Status of SPEE Monograph 4—Estimating Developed Reserves in Unconventional Reservoirs

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Houston SPEE Chapter Luncheon
3 December 2013
I HATE SALES. CAN YOU CROSS-TRAIN ME TO BE AN ENGINEER?

ABSOLUTELY. ALL YOU NEED IS A TIME MACHINE AND A BRAIN WITH TWICE AS MANY FOLDS AS YOUR CURRENT MODEL.

MAYBE I COULD TRY RESERVES.

THAT'S JUST LIQUOR AND GUESSING.
SPEE Monograph 4 -- Committee Members

Jim Erdle (CMG)
Creties Jenkins (Rose & Associates)
John Lee (SPEE, Univ of Houston)
Casey O’Shea (IHS/Fekete)
John Ritter (SPEE, Occidental Petroleum)
John Seidle (SPEE, MHA Petroleum Consultants)
Darla-Jean Weatherford (TextRight, technical editor)
Scott Wilson (SPEE, Ryder Scott)
SPEE Monograph 4 -- Outline

1. Definition of unconventional reservoirs (UCR)
2. Reservoir Characterization Aspects of Estimating Developed Reserves in UCR’s
3. Drilling, Completions, and Operational Aspects of Estimating Developed Reserves in UCR’s
4. Classical Arp’s Decline Curve Analysis (DCA)
5. Fluid Flow Theory & Alternative Decline Curve Methods
6. Analytical Models
7. Modern Performance Analysis
8. Discretized Models
9. Probabilistic Methods and Uncertainty in Forecasts and Estimated Ultimate Recovery
10. Summary of Current Technology and Expected Future Trends
SPEE Monograph 4 -- Timeline

• 1 Dec - Revised chapter drafts to editors

• 1 Jan 2014 – Manuscript draft to authors

• 1 Feb – Revised manuscript to SPEE Executive Committee & RDC

• 1 Apr – Comments back from SPEE Ex Comm & RDC

• 1 May? 1 Jun? – Manuscript released to sister societies

• Release + 2 mons – Comments back from sister societies

• Release + 4 mons – Respond to sister societies, final to SPEE Ex Comm

• Monograph in print 4Q 2014?
US unconventional oil production forecast to be a major source for next 30+ years

EIA AEO 2013, Reference Case
US unconventional gas forecast to be increasing fraction of domestic production over next 30 yrs

Figure 91. Natural gas production by source, 1990-2040 (trillion cubic feet)

US Natural Gas Production by Source, EIA Annual Energy Outlook 2013
Concerned with 3 unconventional reservoirs

1. Shales

2. Tight sands and carbonates

3. Coals
Permeabilities of unconventional reservoirs

Coalseam Gas

Tight sands and carbonates

Shales

Brick

High Strength Concrete

Permeability in Millidarcies

1000  100  10  1.0  0.1  0.01  0.001  1\times10^{-4}  1\times10^{-5}  1\times10^{-6}
Geology is important - Haynesville

Ref: Martin & Ewing, 2009
Geology is important – Eagle Ford

Ref: US EIA
Workflow 1a – Validate data – Bakken well
Workflow 1b – Validate data – DJ Niobrara well
Workflow 2a – DJ Niobrara well - construct diagnostic plot(s)
Workflow 2b – Diagnostic plot variables

Normalized rate = $q_0/(p_i - p_{wf})$

Material balance time = $N_p/q_0$
Workflow 2c – DJ Niobrara well - identify flow regimes

Normalized oil rate, bpd/psi

Material balance time, days

½ slope line

6.1 years

Unit slope line

1000
100
10
1
0.1
10
100
1,000
10,000
100,000
1,000,000
Workflow 3 – Fit data to selected models

Hyperbolic

Stretched Exponential

Duong

Weibull

Ref: Mishra, 2012, SPE 161012
Workflow 4a – Forecasts with selected models

Figure 27 Example 2, comparison of 30-year forecasts for \( q \)

Figure 28 Example 2, comparison of 30-year forecasts for \( G_p \)

Ref: Mishra, 2012, SPE 161012
## Workflow 4b – Forecast summary

<table>
<thead>
<tr>
<th>model</th>
<th>30 yr EUR, mmcf</th>
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<tbody>
<tr>
<td>Arps</td>
<td>407</td>
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<tr>
<td>SEDM</td>
<td>346</td>
</tr>
<tr>
<td>Duong</td>
<td>392</td>
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<tr>
<td>Weibull</td>
<td>315</td>
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<table>
<thead>
<tr>
<th>level</th>
<th>30 yr EUR, mmcf</th>
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</thead>
<tbody>
<tr>
<td>P90</td>
<td>324</td>
</tr>
<tr>
<td>P50</td>
<td>369</td>
</tr>
<tr>
<td>P10</td>
<td>403</td>
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</tbody>
</table>
Workflow 5a – Eagle Ford well - Simulation grid

Ref: Erdle, SPEE mono 4
Workflow 5b – Model history matches

Ref: Erdle, SPEE mono 4
Workflow 5c – Simulation forecasts

Ref: Erdle, SPEE mono 4
## Workflow 5d – Eagle Ford well - Simulated EUR’s

<table>
<thead>
<tr>
<th>Run #</th>
<th>HM Error (%)</th>
<th>Oil EUR (stb)</th>
<th>Gas EUR (MMscf)</th>
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<td>1.865</td>
<td>651,310</td>
<td>915</td>
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<td>252</td>
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<td>290</td>
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<td>649,340</td>
<td>909</td>
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<td>2.596</td>
<td>648,504</td>
<td>900</td>
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<td>373</td>
<td>5.7327</td>
<td>692,528</td>
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</table>

### Oil EUR’s, stb
- **P90** - 597,239
- **P50** - 649,306
- **P10** - 713,591

### Gas EUR’s, mmcf
- **P90** - 863
- **P50** - 917
- **P10** - 976
Interesting but...

What do we do when we have to evaluate 800 wells in a week?
Real life 2 – Bakken data & decline curve
Real life 3 – Bakken 50 yr forecast
EUR = 1,117 mmbo
Real life 4 – Bakken 50 yr forecast w/ 8% min decline
EUR = 740 mbo
What do you do when you have to evaluate 800 wells in a week?

1. Decline curve analysis with minimum decline?

2. DCA w/ min decline + add’l analysis of high value wells?

3. Other?
• UCR’s important US oil and gas source for next 30+ yrs

• Geology is important UCR control

• UCR developed reserves workflow—Ideal case
  1. Assess data quality
  2. Construct diagnostic plots
  3. Simple models fits
  4. Simple model forecasts
  5. Simulation
SPEE Monograph 4 – Summary 2

• UCR developed reserves workflow—Common case
  1. DCA with minimum decline

• Monograph 4 in print 4Q 2014?
Thank you!

Monograph 4 committee is interested in your comments--

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