Coal Conversion to Chemicals, Gaseous and Liquid Fuels

Herminé Nalbandian
Senior Research Analyst
IEA Clean Coal Centre
London – United Kingdom
Coal chemical industry supply chain

1. Coal
2. Gasification
3. Synthesis gas (CO, H₂)
   - IGCC electric power
   - Synthetic ammonia
   - Ethylene glycol
     - Urea
     - Sodium carbonate
     - Polyester
     - Natural gas
     - Dimethyl ether
     - Olefins
     - Oil
4. Indirect coal liquefaction
5. Direct coal liquefaction
China’s coal to chemicals development and deployment programme

- aims to establish a modern coal chemical industry

- Includes projects that offer
  - higher energy conversion efficiency
  - a suitable geographical location, with both adequate suitable coal supplies and sufficient water availability
  - prospects for extending the industrial chain to promote local economic and social development

- the programme includes a focus on the construction of projects for clean production, utilisation, processing and conversion of low-calorific-value coal.
Wide range of coal gasification technologies being supplied/used in China by overseas vendors

GE Energy

Shell

Siemens

SES
Increasing use of domestic technologies also under way

- ECUST is the leading Chinese technology supplier, and has some 31 projects either operational or at the contracted design and construction stage. Now the 3rd biggest gasifier vendor in the world

- Other Chinese suppliers include;
  - TPRI
  - HT-L
  - Tsinghua U
  - ICC-CAS
  - MCSG
  - Sedin
## Environmental considerations

<table>
<thead>
<tr>
<th>Chinese applications</th>
<th>Standard coal consumption</th>
<th>Water consumption</th>
<th>CO₂ emissions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indirect coal liquefaction</td>
<td>4.39 (tonnes/tonnes)</td>
<td>13</td>
<td>5.0</td>
</tr>
<tr>
<td>Coal to olefins</td>
<td>6.68 (tonnes/1000 m³)</td>
<td>33</td>
<td>5.5</td>
</tr>
<tr>
<td>Coal to ethylene glycol</td>
<td>2.55 (tonnes/1000 m³)</td>
<td>14</td>
<td>2.0</td>
</tr>
<tr>
<td>Coal to synthetic natural gas</td>
<td>2.83 (tonnes/1000 m³)</td>
<td>6.58</td>
<td>2.5</td>
</tr>
</tbody>
</table>
• Some 14 coal gasification projects are under construction in China through to 2016

• Total potential annual SNG output of just over 20 billion m$^3$ pipeline quality gas

• Target capacities are 89-96 billion m$^3$/year, although the timelines for these subsequent expansions have yet to be defined
### Coal to SNG projects for construction in China through 2016

<table>
<thead>
<tr>
<th>Owner</th>
<th>Location</th>
<th>Annual output (billion m³)</th>
<th>Schedule 1st phase operations</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1st phase</td>
<td>Target</td>
</tr>
<tr>
<td>Guanghui</td>
<td>Xinjiang</td>
<td>-</td>
<td>0</td>
</tr>
<tr>
<td>Qinghua</td>
<td>Xinjiang</td>
<td>1.4</td>
<td>5.5</td>
</tr>
<tr>
<td>Datang</td>
<td>Inner Mongolia</td>
<td>1.4</td>
<td>4.0</td>
</tr>
<tr>
<td>Xinwne</td>
<td>Xinjiang</td>
<td>2.0</td>
<td>10.0</td>
</tr>
<tr>
<td>Huineng</td>
<td>Inner Mongolia</td>
<td>-</td>
<td>2.0</td>
</tr>
<tr>
<td>Huaneng</td>
<td>Xinjiang</td>
<td>4.0</td>
<td>6.0</td>
</tr>
<tr>
<td>Guodian</td>
<td>Inner Mongolia</td>
<td>2.0</td>
<td>10.0</td>
</tr>
<tr>
<td>Shenhua</td>
<td>Inner Mongolia</td>
<td>-</td>
<td>2.0</td>
</tr>
<tr>
<td>Sinopec</td>
<td>Xinjiang</td>
<td>-</td>
<td>8.0</td>
</tr>
<tr>
<td>Guanghui</td>
<td>Xinjiang</td>
<td>4.0</td>
<td>4.0</td>
</tr>
<tr>
<td>CPIC</td>
<td>Xinjiang</td>
<td>2.0</td>
<td>6.0</td>
</tr>
<tr>
<td>CNOOC</td>
<td>Shanxi</td>
<td>4.0</td>
<td>6-15</td>
</tr>
<tr>
<td>Hongshenggi</td>
<td>Gansu</td>
<td>-</td>
<td>4.0</td>
</tr>
<tr>
<td>Datang</td>
<td>Liaoning</td>
<td>-</td>
<td>4.0</td>
</tr>
</tbody>
</table>
Some key prerequisites for assessing potential coal conversion projects:

- large reserves of low cost coal suitable for gasification at the proposed location;

- stranded coal, due to either its low-quality or location; and

- government ability and will to provide enabling support for the large capital investments required.
Additional issues to consider

- fuel resource analysis;
- coal quality, technical and economic analysis;
- identification of gasification products that would most benefit the national economy;
- extraction and transportation;
- developing a plant infrastructure; and
- workforce.
Candidate developing countries for the introduction of gasification technology

<table>
<thead>
<tr>
<th>Africa</th>
<th>Asia</th>
<th>Eurasia</th>
<th>Europe</th>
<th>South America</th>
</tr>
</thead>
<tbody>
<tr>
<td>South Africa</td>
<td>China</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mozambique</td>
<td>Mongolia</td>
<td>Ukraine</td>
<td>Turkey</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Vietnam</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Botswana</td>
<td>Indonesia</td>
<td>Uzbekistan</td>
<td>Russia</td>
<td>Brazil</td>
</tr>
<tr>
<td></td>
<td>India</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zimbabwe</td>
<td>Pakistan</td>
<td>Kazakhstan</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Challenges and opportunities for Mongolia

- Very strong energy security driver to establish CTL and coal to chemicals
- Abundant, easily mineable lignite reserves and plenty of water in most of these regions
- Positive government support
- Cooperation underway between local companies and CTL technology suppliers
- Initial studies suggest an attractive price differential between CTL and imported oil products

- Limited technical and economic capacity
- Very limited infrastructure
- Small national GDP and need for external financing
- Mongolia seen as a risky investment in the mining sector
Conclusions

- China offers a template for large scale coal to chemicals, gaseous and liquid fuels deployment, for all stages of the industrial development cycle.

- The Chinese experience has shown what can be achieved from a technical standpoint and demonstrated that there are various routes that can be followed to ensure that acceptable economic performance becomes a key factor in deployment.

- Water availability and the need to limit CO2 emissions will have to be taken into account, if the sector is to continue to grow.

- There is scope for early CCS demonstrations on larger coal conversion units.

- There is also a strong market for the development and deployment of cost-effective water-saving, water-recycling and wastewater treatment technologies.
IEA Clean Coal Centre Membership

The centre for all aspects of clean coal knowledge transfer

Countries and Companies:
- Austria
- Germany
- Italy
- Poland
- Republic of Korea
- South Africa
- UK
- USA
- Canada
- China
- Australia
- India
- Indonesia
- Japan
- Malaysia
- Nigeria
- Pakistan
- Philippines
- Singapore
- Thailand
- Vietnam
- Bangladesh
- Bhutan
- Cambodia
- Laos
- Myanmar
- Nepal
- Sri Lanka
- Vietnam

Companies:
- BHEL
- Banpu
- Coal Association
- Suek
- Glencore Xstrata
- Anglo American Thermal Coal
- Beijing Research Institute of Coal Chemistry
- Electric Power Planning & Engineering Institute of China
- Anglo American
- CEC
- CEIC
- BRIC
- Australia

Logos and Flags

© IEA Clean Coal Centre | www.iea-coal.org
Thank you for your attention!

Hermine.Nalbandian@iea-coal.org

www.iea-coal.org