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Distinguished Lecturer Program
www.spe.org/dl
Two Vital Secrets for Building Reliable Type Wells

Randy Freeborn
<table>
<thead>
<tr>
<th>AGENDA</th>
</tr>
</thead>
</table>
| **TYPE WELL** | What is a type well  
The challenge |
| **1st SECRET** | All type wells  
3 Inherent Errors  
Case Study |
| **2nd SECRET** | Probability type wells  
Time slice method  
Aggregation method  
Comparison |
| **WRAP UP** |
What is a type well?

Rate-time production profile
Shift representative wells to a common start date
Average them to represent new wells

**Common** method comprised of two parts
- History: average rate until too few wells
- Prediction: projection of best fit of history
TYPE WELL  The Challenge

Dr. Lee, 2015 Reserve Summit

• SEC’s experience (circa 2008) type wells exceed results by about 25%.

2013 Proprietary Research Report

• Drilling results did not meet the objectives set out in 40 of 100 published play specific type wells.
• Only 14 of 40 companies consistently met targets.

Personal Experience

• EUR more likely to be over estimated, as much as 40%.

Pervasive ... Capital Intensive ... Errors
1st SECRET
Applies to All Type Well Methods

FORECAST EACH WELL
THEN AVERAGE HISTORY & PREDICTION
3 ERRORS

1. Forecast groups
   • Never forecast groups, always group forecasts

2. Survivor bias
   • Concentrating on things that survive
   • The treatment of depleted wells
   • Depleted wells produce with rate = 0

3. No production (declining well count)
   • Recent wells that have no rate to average
   • Also a form of survivor bias
   • Use best available forecast

SPE 162630 & 167215
3 ERRORS  #1 Forecast Groups

Forecast Groups
Usually no clear trend
High quality best fit
Bad business decision
Grouping masked a trend

Group Forecasts
New trends are visible
Forecast errors cancel
Accuracy improves
Type well is accurate
#2 Survivor bias

**Common method**
- Depleted rate = type well rate
- Creates false rate and reserve

**Correct treatment**
- Each well must have a rate

---

SPE 162630
#2 Survivor bias

Common method

Compounding effect
3 ERRORS  #3  No production

Common method  Well rate = average rate
Best wells drilled first

Correct treatment  Include every well
Use best available forecast

AVOID ALL 3 ERRORS
Forecast, then average history & prediction
### Numerical example

<table>
<thead>
<tr>
<th>Well</th>
<th>Monthly Production Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Month 23</td>
</tr>
<tr>
<td>1</td>
<td>1200</td>
</tr>
<tr>
<td>2</td>
<td>1000</td>
</tr>
<tr>
<td>3</td>
<td>35</td>
</tr>
<tr>
<td>Field Total</td>
<td>2235</td>
</tr>
</tbody>
</table>

#### Type Well

<table>
<thead>
<tr>
<th></th>
<th>2235 / 3</th>
<th>2025 / 3</th>
<th>1800 / 2</th>
<th>1600 / 2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>= 745</td>
<td>= 675</td>
<td>= 900</td>
<td>= 800</td>
</tr>
</tbody>
</table>

#### Drill 3 Wells

<table>
<thead>
<tr>
<th></th>
<th>3 x 745</th>
<th>3 x 675</th>
<th>3 x 900</th>
<th>3 x 800</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>= 2235</td>
<td>= 2025</td>
<td>= 2700</td>
<td>= 2400</td>
</tr>
</tbody>
</table>
CASE STUDY  88 Hugoton Kansas wells

Data truncated
Cut off
Type well

5 years drilling + 5 years producing
Stop when too few wells
Looks reliable

EUR = 1.58 bcf

SPE 162630
CASE STUDY  88 Hugoton Kansas wells

<table>
<thead>
<tr>
<th>To Dec 1996</th>
<th>History Only</th>
<th>Cut Off 50%</th>
<th>History &amp; Prediction</th>
<th>Known Nov 2014</th>
</tr>
</thead>
<tbody>
<tr>
<td>EUR, bcf</td>
<td>1.53</td>
<td>1.58</td>
<td>1.74</td>
<td>1.34</td>
</tr>
<tr>
<td>Error, %</td>
<td>13%</td>
<td>16%</td>
<td>28%</td>
<td>-2%</td>
</tr>
</tbody>
</table>

1st SECRET
average history & prediction
Certainty (P10, P50, P90)

What is uncertain?
(EUR, Present Value, Cash Flow, ...)

How many wells?

2<sup>nd</sup> SECRET
Applies to Probability Based Type Wells

STOP USING THE TIME SLICE METHOD
USE THE AGGREGATION METHOD
TIME SLICE METHOD

Uses only history

Normally P10, P50 or P90

For Each Month
  • Sort by rate
  • Get the P90 or P50/P10 rate
  • Decline to complete
Probability

- What is uncertain? Unknown
- No Aggregation (1 well)
- Rates from the full distribution
- Ignores EUR distribution

TIME SLICE METHOD
TIME SLICE METHOD

- 9 well example
- Crossing rate/time

There is a P10 & P90 well
Creates additional error
TIME SLICE METHOD

- Shaded area
- P90 low, P10 high

Rate < P90  or  Rate > P10
Where is the EUR right?
Probability of what?
• Cannot choose at value, e.g. EUR, NPV
• Type well does not match the EUR

Prone to error
• Errors from using only history
• Crossed rate-time profiles
• Rates selected from all wells and probabilities
• Doesn’t represent a defined group of wells
  P90 rates from 19 of 25 wells, P4 to P96
AGGREGATION METHOD

Resolves 4 type well questions
• Which wells to use?
• Should wells have equal weighting?
• How does one account for drill program size?
• What is the right way to handle probabilities?

The Approach
• Find appropriate weighting factors
Aggregated Distribution

- Pick 5 random probabilities
- Get values for each
- Average the values
AGGREGATION 101

Aggregated Distribution
- Pick 5 random probabilities
- Get values for each
- Average the values
- Repeat 100,000 times
- Plot distribution of means

Aggregated Results
- P90 & P50 values increase
- Certainty improves  P10/P90
- P90 economic with 5 wells
AGGREGATION METHOD

Step 1  Get Target EUR (237)

Step 2  Weighting Factor
- Continue 5 well trials
- When mean ~ target
  Tally the selected wells
- Tally more than 1000 trials
- Calculate weighting factor as a % of the total tally

Step 3  Build type well
- Multiply history and prediction by the weighting factor and sum
AGGREGATION METHOD

Step 1  Get Target EUR (237)

Step 2  Weighting Factor

- Continue 5 well trials
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- Calculate weighting factor as a % of the total tally

Step 3  Build type well

- Multiply history and prediction by the weighting factor and sum

Calculate Weighting Factors

<table>
<thead>
<tr>
<th>Well</th>
<th>EUR</th>
<th>Tally</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>175</td>
<td>81</td>
<td>8.9%</td>
</tr>
<tr>
<td>24</td>
<td>197</td>
<td>69</td>
<td>7.5%</td>
</tr>
<tr>
<td>7</td>
<td>203</td>
<td>73</td>
<td>8.1%</td>
</tr>
<tr>
<td>25</td>
<td>214</td>
<td>28</td>
<td>3.1%</td>
</tr>
<tr>
<td>9</td>
<td>220</td>
<td>67</td>
<td>7.3%</td>
</tr>
<tr>
<td>21</td>
<td>241</td>
<td>33</td>
<td>3.7%</td>
</tr>
<tr>
<td>5</td>
<td>277</td>
<td>53</td>
<td>5.8%</td>
</tr>
<tr>
<td>16</td>
<td>293</td>
<td>25</td>
<td>2.8%</td>
</tr>
<tr>
<td>17</td>
<td>326</td>
<td>42</td>
<td>4.6%</td>
</tr>
<tr>
<td>3</td>
<td>378</td>
<td>4</td>
<td>0.5%</td>
</tr>
<tr>
<td>30</td>
<td>396</td>
<td>7</td>
<td>0.8%</td>
</tr>
<tr>
<td>6</td>
<td>434</td>
<td>3</td>
<td>0.3%</td>
</tr>
</tbody>
</table>

910 100%
AGGREGATION METHOD

Advantages

- Designed for new drilling
  - Based on probability of drilling each well
- Properly uses aggregated probabilities
- Will use any uncertain parameter
- Proper ratios for secondary products
  - Calculated with the correct weighting
- Aggregation
  - Increases P90 & P50 reserves
  - Adds certainty
**COMPARISON**  P90 type wells

<table>
<thead>
<tr>
<th>Time Slice Comparison (1 well)</th>
<th>Btax $mm</th>
<th>Atax $mm</th>
<th>EUR mbbl</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>NPV 10% &amp; EUR</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P90 aggregation</td>
<td>-0.8</td>
<td>-0.9</td>
<td>191</td>
</tr>
<tr>
<td>P90 time slice</td>
<td>-3.4</td>
<td>-2.5</td>
<td>111</td>
</tr>
<tr>
<td>Difference</td>
<td>2.6</td>
<td>1.7</td>
<td>79</td>
</tr>
</tbody>
</table>

**Method is critical**

I choose the aggregation method
### Benefit of Aggregation

<table>
<thead>
<tr>
<th>NPV 10% &amp; EUR</th>
<th>Btax $mm</th>
<th>Atax $mm</th>
<th>EUR mbbl</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>P90 drill 5 wells</strong></td>
<td>1.1</td>
<td>0.4</td>
<td>237</td>
</tr>
<tr>
<td><strong>P90 drill 1 well</strong></td>
<td>-0.8</td>
<td>-0.9</td>
<td>191</td>
</tr>
<tr>
<td><strong>Difference</strong></td>
<td><strong>1.9</strong></td>
<td><strong>1.2</strong></td>
<td><strong>46</strong></td>
</tr>
</tbody>
</table>

![Log Time vs. Log Rate graph with two lines representing P90 aggregation (1 well) and P90 aggregation (5 wells).]
TWO VITAL SECRETS

As a Type Well Builder

✔️ Average both history and prediction
✔️ Use Aggregation method for new drilling

As a Consumer of Type Wells

❌ Avoid type wells that use only historical data
✔️ Type wells should represent the number and quality of wells you plan to drill
Your Feedback is Important

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