Making Deep Water Marginal Oil Fields Economical

March 2019
Topics

- West Africa Marginal Oil Fields
- Are Marginal Oil Fields Profitable?
- Production System Solution for Marginal Oil Fields
  - Self Standing Riser
  - Drilling Vessel/Production Vessel (FPSO)
  - Clustered Production Strategy
  - First Revenues Before End of 2\textsuperscript{nd} Year
  - Revenues from First Well Finance Next Well, etc.
West Africa Marginal Oil Fields

71% below 100 MMBOE

- 10
- 10-25
- 25-50
- SO 75
- 75-100
- 100-125
- 125-150
- 150-175

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Are Marginal Oil Fields Profitable?

- Conventional Cost Model - No

Paradigm Shift

- MEPS Model - Yes
  - Self Standing Riser
  - Drilling Vessel/Production Vessel (FPSO)
  - Innovative Production Method
Production System Solution

- Drilling Vessel
- Production Vessel
- Self Standing Riser
- Cluster of Six Wells
- Staggered Drilling and Production Schedule
- Revenues from Production of First Well Finance Second Well and subsequent Wells Drilled in the Cluster
Self Standing Riser

- Any new deep water system needs to:
  - Reduce drilling costs
  - Evaluate the discovery quickly and cost effectively
- Key elements driving the cost of the drilling and extended well testing is the riser and well control systems
Self Standing Riser Components

Kear-surface production tree, typ. 4" s. 7~ bore. bydra'jlic niiH, connector dn
Niusht we I hec. l. rad. casing bead fir tubing hanger ^
A4MA1 na)n^l|MiiibxF^ t
buoy joint assembly. md.
monitoring SB130CS, LfXgt .s].
casing bead up. upper & lower buoy contact shoulders
Zbtii im:til_:al :c un&nivBil

Flowline outlet
Flexible pipe flow line ft tree umbilical
Bend stiffener

Keel joint. tapered. Type H collection dm fiance up
Type 2 riser joint. widt scales to suppress VTV. send
as needed for depth.

Type 2 riser join `. T: OD. threaded coupling connectors
Crossover Pup. Lateral threaded connections. Type 1 do.
Type 1 nser joint. 7½ OD. weld-on threaded connectors

Tapered stress joint. Tange dn threaded, weld-on connector

3D assembly, incl. accamUlars ft electro-optic umbilical
"Well c a sine"
SSR Connected to Production Vessels

Production Tree, Buoyancy Device and Jump Line connected to Production Vessel

Typical Small Production Vessel - FPSO

Typical Small Production Vessel - FPSO
West African Deep Water Oil Field

Key Field Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Net Oil Thickness</td>
<td>50 ft.</td>
</tr>
<tr>
<td>Porosity</td>
<td>35%</td>
</tr>
<tr>
<td>Water Saturation (Sw)</td>
<td>20%</td>
</tr>
<tr>
<td>Permeability</td>
<td>500–1500 md</td>
</tr>
<tr>
<td>Original Oil in Place (OOIP)</td>
<td>150 million</td>
</tr>
<tr>
<td>Water Depth</td>
<td>3000 ft.</td>
</tr>
<tr>
<td>Depth Below Mudline</td>
<td>8500 ft.</td>
</tr>
<tr>
<td>Initial Reservoir Pressure</td>
<td>3950 PSI</td>
</tr>
<tr>
<td>Reservoir Temperature</td>
<td>202°F</td>
</tr>
<tr>
<td>GOR</td>
<td>400 SCF/Barrel</td>
</tr>
<tr>
<td>Saturation Pressure</td>
<td>1600 PSI</td>
</tr>
<tr>
<td>Oil Viscosity</td>
<td>1.2 CP</td>
</tr>
</tbody>
</table>
### Timing of Drilling and Production

Table 2: Timing of Events for Drilling Six Wells using MEPS SSR Model with FPSO

<table>
<thead>
<tr>
<th>Year 1</th>
<th>Year 2</th>
<th>Year 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>4000 BOPD - Well #1</td>
<td>4000 BOPD - Well #1</td>
</tr>
<tr>
<td>2</td>
<td>Move in and drill well #1</td>
<td>Complete, test, put on production</td>
</tr>
<tr>
<td>3</td>
<td>Complete, test, put on production</td>
<td>4000 BOPD - Well #2</td>
</tr>
<tr>
<td>4</td>
<td>4000 BOPD - Well #2</td>
<td>4000 BOPD - Well #2</td>
</tr>
<tr>
<td>5</td>
<td>Move in and drill well #3</td>
<td>Complete, put on injection well</td>
</tr>
<tr>
<td>6</td>
<td>0 BOPD Injection Well #3</td>
<td>0 BOPD Injection Well #3</td>
</tr>
<tr>
<td>7</td>
<td>Drill well #4</td>
<td>Complete and put on production</td>
</tr>
<tr>
<td>8</td>
<td>4000 BOPD - Well #4</td>
<td>4000 BOPD - Well #4</td>
</tr>
<tr>
<td>9</td>
<td>Drill well #5</td>
<td>Complete and put on production</td>
</tr>
<tr>
<td>10</td>
<td>4000 BOPD - Well #5</td>
<td>4000 BOPD - Well #5</td>
</tr>
<tr>
<td>11</td>
<td>Move in and drill well #6</td>
<td>Complete, put on injection well</td>
</tr>
<tr>
<td>12</td>
<td>0 BOPD Injection Well #6</td>
<td></td>
</tr>
</tbody>
</table>
SSR, Buoyancy Can, Wellhead, Tree

► Depicts an SSR being run by the drilling machine through the moon-pool.

► Shows the buoyancy unit and riser pipe under the drilling unit ready to connect to the well head.
Production Tree Connected to FPSO

- Production tree added.
- A jumper (flexible production line) from the production tree to the docking station/production unit is connected to a manifold for the oil, gas, water separation module.
Within 1 ½ to 2 years from the first sanctioning of the development, three wells are completed with a total production of 8,000 BOPD.
Closing Remarks

The use of the SSR for deep water drilling, completion, production, intervention and well testing is technically and economically feasible.

Owners of deep water assets deemed non-commercial using conventional deep water technologies are encouraged to recognize, that these assets can be profitable and produce an early cash flow to help finance the exploitation.