IMPLEMENTING CLEAN COAL TECHNOLOGY
THROUGH GASIFICATION AND LIQUEFACTION
– THE INDIAN PERSPECTIVE

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Coal Energy in India

Emission from a power plant depends on total generation fuel consumption efficiency, and fuel quality

Coal constituents:
Organic and Inorganic material

Mineral Matter in Coal:
Inherent
- Extraneous

Clean coal technology is important because:
- Coal is abundant and will remain a major source of energy for future years
- Emission from coal based generation is a matter of serious concern
Surface Coal Gasification

- Coal put in gasifier with oxygen and steam where heat and pressure are used to form a synthetic gas, known as “syngas”

- CO$_2$ can then be captured
  - Before combustion (IGCC)
  - After combustion (Pulverized Coal plants)
Product: Syngas

- **Composition** – Carbon Monoxide and Hydrogen

- **Potential Uses**
  - Power Generation (IGCC)
  - Fertilizers & Methanol
  - Natural Gas
  - Gasoline & Diesel Fuels
UNDERGROUND COAL GASIFICATION

- Low Air Emissions
- Electricity Production
- CO2 Separation
- Gas Cleaning

- Injection Well
  - Oxygen + Water
- CO2 separation Stream to unmineable coal
- Production Well
  - H2, CH4, CO
  - CO2 + minor constituents
- Stressed & Contaminated Zone
- Coal Seam
- Ash + Char
WHY UCG?

✓ UCG eliminates much of the energy waste associated with moving waste as well as useable product from the ground to the surface.

✓ UCG produces less greenhouse gases and has the advantage for geologic carbon storage. The well infrastructure for UCG can be used subsequently for geologic CO₂ sequestration operations. It may be possible to store CO₂ in the reactor zone underground as well as adjacent strata.

✓ No surface gasification systems are needed; hence capital costs are substantially reduced.

✓ UCG is particularly advantageous for deep coal deposits and steeply dipping coal seams since at these conditions less gas leakages to the surroundings and high pressures favour methane formation.
### UCG potential

#### Coal and Lignite reserves in India (in Billion Tonnes)

<table>
<thead>
<tr>
<th></th>
<th>Proved</th>
<th>Indicated</th>
<th>Inferred</th>
<th>Total</th>
<th>Extractable</th>
<th>Un-extractable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coal</td>
<td>114.002</td>
<td>137.471</td>
<td>34.39</td>
<td>285.862</td>
<td>45.231</td>
<td>240.631</td>
</tr>
<tr>
<td>Lignite</td>
<td>6.146</td>
<td>25.794</td>
<td>8.966</td>
<td>40.906</td>
<td>5.7816</td>
<td>35.1244</td>
</tr>
<tr>
<td>Total</td>
<td>120.148</td>
<td>163.265</td>
<td>43.356</td>
<td>326.768</td>
<td>51.013</td>
<td>275.755</td>
</tr>
</tbody>
</table>
# POTENTIAL USE OF UCG IN INDIA

<table>
<thead>
<tr>
<th>Location</th>
<th>Reserve, million tonnes</th>
<th>Deposit</th>
<th>Depth, m</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mehsana and Shobhasan areas in Gujarat</td>
<td>63,000</td>
<td>Ligno-bituminous coal</td>
<td>700 to 1700</td>
</tr>
<tr>
<td>Lapanga (Chordhara), South Karanpura Coalfield</td>
<td>111</td>
<td>Bituminous coal</td>
<td>100 to 500</td>
</tr>
<tr>
<td>Palana - Merta Road, near Bikaner city in Rajasthan</td>
<td>23.57</td>
<td>Lignite</td>
<td>100 to 200</td>
</tr>
<tr>
<td>South Sayal, South Karanpura Coalfield</td>
<td>199</td>
<td>Bituminous coal</td>
<td>300 to 540</td>
</tr>
</tbody>
</table>
ENVIRONMENTAL ISSUES WITH UCG

CO₂ Emission

Surface Subsidence

Ground Water Pollution
COAL LIQUEFACTION

LIGNITE / BROWN COAL*
2000 - 4000 kcal/kg

SUB-BITUMINOUS COAL*
4000 - 6000 kcal/kg

BITUMINOUS COAL*
6000 - 7000 kcal/kg

HYDROGENATION

HYDROGEN & CATALYST

HEATING & PRESSURIZING

COAL LIQUID
10,000 kcal/kg

DISTILLATION

GASOLINE

KEROSENE

The reaction of coal liquefaction is the conversion of coal into liquid by the thermal decomposition and hydrogenation with catalyst under pressurized condition.

It is more effective to use low rank coal with low energy density and limited utilization as the feedback for liquefaction.

*Moisture and ash containing basis
Methods

1. **Direct Liquefaction:**
   - Dissolves coal in a solvent at elevated temperature and pressure
   - Combined with hydrogen gas and a catalyst

2. **Indirect Liquefaction:**
   - Involves first gasifying coal, followed by reacting carbon monoxide and hydrogen together
   
   \[
   n\text{CO} + (2n+1)\text{H}_2 = C_n\text{H}_{2n+2} + n\text{H}_2\text{O}
   \]
Comparison of Processes

**DIRECT LIQUEFACTION**
- Adds hydrogen to break down the coal
- Dissolves in a solvent followed by hydrocracking
- Operates at 450 C and 170 bars
- Light products are distilled
- Medium and heavy distillates obtained from vacuum distillation
- Liquid yields of 70% of the dry weight of coal feed
- Further upgrade is needed for use as transportation fuels

**INDIRECT LIQUEFACTION**
- Complete breakdown of coal with steam and oxygen
- Sulfur is removed from the syngas
- Syngas reacted over catalyst at 300 C and 20 bars
- Produces a lighter suite of products; high quality gasoline and petrochemicals
- Oxygenated chemicals
Coal gasification with carbon capture and storage (CCS), surface or underground, also offers a practical medium-term option for the continuing use of coal and a bridging strategy to eventual energy production with zero emissions, i.e. renewable energy and the hydrogen economy.

The gaseous and liquid fuels, thus produced, may help to reduce our import dependence.

UCG can utilize low grade coals in India that are available in Gujrat, Rajasthan and Tamil Nadu economically.

Though less polluting still many challenges exist which have to be tackled.

Extensive pilot studies are required in different categories of mines in India to suit the technology.

Indian mining industry and research institutes should come forward in a big way to take Gasification and Liquefaction activity forward in India.
Thank You

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