UPDATE OF PETCOKE GASIFICATION PROJECT
AT JAMNAGAR, INDIA

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• Petcoke gasification
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• Project details and Status
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• Conclusion
Reliance – An Introduction

Growth Journey

- 1958: Reliance Commercial Corporation – Trading House
- 1966: Naroda Textile Units – Vimal Fabric
- 1977: Reliance goes Public – Reliance IPO
- 1982-88: Patalganga Complex – POY/ PSF/ PTA/ LAB/ PX
- 1997-97: Hazira Phase II- PTA 1,2/ PFY/ PSF/ PET/ PP/ Naphtha Cracker
- 1999-00: Jamnagar DTA Refinery (J1)
- 2000-01: Reliance Info-comm
- 2005-06: Reliance Retail
- 2008-09: Jamnagar SEZ Refinery (J2)/ KGD6 Gas Production
- 2016-17: J3 Project Implementation: Gasification Project & Jio 4G

Make-in-India & Digital India
Reliance: An Introduction

Reliance Industries Ltd, India

- **#1 company in India**, in private sector
- **Global rankings**, (Fortune 2017)
  
  #203 in revenues; #110 in profits

- **Performance**, FY ’17

<table>
<thead>
<tr>
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<th>$bn</th>
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<tbody>
<tr>
<td>Revenue</td>
<td>50.9</td>
</tr>
<tr>
<td>Earnings, EBDIT</td>
<td>8.6</td>
</tr>
<tr>
<td>Market capitalization</td>
<td>90</td>
</tr>
<tr>
<td>Net worth</td>
<td>44.5</td>
</tr>
</tbody>
</table>

- **Growth**, CAGR (1)

<table>
<thead>
<tr>
<th></th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Earnings</td>
<td>26.7</td>
</tr>
<tr>
<td>Market capitalization</td>
<td>31.5</td>
</tr>
<tr>
<td>Net worth(NW)</td>
<td>13.9</td>
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</tbody>
</table>

- **Returns** (adjusted) (2)

<table>
<thead>
<tr>
<th></th>
<th>%</th>
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<tbody>
<tr>
<td>ROCE</td>
<td>25.4</td>
</tr>
<tr>
<td>RONW</td>
<td>16.8</td>
</tr>
</tbody>
</table>

Note: (1) CAGR = compounded annual growth rate since IPO in 1977
(2) Adjusted for work in progress

⇒ Indian company, with a global footprint
## Jamnagar Refinery: A profile

### Jamnagar refinery

- **Largest refinery**
  - Crude processed, kb/d: 1380
  - World rank, #: 1

- **Superlative performance**
  - Complexity Index: 12.7
  - Energy Intensity Index: 64
  - Availability, %: ~97

- **Integrated complex**
  - Petrochemicals, % of crude: 14.5
  - Utilities & power, % captive: 100
  - Ports & terminal: 5 SPM + 5 berth jetty

- **Global exports**
  - By revenues, %: 51
  - By volume, %: 56

- **Margins**
  - **GRM, FY’17** USD/bbl
    - Jamnagar: 11.0
    - USGC/WTI: 8.7
    - Singapore/Dubai: 5.8
    - Rotterdam/Brent: 5.3

Note: GRM = Gross refining margin

⇒ Arguably the best refinery in the world
Scope:

- **Refinery**: 4 trains
- **Coker**: 2 x 8 drums
- **Petcoke Gasification**: 10 gasifiers
- **Crude oil**: 1380 kb/d
- **Vac resid**: 340 kb/d
- **Petcoke import**: 6.3 mmt/yr
- **Petcoke**: 4.0 mmt/yr
- **LNG Import**: Syngas @10 GWth, 23.2 mmscm/d NG equiv.
- **Sulphur**: 2000 t/d

⇒ **Gasify petcoke to syngas, for 100% Jamnagar consumption**
SCOPE: Gasification Configuration: BFD

- ASU
- Gasification
- Open Art Units
  - LTGC
  - Shift & GC
  - SWS
- SRU/TGTU
- SFU
- Sulfur
- PSA
- H₂
- Methanation
- SNG
- CPP
- CO₂
- Power
- CO recovery
- Chemic als

Dotted line indicates future vistas

- HHP steam export
- HHP steam
- O₂
- Pet coke
- OSBL
- Offsite
Gasification Configuration:

- **Config**
  - 10 Gasifiers
  - 4 in DTA refinery; 6 in SEZ refinery
  - Modular design, 2 gasifiers /modules

- **Feed**
  - 1,150 MWth gasifier largest in the world
  - 100% petcoke feed, ~2,900 tpd per gasifier
  - 65% petcoke + 35% coal feed blend flexibility

- **ASU**
  - 5 ASU, 1 ASU/ gasifier module
  - 5,250 t/d 99% $O_2$

- **Product**
  - 2.3 mmscmd NG equiv / gasifier (272 kNm3/hr)
  - Repower 1,300 MW CPP with syngas and 1,700 tph of steam
  - 1,160 t/d H2, 2-4 mmscmd SNG (balancing product)
## Project: Scope

**Engineering:**
- PFD: 115
- P & ID: 1700

**Equipment:**
- Equipment: 2920
- Piping isometrics: 44,000

**Materials:**
- Concrete, million cum: 1.1
- Structural steel, kt: 210
- Piping, million in m: 14
- Electrical cable, km: 3900
- Instrumentation cable, km: 6500

**Construction:**
- Construction workers, peak: >1,000,000
- Cranes, peak: >1700

⇒ Flagship gasification project of the world
CURRENT STATUS

• World’s largest ASU 1 unit commissioned successfully and operational

• First Gasifier unit refractory drying and alkali boil out completed

• All utilities are operational

• AGR unit commissioning under progress

⇒ No compromise on safety
CURRENT STATUS

⇒ No compromise on safety
CURRENT STATUS

⇒ No compromise on safety
CURRENT STATUS

No compromise on safety
No compromise on safety
Operational Challenges: Successful Gasifier operation depends on

- Consistent quality of feed-stock
- Proper blend of fluxant
- Slurry properties like stability, strength, and viscosity (Flowability / Pumpability)
- Life of slurry mixer (burner)
- Gasifier design to provide right volume and temperature
- Slag flow characteristics
- Refractory Life

⇒ No compromise on safety
Technology Challenges

Process Safety

- Handling of Toxic chemicals - Hydrogen Sulphide (TLV 1ppm), Syngas- Carbon Monoxide (TLV – 25 ppm)
- Handling of Flammable & Explosion Hazards- H2, pure Oxygen, methanol,
- Handling of solids - Dust explosion Hazards- Petcoke, coal,

- Conservative designs – compliance to international standards (AIGA/ EIGA)
- Developed standards for handling toxic chemicals
- Detail Consequence Analysis studies of complete complex and action plan

⇒ No compromise on safety
Operational Preparedness:

- Study on effect of fluxant to feed ratio on ash viscosity with temperature – Optimized fluxant to feed ratio

- Study on slurry preparation using optimized fluxant to feed ratio – Optimized slurry stability, strength, and viscosity

- Study using optimized slurry for understanding the reaction kinetics using equipment in entrained flow environment

- Validating scaled up Gasifier design using kinetics and CFD modeling

- A detail work plan prepared. Various teams comprising members from different areas prepared to handle each concerned area.

⇒ Flawless and smooth Start-up
Operational Preparedness

Operational Preparedness:
Tie up with renowned research institutes / Universities:

• Working with Penn State Universities, Micro beam Technology, USA. Planning to collaborate with NETL, Frieberg University, Germany.

• Generate the property data for actual feed stocks and develop correlations for predicting properties

• Generate kinetic data for development of model

• Develop CFD models

Extensive Dynamic simulation study of:

• Gasification module to validate control philosophy provided by licensor

• Control system for all units in Gasification complex individually and integrated way

• Control system of Gasification complex with rest of the Jamnagar complex

• Extensive use of OTS for operational training

⇒ Flawless and smooth Start-up
## Gasification: Future Enhancements

| NH<sub>3</sub> | Recover NH3 @ 140 kt/yr from sour water  
|              | 43% from gasification + 57% from refinery  
|              | Convert N, a crude contaminant, into an opportunity  
|              | Substitute imports, into India  

### Urea
- Exploit pure CO<sub>2</sub> from gasification shift  
- Add CO2 to NH3, recovered + imports  
- Boost fertilizer supply + food security of India  

### V
- Recover vanadium(V) @ 9.5 kt/yr from gasification slag  
- Recover Ni @ 2.0 kt/yr as co product  
- Convert V, a crude contaminant into a metals opportunity  
- Global #1 in V, a micro alloy for high strength steel  

### Ethanol
- Exploit syngas for synthetic ethanol  
- Use biochemical reaction kinetics  
- Blend ethanol into crude derived gasoline  
- Stretch gasoline without crude increase  

### APC + RTO
- Develop integrated gasification model  
- Model scope = 10 gasifiers + syngas headers  
- APC = Advance process control  
- RTO = Real time optimization using ROMeo software  
- Enhance gasification performance

⇒ **Enhance gasification economics**
Future Syngas Utilization

<table>
<thead>
<tr>
<th>Gasification</th>
<th>Syngas quality @ $H_2/CO = 0.62$</th>
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<tbody>
<tr>
<td></td>
<td>Syngas price @ 40% discount to LNG derived syngas</td>
</tr>
<tr>
<td></td>
<td>Base syngas utilization = $H_2 +$ plant fuel</td>
</tr>
<tr>
<td></td>
<td>Future syngas utilization = Oxygenated chemicals</td>
</tr>
</tbody>
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<table>
<thead>
<tr>
<th>CO</th>
<th>Recover CO from low $H_2/CO$ syngas</th>
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<tbody>
<tr>
<td></td>
<td>Exploit low cost CO feed for acetic acid + ethylene glycol</td>
</tr>
<tr>
<td></td>
<td>Derive acetyl chemicals from acetic acid</td>
</tr>
<tr>
<td></td>
<td>Acetates + VAM + VAE + PVAcetate + PVAlcohol</td>
</tr>
<tr>
<td></td>
<td>Ethylene glycol, via unconv.process from CO</td>
</tr>
<tr>
<td></td>
<td>Acrylic acid ,via unconv. process from CO, in future</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Syngas</th>
<th>Target chemicals, requiring low $H_2/CO$ syngas as feed</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>Oxo–alcohols + DME + MMA/ PMMA</td>
</tr>
<tr>
<td></td>
<td>Blend DME into crude derived LPG</td>
</tr>
<tr>
<td></td>
<td>Methanol and its derivatives</td>
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<tr>
<th>$CO_2$</th>
<th>CO2 capture ready plant</th>
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<tr>
<td></td>
<td>Identify technology for CO2 utilization/sequestration</td>
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</table>

⇒ Maximize value addition with syngas to chemicals
Global landmark in Gasification

Path-breaker for Indian Energy Sector
Thank You