Chemical Quarterly 2012.Q4

China coal-to-olefin (CTO/MTO). Exploring for the new El Dorado

A broad range of industry players are currently trying to enter China's coal-to-olefin business, but based on which fundamentals and other specific business rationales? This paper highlights both preliminary potential and major challenges to come such as the carbon tax. The salient finding is the need to look at this sector from a polyolefin perspective (and its derivatives) rather than a more narrow focus on olefins.

China's Energy Policy 2012 White Paper issued by the State Council in October 2012 interprets China's dependence on foreign energy sources as a major threat. For example, the proportion of imports in total Chinese oil consumption rose from 32% in 2000 to 57% presently, which makes China vulnerable to potential risks from international transportation and oil price fluctuations. In line with the intent of the country's feedstock diversification strategy, alternative routes to produce olefin, whether coal-based (CTO) or directly methanol-based (MTO), are currently explored to complement the oil (naphtha) route.

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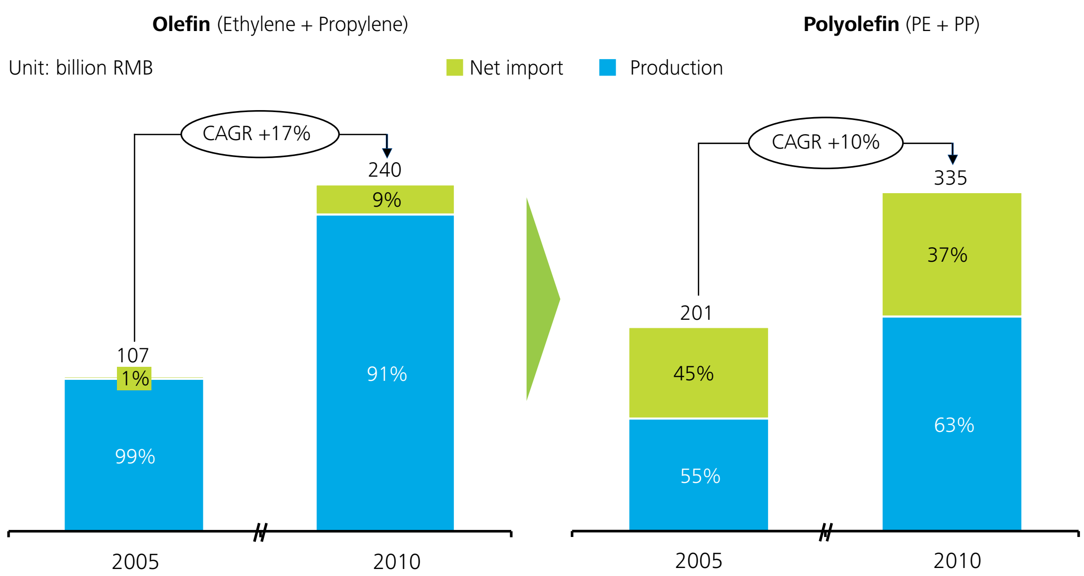
CTO/MTO as alternatives to produce highly needed olefin and polyolefin

Driven by China's economic development, domestic demand for olefin and polyolefin has steadily increased in recent years. From 2005 to 2010, the volume of China's consumption of olefin and polyolefin grew by 14% and 10% per annum respectively, to reach 27.8 million metric tons (RMB 240 billion in value) of olefin and 30.0 million metric tons (RMB 335 billion) of polyolefin. To satisfy this demand, China has been sourcing increasing amounts of olefin and polyolefin from overseas. In 2010, imports represented as much as 37% of total Chinese polyolefin consumption. The import ratio of olefin is much lower (9%) because it must be cryogenically transported (Exhibit 1).

In line with the intent of the country's feedstock diversification strategy, alternative routes to produce olefin (coal-based or directly methanol-based) are currently being explored to complement the oil (naphtha)-route. Since the 11th Five-Year Plan (2006-2010) in China, coal-to-olefin (CTO) has been prioritized as one of the key directions of Advanced Coal Chemicals (CPCIF definitions: Methanol, DME, EG, Olefin, Fuel, NG).

While the Chinese administration is pushing CTO, it is taking a very structured approach, since it is keen to avoid over-heated and disorderly investment in this sector, and avoid past experience in some other coal-based chemical sectors such as methanol. The CTO project approval authorization process is thus centralized at National Development and Reform Commission (NDRC) level with a set of entry barriers to ensure asset efficiency and environmental protection.

Exhibit 1: China consumption value of olefin & derivatives (2005-2010, bn RMB)



Source: China Custom, China Statistical Yearbook, World Economy Year Book, Deloitte analysis

First, the NDRC has fixed a given threshold to prevent a diffusion of effort through projects of smaller scale (the minimum capacity required is 500,000 metric tons/year). Second, it aims at reducing energy consumption and environmental impact (see inset box) such as by fixing a maximum consumption rate of fresh water (CTO projects are directed to locate in areas rich in coal as well as abundant supplies of water).

Overall, the NDRC is managing the site selection and pace of new CTO projects, limiting annual coal-to-olefin capacity to 4 to 5 million metric tons in 2015 (according to the deep-processing coal projects planning draft). In contrast, methanol-to-olefin (MTO) projects seem not to have been fully considered in current regulatory directives. While they may be able to disregard some of those constraints, new regulation in this sector should be continuously monitored over the coming months and years.

China water scarcity: a major issue for CTO

CTO projects consume large amounts of fresh water. For instance, a past CTO project roughly consumed 40 metric tons of fresh water to produce 1 metric ton of olefin as reported by Chem99.

China challenge: The top eight coal-rich provinces are mostly scarce of water. The autonomous region of Inner Mongolia and the province of Shanxi are richest in coal basic reserves (> 70 billion metric tons), but are both dramatically lower than most other provinces in water reserves. Guizhou, Xinjiang and Anhui are around the national average for water, but their water tables lack balance and are hard to reach. Finally, Henan, Shandong and Shaanxi are also far below the national average.

To increase environmental protection, NDRC wants to specify, albeit tentatively, that CTO demo projects should consume less than 13.2 metric ton per ton olefin production of fresh water for basic and 10 ton for advanced projects.

Broad range of CTO/MTO new entrants, raising concerns about overcapacity

China's current olefin capacity is mostly based on oil (naphta) route, and production is highly concentrated among the three top national oil companies (NOCs), which together accounted for 86% of the total capacity (31 million metric tons) in 2010. Actually, 81% of production that year was attributed to two of the three NOCs (Sinopec and PetroChina). CTO/MTO capacity is relatively low, with just four projects accounting for about 1.8 million metric tons in 2010: Shenhua (two CTO projects, one in Baotou, Inner Mongolia; and a second in Yinchuan, Ningxia), Datang (one CTO project in Duolun, Inner Mongolia), and Sinopec (one MTO project in Puyang, Henan).

In the 12th Five-Year Plan (2011–2015), a 20-million-metric-ton increase in olefin production capacity has already been planned for the oil (naptha) route, which would be an increase of nearly 70% from the 2010 capacity of 29 million metric tons. So one might ask, what is driving these investments in CTO/MTO?

Actually, there is not one factor, but rather a convergence of the interests of several types of players, each pursuing these investments for their own reasons. First, most coal mining players have begun to anticipate a future plateau of coal demand due to the development of shale gas (Whether this will happen anytime soon is not the question to those players, for whom the perceived threat is sufficient motivation). These players want to diversify into advanced coal chemicals, CTO production requiring mega projects with capital expenditures ranging from RMB 15 to 30 billion. Second, power generation companies (with large coal reserves) are looking for alternative investments in non-regulated activities to expand their margins, with advanced coal chemicals being one possible direction. Examples of Gencos with coal chemical activities are Huaneng, Datang, CPI, Guodian and Huadian. Third, some private or regional SOE chemical players are willing to surf the current investment wave and capture most of the short-term value around not only CTO, but also MTO.

Each of these players are participating in the development of the CTO/MTO sector either alone or in cooperation with each other. For instance, joint development projects are occurring between coal-rich power gencos, and petroleum companies such as China Coal and Shaanxi Yanchang Petroleum, or China Power Investment and Total, and between coal miners and chemical companies such as Shenhua and Dow Chemical.

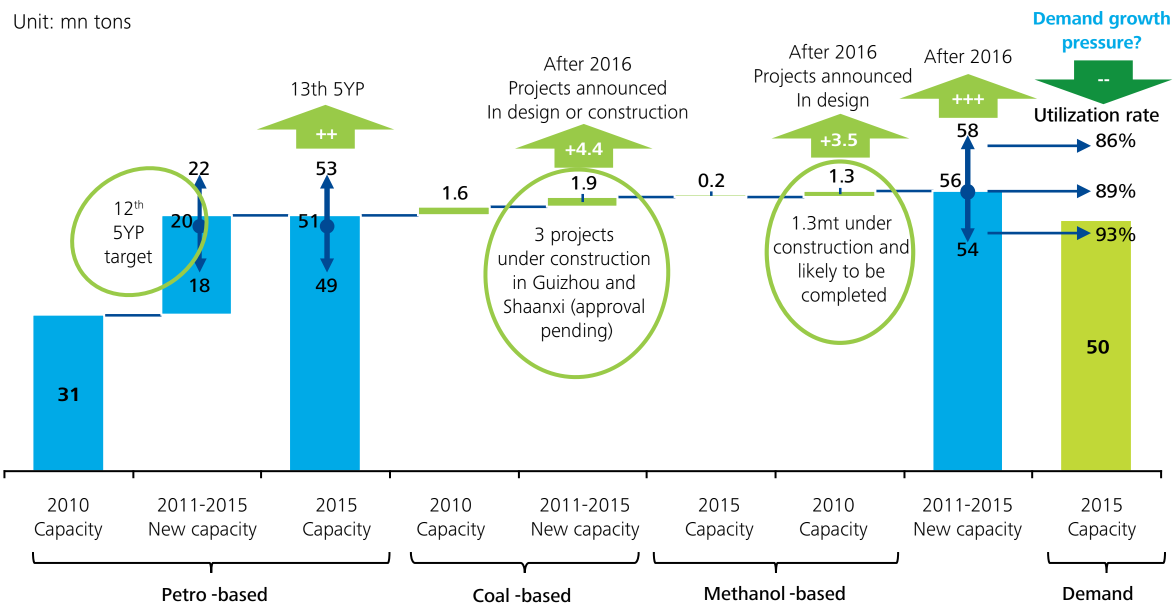
By the end of the 12th Five-Year Plan, China's olefin capacity may reach 56 million metric tons at minimum; but there are uncertainties in new MTO projects that could cause that capacity to be expanded even further. Combining new capacity and potential pressure on the olefin demand growth, the sector overall may see some overcapacity coming online over the next few years. After 2015, overcapacity could accelerate. CTO/MTO projects with a combined capacity of at least 7.1 million metric tons are being planned, are awaiting approval, or are being constructed. In addition, there are already over 10 PDH (Propane Dehydrogenation) projects announced with total capacity of around 4.7 million metric tons. These and forthcoming developments in the industry should be closely monitored, and any prospective new entrants should reinforce their competitive advantages or rationales to enter such as forward integration (Exhibit 2).

For CTO project completion by 2015, three new projects have received approval and may finish construction in due time (combining 1.88 million metric tons of olefin capacity: Sinopec Zhijin, 600kt; Yanchang – China Coal Yulin, 600kt; and Pucheng Clean Energy, 680kt [awaiting approval]). Other projects such as between China Power Investment (CPI) and Total are expected to be approved, which would add additional capacity to the market after 2016 or 2017.

For MTO project completion by 2015, four projects may be finished by 2015, most located near China's east coast and combining 1.49 million metric tons of olefin capacity: Sinopec Puyang, 200kt-already finished in 2011; Nanjing Wison (Huisheng), 300kt; Ningbo Heyuan, 300kt; and Zhejiang Xingxing New Energy, 690kt. However, upcoming MTO capacity may be much greater, since there are as yet no specific policy constraints regarding MTO project development.

A major NOC (Sinopec Corp.) has set up a coal-to-chemical company (Sinopec Great Wall Energy Chemical Co Ltd), which aims at becoming a frontrunner in the coal-to-chemical field in China within eight to ten years."Sinopec will play a bigger role in converting China's rich coal resources to chemical raw materials, which is of great significance in adjusting China's energy structure," Sinopec Chairman Fu Chengyu said in the statement to Reuters on September 28, 2012.

Exhibit 2: China olefin capacity[1] 2010 vs.2015



Source: Deloitte Consulting estimates; Note: 1) Operative capacity with approval of production from regulatory bodies

Can the initial profitability be sustained?

To understand the economics behind China CTO projects, Deloitte has built a simplified financial model to show what is driving profits. In the pro forma calculations, key assumptions were considered such as a plant's use of DMTO-II technology, a utilization rate of 85%, and an assumption that by-products (butylene and sulphur) will be sold out at market prices. These assumptions cannot be guaranteed for all players, and new entrants may find them especially challenging. For instance, past CTO projects typically had a long time to ramp up before being fully operational.

At first, China CTO seems to display good profitability. From April 2011 to April 2012, the pro forma average gross margin stood at around 35% (Exhibit 3).

However, CTO projects' profitability margin can vary a lot depending on the prices of coal and oil. For example, the pro forma financial model shows a 30-point difference in gross margin between the months of April and November 2011. Coal price is a major determinant on COGS, and the variance in oil prices impacts the prices of olefin in a simplified approach. This means that to ensure sustainable profitability, CTO projects must either backward integrate into coal production, or forward integrate, especially if starting directly from methanol. At present, most Chinese CTO players are fully backward integrated into coal mining, but the coal price gain is not that big (at a discount of up to 10%), since coal groups have structured transfer pricing in place across business units. This gives them partial protection when coal prices vary. On the other hand, MTO players start from either domestic or imported methanol to produce polyolefin. For MTO projects any methanol price variance, or tariff risk in the case of imports, may significantly alter their profitability outlook.

Core technology process: Methanol-to-Olefin

CTO projects have multiple production process steps, with MTO being the most critical one. A number of Chinese organizations, including DICP (Dalian Institute of Chemical Physics), Sinopec and Tsinghua University, are among the pioneers to have developed various MTO technologies

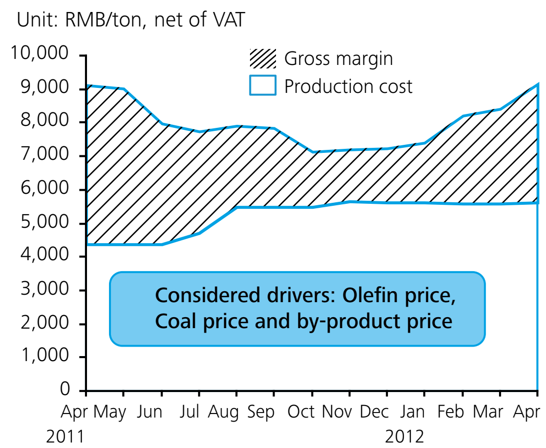
Some players claimed to have developed the 2nd-generation technology; UOP (a Honeywell company), DICP and Tsinghua University are three representatives. The 2nd-generation technology is meant to be more efficient, targeting to use only 2.6 tons methanol to produce 1 ton olefin, while the first generation technology requires 3 tons methanol. This would lead to significant reduction of coal and water consumption. The UOP-Total and DICP 2nd generation technologies, named UOP/OCP and DMTO-II respectively, are yet to be fully tested in large scale commercial projects.

On a separate approach Tsinghua University and Lurgi have developed MTP (methanol to propylene) technology with higher ratio of propylene in the olefin mix (from over 80% up to 98%). However, it may be difficult and costly to purify ethylene through cryogenic process due to the low ethylene ratio in olefin mix. Lurgi MTP is used in two projects in China.

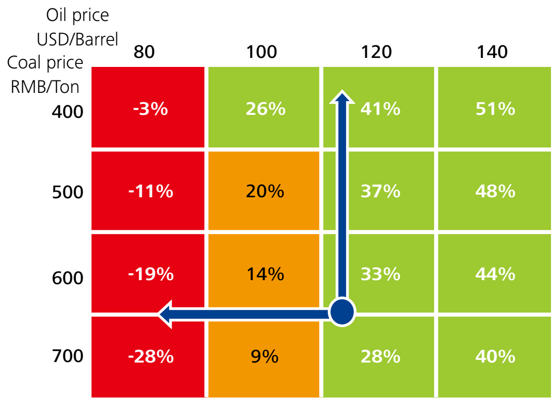
Sensitivity analysis on the pro forma financial model further indicated how coal and oil price changes will impact CTO profitability. It shows that when the price of oil stands at US$140/barrel and the price of coal at RMB400 /metric ton, then the CTO project's EBIT margin can attain as much as 51%. In contrast, with oil at US$100/barrel and coal at RMB700 /metric ton, the EBIT margin can shrink to as little as 9%; and if oil falls below US$80/barrel, there may be a systemic loss for the CTO project (Exhibit 3).

Compared with the traditional oil (naphta) route, the coal route to produce olefin demonstrates a better cost position. For example, CTO projects reaped 52% gross margins in April 2011 and 21% in November, outshining the naphta-based steam crackers (using KBR SC-I technology) by 35 and 21 points of margin, respectively (Exhibit 4).

Exhibit 3: China CTO gross and EBIT margin PROFORMA



EBIT margin sensitivity analysis



Coal price RMB/Ton \ Oil price USD/Barrel	80	100	120	140
400	-3%	26%	41%	51%
500	-11%	20%	37%	48%
600	-19%	14%	33%	44%
700	-28%	9%	28%	40%

Note: **Production cost is net of by-product sales (Butylene and Sulphur) – Sulphur might be more difficult to sell**

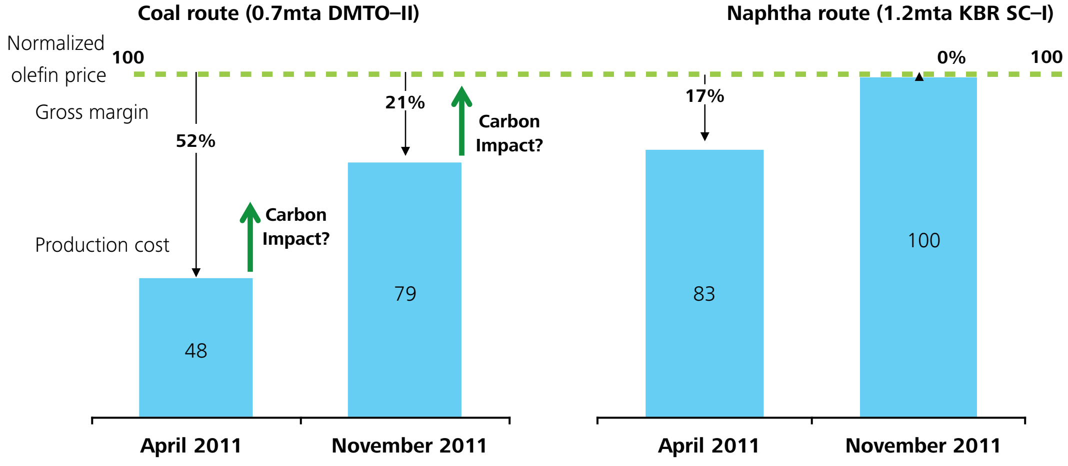
Key assumptions: 1) **85% utilization rate** 2) **0.7 mta capacity, using DMTO-II technology** 3) All by-products (0.17ton Butylene and 0.02ton Sulphur produced per ton of olefin) are sold 4) USD:RMB fixed to 6.3 5) SG&A as 6.4% of sales in base scenario (then fixed value)

Source: Deloitte Consulting estimates

However, optimism should be tempered with extreme caution about CTO economics in the Chinese market. Indeed, the CTO industry still presents many challenges and risks to be overcome, such as the price and quality consistency of coal; water supply access and cost; MTO technology stability and maturity; and superior sales and forward integration capabilities.

Finally, one major uncertainty of the economic viability of CTO projects concerns the carbon tax (Exhibit 4). Some academic papers estimate that the carbon tax delta could be as high as RMB 2,000 /metric ton olefin, considering that the coal route emits seven metric tons more carbon for every metric ton of olefin output than the oil (naphta) route. If so, the carbon tax would offset all current cost advantages of CTO projects over the oil (naphta) route. A trade-off might be defined by the Chinese administration between RMB 300 and 1500 /metric ton olefin to ensure the development of that sector in the coming 10 to 15 years.

Exhibit 4: China olefin production gross margin PROFORMA (85% utilization rate)



- Olefin P/E ratio = 1:1

- Olefin P/E ratio = 2.1:1
- Backward integrated in Naphtha production (based on crude oil cost)

Source: Deloitte Consulting estimates

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Acknowledgements

The authors would like to thank Tracy Wang, Lydia Chen, Sylvia Yu and William Hillis for their contributions in editing, review and design of this Deloitte Chemical Quarterly report.

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