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The Cleaner Coal Conversion & Utilization Technologies in Shenhua and China

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Corporate Profile of Shenhua Group

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- One of the State-Owned Enterprises (SOEs), established in 1995
- The largest coal company in China and the largest coal supplier in the world

- An integrated mega-large energy company with the businesses covering mining, power, railway, port and coal to liquids & chemicals.
- 37 subsidiaries (Branches), 210,000 employees and RMB 530 billion total assets (at end 2009)

Shenhua Business 2010

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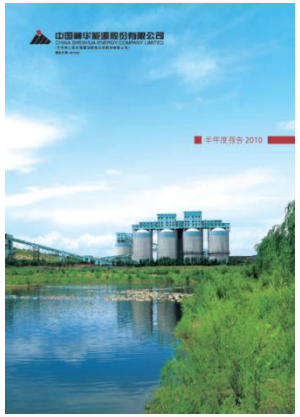
Coal Production: 352 million tons (+7% than 2009)

Coal Trading: 440 million tons (+24%)

Power Generation: 160 billion kWh (+34%)

Revenues: RMB 217 billion (+35%)

Profit & Tax: RMB 57.5 billion (+24%)







Shenhua Technology Innovation System

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Items	5-Year Objective
Coal Production	600 million ton/yr
Power Generation Capacity	60 GW
Railway Length	3,000 km
Port Handling Capacity	230 million ton/yr
Shipping Capacity	4 million ton
Coal-based Oil & Chemicals	5 million ton/yr

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Clean coal conversion: an inevitable choice for sustainable development

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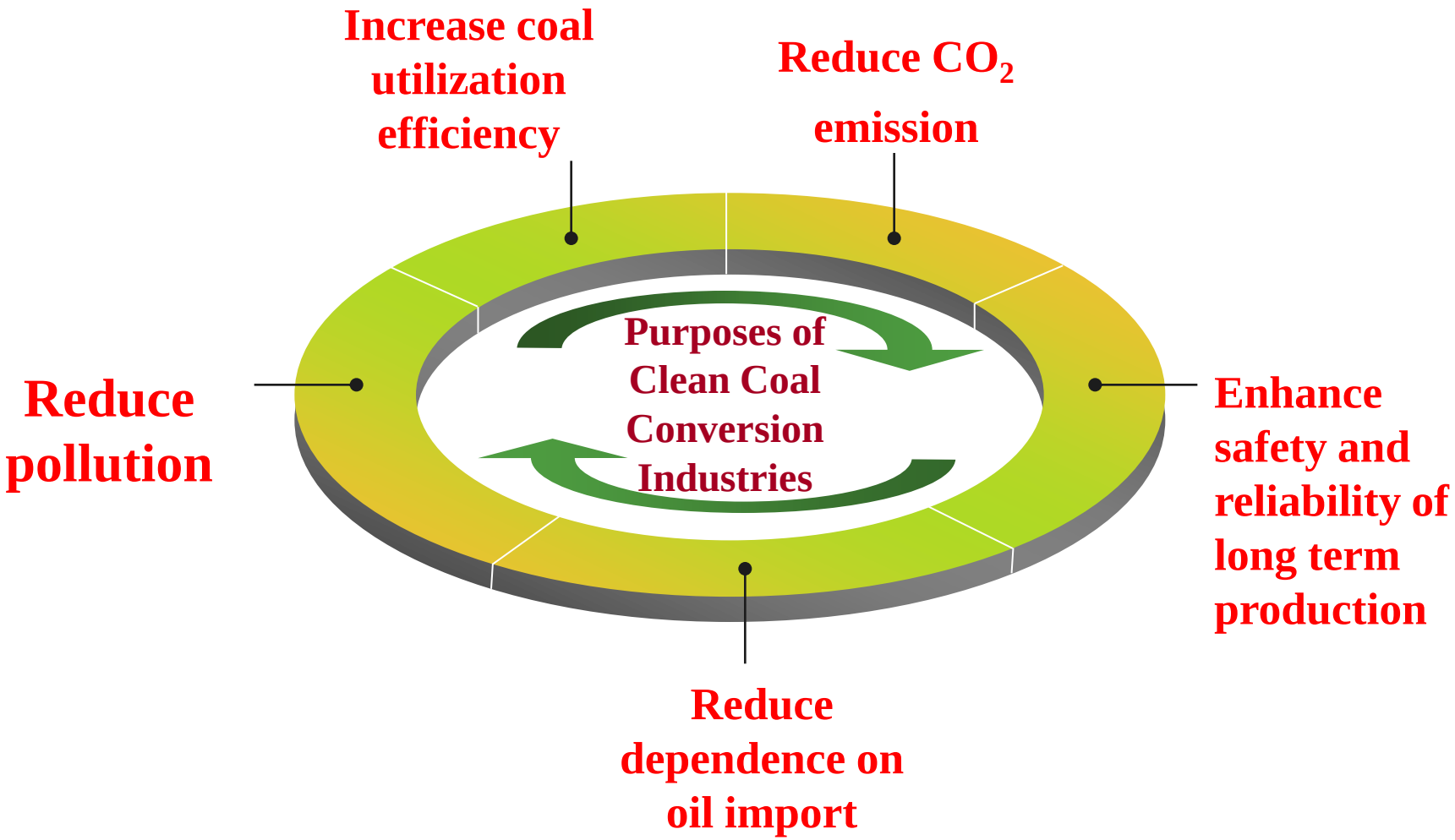
- China actively develops clean coal conversion technologies
- Coal to liquids chemicals industry grows rapidly in recent years



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Major Clean Coal Conversion Demo Projects in China

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Key techniques	Owner	Kilo -ton/a	Construction /Operation	Key indicators
Shenhua DCL	Shenhua Group	1,080	Start-up in late 2008, operation for accumulated 8,000-hours	Max: 100% of capacity
SYNFUELS CHINA slurry bed FT synthetic oil	Yi Tai, Inner Mongolia	160	Products produced in March 2009, running for accumulated 9,600-hours	Max: 90%～110% of capacity
SYNFUELS CHINA slurry bed FT synthetic oil	Lu'an, Shanxi	160	Start-up in July 2009, running for accumulated 8,800-hours	Max: 50%～60% of capacity
SYNFUELS CHINA slurry bed FT synthetic oil (with Shenhua catalyst)	Shenhua Group	180	Start-up in July 2009, running for accumulated 1,300-hours	$CO+H_2$ conversion rate: >88%
Mobil MTG technologies	Shanxi Jincheng Group	100	Start-up in June 2009, running for accumulated 8,000-hours	Reached designed capacity
DICP, Chinese Academy of Sciencess, MTO technologies	Shenhua Group	600	Start-up in August 2010, producing over 80,000 tons of poly-olefins the same year	MTO reached full capacity
FJIRSM, Chinese Academy of Sciencess Coal-to-MEG	Tongliao Gold Coal Chemical	200	Construction completed, products produced in late 2009	Max: 50%～70% of capacity

Major Clean Coal Conversion Demo Projects in China

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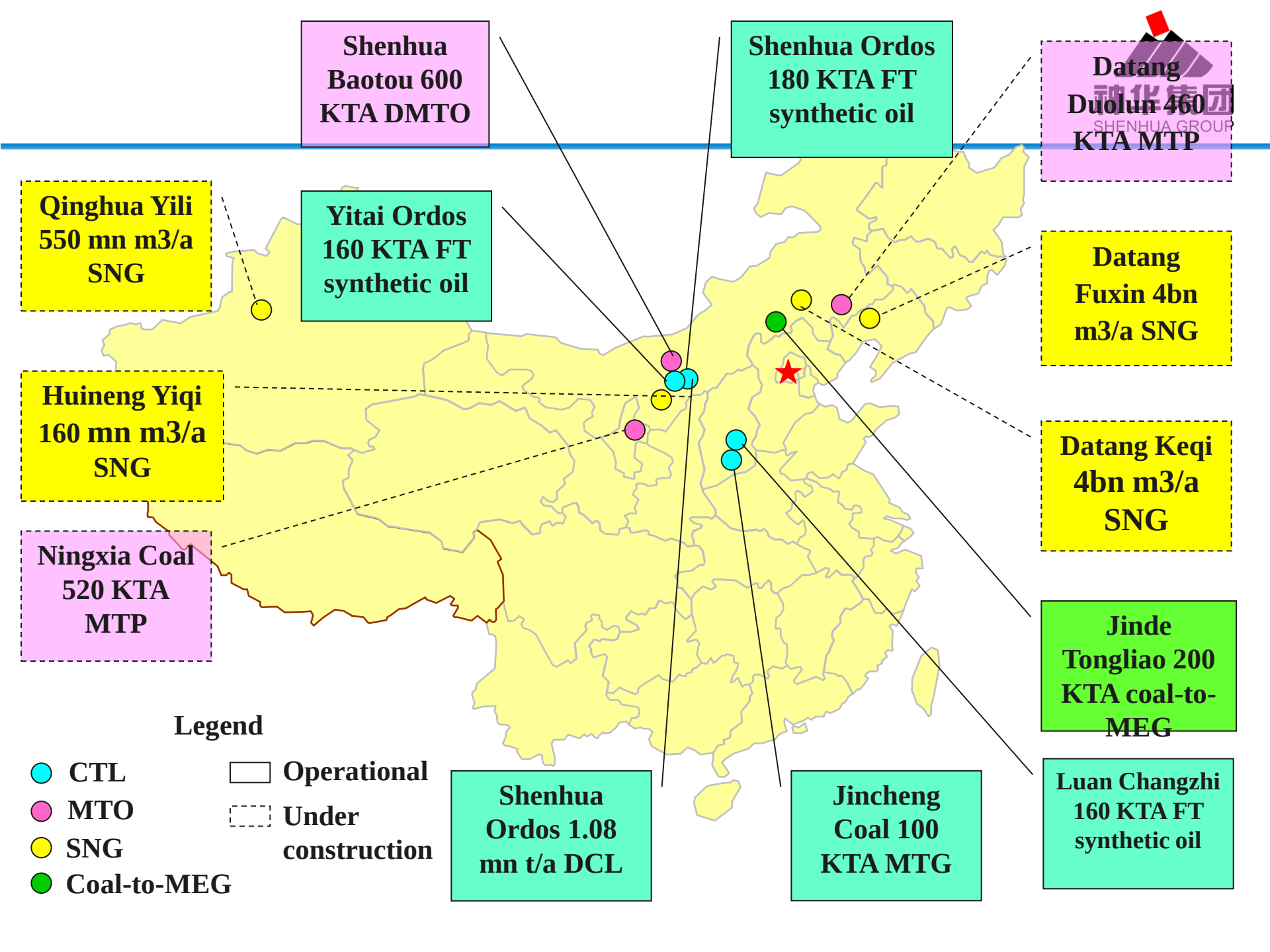
Summary of industrial demonstration（13 projects）

- **Five coal-to-liquids demo projects up and running with total capacity of 1.68 MM ton/a (another 200,000 ton/a methanol-to-gasoline project under construction)**
- **One 600,000 ton/a MTO project running, construction of two projects being completed with total capacity of 980,000 ton/a.**
- **One 200,000 ton/a coal-to-MEG demo project just completed.**
- **Four SNG demo projects approved and at preparation stage, with planned annual capacity totaling 15.1 billion cubic meters.**


Shenhua Baotou 600 KTA DMTO
Shenhua Ordos 180 KTA FT synthetic oil
Datang Duolun 460 KTA MTP
Qinghua Yili 550 mn m3/a SNG
Yitai Ordos 160 KTA FT synthetic oil
Datang Fuxin 4bn m3/a SNG
Huineng Yiqi 160 mn m3/a SNG
Datang Keqi 4bn m3/a SNG
Ningxia Coal 520 KTA MTP
Jinde Tongliao 200 KTA coal-to-MEG
Legend
CTL
MTO
SNG
Coal-to-MEG
Operational
Under construction
Shenhua Ordos 1.08 mn t/a DCL
Jincheng Coal 100 KTA MTG
Luan Changzhi 160 KTA FT synthetic oil

Shenhua DCL Demonstration Project

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1 MM ton/y DCL unit reached max. 100% of designed capacity, coal conversion rate reached 91% of the design and the DCL plant realized long-time steady operation.

Shenhua Indirect Coal to Liquids Demo Project

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- **Licensor: SYNFUELS CHINA slurry bed FT synthetic oil technology with catalyst developed by Shenhua**
- **Location: Shenhua DCL demonstration project site**
- **Capacity： 180,000 tons/a**
- **Construction completed: July 30, 2009. Commissioning in Dec., 2009, stable operation of 255 hr. 2nd commissioning in March 2010, stable operation of 1,113 hr.**

Operation of Shenhua Baotou MTO Demo Project

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- Start-up on May 30th, Methanol-to-Olefins (MTO) unit—the core unit—started-up successfully at first try; PP and PE produced in August. Over 80,000 tons of PE & PP produced in 2010.
- Commercial operation in 2011 and ~500,000 tons of polyolefin to be produced this year (85% of the design capacity).
- MTO unit is running at full capacity now.

SNG Demonstration Project

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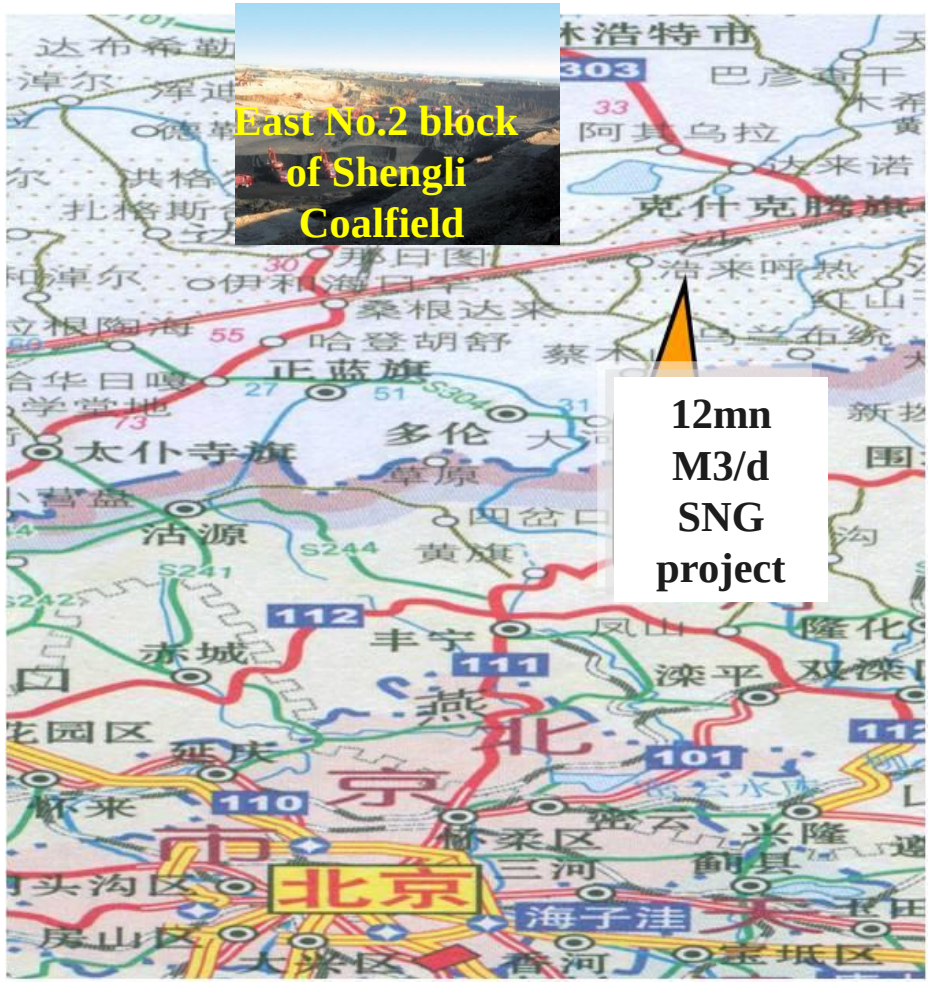
- Four SNG demonstration projects approved. Located in Inner Mongolia, Liaoning and Xinjiang respectively with a total capacity of 15.1 billion m^3/y.
- The 1st project is Dangtang's 4 billion m3/y SNG project located in Shiketeng Banner of Inner Mongolia. The first phase project will be completed by June 2012 with a capacity of 1.33 billion m3/y and start to supply gas to Beijing with 400 km pipeline.



Shenhua CCS Demo Project

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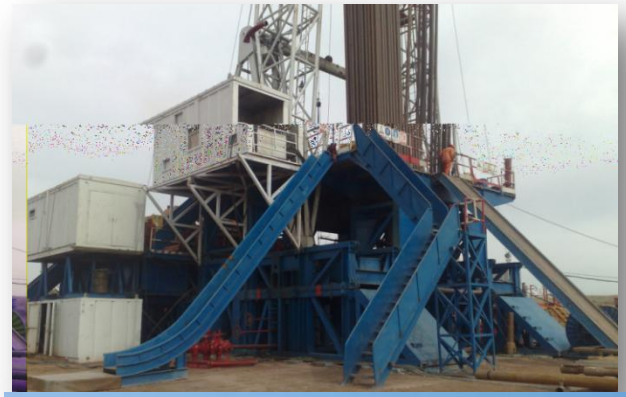

Feasibility Study started in 2007, concluded in Nov. 2009; Injecting CO2 from DCL plant close to the DCL site.

100 KTA CCS pilot plant successfully injected supercritical CO2 into the saline aquifer with a depth of 2,243.6m on Jan 2nd, 2011.

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Coal conversion process analysis

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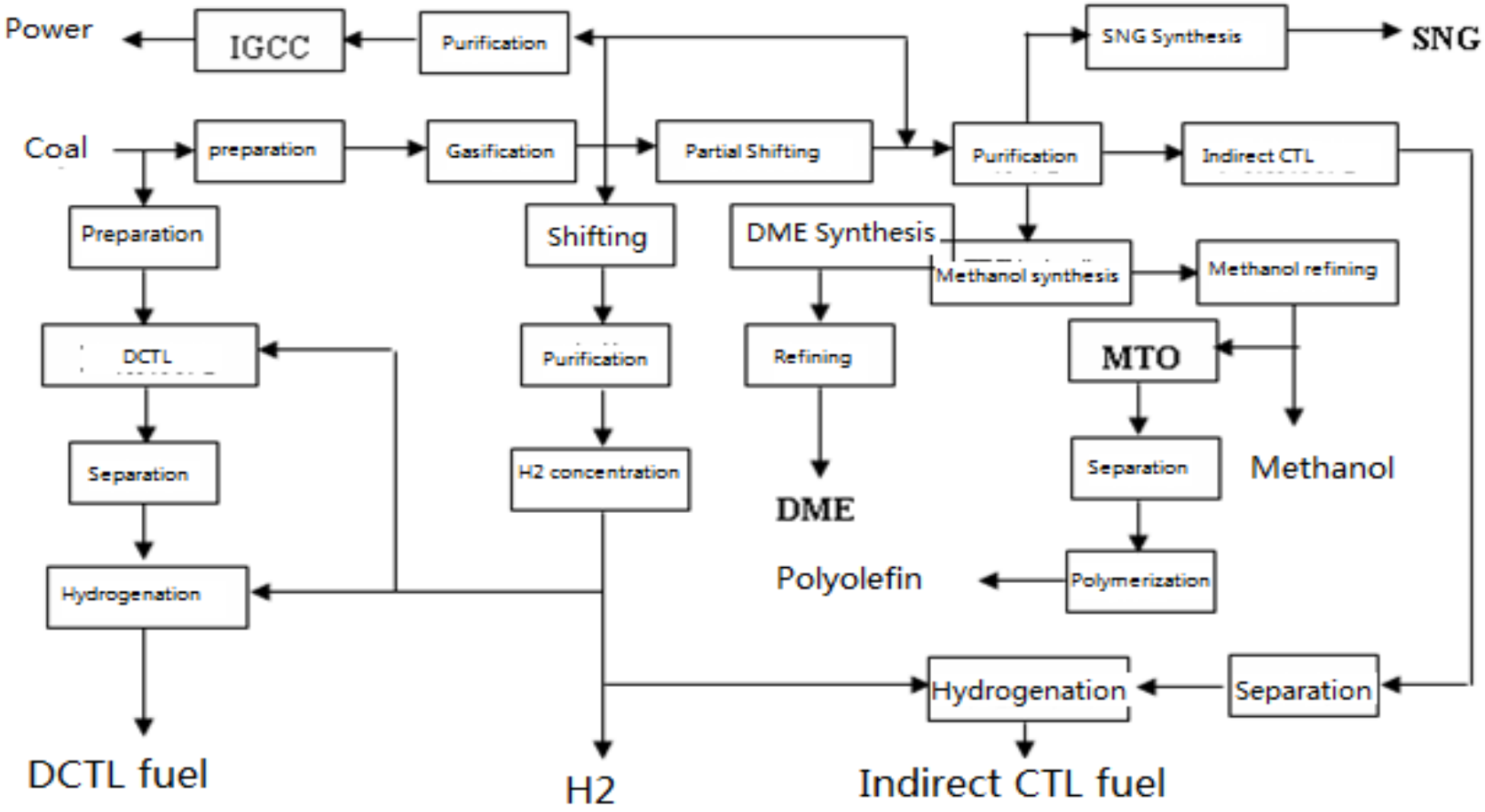
Different coal conversion processes: comparison and relationship



Coal to H2 is the simplest process while CTO is the longest one.

Coal conversion:Energy consumption Analysis

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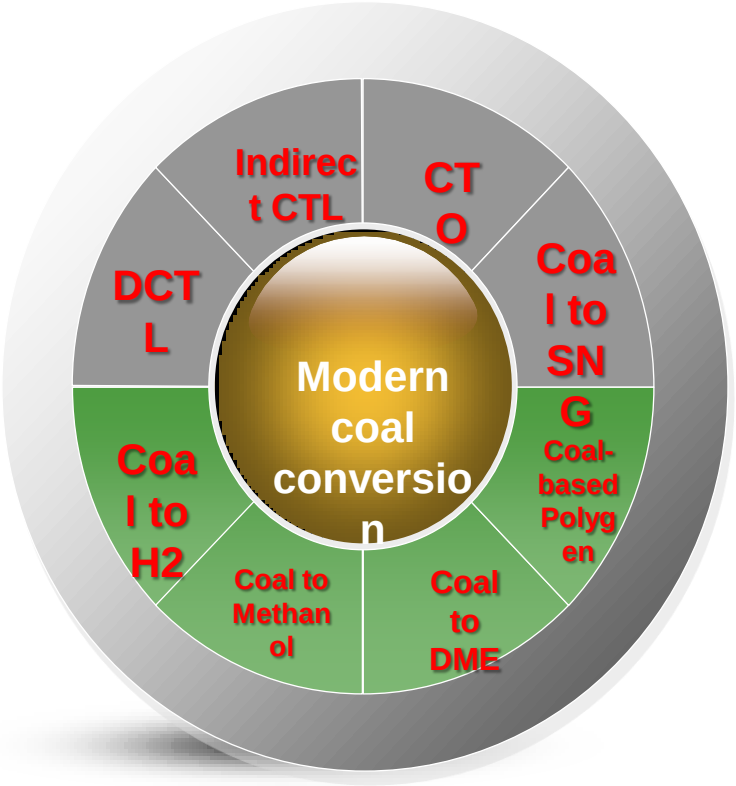
- Depends on the end product mix, coal to H2, coal to SNG and DCL are relatively efficient among all coal conversion processes since the conversion efficiency can be over 60% for certain coals & process.

- Coal to methanol/DME, indirect CTL and IGCC's energy conversion efficiency are roughly of the same level. CTO, the longest process, is the lowest one in terms of energy efficiency.



Coal conversion process analysis

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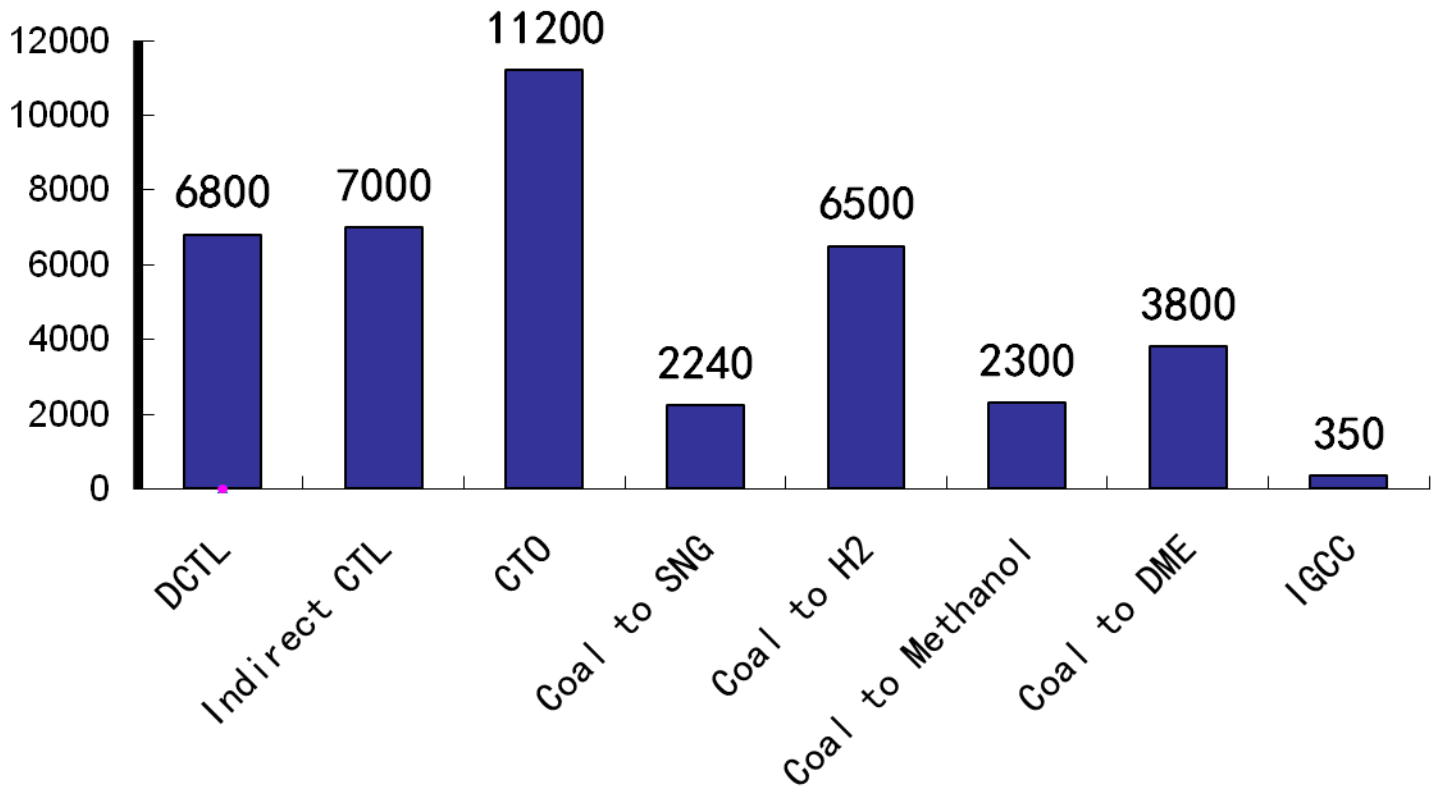
Industry value analysis

Product Price（RMB/T，RMB/1000KWh）



Product market is the main factor impacting the industry value of modern coal conversion

Coal conversion process analysis

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Industry value analysis

- In current market price, the value of CTL (either direct or indirect) and CTO are promising
- The current price of NG and H2 is only 30% of the oil product with the same BTU and 20% of the olefin products with the same BTU.
- According to oil/gas ratio in the current international market, if the price of natural gas or H2 can be 60% of oil with same BTU, the energy consumption, water consumption and pollutants emission per 10,000 industrial value-added for coal to SNG and H2 will be close to those in CTO.
- For those areas with no NG, but a lot of Coal, Coal to SNG and H2 with CO2 capture could provide the cleaner energy for the local market.

Coal conversion process analysis

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Economics of CTO

Baotou MTO	Refinery in Sinopec	Competitiveness
The overall cost (tax excl.) per ton of PE, when in full capacity is:	When oil at USD80/barrel, in an integrated large scale refinery with a capacity of 1 MM t/a, the total cost per ton of PE is:	PE, produced from CTO is more competitive than that derived from naptha, and the cost gap is：
RMB 6,985/t	RMB 8870/t	RMB 1885/t

Selecting strategic direction of coal conversion process

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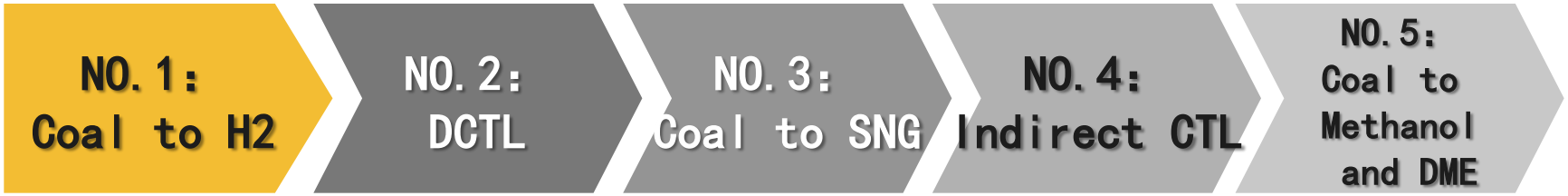
- In terms of life cycle energy efficiency, coal-based olefin to substitute oil-derived olefin, and coal-based H2 to produce fuel cell for car use are the highest.
- The lifecycle energy efficiency sequence among all modern coal conversion technologies, compared with conventional oil routes,is：



Shenhua Clean Coal Conversion Projects to be Executed during the 12th Five-Year Plan Period

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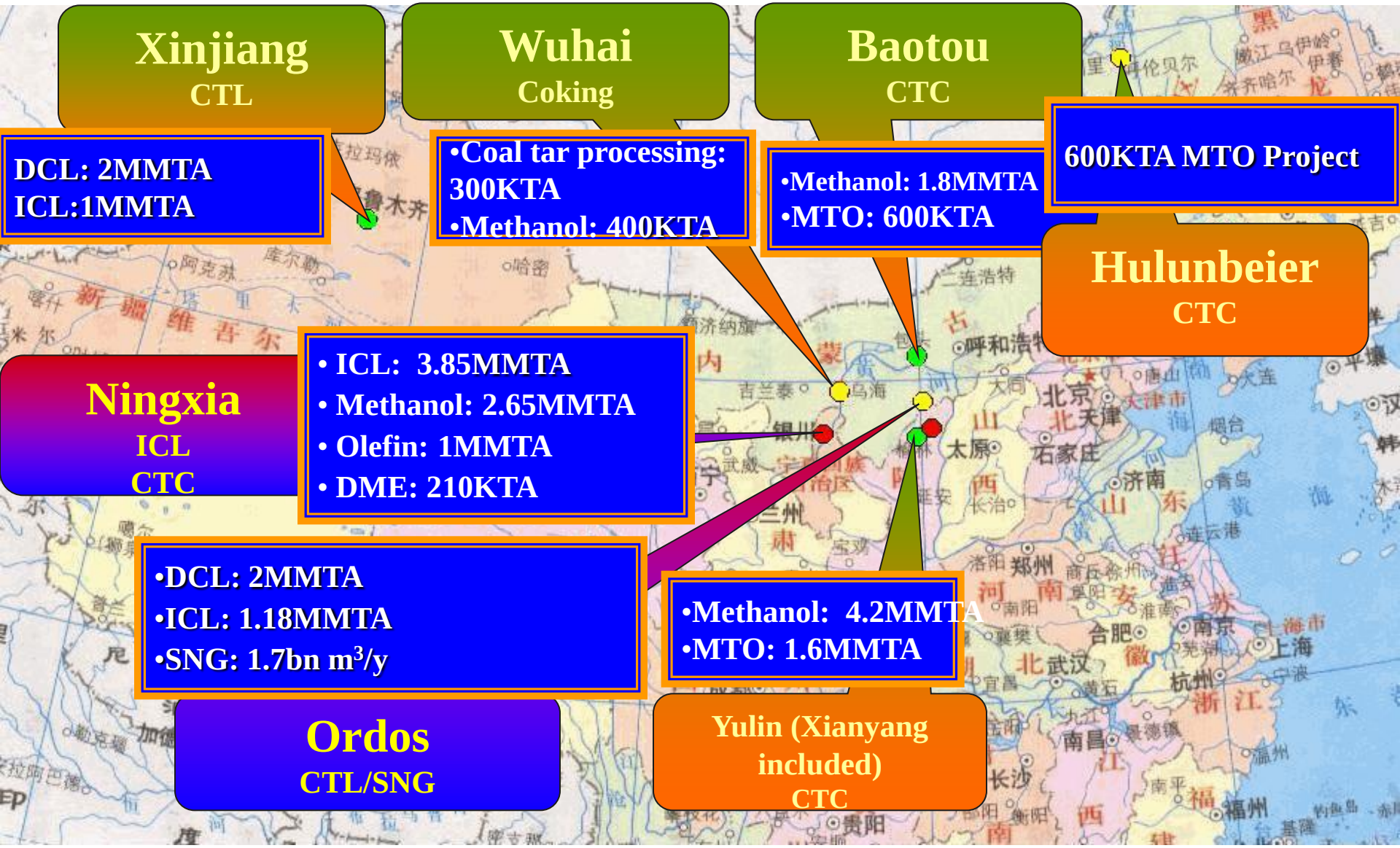

Shenhua Clean Coal Conversion Blueprint during the 12th Five-Year Plan Period

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Capacity by the end of the 12th Five-Year Plan period:

- **CTL: 10MMTA**
- **Coal-to-Methanol: 10.85MMTA (including methanol from MTO plant)**
- **Coal-to-Olefins: 3.8MMTA**
- **SNG: 1.7 bn m3/y**

Total investment: over 100 billion RMB (excluding capital contribution from partners)

R&D on Clean Coal Conversion Technologies

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- **Improve & optimize the DCL, ICL, Methanol-to-Olefins, Coal-to-EG technologies, and all of them have been demoed in commercial plant; enhance product yield and reduce energy consumption;**
- **Further R&D of SNG, MTG (methanol-to-gasoline) and MTA (methanol-to-aromatics) process, carry out scale-up test and build commercial demo plants;**
- **Reduce the cost by optimizing above processes, and making those large equipments in China.**
- **R&D on the polygen technology to commercialize polygen plant by combining chemical synthesis and power generation;**
- **R&D on CO2 mitigation, separation and recycle, storage and utilization (CCUS).**

R&D on Clean Coal Conversion Technologies

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Improvement, optimization and upgrade of the process used in the existing demo plants

E.g.: DMTO-II process development lead to methanol-to-olefins ratio from 3 tons:1 ton to 2.7 tons:1 ton. A 10,000 t/a pilot plant was built in 2009 and all the tests were completed in 2010, showing that the technology is ready to be commercialized.

R&D on Clean Coal Conversion Technologies

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Pilot plants and demo plants with new process

E.g.:

- **MTA (Methanol-to-Aromatics): Tsinghua University and Shanxi Institute of Coal Chemistry, Chinese Academy of Sciences have been engaged in the field for multiple years. The process has passed benchscale test and is ready for scale-up.**
- **Synthetic mixture of lower alcohols**

R&D on Clean Coal Conversion Technologies

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Explore the execution of clean coal conversion project

E.g.:

- **Optimization of clean coal conversion process: Choose right technology for main units according to the properties of raw materials and products to reduce capital cost, material consumption and energy consumption in order to maximize the overall efficiency;**
- **Major & critical equipment manufacturing by domestic vendors: For example: large compressors, high pressure valves and high temperature/ high pressure reactors are currently imported. Domestic vendors need to produce those equipment for lower cost.**

Key Focus of China's Clean Coal Conversion R&D

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Carbon Capture, Utilization and Storage (CCUS) Research

To conduct CCUS research on the basis of existing technology and project demonstration:

- **CCS: to develop low-cost separation technology of CO_2, packaged technology for geological storage, storage safety monitoring, evaluation system and alarm management system; larger project needed.**
- **CCU: to continue developing CO_2-EOR and CO_2—microalgae—biofuel as well as to explore other CO_2 applications for breakthroughs**

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Concluding Remarks

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- As China's economy grows, from national energy and security perspectives, coal conversion can be one of the important solutions for China to address the shortage of oil.

- The overall energy efficiency sequence among all coal conversion processes are: coal to H2, IGCC, coal to SNG, CTO, DCTL, coal to methanol, indirect CTL, coal to DME.

Concluding Remarks

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- **The oil substitution efficiency for CTO and direct CTL is approximately 2.45tce/toe，relatively high and it has potential room to improve.**

- **If the natural gas price is 60% of oil with the same BTU, the economic and environmental advantages of coal to SNG will appear. In addition, coal to natural gas, with 65% energy conversion efficiency, is an efficient process. The oil substitution factor with coal can be 2.15tce/toe，which is quite promising and is of significant potential.**

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Questions ? Thank You!

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