Coal/Petcoke Gasification
And
Reliance’s Jamnagar Gasification Project
by
Mr. Thomas Mathew
President- Reliance Technology Group
Reliance Industries Ltd
July 2013
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- WHAT IS GASIFICATION?
- HISTORY OF GASIFICATION
- THEORY OF GASIFICATION
- APPLICATIONS OF GASIFICATION PROCESS
- TYPES OF GASIFIERS
- GASIFICATION TECHNOLOGY DEVELOPMENT
- IGCC
- RELIANCE’S JAMNAGAR GASIFICATION PROJECT
- CENTRE OF EXCELLENCE FOR GASIFICATION
WHAT IS GASIFICATION?

- Conversion of any carbonaceous fuel to a gaseous product with a useable heating value.

- The feed for Gasification can be
  - Gas (e.g., Natural gas)
  - Liquid (e.g., Light or Heavy oils)
  - Solid (e.g., Coal, Petroleum Coke, Lignite or Biomass)
## HISTORY OF GASIFICATION

<table>
<thead>
<tr>
<th>PERIOD</th>
<th>TECHNOLOGY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before 1700</td>
<td>Major fuels were Wood and Charcoal</td>
</tr>
<tr>
<td>1700-1750</td>
<td>Industrial revolution – Coal as fuel</td>
</tr>
<tr>
<td>1800-1900</td>
<td>Coal Pyrolysis – Town gas supply</td>
</tr>
<tr>
<td></td>
<td>Water gas, Producer Gas</td>
</tr>
<tr>
<td>1920</td>
<td>Cryogenic air separation – Oxygen replaces air</td>
</tr>
<tr>
<td>1926</td>
<td>Winkler Fluidized Bed Gasifier</td>
</tr>
<tr>
<td>1931</td>
<td>Lurgi Moving Bed Gasifier</td>
</tr>
<tr>
<td>1940</td>
<td>Koppers-Totzek Entrained Flow Gasifier</td>
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<table>
<thead>
<tr>
<th>PERIOD</th>
<th>TECHNOLOGY</th>
</tr>
</thead>
<tbody>
<tr>
<td>1950s</td>
<td>Texaco and Shell develop Oil Gasification</td>
</tr>
<tr>
<td>1970s</td>
<td>Oil crisis</td>
</tr>
<tr>
<td>1973</td>
<td>Texaco develops Slurry Process for Coal Gasification</td>
</tr>
<tr>
<td>1974</td>
<td>Shell and Koppers-Totzek Pressure Gasification JV</td>
</tr>
<tr>
<td>1981</td>
<td>High Temperature Winkler Gasification</td>
</tr>
<tr>
<td>1984</td>
<td>Lurgi Slagging Gasifier (together with British Gas)</td>
</tr>
<tr>
<td>1999</td>
<td>Shell/Krupp-Uhde develops Pressurised Entrained Flow (PRENFLO) Gasifier</td>
</tr>
<tr>
<td>PERIOD</td>
<td>TECHNOLOGY</td>
</tr>
<tr>
<td>---------</td>
<td>--------------------------------</td>
</tr>
<tr>
<td>1940s</td>
<td>Wood Gasification</td>
</tr>
<tr>
<td>1945-1950</td>
<td>Lurgi Fixed Bed</td>
</tr>
<tr>
<td>1960s</td>
<td>Winkler Fluidized Bed</td>
</tr>
<tr>
<td>1960s</td>
<td>Texaco</td>
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<tr>
<td>1970s</td>
<td>Krupp-Koppers</td>
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<td></td>
<td>Entrained Bed Atm.</td>
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<td>1970s</td>
<td>Shell</td>
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<td>1980s</td>
<td>Shell</td>
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<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>1980s</td>
<td>Texaco</td>
</tr>
</tbody>
</table>

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Gasification Theory
GASIFICATION Vs. COMBUSTION

- Partial oxidation
- Higher temperature, often high pressure
- Purpose - Get Fuel-rich gas & not High temperature gas
- Product gases (CO, H₂, CH₄, CO₂, H₂O) have fuel value
- Oxygen as feed instead of air
- Intermediate scrubbing of gas
- Char reaction rate is slower
GENERAL REACTIONS

\[ \text{CH} + \text{O}_2 + \text{H}_2\text{O} \rightarrow \text{CO} + \text{H}_2 + \text{CO}_2 + \text{H}_2\text{O} + \text{CH}_4 \]

\[ \text{H}_2 + \text{S} \quad = \quad \text{H}_2\text{S} \]

\[ \text{C} + \frac{1}{2} \text{H}_2 + \frac{1}{2} \text{N}_2 \quad = \quad \text{HCN} \]

\[ \frac{1}{2} \text{N}_2 + \frac{3}{2} \text{H}_2 \quad = \quad \text{NH}_3 \]

\[ \text{C} + \text{S} + \frac{1}{2} \text{O}_2 \quad = \quad \text{COS} \]

\[ \frac{1}{2} \text{H}_2 + \frac{1}{2} \text{Cl}_2 \quad = \quad \text{HCl} \]

\[ \text{ASH} \quad \rightarrow \quad \text{SLAG} + \text{FLY ASH} \]
Combustion reactions

\[ \text{C} + \frac{1}{2} \text{O}_2 \rightarrow \text{CO} \quad \Delta H = -111 \text{ MJ/kmol} \]

\[ \text{CO} + \frac{1}{2} \text{O}_2 \rightarrow \text{CO}_2 \quad \Delta H = -283 \text{ MJ/kmol} \]

\[ \text{C} + \text{O}_2 \rightarrow \text{CO}_2 \quad \Delta H = -394 \text{ MJ/kmol} \]

\[ \text{H}_2 + \frac{1}{2} \text{O}_2 \rightarrow \text{H}_2\text{O} \quad \Delta H = -242 \text{ MJ/kmol} \]

Boudouard reaction

\[ \text{C} + \text{CO}_2 \rightleftharpoons 2 \text{CO} \quad \Delta H = +172 \text{ MJ/kmol} \]

Water gas reaction

\[ \text{C} + \text{H}_2\text{O} \rightleftharpoons \text{CO} + \text{H}_2 \quad \Delta H = +131 \text{ MJ/kmol} \]
GENERAL REACTIONS

ΔH
(+ Endothermic / - Exothermic)

Methanation reaction

C + 2 H₂ ⇌ CH₄  - 75 MJ/kmol
CO + 3 H₂ ⇌ CH₄ + H₂O  - 206 MJ/kmol
CO₂ + 4 H₂ ⇌ CH₄ + 2 H₂O  - 165 MJ/kmol

The reverse Steam-reforming reactions are endothermic

CO shift reaction

CO + H₂O ⇌ CO₂ + H₂  - 41 MJ/kmol

Gasification Reaction – Summary

CH + O₂ + H₂O → CO + H₂ + CO₂ + H₂O + CH₄

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PICTURE OF A HYPOTHETICAL COAL MOLECULE
Coal reactions are generally divided into two distinct components:

- Devolatilization of the raw coal
- Oxidation of the residual char

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ENERGY CONTENT AND COMPOSITION OF COALS

Petcoke
COAL ANALYSIS

• PROXIMATE ANALYSIS
  Water
  Volatile matter
  Fixed carbon
  Ash
  Calorific value

• ULTIMATE ANALYSIS
  Carbon
  Sulphur
  Hydrogen
  Chlorine
  Oxygen
  Metals
  Nitrogen

• ASH ANALYSIS
  Metal oxides

• ASH FUSION TEMPERATURE
  Ash melting point
  Initial Deformation Temperature
  Hemispherical Point
  Flow Point
REACTIVITY OF FUELS AS FUNCTION OF TEMPERATURE
RESIDENCE TIME AS FUNCTION OF PARTICLE SIZE

![Graph showing the relationship between residence time and particle size. The x-axis represents particle size in millimeters, ranging from 0.01 to 100. The y-axis represents residence time in seconds, ranging from 1 to 10,000. The graph indicates a positive correlation between particle size and residence time.](image-url)
- The relationship between ash-melting characteristics and composition is a complicated one and is dependent largely on the quaternary SiO$_2$-Al$_2$O$_3$-CaO-FeO.

- In general, slags that are high in SiO$_2$ and/or Al$_2$O$_3$ will have high ash melting points, but this is reduced by the presence of both CaO and FeO.

- The SiO$_2$/Al$_2$O$_3$ ratio is also important – where the Calcium content is already high, SiO$_2$ addition can lower the ash melting point.

- Slag is very different from ash as it has been molten and is in fact a fusion-cast material similar to glass.
O2 consumption depending on Ash content and CV

Oxygen Consumption, 98% pure, \( \text{Nm}^3/(\text{CO}+\text{H}_2) \)

Ash content of coal dust (wt%)
Coal dust consumption depending on Ash content and CV

![Graph showing the relationship between ash content and coal dust consumption.](image-url)
Synthesis gas composition changes with pressure

- Methane and CO\textsubscript{2} content go up with increasing pressure
- H\textsubscript{2} and CO content go down
- However, at high temperatures (1500 deg C), the change in gas composition with pressure is negligible.
EFFECT OF TEMPERATURE

- Below the ash softening point for fluidized bed and dry ash moving bed Gasifiers
- Above the ash melting point for slagging (entrained bed) Gasifiers
- Flux may be required to be added for coal/coke having very high ash melting point
- CO content goes up while H₂ content goes down with increasing temperature
- CO + H₂ yield goes through a mild maximum between 1200 and 1300 deg C
- Methane content goes down with increasing temperature
- Oxygen demand is more at high temperatures
Application of Gasification Process
APPLICATIONS OF GASIFICATION PROCESS

Carbon Source

Power & Steam
- Naptha
- Waxes
- Fischer-Tropsch Liquids

Gasification

Synthesis Gas
- Diesel/Jet/Gas Fuels
- Synthetic Natural Gas

Methanol
- VAM
- Ketene

Methyl Acetate
- Acetate Esters
- Acetic Anhydride

Iron Reduction

Fuel/Town Gas

H2

Ammonia & Urea

Dimethyl Ether

Ethylene & Propylene

Oxo Chemicals

Polyolefins
Types of Gasifiers
TYPES OF GASIFIERS

1) **Moving/Fixed bed**
   - Lurgi/BGL
   - Counter-current
   - Co-current

2) **Fluidized bed**
   - Winkler/KBR etc

3) **Entrained flow**
   - GE/Shell/Conoco/Siemens/Uhde
   - Dry pulverized solid fuel
   - Fuel slurry
   - Atomized liquid fuel
TYPES OF GASIFIERS

MOVING BED GASIFIER

FLUIDIZED BED GASIFIER

ENTRAINED FLOW GASIFIER
# TYPES OF GASIFIERS

<table>
<thead>
<tr>
<th></th>
<th>Fixed bed</th>
<th>Fluidized bed</th>
<th>Entrained bed</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Residence time</strong></td>
<td>1-3 hr</td>
<td>20-150 min</td>
<td>0.4-2 s</td>
</tr>
<tr>
<td><strong>Coal size</strong></td>
<td>6-50 mm</td>
<td>6-10 mm</td>
<td>&lt; 100 microns</td>
</tr>
<tr>
<td><strong>O₂/Coal</strong></td>
<td>0.14-0.81</td>
<td>0.25-0.97</td>
<td>0.28-1.17</td>
</tr>
<tr>
<td><strong>Steam/Coal</strong></td>
<td>0.28-3.09</td>
<td>0.11-1.93</td>
<td>0.10-1.20</td>
</tr>
<tr>
<td><strong>Coal type</strong></td>
<td>Most types - No fines</td>
<td>Non-caking coals</td>
<td>All types</td>
</tr>
<tr>
<td><strong>Temperature range (°C)</strong></td>
<td>420-650</td>
<td>900-1050</td>
<td>1250-1600</td>
</tr>
<tr>
<td><strong>Pressure range (Atm)</strong></td>
<td>1-10</td>
<td>10-30</td>
<td>30-80</td>
</tr>
<tr>
<td><strong>Product gases (Mol%)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CO + H₂</td>
<td>40-70</td>
<td>60-80</td>
<td>65-95</td>
</tr>
<tr>
<td>CH₄</td>
<td>5-15</td>
<td>3-5</td>
<td>0.1-2</td>
</tr>
<tr>
<td>HHV (BTU/SCF)</td>
<td>250-320</td>
<td>300-400</td>
<td>300-550</td>
</tr>
<tr>
<td><strong>Efficiency</strong></td>
<td>Low</td>
<td>Medium</td>
<td>High</td>
</tr>
</tbody>
</table>
EQUILIBRIUM EXIT GAS COMPOSITION
LURGI DRY ASH GASIFIER – MOVING BED
LURGI CIRCULATING GASIFIER – FLUIDIZED BED
WHY ENTRAINED FLOW GASIFIER?

- Ability to handle variety of solid fuels
- High throughput because of high reaction rates/temperature
- High carbon conversion
- Syngas free of oils and tars
- Low methane production
Gasification Technology Development
Conoco Philips E-GAS – Two stage gasifier

DOW (LGTI)

DESTEC

CONOCOPHILLIPS

P 66

CB & I
TPRI/Future Fuels Generic Gasifier Design
TPRI Syngas Cooler Gasifier (SCG)  

TPRI Syngas Quench Gasifier (SQG)
1. Steel Pressure Shell
2. Insulation Layer
3. Castable Layer
4. Hot-face Refractory

**Products (syngas):**
- **CO** (Carbon Monoxide)
- **H₂** (Hydrogen)

**H₂/CO Ratio:** ~ 0.7 - 1.0

**By-products:**
- **H₂S** (Hydrogen Sulfide)
- **CO₂** (Carbon Dioxide)
- **Slag** (Minerals from coal)

**Extreme Conditions:**
- Up to 1,000 psig or more
- Nominal 2,500 Deg F
- Corrosive slag and H₂S gas

**General Electric: Quench Gasifier**
General Electric: PHR Gasifier
Shell Gasifier
1. Flowing Slag Layer
2. Solid Slag Layer
3. High Alumina Refractory Material
4. Metallic Studs (Incolloy)
5. Membrane Tube Wall
6. Free Space
7. Refractory Lining on Pressure Vessel
8. Pressure Vessel
Siemens Gasifier

Source: Siemens
IGCC POWER STATION BASED ON SHELL TECHNOLOGY
# COMMERCIAL SCALE IGCC PLANTS

<table>
<thead>
<tr>
<th>TECHNOLOGY SUPPLIER</th>
<th>SOLID FUEL FEED TYPE</th>
<th>INSTALLATIONS</th>
</tr>
</thead>
</table>
| GE Technology       | Water Slurry         | 1. Tampa Electric IGCC Plant, (250 MW)  
                        |                      | 2. Cool Water IGCC Plant (100 MW)  
                        |                      | 3. Eastman Chemical, Kingsport |
| Conoco Philips E-GAS | Water Slurry         | 1. Wabash River IGCC Plant (262 MW) |
| SHELL (SCGP)        | N₂ Carrier/Dry       | 1. Demkolec IGCC plant, (Buggenum Netherlands) (253 MW)  
                        |                      | 2. SHELL-Pernis IGCC Plant (Netherlands), Hamburg |
| PRENFLO / Uhde      | N₂ Carrier/Dry       | 1. Elcogas, Puertollano IGCC Plant (Spain) (298 MW) |
RIL’s Jamnagar Gasification Project
Options for Petcoke Usage

First Refinery at Jamnagar started up in Q4’99. Petcoke production ~ 8500 TPD

During project engineering phase several options for petcoke usage were discussed:

- Thermal power plant – CFBC Boiler + STG
- Petcoke gasification to generate H₂ for refinery. Back up of coal feed during start up
- Storage of petcoke during intervening period between start up of refinery and proposed units above
- Focused effort for marketing of petcoke – National + International Customers

Marketing efforts were so successful, that RIL didn’t pursue any of the other options.
## Petcoke Analysis

<table>
<thead>
<tr>
<th>Property</th>
<th>Wt% (dry basis)</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon</td>
<td>89.1</td>
<td></td>
</tr>
<tr>
<td>Hydrogen</td>
<td>2.8</td>
<td>Volatile matter</td>
</tr>
<tr>
<td>Sulfur</td>
<td>7.5</td>
<td>High S crude dependent</td>
</tr>
<tr>
<td>Ash</td>
<td>0.6</td>
<td>Contains metals</td>
</tr>
<tr>
<td>Nitrogen</td>
<td>500 ppm</td>
<td></td>
</tr>
<tr>
<td>Oxygen</td>
<td>100 ppm</td>
<td></td>
</tr>
<tr>
<td>Hard grove index (HGI)</td>
<td>30 - 35</td>
<td>Hard coke</td>
</tr>
<tr>
<td>Moisture</td>
<td>8.0</td>
<td>As delivered</td>
</tr>
<tr>
<td>Gross calorific value</td>
<td>8350 kcal/kg</td>
<td>As measured</td>
</tr>
</tbody>
</table>
Indian Petcoke Scenario

- Second Refinery at Jamnagar started up in Q4’08
- Petcoke production: ~9500 TPD
- Total Reliance petcoke generation: ~6.4 MMTPA
- Total petcoke generation in India: ~12 MMTPA
- Expected additional generation of petcoke in India by 2016: ~10 MMTPA
- Surplus petcoke will be available
- Reliance considers petcoke gasification as opportunity for value addition
Business Drivers

- Transform “Jamnagar” into “bottomless” refinery
- Exploit price delta between natural gas and petcoke/coal
- Insulate the Jamnagar refinery from future energy cost escalation
- Utilize H2 to maximize refinery performance
- Recover C2+C3 from RFG for advantage petrochem feed
- Recover CO for acetyl chemicals
- Pursue reduction in GHG through possible CO2 capture and sequestration or effective utilization

Gasification as alternate processing
# Integration with Refinery

<table>
<thead>
<tr>
<th>Refinery</th>
<th>• 1.35 mmbbl/d crude, w/ 12.6 Nelson complexity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coker</td>
<td>• 340 kb/d, 2 trains, world’s largest</td>
</tr>
<tr>
<td></td>
<td>• 18300 tpd of petcoke production</td>
</tr>
<tr>
<td>CPP fuel*</td>
<td>• Power + steam, MW = 1510 (cogen)</td>
</tr>
<tr>
<td></td>
<td>• Repower by syngas</td>
</tr>
<tr>
<td>H₂</td>
<td>• Demand = 1300 t/d (on-purpose)</td>
</tr>
<tr>
<td></td>
<td>• Recovery from syngas</td>
</tr>
<tr>
<td>RFG*</td>
<td>• Demand = 3500 Gcal/hr (fired heters)</td>
</tr>
<tr>
<td></td>
<td>• From syngas via SNG</td>
</tr>
</tbody>
</table>

Integration: Refinery + petrochem + utilities/power + port/terminal

* CPP: Captive Power Plant  * RFG : Refinery Fuel Gas

Stepping stone for Gasification
Gasification Overview

- Modular design
- Flexible feed: petcoke or blend of coal and petcoke
- Implementation in two phases
  - Phase I
    - 4 modules, 2 gasifiers per module
    - 4 ASUs, 1 per gasifier module
  - Phase II
    - 2 more modules
    - 2 more ASUs

- Gasifier capacity:
  - ~2900 tpd petcoke per gasifier
  - ~272 KNm3/hr syngas production per gasifier (2.35 MMSCMD NG eqv.)

- World’s largest ASU
  - 5250 tpd O2 per ASU
  - 99% pure O2 product

- Other units
  - AGR, PSA, SNG, CO Recovery, SRU/TGTU & SFU

- Open art design
  - LTGC, shift with gas cooling & Sour water strippers

ASU: Air Separation Unit  AGR: Acid Gas Removal Unit  SNG: Synthetic Natural Gas  LTGC: Low Temperature Gas Cooling  SRU: Sulfur Recovery Unit  SFU: Sulfur Forming Unit

World’s Largest gasification complex
Technological Selection

**Entrained flow gasifiers:**

- Type: Up flow or down flow
- Operate above ash melting point
- Feed: Slurry or dry feed
- High per pass carbon conversion
- High pressure & throughputs
- Short residence time
- Suitable for wide range of coals, including petcoke

Selected for Jamnagar
Gasification Technology Technology Licensors considered:
EmberClear-TPRI, GE, CB&I, Shell, Siemens, Uhde

<table>
<thead>
<tr>
<th>Design</th>
<th>Risk</th>
<th>FRAME</th>
<th>Performance</th>
<th>Financials</th>
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</thead>
<tbody>
<tr>
<td>Gasifier design</td>
<td>Experience</td>
<td>Availability</td>
<td>Cold gas $\eta$</td>
<td>Capex</td>
</tr>
<tr>
<td>Operating conditions</td>
<td>Scale-up</td>
<td>Feeding system</td>
<td>Thermal $\eta$</td>
<td>Opex</td>
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<tr>
<td>Heat recovery system</td>
<td>Gasifier</td>
<td>Carbon $\eta$</td>
<td>Life cycle cost</td>
<td></td>
</tr>
<tr>
<td>Syngas &amp; slag flow</td>
<td>Syngas cooling system</td>
<td>Useful gas $\eta$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maintenance schedule</td>
<td>Maintenance schedule</td>
<td>$O_2$/feed</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

CB & I selected for Jamnagar
<table>
<thead>
<tr>
<th>Unit</th>
<th>Technology Licensor</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASU</td>
<td>Air Liquide, Air Products, <strong>Linde</strong>, Praxair</td>
</tr>
<tr>
<td>AGR</td>
<td>Air Liquide, <strong>Linde</strong>, UOP/Technip</td>
</tr>
<tr>
<td>PSA</td>
<td><strong>Linde</strong>, UOP</td>
</tr>
<tr>
<td>SNG</td>
<td>BASF, Haldor Topsoe, Johnson Matthey</td>
</tr>
<tr>
<td>Shift Catalyst</td>
<td>Haldor Topsoe, Johnson Matthey, Sudchemie</td>
</tr>
<tr>
<td>Shift/LTGC/SWS</td>
<td>Open art design by Fluor</td>
</tr>
<tr>
<td>SRU</td>
<td>Black &amp; Veatch, Lurgi, <strong>Worley Parsons-Linde</strong></td>
</tr>
<tr>
<td>SFU</td>
<td><strong>Enersul</strong>, Brimrock, Sandvick, Devco</td>
</tr>
</tbody>
</table>

SWS: Sour water stripping Unit

Technology selection almost completed
Status update

- **Licensor Selection**
  - Gasification licensor: CB & I
  - E&P contractor: Fluor
  - Construction mgmt.: Reliance

- **Gasification updates**
  - Kickoff: May 2012
  - PFD review: June 2012
  - P&ID review: October 2012
  - PDP delivered: November 2012
  - Equipment: RFQ issued / Bid evaluation

- **ASU updates**
  - HAZOP in progress

- **OGBL updates**
  - Package units: Licensors selected
  - Open art unit: Design in progress/RFQ issued

- **OSBL/Offplot**
  - Issue RFQ & bid evaluation

- **Start-up**
  - Q2 2015

* ASU: Air Separation Unit * OGBL: Outside Gasification Battery Limit * OSBL: Outside Battery Limit

Site preparation complete
### Project Status

<table>
<thead>
<tr>
<th>Task</th>
<th>Timeframe/Assignee</th>
</tr>
</thead>
<tbody>
<tr>
<td>Selected Gasification Licensor</td>
<td>Phillips 66 now CB&amp;I</td>
</tr>
<tr>
<td>Selected PMC &amp; EP</td>
<td>Fluor</td>
</tr>
<tr>
<td>Kick off</td>
<td>May 2012</td>
</tr>
<tr>
<td>PDP completed</td>
<td>November 12</td>
</tr>
<tr>
<td>Selected ASU &amp; AGR Licensor</td>
<td>Linde</td>
</tr>
<tr>
<td>Selected SRU Licensor</td>
<td>Linde/Worley Parsons</td>
</tr>
<tr>
<td>Start-up</td>
<td>36 months post kick-off</td>
</tr>
</tbody>
</table>

**Typical Reliance Aggressive Project Schedule**
Jamnagar at 2015
Centre of Excellence (CoE) for Gasification

✓ Acquiring knowledge of:
  ➢ All existing and emerging gasification technologies
  ➢ All downstream and auxiliary process technologies
  ➢ Suitability of different feedstocks

✓ Understanding economics of all processes

✓ Develop expertise on modeling of gasification processes

✓ Explore opportunities for development of own technology
Centre of Excellence (CoE) for Gasification

✓ Creation of knowledge repository:
  - Gasification portal
  - Keeping abreast with gasification-related activities globally

✓ Techno-economic evaluation of:
  - Existing & emerging gasification technologies
  - Downstream products & processes

✓ Pilot plant studies with technical / commercial collaboration for:
  - Characterization of feedstocks (coal, lignite, pet coke, biomass)
  - Understanding reaction kinetics
  - Building capability for gasifier design
  - Developing Gasification Technology for high ash content Indian Coal
Reliance sees coal business as a strategic growth sector

- Jamnagar Petcoke/Coal gasification Project: Under Implementation
- Coal Bed Methane – Commercial pilot
- Underground Coal Gasification – Business case prepared
- Direct Coal Liquefaction – Pilot tests performed
- Hybrid Coal Liquefaction – Business case prepared
- Microbial Coal Conversion – Prefeasibility in progress
- Creating Centre of Excellence for Gasification
Microbial Coal Conversion

Technology being developed to efficiently convert in-ground and extracted low rank coal to gas

- **In-situ Bioconversion**-
  - Low cost chemicals (bio-stimulants) are injected into coal seams to stimulate microbes to convert coal to methane.
  - Technology may also be used to enhance or generate methane from fully depleted CBM wells

- **Ex-situ Bioconversion**-
  - Low grade coal converted by chemical solubilization and anaerobic fermentation
  - Does not produce CO$_2$ and hazardous waste

**Technology providers:**
Luca, Ciris, Next fuel, Synthetic Genome Institute, MicGas-Arctech

Proposal for feasibility study in Progress
Challenges for Clean Coal

- Complex projects
- High cost of new technology
- Need to strengthen research environment
- Expensive & high risk investment for any single industry player
- Need collaborations with emerging technology providers
- Needs strong support from Indian Government
- Need Public/ Private partnerships and partnership with technologically advanced players

Access to technology & stronger national/ international partnerships needed
Progressive policy needed to accelerate improved coal utilization

- Accelerate opening up of Coal sector for private sector investments
- Develop clear policy on bidding and allotment of coal blocks
- Open new coal blocks for bidding
- Expedite clearances for new projects
- Strengthening of coal supply chain
- Promote consortia (private + public) for pre competitive technology development with financial support
- Policy concessions and economic incentives for development and deployment of new technologies in India
- Coal pricing to be market linked

Government’s proactive role in building technical & operational capabilities is crucial
Innovation Led Growth

Growth is Life

THANK YOU