Identifying Upside Potentials
In Tembungeo West

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RETW
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Topics

- Background
- Field Overview
- Tembunso West Reservoir Performance
- Operational Issues
- Challenges To Maximize recovery
- Conclusion & Recommendation
Background
• 80% of Tembungeo oil production is produced from Tembungeo West.

• Tembungeo West production is coming only from 5 reservoirs (out of 14 reservoirs) through 6 strings (out of 17 strings).

• Overall Tembungeo West Recovery factor is 22%.

• Lack of aquifer support, facility limitation and unavailability of effective artificial lift are the main constraints in maximizing recovery.

• Lack of integrated surface and subsurface study to support long term exploitation plan.

• Potentials were observed from surface and subsurface works.
Field Overview
GENERAL INFORMATION
Field Location : 35 Km NW of Erb West Field
Discovery : 1971 by EPMI
First Oil : Sept, 1974
PSC Expiry : March 31, 2024
Structures : TMBG-A and TMBG B
Main Reservoirs : L1, L5 and L6 of Western Block

DEVELOPMENT HISTORY
1974-1977 - 1st Phase Development : 13 wells (EPMI)
1981-1982 - 2nd Phase Development : 6 wells (EPMI)
1986 - PSCB takeover operatorship
01-Apr-89 - Tembungo PSC Signed
1989 - 1st Work : 4 workovers
1991 - Western Field Exploration : 2 Exp/Appr wells
1994-1995 - TMBG-B Development : 7 wells
2000 - TMBG-B Further Development : 2 wells
Production

- One of the Successful PCSB operation as it could double the production
- Tembungo B development is the key success
**GEOLOGICAL SUMMARY**

- ENE-WSW asymmetric anticline
- Dissected by mainly NNW-SSW normal faults.
- 3 major areas: Eastern, Main and Western area.
- Main reservoir is Stage IVD ‘Turbidite’ sandstone (Upper Miocene)
- Secondary reservoirs are deep marine claystone and shallow marine ‘neritic’.
- Oil was found mainly in Main and West areas and gas in Eastern area.
Tembungo West

- Discovered by T-7 and T-7A exploration wells
- Consists of 2 major fault blocks
- Drilling Platform B with 9 wells (17 strings) with 5 string active
- Currently producing 3500 bopd
  15% water cut
  4000 scf/stb GOR
Drilling Platform B
- No of slot : 9
- No of wells : 9 (8 dual, 1 single string)
- No of strings : 17
- No of producing strings : 5

Drilling Platform A
- No of slot : 17
- No of wells : 17 (all single string)
- No of strings : 17
- No of producing wells : 4

3 Phase
6" x 3.5Km

2 Phase
6" x 35Km
Oil Resource Summary
(As of 1.1.2007 ARPR)

- 50% of STOIIP is located in Tembungo West, 37% in Tembungo Main
- As of 1.1.2007, 86% of the UR has been produced
- Although field UR is 30%, Tembungo West has only 22% RF, due to operational constraints.
Tembungo West Reservoir Performance
## Reservoir Performance

<table>
<thead>
<tr>
<th>FB</th>
<th>Formation</th>
<th>Reservoir</th>
<th>STOIIP (MMSTB)</th>
<th>RF (%)</th>
<th>Key Performance</th>
<th>Production</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>NERITIC</td>
<td>N1.1 - N1.3</td>
<td>17</td>
<td>19</td>
<td>good reservoir quality, water drive</td>
<td>Low FTHP (&lt; 400 psi)</td>
</tr>
<tr>
<td>I/II</td>
<td>D CLAYSTONE</td>
<td>U1/3, M5/6</td>
<td>5</td>
<td>23</td>
<td>low reservoir quality, solution gas drive</td>
<td>Low FTHP (&lt; 400 psi)</td>
</tr>
<tr>
<td></td>
<td>SANDSTONE</td>
<td>L1 - L7</td>
<td>79</td>
<td>28</td>
<td>good reservoir quality, solution gas drive</td>
<td>High FTHP (&gt; 1000 psi)</td>
</tr>
<tr>
<td>III/IV</td>
<td>NERITIC</td>
<td>LN1 - LN3</td>
<td>4</td>
<td>51</td>
<td>good reservoir quality, water drive</td>
<td>Low FTHP (&lt; 400 psi)</td>
</tr>
<tr>
<td></td>
<td>SANDSTONE</td>
<td>L3</td>
<td>11</td>
<td>8</td>
<td>good reservoir quality, solution gas drive</td>
<td>High FTHP (&gt; 1000 psi)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>L4/5</td>
<td>15</td>
<td>0</td>
<td>good reservoir quality, depleted due to communication with FB V</td>
<td>Low FTHP</td>
</tr>
<tr>
<td></td>
<td></td>
<td>L7</td>
<td>4</td>
<td>0</td>
<td>moderate reservoir quality</td>
<td>Openhole integrity</td>
</tr>
</tbody>
</table>
Recovery Factors

- Average RF is 22%
- Low RF is mainly caused by
  - production constraints
  - Unavailability of artificial lift
  - Lack of aquifer support
Operational Issues
Surface Issues

- Back Pressure
- No effective artificial lift
- Limited platform space

Subsurface Issues

- Multiple packers completion
- Delayed FFR
- Data acquisition
Back Pressure

- Currently trunkline pressure ~ 350 psi, due to
  - Production from high FTHP wells
  - Small pipeline capacity (3 phase, 6 inch ID)
- Low FTHP wells can’t flow due to high trunkline pressure
- More wells in future to be closed in future

<table>
<thead>
<tr>
<th>Well / Reservoir</th>
<th>Choke (/64&quot;)</th>
<th>FTHP (psi)</th>
<th>Oil (BOPD)</th>
<th>GOR (SCF/STB)</th>
<th>WC (%)</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>B-1S (L5)</td>
<td>14</td>
<td>880</td>
<td>649</td>
<td>1,160</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>B-1L (L-6U)</td>
<td>24</td>
<td>640</td>
<td>1,229</td>
<td>829</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>B-2L (N1.3/1.4)</td>
<td>72</td>
<td>353</td>
<td>544</td>
<td>1,033</td>
<td>12</td>
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<tr>
<td>B-3S (L1)</td>
<td>23</td>
<td>1,100</td>
<td>353</td>
<td>4,109</td>
<td>0</td>
<td>Fluid Lift B-6L</td>
</tr>
<tr>
<td>B-6L (L5)</td>
<td>48</td>
<td>540</td>
<td>281</td>
<td>6,129</td>
<td>0</td>
<td></td>
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<tr>
<td>B-8L (L2)</td>
<td>72</td>
<td>600</td>
<td>1,246</td>
<td>2,853</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

Remarks:
- Choke Choke Choke Choke
- 6" subsea, 3 Phase
- Choke Choke Choke
- Wide difference FTHP Cause high trunkline pressure
- Low FTHP wells can’t produce
- Pipeline size can not Handle high pressure production
- Remarks
- Close In
- 350 PSI
No Effective Artificial Lift

- No gas lift supply to platform B
  - Although every wells are equipped with gas lift mandrels
- Jet pump is not too practical

Limited Platform Space

- Can’t handle WO rig
- Can’t handle CTU, E-Line
Challenges To Maximize Recovery
Multiphase Pump for LP Wells

- Increase LTHP wells to HTHP by installing Multiphase Pump
- Increase wells’ drawdown pressure by 150 - 200 psi
- On going projects (first batch will be 5 wells)
- Estimated additional recovery of 1.4 MMSTB
Pipeline Upgrade and Gas Lift Line Installation

- Pipeline upgrade will
  - decrease trunkline pressure and reduce back pressure
  - provide bigger capacity for future projects
- Gas Lift line will provide artificial lift for low FTHP wells to maximize production/recovery

### N1.3/1.4 Production Forecast

<table>
<thead>
<tr>
<th>Well / Reservoir</th>
<th>GL depth (ft btf)</th>
</tr>
</thead>
<tbody>
<tr>
<td>B-2S (N1.1)</td>
<td>3200</td>
</tr>
<tr>
<td>B-2L (U1)</td>
<td>3175</td>
</tr>
<tr>
<td>B-3L (L4)</td>
<td>6872</td>
</tr>
<tr>
<td>B-3L (L5)</td>
<td>6872</td>
</tr>
<tr>
<td>B-5S (U3)</td>
<td>6530</td>
</tr>
<tr>
<td>B-5S (L2)</td>
<td>6530</td>
</tr>
<tr>
<td>B-5L (L6)</td>
<td>6650</td>
</tr>
<tr>
<td>B-7S (LN1)</td>
<td>4190</td>
</tr>
<tr>
<td>B-7L (LN3)</td>
<td>4160</td>
</tr>
<tr>
<td>B-8S (L2)</td>
<td>4740</td>
</tr>
<tr>
<td>B-9S (M6)</td>
<td>7215</td>
</tr>
<tr>
<td>B-9S (M6)</td>
<td>7215</td>
</tr>
<tr>
<td>B-9S (L1)</td>
<td>6930</td>
</tr>
</tbody>
</table>
INFEIING UPSIDE POTENTIALS IN TEMBUNGO WEST

Infill / Sidetrack Opportunities

- N Reservoir
- L Reservoir (FB I/IIS)
- L Reservoir (FB III/IV)
- Undiscovered
Secondery Recovery

- No study has been conducted
- Challenge to increase RF in L Reservoirs
- Lab experiments shows final oil saturation of 31 – 36% after waterflood test

<table>
<thead>
<tr>
<th>FB</th>
<th>Reservoir</th>
<th>STOIP (MMSTB)</th>
<th>UR (MMSTB)</th>
<th>RF (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I/II</td>
<td>-L1</td>
<td>19.4</td>
<td>4.8</td>
<td>24.4</td>
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<tr>
<td></td>
<td>-L2</td>
<td>11.2</td>
<td>5.8</td>
<td>51.3</td>
</tr>
<tr>
<td></td>
<td>-L3</td>
<td>4.3</td>
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<td>0.0</td>
</tr>
<tr>
<td></td>
<td>-L4</td>
<td>8.0</td>
<td>1.7</td>
<td>21.7</td>
</tr>
<tr>
<td></td>
<td>-L5</td>
<td>7.1</td>
<td>1.5</td>
<td>21.0</td>
</tr>
<tr>
<td></td>
<td>-L6</td>
<td>28.5</td>
<td>8.6</td>
<td>30.1</td>
</tr>
<tr>
<td></td>
<td>-L7</td>
<td>0.8</td>
<td>0.0</td>
<td>2.4</td>
</tr>
<tr>
<td>III/IV</td>
<td>-L3</td>
<td>10.7</td>
<td>0.8</td>
<td>7.7</td>
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<tr>
<td></td>
<td>-L4</td>
<td>0.4</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td></td>
<td>-L5</td>
<td>14.2</td>
<td>0.0</td>
<td>0.0</td>
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<tr>
<td></td>
<td>-L7</td>
<td>3.6</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td></td>
<td>Subtotal</td>
<td>108.2</td>
<td>23.1</td>
<td>21.4</td>
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</table>
Further Artificial Lift

- i.e. ESP

<table>
<thead>
<tr>
<th>Well / Reservoir</th>
<th>GL Depth (ft bthf)</th>
<th>Top Perf (ft bthf)</th>
<th>Head (ft TVD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>B-1</td>
<td>4630</td>
<td>8048</td>
<td>3,418</td>
</tr>
<tr>
<td>B-3</td>
<td>6872</td>
<td>8298</td>
<td>1,426</td>
</tr>
<tr>
<td>B-4</td>
<td>6305</td>
<td>7499</td>
<td>1,194</td>
</tr>
<tr>
<td>B-5</td>
<td>6648</td>
<td>6776</td>
<td>128</td>
</tr>
<tr>
<td>B-6</td>
<td>5406</td>
<td>8148</td>
<td>2,742</td>
</tr>
<tr>
<td>B-7</td>
<td>4161</td>
<td>7230</td>
<td>3,069</td>
</tr>
<tr>
<td>B-8</td>
<td>5673</td>
<td>8380</td>
<td>2,707</td>
</tr>
<tr>
<td>B-9</td>
<td>4190</td>
<td>8858</td>
<td>4,668</td>
</tr>
</tbody>
</table>
NAG Potentials

- Registered NAG
- TX-1 discovery
- Gas recovery during water flood

<table>
<thead>
<tr>
<th>Category</th>
<th>ALL</th>
<th>WEST</th>
<th>MAIN</th>
<th>EAST</th>
</tr>
</thead>
<tbody>
<tr>
<td>AG - SOL*</td>
<td>50</td>
<td>29</td>
<td></td>
<td>21</td>
</tr>
<tr>
<td>AG - GC**</td>
<td>146</td>
<td>13</td>
<td>18</td>
<td>116</td>
</tr>
<tr>
<td>NAG</td>
<td>130</td>
<td>13</td>
<td>31</td>
<td>86</td>
</tr>
<tr>
<td>Total</td>
<td>325</td>
<td>55</td>
<td>48</td>
<td>222</td>
</tr>
</tbody>
</table>

* Remaining solution gas after UR achieved for West
** 25% of original GC for West & Main area
Conclusion
Conclusion & Recommendation

- Tembungo West contributes 80% of Tembungo field production. Production is coming only from 5 reservoirs (out of 14 reservoirs) through 6 strings (out of 17 strings). With current situation, production in Tembungo West will shortly fall down.

- Overall Tembungo West Recovery factor is 22% with remaining reserves of 6 MMSTB.

- Lack of aquifer support, facility limitation and unavailability of effective artificial lift are the main constraints in maximizing recovery.

- Integrated surface and subsurface study is urgently required to increase recovery from Tembungo field.
Thank You
Back Up
Gas Resource Summary
(As of 1.1.2007 ARPR)

- 38% of GIP is located in East area, 33% in Main area
- 78% of gas is gas cap and non associated gas
- Although field RF has reached 30%, most of the recovery is from solution gas.
- East area has not been touched!!
IDENTIFYING UPSIDE POTENTIALS IN TEMBUNGO WEST

- Facility Bottlenecks
- Well Test Accuracy
- Pipeline Capacity
- Artificial lift
- Reservoir

Well Test Separator