Maximizing Asset Value with Full Field Development

Case Studies in the Permian Basin

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UNIVERSITY LANDS
Overview

• Introduction
• Drivers for Well Performance in Unconventional Reservoirs
• Comparing Different Field Developments (FDPs) – Case Study 1
• Workflow for Systematic FDP Optimization
• Case Study 2 – FDP Optimization Results
• Conclusions
Well Spacing Decision Progress and Difference

Eagle Ford

More wells with time

URTeC 2671245 (COP IR)

North Midland Basin

Different operators make different decisions

FANG 2019 Q1 IR
Testing Different Completion Designs

Cluster Spacing vs Completion Date (Southern Midland Basin)

Permian Basin

It is hard to create uniform long fractures for all perforation clusters. It is a better strategy to target more effective fractures with shorter cluster spacing – HD Completion.
Pressure depletion propagation is very slow in the unconventional reservoirs!

Field Data Set - Tighter Cluster Spacing Wells Over-Perform

Thus, we need
(1) larger fracture surface area for higher rate; and
(2) tighter fracture spacing for faster depletion
Ultra Tight Reservoirs Need Tight Cluster Spacing

Given cluster/fracture spacing of 20ft, there is more depletion area comparing to the 40ft cluster spacing. \[ \text{EUR} = \int f(Rqi, A, k)\Delta p\,dt \]
Case Study 1 - Northern Midland Basin

New Completion Design | Operator A | Operator B | Operator C (version 3.0+)
---|---|---|---
Average Effective LI, ft | 7,400 | 13,000 | 9,100
Fluid Type | Slickwater | Slickwater | Slickwater
Fluid Amount, bbl/ft | 42 | 45 | 55
Proppant Type | 100 Mesh 30/50 | 100 mesh 30/50 | 100 Mesh, 30/50, 40/70, 20/40
Proppant Amount, lb/ft | 1,400 | 1,600 | 3,000
Cluster Spacing, ft | 30 | 25 | 40
Cluster/Stage | 5 | 8 | 6
Stage Length, ft | 150 | 198 | 240
Pump Rate, bpm | 65-70 | 95-100 | 100
Well Spacing, WPS | 12-14 | 8 | 6

The integrated event for unconventional resource teams
The Case Study 1 - EUR Estimation of Different Well Patterns

- EUR per 7500’ section is calculated by sum of all EUR/well in that section divided by total lateral length and then multiply by 7,500 and number of wells/section.
- EUR per well trend decreases as number of well per section increases.
- A-8 WR pattern yields abnormal results, probably due to sub-optimal completion effectiveness.

OOIP Estimation:
Sw = 50%, porosity = 5.5%, Bo =1.56 bbl/stb, net pay = 200 ft → OOIP = 25 MBO per 7500 section
More wells, as expected, bring in more resource recovery and more value to both the operator and UL. However, the Return of Return may show a different trend.

Depending on the well spacing/placement and corresponding completion design, the value of developing the reservoir is different.
Workflows for FDP Optimization

1. Built and calibrated the reservoir simulation model

2. Predicted well performance based upon well spacing and completion design for multiple cases

3. Evaluated economics

4. Identified the “optimal” field development scenarios with the optimal completion designs
Case Study 2 – Model Calibration (Southern Midland Basin)

“Gun barrel” well schematic

Model calibration with production data

“Gun barrel” well schematic in the simulation model
Case 2 FDP Scenario Setup

Fixed reservoir properties based upon history match, and general geological and petrophysical interpretations, including:

- Matrix Perm is around 200-300nd
- Porosity ranges from 7 to 9%; Avg Sw=48%
- 40-41° API Black oil model with Initial GOR of 700-800 scf/stb
Well EUR vs Section EUR

Signal Well EUR depends on the drainage area and completion effectiveness!

Signal Well EUR depends on the drainage area and completion effectiveness!
Cost for HD (Well Cost, Price, and OPEX Assumptions)

<table>
<thead>
<tr>
<th>Scenario Note</th>
<th>Exp Frac Half Length (ft)</th>
<th>Cluster Spacing Cs (ft)</th>
<th>Xf Incr Factor</th>
<th>Cs Incr Factor</th>
<th>D&amp;C Cost adjusted</th>
<th>Compl Cost ($MM)</th>
<th>D&amp;C Cost ($MM)</th>
<th>Total Well Cost ($MM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 - HD Compl</td>
<td>70</td>
<td>10</td>
<td>-19%</td>
<td>60%</td>
<td>41%</td>
<td>5.0</td>
<td>7.0</td>
<td>7.5</td>
</tr>
<tr>
<td>2 - Less HD Compl</td>
<td>100</td>
<td>20</td>
<td>-15%</td>
<td>17%</td>
<td>1%</td>
<td>3.6</td>
<td>5.5</td>
<td>6.0</td>
</tr>
<tr>
<td>3 - Best Compl</td>
<td>150</td>
<td>10</td>
<td>2%</td>
<td>60%</td>
<td>62%</td>
<td>5.8</td>
<td>7.7</td>
<td>8.2</td>
</tr>
<tr>
<td>4 - Med Better Compl</td>
<td>150</td>
<td>20</td>
<td>2%</td>
<td>17%</td>
<td>19%</td>
<td>4.2</td>
<td>6.2</td>
<td>6.7</td>
</tr>
<tr>
<td>5 - Base Case (Mediocre)</td>
<td>150</td>
<td>30</td>
<td>2%</td>
<td>-2%</td>
<td>0%</td>
<td>3.6</td>
<td>5.5</td>
<td>6.0</td>
</tr>
<tr>
<td>6 - Most Intensive Compl</td>
<td>200</td>
<td>10</td>
<td>34%</td>
<td>60%</td>
<td>93%</td>
<td>6.9</td>
<td>8.8</td>
<td>9.3</td>
</tr>
<tr>
<td>7 - Large Compl</td>
<td>200</td>
<td>40</td>
<td>34%</td>
<td>-7%</td>
<td>27%</td>
<td>4.5</td>
<td>6.5</td>
<td>7.0</td>
</tr>
<tr>
<td>8 - Super Long</td>
<td>200</td>
<td>60</td>
<td>34%</td>
<td>-15%</td>
<td>19%</td>
<td>4.2</td>
<td>6.2</td>
<td>6.7</td>
</tr>
</tbody>
</table>

Base case D&C well cost - $5.5MM (as in Scenario 5): 2/3 for completion, 1/3 for drilling; plus 0.55 for wellhead facility

Wellhead Price (Flat)

<table>
<thead>
<tr>
<th>Commodity</th>
<th>Price ($/MMBtu)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oil</td>
<td>60</td>
</tr>
<tr>
<td>Gas</td>
<td>2.75</td>
</tr>
<tr>
<td>NGL</td>
<td>20</td>
</tr>
</tbody>
</table>

- 25% Royalty Rate
- 10% discount rate for operator
- 6% discount rate for landowner
- 30 year economics
- Wells start at the same time

OPEX

<table>
<thead>
<tr>
<th>Commodity</th>
<th>Price ($/MMBtu)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
<td>0.5</td>
</tr>
<tr>
<td>Oil</td>
<td>1</td>
</tr>
<tr>
<td>Gas</td>
<td>0.1</td>
</tr>
</tbody>
</table>

Fixed Well OPEX

<table>
<thead>
<tr>
<th>Commodity</th>
<th>Price ($MM/Well/Yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
<td>60</td>
</tr>
</tbody>
</table>

Base case D&C well cost - $5.5MM (as in Scenario 5): 2/3 for completion, 1/3 for drilling; plus 0.55 for wellhead facility

URTeC 554 - Maximizing Asset Value
Field Development Plan Optimization Results
Simple Sensitivity Analysis

### NPV Sensitivity

- **Eff. Cluster Spacing (100%, -67%)**
- **Well Cost (+10%, -10%)**
- **Frac Half-Length (-53%, 33%)**
- **Vertical Spacing (0, 100%)**
- **Well Spacing (-50%, 100%)**
- **Oil Price (-10%, +10%)**

### IRR Sensitivity

- **Eff. Cluster Spacing (100%, -67%)**
- **Oil Price (-10%, +10%)**
- **Well Cost (+10%, -10%)**
- **Frac Half-Length (-53%, 33%)**
- **Vertical Spacing (0, 100%)**
- **Well Spacing (-50%, 100%)**

Base Case:
- Cluster Spacing = 30 ft
- Fracture Half-Height = 150 ft
- Well Lateral Spacing = 660 ft
- Well Vertical Spacing = 180 ft
Identify Potential Value Zone

Operator Realized Value = \[ \frac{NPV}{\text{Max}(NPVs \text{ of all Cases})} \]
Conclusions

- We can realize the maximum potential values by high density (HD) development of targeting very tight cluster spacing and tighter well spacing.
  - Larger fracture surface area for higher production rate
  - Tighter fracture spacing speeds up depletion
  - Tighter fracture spacing may reduce the investment risk brought by the tighter well spacing

- The drilling and completion cost structure and operation efficiency are very critical to realize potential value. The key economical motivator, such as Rate of Return Vs Net Present Value, will drive very different full field development decisions.

- With the max NPV, for the given reservoir in the case study, the optimal lateral well spacing could range from 440 ft to 880 ft depending on the cost and oil price, and the operator’s operation efficiency. The 660’ well spacing is recommended. The tighter effective cluster spacing 20 ft or less will significantly enhance the value, which is highly recommended as the completion design for the reservoir.
Dual Porosity Modeling Indicates Low Recovery Efficiency

Recovery efficiency depends on the cluster/fracture spacing - tighter effective cluster/fracture spacing increase recovery efficiency!
Single Porosity Modeling Indicates High Recovery Efficiency

Recovery efficiency depends on the cluster/fracture spacing - tighter effective cluster/fracture spacing increase recovery efficiency!
**Single Porosity Modeling** Indicates Significant Pressure Depletion inside Matrix Blocks, which seems not suitable based upon well performance data.

Single Porosity Modeling may not be suitable!

**Dual Porosity Modeling** Indicates Little Pressure Depletion within Matrix Blocks.

Dual Porosity Modeling may be more suitable!!

Xiong 2017, SPE TWA
Identify Potential Value Zone

Operator Realized Value = \frac{NPV}{\text{Max}(NPVs \text{ of all Cases})}