Coal for fuels and chemicals:
worldwide challenges and
opportunities

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Membership status of the IEA Clean Coal Centre at June 2015

The foremost centre of excellence for all aspects of clean coal knowledge transfer
Scope of the presentation

- Rationale for coal to chemicals, gaseous and liquid fuels deployment
- Global overview of prospects and activities
- Status of the key conversion routes
- Issues arising
  - Economic considerations
  - Environmental issues
  - Early opportunities for CCS deployment
- Conclusions
New coal chemical industry supply chain is extensive but comes with challenges

- Concerns re high capital costs and uncertainty of forward oil prices, which has been emphasised recently

- Concerns re water availability (such as in northern parts of China where majority of suitable coal is located)

- Increasing recognition that these are high CO2 intensity coal conversion processes
Prerequisites for assessing potential coal conversion projects

- Large reserves of low cost gasifiable coal required;
- Stranded coal, due to either its low-quality or location, can be attractive;
- Government ability and will to provide enabling support for the very large capital investments.
Further considerations (IEACCC 2011)

- Coal availability compared to either indigenous supplies or imports of oil and natural gas;

- Technical and economic issues must be attractive;

- Gasification products selection in terms of usage within the country itself and as exports;

- Infrastructure needs both for the supply of feedstocks and for transporting the end products;

- Institutional capacity requirements.
More promising developing countries for coal conversion development

<table>
<thead>
<tr>
<th>Africa</th>
<th>Asia</th>
<th>Eurasia</th>
<th>Europe</th>
<th>South America</th>
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</thead>
<tbody>
<tr>
<td>South Africa</td>
<td>China</td>
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<tr>
<td>Mozambique</td>
<td>Mongolia</td>
<td>Ukraine</td>
<td>Turkey</td>
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<td>Vietnam</td>
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<td>India</td>
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<td>Uzbekistan</td>
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<td>Botswana</td>
<td>Russia</td>
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<td>Brazil</td>
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<td>Zimbabwe</td>
<td>Pakistan</td>
<td>Kazakhstan</td>
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Commercial scale operations in South Africa

- Coal-based economy with significant domestic use and exports
- Sasol operates the world’s only gasification-based commercial CTL facility at Secunda with an output capacity of 160,000 bbl/d of oil equivalent.
- Major petrochemicals production plant at Sasolburg, but in 2004 Sasol switched this from coal to natural gas feedstock
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
Activities in Vietnam

- Significant coal resources, in north of the country
- Joint ventures for exploitation proposed
- Interest in power and conversion projects
- One coal-to-chemicals project established at the Ninh Binh Nitrogenous Fertiliser Plant
- China Huadian Energy Development Company fulfilled EPC role
  - Shell gasification technology used
  - Full operation will produce 560,000 tonnes urea
Slow start in India

- Major user of coal and a rapidly growing economy
- Very large reserves of hard coal (60Gt) and lignite (38Gt)
- Hard coal far from industrial demand regions
- Major coal quality issues
- Government driven initiatives have been ineffective but some positive activities underway
- Jindal Steel and Power Ltd developing coal to chemicals project to produce a substitute reducing gas for the production of Direct Reduction Iron in a shaft furnace

- Rashtriya Chemicals and Fertilisers Ltd, Coal India Ltd and the Fertiliser Corporation of India Ltd refurbishing several fertiliser production units
Aim is to establish a modern coal chemical industry, to include the upgrade of those demonstration projects that offer the higher energy conversion efficiency, a suitable geographical location, with both adequate suitable coal supplies and sufficient water availability, as well as offering prospects for extending the industrial chain to promote local economic and social development.

This will include a focus on the construction of projects for clean production, utilisation, processing and conversion of low-calorific-value coal.
## Indicative economic assessment for coal to oil products

<table>
<thead>
<tr>
<th>Input coal price (US$/tonne)</th>
<th>Crude oil production costs (US$/barrel)</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>ICL</td>
</tr>
<tr>
<td>15</td>
<td>35-45</td>
</tr>
<tr>
<td>125</td>
<td>80-90</td>
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<tr>
<td>155</td>
<td>110-120</td>
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**Diagram:**
- Coal to oil conversion process:
  - Coal preparation
  - Reaction
  - Separation
  - Refining
  - Gas clean-up and conditioning
  - Hydrocracking
  - Catalytic tar conversion
  - LFT
  - Gasoline production
  - Diesel production
  - Jet fuel production
  - Residue production

**Flowchart:**
- Coal to oil conversion process with inputs and outputs clearly labeled.
- Diagram includes catalyst and hydrogen inputs, along with various stages of transformation.
# Environmental considerations

## Chinese applications

<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>ICL</td>
<td>4.39</td>
<td>13</td>
<td>5.0</td>
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<tr>
<td>Coal to olefins</td>
<td>6.68</td>
<td>33</td>
<td>5.5</td>
</tr>
<tr>
<td>Coal to ethylene glycol</td>
<td>2.55</td>
<td>14</td>
<td>2.0</td>
</tr>
<tr>
<td>Coal to SNG</td>
<td>2.83</td>
<td>6.58</td>
<td>2.5</td>
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**Note:**
- Standard coal consumption: tonnes/tonnes
- Water consumption: tonnes/1000 Nm3
- CO2 emissions: tonnes/tonnes
Near term low cost carbon intensity reduction opportunities in China

CO2 EOR offers best near term prospect in China to compensate for CO2 transport and injection costs.

USA (NETL) work suggests that Coal to Chemicals with CCS can achieve a smaller (5-12% less) carbon footprint compared petroleum-derived diesel.

Inclusion of CCS on CTL would add ¥7 per gallon to the required selling price of the diesel product.
Initiatives to establish major CCS projects based on coal to chemicals projects by multilateral development banks

<table>
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<tr>
<th>Project Name</th>
<th>Storage Site</th>
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<tbody>
<tr>
<td>CCUS demo project of Yulin Energy and Chemical group in Shaanxi Province</td>
<td>Jingan oilfield</td>
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<td>Ansai oilfield</td>
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<td>Yanchang oilfield</td>
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<td>Huachi oilfield</td>
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<tr>
<td>Shenhua Group Yulin Coal to Liquid Project</td>
<td>Jingan oilfield</td>
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<tr>
<td></td>
<td>Ansai oilfield</td>
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<tr>
<td></td>
<td>Yanchang oilfield</td>
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<tr>
<td>Shenhua Ningxia Coal to Liquid Plant Project</td>
<td>Lizhuangzi oilfield</td>
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<td>Majiatan oilfield</td>
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<tr>
<td>Regional CO₂ capture, EOR and industrial chain project</td>
<td>Lizhuangzi oilfield</td>
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<td>Majiatan oilfield</td>
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<tr>
<td>Ordos coal chemical industry projects</td>
<td>Ansai oilfield</td>
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<td>Saline aquifer</td>
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People’s Republic of China:
ROAD MAP FOR CCS DEMONSTRATION AND DEPLOYMENT
Conclusions

• Coal gasification for chemicals, gaseous and liquid fuels production can fulfil an important need, particularly in various developing and industrialising countries where coal is the primary fuel source and oil and gas energy security is an issue.

• However, the establishment of projects in such countries can be problematical for a number of technical and economic reasons, although it is encouraging that some projects appear to be moving forward.

• China offers a template for large scale coal to chemicals, gaseous and liquid fuels deployment, for all stages of the industrial development cycle. It can also financially underpin such projects, including the associated infrastructure needs.

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