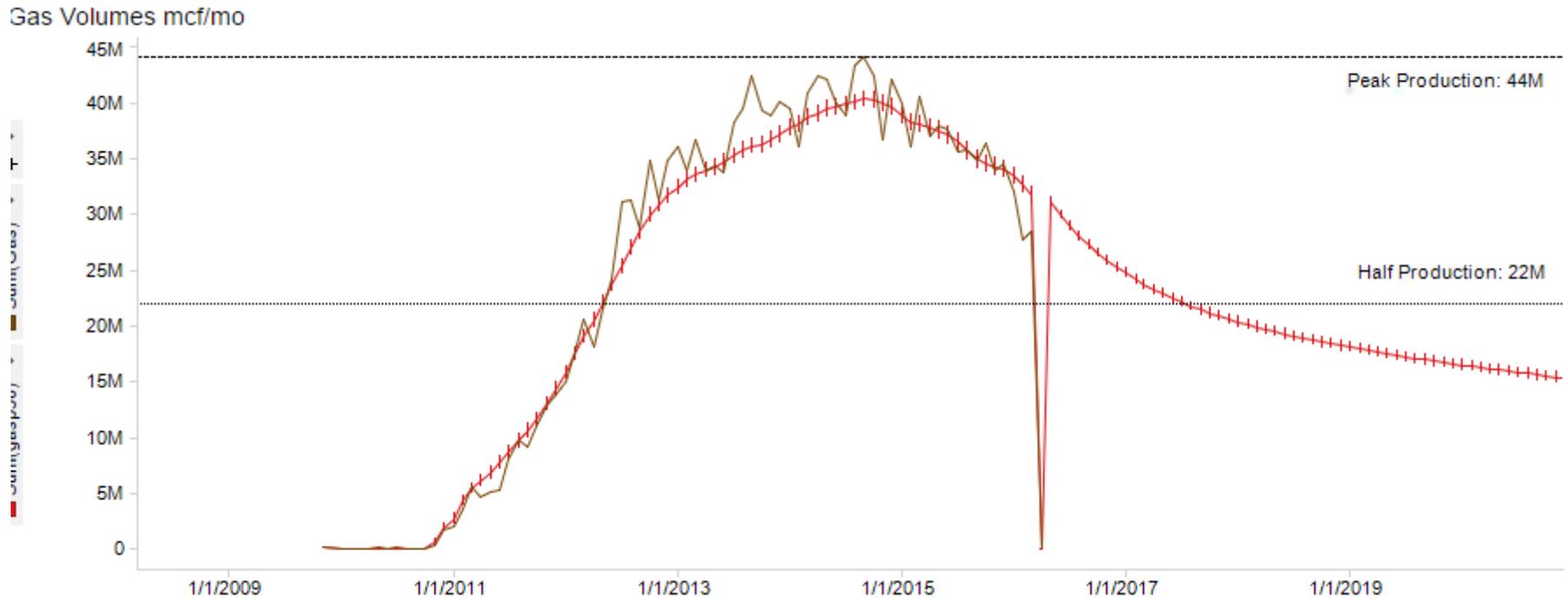
Will hit half production in 2018

Operator profile Company A
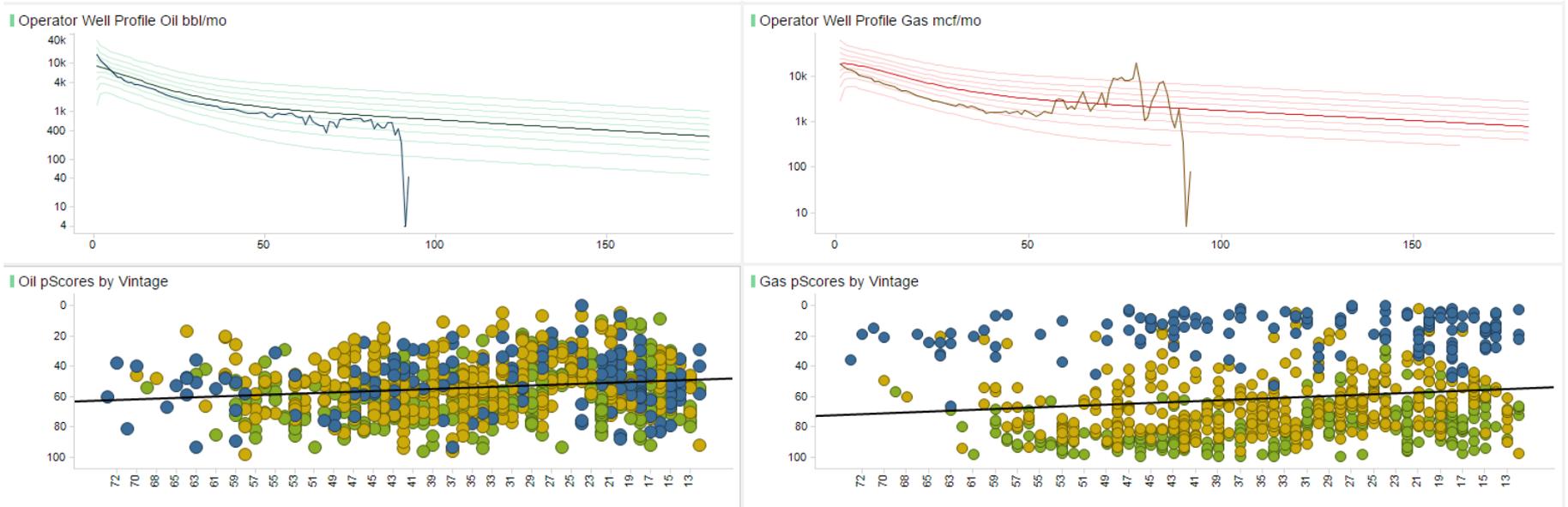
If they have the acreage, they can get back to 2015 levels by drilling about 300 wells – current well count is 876.

Compare A to B
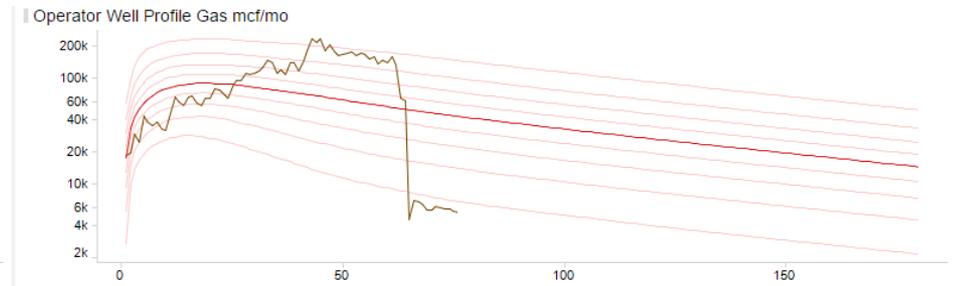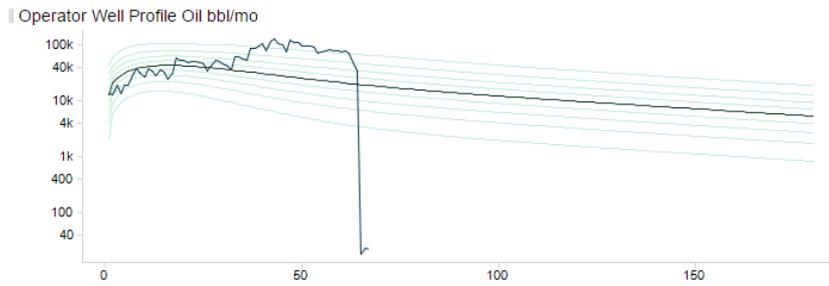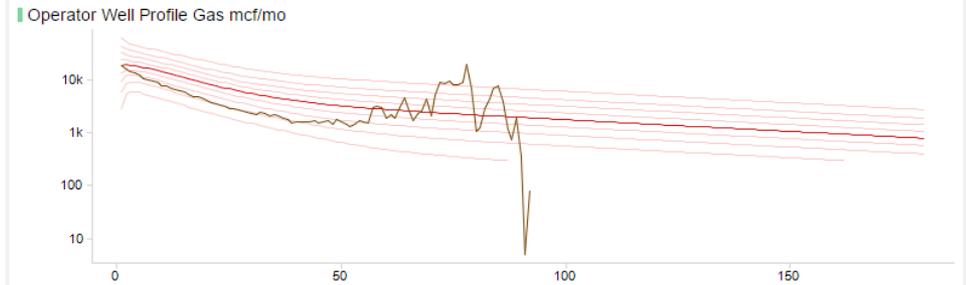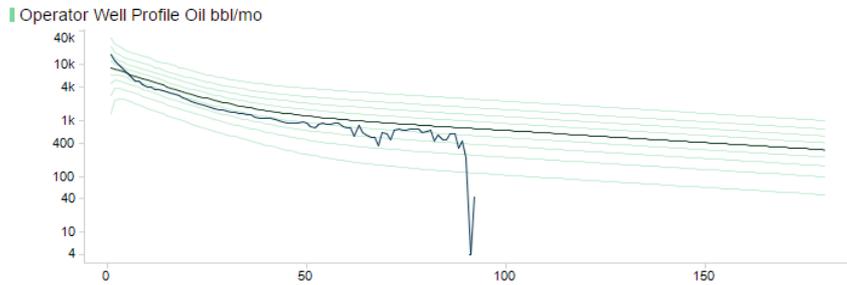
You can learn to read off this plot that Company B has about 4x production per well than Company A as well as a conventional base. (Provided with Eagle Ford Basin Study)

Company Production Potential

Accurate forecasts and type curves are a data point you need to make good decisions..

	AH	AI	AJ	AK	AL	AM
	Operator	ratio 2030/2016	WellCount 201	Half-Production	Years to	alf
	A	0.418857454	272	598,741	9	
	B	0.387079859	156	185,075	9	
	C	0.327047845	281	1,904,237	9	
	D	0.311138686	177	1,151,552	6	
	E	0.287701045	1366	22,073,215	5	
	F	0.282848548	338	3,842,005	3	
	G	0.281934858	105	1,175,669	3	
	H	0.275101036	518	9,087,889	5	
	I	0.26576247	262	3,908,619	4	
	J	0.264129145	146	1,864,083	4	
	K	0.26192561	396	4,355,955	4	
	L	0.260121927	280	4,280,873	2	
		0.25984416	652	9.795.173	4	

et5 | Rate Calculations | (+) | : | ◄

BetaZi™

Case: Production Decline Example

Bakken

Months
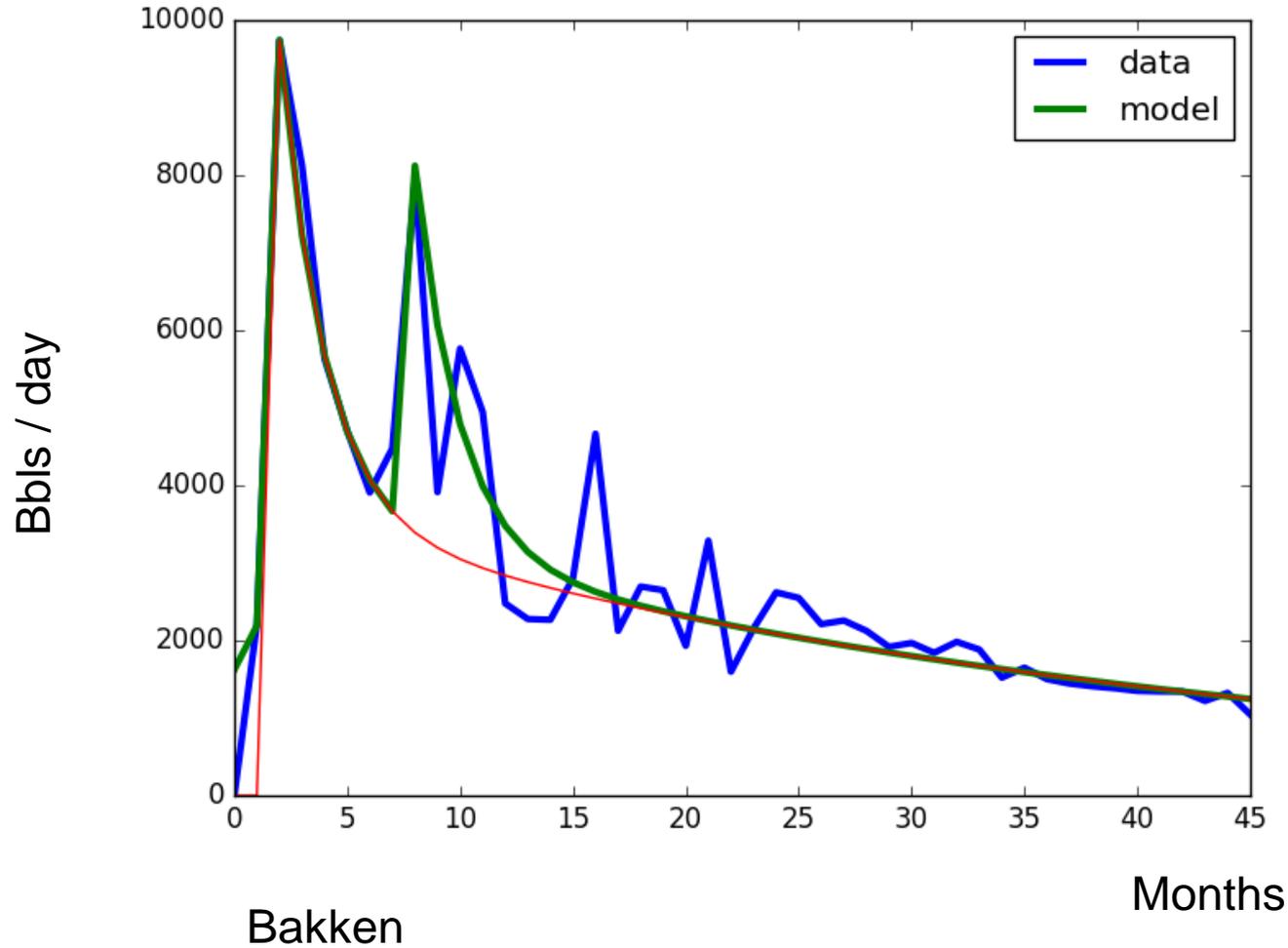
Case: Production Decline Example Probability distribution on 2nd peak area

Gain from oil ~ 70 Mbbl, gain from gas ~90 Mmcf = 85 Mboe ~ $2.3m

oil gain : alpha= 16.079494, loc= 0.000000, scale= 4558.705530

Mbbl

gas gain : alpha= 12.445801, loc= 0.000000, scale= 8463.679604

Mmcf
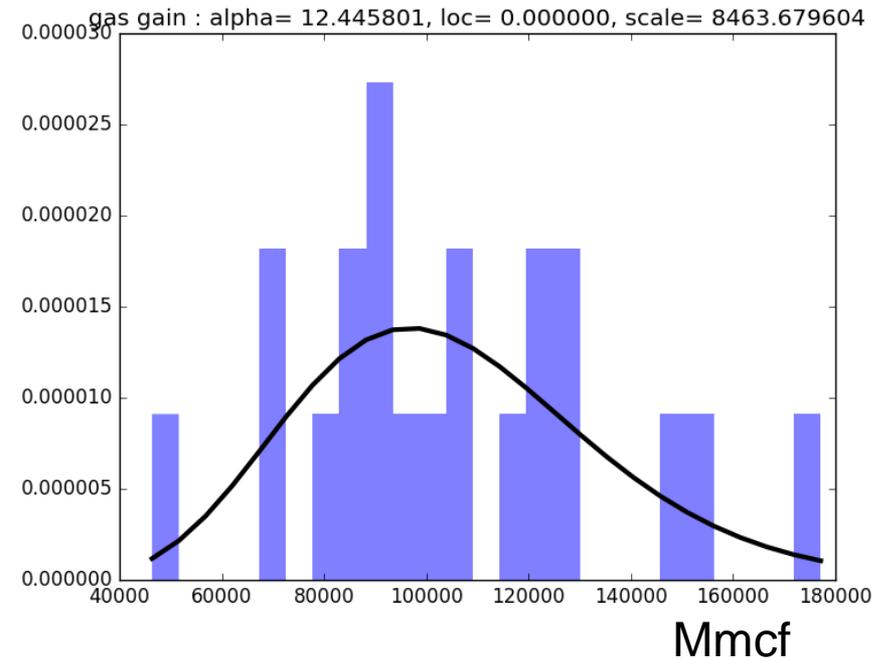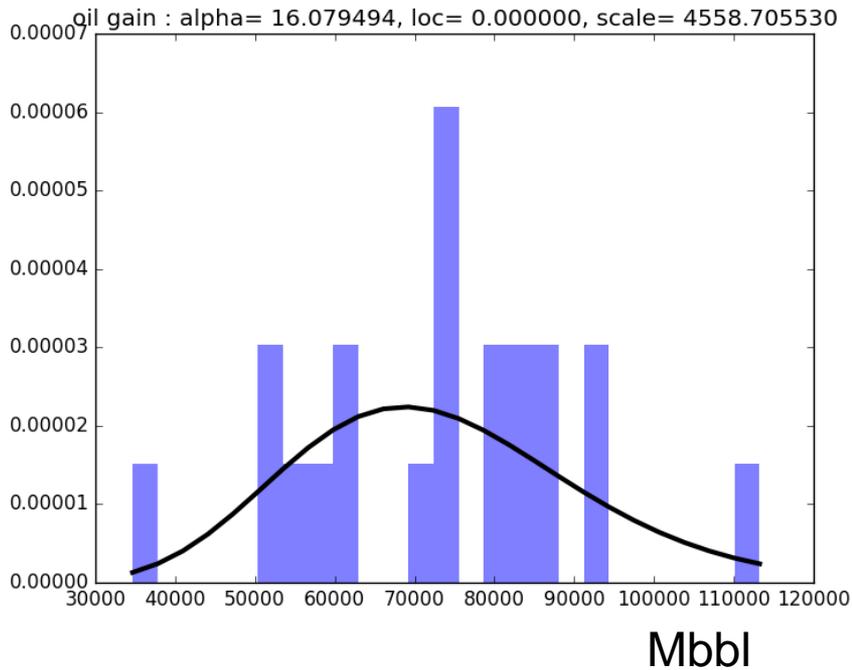
Bakken

What if? Scenarios

What was the production gain from Bakken well workover?

Scenario 1: pre-workover
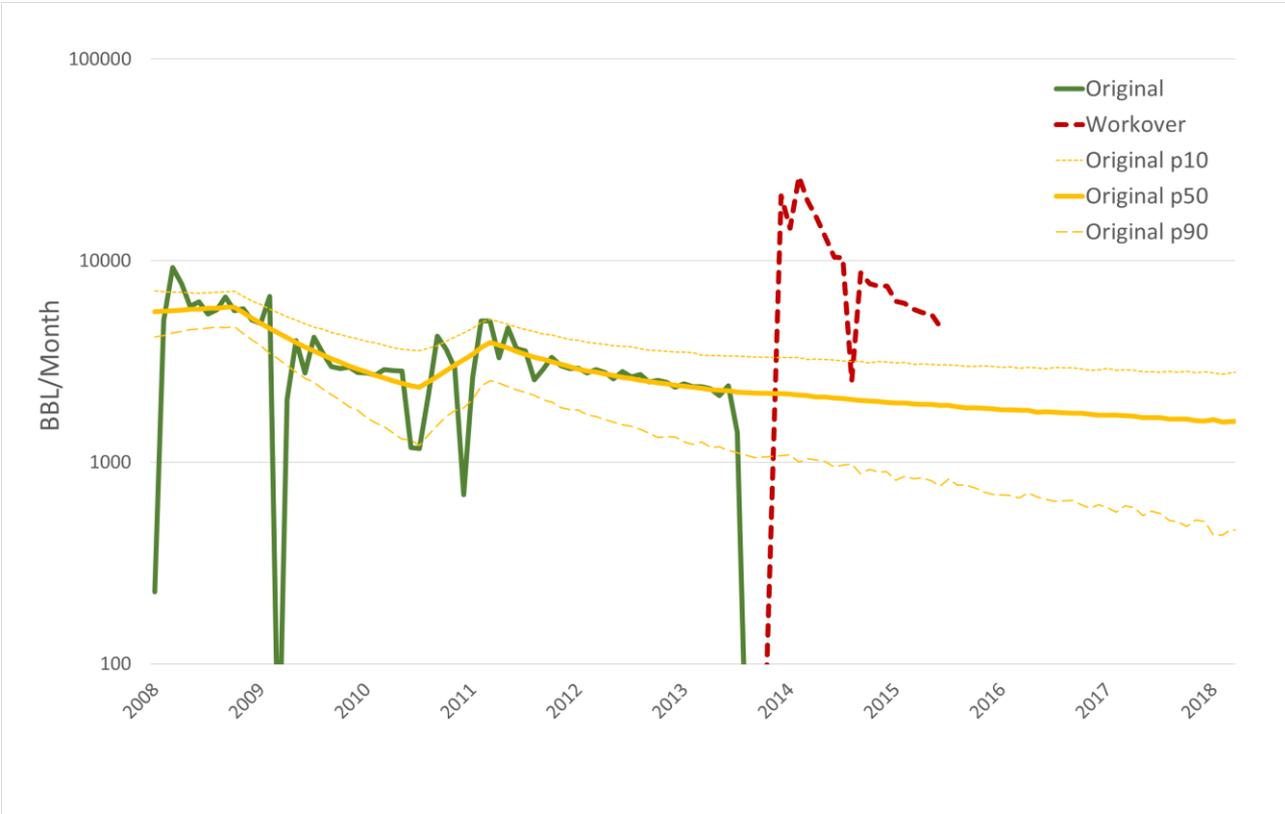
Scenario 2: Post workover
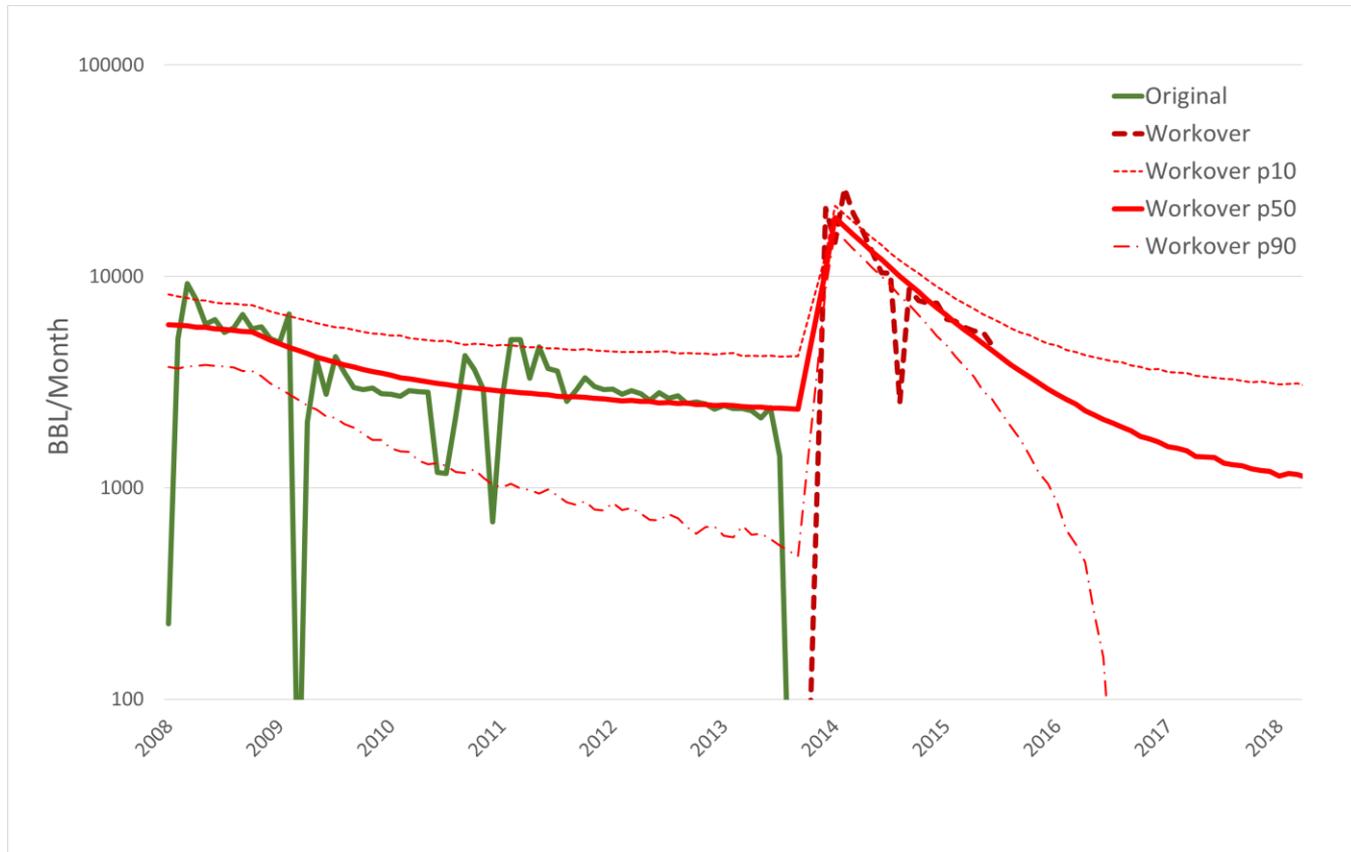
Subtract Pre from Post
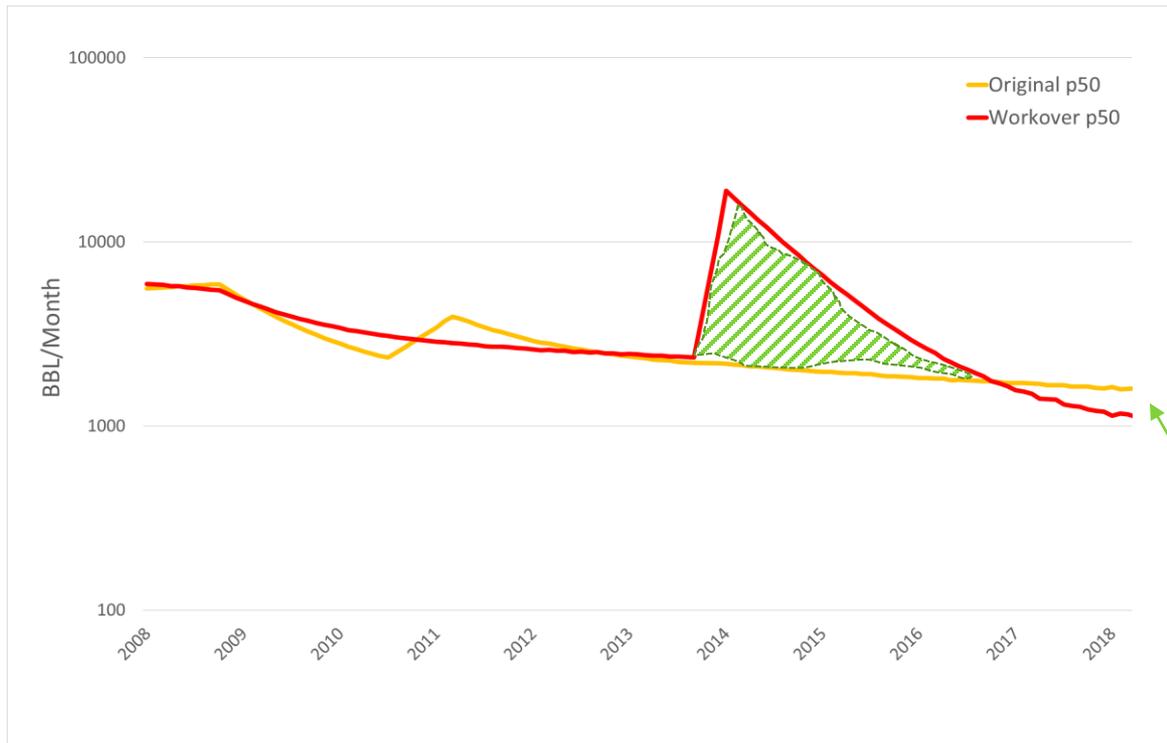
Delta = 164,000 bbl

Are you really going to lose pre-workover production?

Are you really going to lose pre-workover production?

BZ-P2 partnership

Started in 2013 – Partnership with Merrick Systems

P2 Forecast

- BetaZi powered forecasting engine for ProCount - Carte - Forecasts on demand, Client's own data.

BZ ALMANAC – October 2016

- Forecasts on every well in the USA, available by subscription
  - Tobin Insight - Resources and expertise to handle 6T of new data

BASIN STUDIES – October 2016

- Snapshot of Almanac for a single basin or play in Spotfire
- Extensive and easily customizable analysis tools.
  - **Anadarko Basin: The Scoop/Stack**
  - **Western Gulf Basin: Eagle Ford**
    Permian Basin: (Midland, Delaware, Central)
  - **Appalachian Basin: Marcellus**
  - **Williston Basin: Bakken**
  - **DJ Basin: Niobrara**
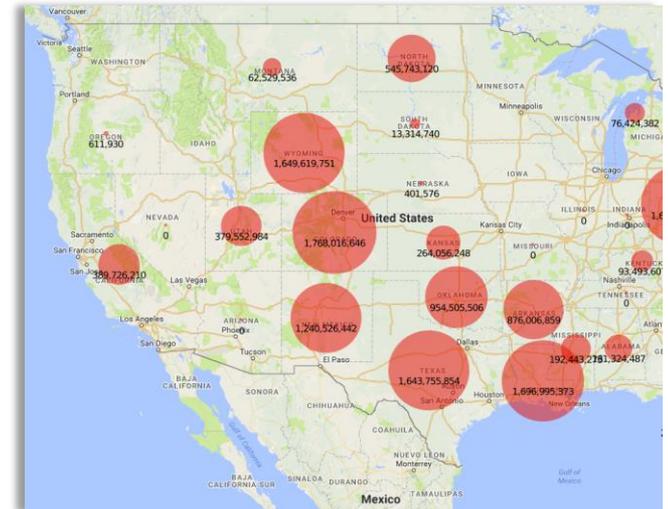
Bottom Line

✓ Production forecasting matters for asset valuation.

✓ There are a lot of devils in the details of a reserve report.

✓ Due diligence should start from the beginning, use statistics and back-testing. This is true independent verification.

✓ New science exists: exploit it. Let engineers do what they do best, analyze data and trends.

✓ Pre-computed forecasts on every active well in the USA with uncertainty are going to change the way deals are done. Adapt now.

Thank You!

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