The Jamnagar Gasification Project

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Vision

- Boost Jamnagar refinery margins, by petcoke gasification
- Eliminate high cost LNG imports, w/ syngas from gasification
- Supply petrochem feed w/sustainable competitiveness
- Create platform to diversify to unconv. fuels + petrochem
Reliance

<table>
<thead>
<tr>
<th>RIL, $ bn</th>
<th>2010-11</th>
<th>2011-12 (annualized)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sales</td>
<td>58.0</td>
<td>74.8</td>
</tr>
<tr>
<td>Exports</td>
<td>32.9</td>
<td>46.3</td>
</tr>
<tr>
<td>EBDIT</td>
<td>9.2</td>
<td>9.8</td>
</tr>
<tr>
<td>Cash profit</td>
<td>7.7</td>
<td>8.0</td>
</tr>
<tr>
<td>Net profit</td>
<td>4.5</td>
<td>5.1</td>
</tr>
</tbody>
</table>

- Operates world’s largest refinery
- Top 5 in deep water E&P
- 3 shale gas projects in the US
- Global #1 in polyester
- 22% CAGR in sales and 25% CAGR in profits since 1977 IPO

⇒ Growth company
Jamnagar refinery

- **Jamnagar**
  - Largest refinery in the world
  - 1.34 mb/d crude feed in 2010
  - 1.5% of global refining

- **VR processing**
  - 2 cokers
  - 346 kb/d combined capacity

- **Petcoke**
  - 6.4 mmt/yr, high S petcoke
  - Lowest value refinery product
  - Value add petcoke w/ gasification

- **Gasification**
  - "Bottomless" refinery w/ gasification
  - Significant boost to refinery margins
  - Widen margin delta over refinery peers

**Sustainable competitiveness in refining**
<table>
<thead>
<tr>
<th>Demand driver</th>
<th># gasifier</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>LNG imports</td>
<td>4.2</td>
<td>Supplemental fuel</td>
</tr>
<tr>
<td>Total gasifiers</td>
<td>4.2</td>
<td>Support Jamnagar refinery</td>
</tr>
</tbody>
</table>

- **Gasifier size**
  - = 2 mmscm/d of syngas, NG equiv
  - = Exploit economy of scale
  - = Min capex

- **Beat LNG price**
  - = Target lowest life cycle cost
  - = Minimize capex + opex of gasification
  - = Syngas at a price discount to LNG
Petrochem feed

- Refinery offgas (ROG) = 400 kt/yr ethylene
  = 1200 kt/yr ethane

- ROG for petrochem
  = Recover ethylene + propylene
  = Recover ethane
  = Crack ethane to ethylene
  = Recover hydrogen

- ROG Cracker
  = 1350 kt/yr ethylene
  = 150 kt/yr propylene
  = World scale

- 5.4 gasifiers for ROG Cracker feed + fuel
CO recovery

- **Feed**
  - Recover CO from syngas
  - Feed CO for acetyl chemicals
  - Import methanol for feed

- **Acetyl chemicals**
  - Acetic acid
  - Acetic acid derivatives

- **0.4 gasifiers for Acetyl feed + fuel**
# Scope

<table>
<thead>
<tr>
<th>Demand</th>
<th>#</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>LNG substitution</td>
<td>4.2</td>
<td>Power &amp; steam, H₂</td>
</tr>
<tr>
<td>ROG Cracker</td>
<td>5.4</td>
<td>SNG, power + steam</td>
</tr>
<tr>
<td>Acetyl chemicals</td>
<td>0.4</td>
<td>CO recovery</td>
</tr>
<tr>
<td><strong>Total gasifiers</strong></td>
<td>10</td>
<td>Demand driven</td>
</tr>
</tbody>
</table>

Demand

- = 10 large gasifiers
- = 2 mmScm/d NG equiv. syngas/gasifier
- = 20 mmScm/d total
## Feed

<table>
<thead>
<tr>
<th>Supply</th>
<th>#</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pet coke</td>
<td>7.5</td>
<td>Jamnagar cokers</td>
</tr>
<tr>
<td>Pet coke/coal</td>
<td>2.5</td>
<td>Supplemental feed</td>
</tr>
<tr>
<td><strong>Total gasifiers</strong></td>
<td><strong>10.0</strong></td>
<td></td>
</tr>
</tbody>
</table>

- **Feed shortfall** = 25% pet coke
  = 2.1 mmt/yr pet coke import
- **Coal**
  = Select low grade coal
  = Match syngas demand w/ 10 gasifiers
  = 3.5 mmt/yr or 35% coal import
- **Feed basis**
  = 65/35 pet coke + coal blend = 10 mmt/yr
  = 100% pet coke = 8.5 mmt/yr

*75% captive feed w/ pet coke*
<table>
<thead>
<tr>
<th>Syngas utilization</th>
<th>#</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power &amp; steam</td>
<td>5.7</td>
<td>Cogen. power plant (existing + new)</td>
</tr>
<tr>
<td>H₂</td>
<td>1.4</td>
<td>Substitute existing H₂ plants</td>
</tr>
<tr>
<td>SNG</td>
<td>2.5</td>
<td>RFG for process heaters</td>
</tr>
<tr>
<td>CO</td>
<td>0.4</td>
<td>Acetyl chemicals</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>10.0</td>
<td></td>
</tr>
</tbody>
</table>

Design enabled for 8 mmt/yr CO₂ recovery

100% captive consumption of syngas
Min lifecycle cost for gasification

**Configuration**

- **Min capex**
  - Largest gasifier w/min scale up risks
  - 2 mmscm/d NG equiv. syngas, per gasifier
  - 2 gasifiers + 1 ASU per standard gasifier module
  - Repeat design of standard gasifier module

- **Min opex**
  - HHP steam gen in syngas cooler/SNG
  - Employ “pinch’ design
  - Overall integration

- **Licensor selection**
  - Low syngas cost
  - Petcoke experience
  - Min technology risk
Gasification

- 10 gasifiers
- 2 mscm/d syngas/gasifier
- 0.85 mmt/yr petcoke
- 1.0 mmt/yr petcoke + coal

ASU = Air separation unit
OGBL = Outside gasification battery limit
OSBL = Outside battery limit

ASU
- 5 trains
- O₂ to gasifier
- 5250 t/d O₂/ASU

OGBL
- Processing
  - AGR
  - SRU/TGT
  - SWS
  - CO shift
- Product
  - PSA for H₂
  - SNG
  - CO recovery

OSBL
- Utility
  - CPP/power & steam
  - Desal
  - Water system
  - Fuel system
- Offsite
  - ETP
  - Flare
  - Feed system
  - Sulphur/slag

Manage project effectively
Schedule

- Reliance + PMC
  - Licensor
  - EPCM contractor
  - Suppliers

- Target 36 months for 4 gasifiers
- Target 42 months for 10 gasifiers
Conclusion

- Ensure competitive gasification w/ lowest life cycle cost
- Value add low cost petcoke/coal to boost refinery margins
- Substitute LNG w/syngas from gasification
- Generate ethylene + ethane feed for petrochem
- Generate CO for acetyl chemicals
- Diversify into unconventional fuels (XTL) in future

Bet on gasification
Thank You