Feasibility of IGCC Technology for Power Generation Using Indian Coal

Coal Based Power
Confronting Environmental Challenges
March 17-18, 2016

Sandeep Tandon
Project Manager
U.N.I.D.O
Presentation Outline

- Interest in Gasification
- Gasifier Types and Indian Coal Characteristics
- Gasification Technology choice for Indian Coal
- Roadmap
Coal is the cheapest and major source of power generation in India.

India plans to significantly increase installed power generation capacity; 60% share from coal.

IGCC offers – low emissions, low water use while using coal as feedstock.
Integrated Gasification Combined Cycle (IGCC)
Gasifier Types and Indian Coal Characteristics
Major Types of Coal Gasifiers

Moving Bed

Entrained Bed

Fluidized Bed

Transport

- Steam, Oxygen, or Air
- Coal, Char Recycle, Gas
- Steam, Oxygen, or Air
- Gasifier Bottom
- Recycle Drive
- Gasifier Top
Characteristics of India Coal

- High ash content (35-45%)
- High ash fusion temperature (>1500°C)
- High reactivity (sub-bituminous coal)
- Low sulfur content (0.5%)
# Properties of Indian Coals

<table>
<thead>
<tr>
<th></th>
<th>N. Karanpura</th>
<th>N. Karanpura washed</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Ultimate Analysis (as-received, wt%)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moisture</td>
<td>8.7</td>
<td>7.4</td>
</tr>
<tr>
<td>Carbon</td>
<td>40.3</td>
<td>46.0</td>
</tr>
<tr>
<td>Hydrogen</td>
<td>3.2</td>
<td>3.6</td>
</tr>
<tr>
<td>Nitrogen</td>
<td>0.9</td>
<td>1.0</td>
</tr>
<tr>
<td>Sulfur</td>
<td>0.5</td>
<td>0.5</td>
</tr>
<tr>
<td>Ash</td>
<td>38.2</td>
<td>33.0</td>
</tr>
<tr>
<td>Oxygen (by difference)</td>
<td>8.2</td>
<td>8.6</td>
</tr>
<tr>
<td><strong>Proximate Analysis (as-received, wt %)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Net Calorific Value (kcal/kg)</td>
<td>4,180</td>
<td></td>
</tr>
<tr>
<td>Gross Calorific Value (kcal/kg)</td>
<td>3,692</td>
<td>4,228</td>
</tr>
<tr>
<td>Coal per unit of electricity (kg/kWh)</td>
<td>.7</td>
<td></td>
</tr>
<tr>
<td>Ash Fusion Temperature (°C)</td>
<td>1,500</td>
<td>1,500</td>
</tr>
</tbody>
</table>

Chen, Tan-Ping. "Effects of Coal Ash Content on Cost of Generation for IGCC Power Plant"
Gasifiers Not Suitable for India Coals

**Slurry Feed**
- GE gasifier (WHB)
- GE gasifier (quench)

**Dry Feed**
- E-Gas gasifier
- Shell/Prenflow/Noell gasifier
Suitable Gasifiers for India Coals

- **Fluidized Bed**
  - U-Gas, HT Winkler gasifiers
  - No slagging
  - Medium oxidant use
  - Medium cold gas efficiency

- **Transport**
  - KBR gasifier
  - No slagging
  - Medium oxidant use
  - Medium cold gas efficiency
  - High throughput

- **Moving Bed**
  - Lurgi gasifier
  - No slagging
  - Low oxidant use
  - High cold gas efficiency
  - Require lump coal
Gasification Technology Choice for Indian Coal
Coal Tests

- 250 tons Run-Of-Mine (raw) and washed coals from N-Karanpura shipped to GTI, US; 100kg to Sasol, SA for testing

- GTI: 10-tons per day (tpd) U-Gas pilot plant in Chicago

- Sasol: coal characterization to predict gasifier performance

- Univ. North Dakota-EERC: 5-tpd transport gasifier pilot unit using Dadri coal shipped to US

- BHEL: 18-tpd fluid bed pilot at Hyderabad
Gasifiers for Low Rank Coal cont.

Lurgi

KBR Transport

U-Ga

Feed
Feed Lock
Gas Offtake
Wash Cooler
Crude Gas
Ash Grade (rotating)
Steam/Oxygen
Ash Lock
Ash

Disengager
Bed Material Charge Hopper
Standpipe
Coal Feed Hopper
Steam Superheater
Air Preheaters
U-Valve Steam Manifold

COAL
Primary Cyclone
Hot-Gas Filter Vessel and Ash Hopper
Dip Leg
Quench Systems

Air / O2 / Steam
AIR / O2 / STEAM
AIR / O2 / STEAM

FLUIDIZED BED
BOTTOM ASH REMOVAL

SYNGAS
COAL
GASIFIER
CYCLONES
Test Result Summary

- Tests at GTI, EERC, and BHEL indicate fluid bed and transport systems can gasify Indian coals very well due to coal high reactivity.

- Operating temperature need not to be high.

- High-ash Indian coal did not present operation problems in operation of gasifiers.

- Carbon conversion in fluid bed gasifier is 85-90%; can reach 95% if adjusted for heat loss and N\textsubscript{2} use.
Configuration of 100 MW Plant
<table>
<thead>
<tr>
<th>Description</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coal Receiving, Storage and Preparation</td>
<td>5.56</td>
</tr>
<tr>
<td>Enriched Air Supply</td>
<td>18.89</td>
</tr>
<tr>
<td>Coal Gasification</td>
<td>21.42</td>
</tr>
<tr>
<td>Syngas Cooling and Re-heat</td>
<td>2.78</td>
</tr>
<tr>
<td>Acid Gas Removal and sulfur Recovery</td>
<td>5.00</td>
</tr>
<tr>
<td>Sour Water Stripping</td>
<td>5.56</td>
</tr>
<tr>
<td>Gas turbines with Auxiliaries</td>
<td>29.78</td>
</tr>
<tr>
<td>Waste heat recovery boiler w/ auxiliaries</td>
<td>9.33</td>
</tr>
<tr>
<td>Steam turbine with auxiliaries</td>
<td>7.56</td>
</tr>
<tr>
<td>Balance of Plant Facilities</td>
<td>35.98</td>
</tr>
<tr>
<td><strong>Sub-total Equipment Cost</strong></td>
<td><strong>136.19</strong></td>
</tr>
<tr>
<td>Initial Spares (@ 3% of equipment cost)</td>
<td>4.0</td>
</tr>
<tr>
<td>Custom Duties</td>
<td>7.42</td>
</tr>
<tr>
<td>Excise Duty, Freight and Insurance</td>
<td>Included in individual package cost</td>
</tr>
<tr>
<td><strong>Total Equipment Cost</strong></td>
<td><strong>147.70</strong></td>
</tr>
<tr>
<td>Erection Testing and Commissioning of Gas Turbine</td>
<td>2.98</td>
</tr>
<tr>
<td><strong>Total Works Cost</strong></td>
<td><strong>150.7</strong></td>
</tr>
<tr>
<td>Owner’s cost, incl. license fee</td>
<td>4.56</td>
</tr>
<tr>
<td>Engineering (6% of total work cost and vendor support)</td>
<td>9.04</td>
</tr>
<tr>
<td>Contingency (5% of total work cost)</td>
<td>7.53</td>
</tr>
<tr>
<td><strong>Total Capital Requirement excluding IDC</strong></td>
<td><strong>171.8</strong></td>
</tr>
<tr>
<td>Interest During Construction</td>
<td>20.49</td>
</tr>
<tr>
<td><strong>Total Project Cost including IDC</strong></td>
<td><strong>192.3</strong></td>
</tr>
</tbody>
</table>
Future of Coal Gasification In India

- The demo plant high cost ($1,900-2,000/kW) are not indicative for commercial plants.
- Efficiency can increase to 40% when large gas turbines (9F or 9H class) are used in commercial plants.
- The commercial plant cost can reduce to $1,200-1,300/kW (under Indian condition).
- IGCC is a young technology with large room for improvements; while sub- & super-critical PC is mature.
- New technology and product developments need to be tracked for integration with the IGCC for Indian coal.
IGCC Roadmap in India

- **More coal tests** - gasifiers suitable for Indian coals are not fully developed; also need to monitor new technology developments

- **Construct and operate demo plant** – R&D flavor, learning, gaining operational experience to operate commercial plant

- **Policy changes** – more stringent emission standards for power plants, tax credits or other incentives for using IGCC, soft loans for building IGCC plants

- **Local technology ownership** - major power /chemical plant equipment suppliers and engineering/construction firms get involved; develop standardize Plant Design

- **Gasification technology demonstrated for IGCC can be extended to other sector transportation fuels, fertilizers, and petrochemicals** – attractive option and
PROTOCOL OF INTENT BETWEEN
THE GOVERNMENT OF THE UNITED STATES OF AMERICA
AND
THE GOVERNMENT OF THE REPUBLIC OF INDIA

THIS PROTOCOL OF INTENT sets forth certain areas of mutual cooperation and collaboration in the energy sector and is made between the Government of the United States of America (represented by the United States Agency for International Development ("USAID") and the United States Department of Energy ("USDOE")) and the Government of India (represented by the Ministry of Power ("MOP") and the National Thermal Power Corporation Limited, India ("NTPC"), and collectively with the MOP, USDOE and USAID, the ("Parties") on this 13 day of September, 2000.

WHEREAS, in a Joint Statement on Cooperation in Energy and Environment signed at New Delhi on March 22, 2000 ("Joint Statement"), the Government of the United States of America and the Government of India articulated their desire to increase cooperation in energy and the environment.

WHEREAS, in pursuit of the collaborative goals set forth in the Joint Statement and subject to applicable law, USAID and USDOE intend to cooperate with the MOP and NTPC to support the development of advanced power generation technologies in India.

WHEREAS, as a first step towards this cooperation, USAID will collaborate with MOP and NTPC in conducting a detailed technical and economic feasibility study for setting up a commercial scale integrated gasification combined cycle (IGCC) demonstration power plant at one of the NTPC power plant sites. The study will seek to establish: (i) the most suitable IGCC technology for Indian coal and environmental conditions; (ii) explore possible financing structures to make the technology most competitive for India; (iii) and develop a time-bound implementation plan for technology demonstration in India.

RESOLVED, that as one of the next steps in the Joint Statement, the Parties will cooperate and collaborate to achieve the objectives set forth herein.

A.K. Basu
Secretary
Ministry of Power

T.J. Glaubith
Deputy Secretary
U.S. Department of Energy

A. Palit
Director
National Thermal Power Corporation

Harriet Babbitt
Deputy Administrator
USAID
125 MW Demonstration Plant

- BHEL and APGENCO have signed an agreement to setup 125 MW IGCC plant at Vijaywada (in the state of A.P.)
- Using U-Gas gasifier and GE 6FA gas turbine
- India ROM coal is the design coal
- Technical details being discussed
- Financial structuring yet to be decided
THANK YOU

Sandeep Tandon
UNIDO
Email: s.tandon@unido.org

011- 4386 6416