Gasification based coal to chemicals in China: economic and environmental challenges

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Membership status of the IEA Clean Coal Centre at April 2016
Scope of presentation

- Rationale for coal to chemicals deployment in China
- Status of development through to 2014
- Global economic instability and downturn in oil prices through to 2016
- Economic issues arising and possible factors that impact on the way forward
- Environmental issues that need to be addressed
- Current difficulties in reconciling economic and environmental concerns within the overall strategic framework
Rationale for coal to chemicals deployment in China

- China is a coal-rich but oil- and gas-lean nation

- Security of energy supply is a critical issue

- Coal to chemicals, liquid fuels and synthetic natural gas is seen as a potentially attractive means to counter this situation

- Also provides a means for the major cash rich State Owned Enterprises to diversify their energy product portfolios, in line with national strategic initiatives.
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 in northern parts of China where majority of suitable coal is located
- Need to optimise both high efficiency operation and the production of top quality products
- Ensuring these needs are addressed represents a key part of process approval procedure
- Increasing recognition that these are high intensity coal conversion processes
Economic challenges

• These large scale projects represent a massive upfront capital investment to cover the coal conversion plant itself and the associated infrastructure.

• The production cost of the coal can be reasonably well estimated and normally is relatively stable. In contrast, the costs of oil and gas, from which the end products can also be made, have always been more volatile.

• Consequently, the overall profitability is very difficult to estimate, for the 50 year lifetime of the process since there will be times when oil/gas-based end products are more competitive than the coal based versions.

• As such, the financial stability of the coal based conversion technologies projects is always vulnerable to changes in oil and gas prices.
Key coal conversion products

- **SNG**
- **Olefins**
- **MEG**
- **Synthetic petroleum**
### 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>ICL</td>
<td>4.39</td>
<td>13</td>
<td>5.0</td>
</tr>
<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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</table>

**Standard coal consumption**

吨/吨

**Water consumption**

吨/1000Nm³

**CO2 emissions**

吨/吨
Status of coal to liquid fuels projects

- Three indirect processes, each of 160,000 t/year established and one direct process of 1Mt annual capacity
- Performance has steadily improved to achieve close to full specification
- 16 coal-to-liquids plants, with a cumulative annual production capacity of over 22 Mt, are at advanced planning stages.
- It is questionable that preparations are significantly under way for such projects, given the fall in crude oil prices and the impact on the financial viability of such coal conversion products.
- Break even is when crude oil international prices are in excess of US$60 / barrel
Status of coal to SNG projects

- Original deployment schedule has not been maintained and the coal to SNG industry in China is still in the large demonstration stage.
- Plants are running at low utilisation rates as a result of technical problems and design issues.
- Technological requirements to ensure adequate efficiency, minimisation of water usage and ensuring adequate environmental performance are challenging, with consequent need for a high standard of management.
- These issues are being addressed but this has had a knock-on effect on approval procedures for other projects.
- In particular, trade-off between gasifier type and wastewater pollutant content is critical.
- SNG breaks even with oil based products at a crude oil price around US$60-70/barrel.
- Operation continuing for functioning units, to get some return on investment and limit unemployment consequences.
- For units at the design, FEED or construction phases, the preferred option is to slow down preparatory work until the market recovers.
National sales are some 30-50,000 tonnes/month.

Development drivers are to optimise operation of MEG production through carbonylation and hydrogenation of synthesis gas, scale-up of major equipment, such as dimethyl oxalate synthesis reactors and dimethyl oxalate hydrogenation reactors. There is also a need for optimization of technologies for wastewater treatment and reuse.

MEG distillation efficacy and product quality improvements are also critical, as is identification of other economic and practical coal-to-MEG routes.

Economic viability of the process is not yet proven although it appears that products are competitive when oil is $US40-50/barrel and there are technical issues to be resolved, including maintaining stable operation at high load factors while ensuring that polyester-grade quality MEG products can be produced.
Many projects have been placed into service and several more facilities are scheduled to come online over the next year, which if achieved would provide some 12 Mt of coal to olefins production by the end of 2016.

Need to introduce more highly efficient catalysts for improvement of product selectivity and yield, in order to penetrate the higher value end-use markets.

Need to ensure operational stability, optimise the individual system components such as gasifiers as well as better integrate the overall engineering design, including air-cooling and other water management technologies.

From a purely economical perspective, coal-based olefins production is still a viable source of supply compared to a naptha based product, even when crude oil prices are at distressed levels. Breakeven price is thought to be in US$ 40-50/barrel range.
Prospects for commercial scale clean coal conversion in China

Strategic impact

• Supports energy security while promoting regional economic opportunities

• Has provided a major national economic stimulus through enhanced employment, and cost reduction caused by localization of equipment & technology

• Offers export opportunities for the technology and associated engineering contracts
Interconnected economic, energy and environmental challenges

- Coal to synthetic fuels processes appear to operate adequately but are not optimised in all cases.
- Only nominally financially attractive when crude oil international prices are in excess of US$60 / barrel although there is a range of breakeven values depending on the process and the local circumstances.
- CTO and CTMEG have both shown that they can be economically attractive even when oil prices fall to $40-50/barrel but not every demonstration project has been successful.
- Operational performance of coal to SNG, has been unacceptable while the required environmental standards have not always been met, due in part to the type of gasifier selected.
- It appears that problems are due to ineffective decision-making, inappropriate technology selection, and the need for comprehensive high standard project management.
- The other issue of concern is the release of CO2 into the atmosphere. Should the sector continue to grow, this will impact adversely on China’s declared intention to peak its national CO2 emissions by 2030.
Knock-on impacts on plans to establish major CCS projects based on coal to chemicals projects

<table>
<thead>
<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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<td>Shenhua Group Yulin Coal to Liquid Project</td>
<td>Jingen oilfield</td>
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<td></td>
<td>Ansai oilfield</td>
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<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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<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 aquifier</td>
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People’s Republic of China:
ROAD MAP FOR CCS DEMONSTRATION AND DEPLOYMENT
Export opportunities

- Seeking export opportunities for its own gasification technologies as well as to establish a major engineering, procurement and construction role on overseas projects, where it has in some cases licensed technology from international suppliers.

- It can provide the technical expertise and financially underpin such projects, including the associated infrastructure needs, which becomes a very competitive option.

- The potential to export technology and expertise is reasonable, particularly in Mongolia, which has adequate low grade coal and water supplies. Discussions for a major coal to SNG project, with the end-project being transported to China, are underway. Elsewhere in Asia, Chinese companies have established a coal to fertiliser project for a company in Vietnam. Further prospects are being pursued.
Final thoughts

- China does not yet have a commercial scale coal to chemicals and fuels sector established, but it does have the necessary framework in place at large scale.
- Besides options just considered, there are others being trialled at industrial pilot scale.
- However, like all previous attempts worldwide, China is struggling to reconcile national strategic requirements with international market forces.
- That said, China has established long term plans.
- The energy optimisation challenges can be solved, while the government can underpin the economic uncertainties on strategic grounds.
- The biggest issue may yet be environmental sustainability.