CMI Eighth Annual Meeting

Fossil Energy in China

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Outline

- Fossil energy flow in China
- Fossil energy technologies in China
  - Power generation
  - Alternative fuel activities
- Energy dilemma and policies
Fossil fuel consumption in China@2005

**Coal**
- Prod.: 15.75
- Conspt.: 15.32
- For coke: 2.85
- For power: 6.84
- For heat: 0.94

**NG**
- Prod.: 0.65
- Conspt.: 4.15
- Pipe loss: 0.01
- Crude oil for power and heat: 0.01

**Crude Oil**
- Prod.: 2.59
- Imp.: 1.81
- Crude oil export: 0.11
- Crude oil storage: +0.01

**Power/Heat production 8.74**
- Power: 3.06
- Heat: 2.35
- Coke: 3.15
- Coke export: 0.12

**Loss 4.9**
- Line loss: 0.21
- Heat loss: 0.01

**End use 2.85**
- End use coal: 4.73
- End use NG: 0.53
- End use crude oil: 1.13
- End use crude oil: 0.25

**Other sectors 14.5**
- Diesel for other sectors: 0.36
- LPG for other sector: 0.34
- Boat fuel oil: 0.16

**Transportation 2.3**
- Fuel oil import: 0.34
- Fuel oil prod: 0.25
- LPG produced: 0.25
- LPG import: 0.1

**Unit: 100 million tce**


Note: 2005: 2.224btce, 2006: 2.46btce, 2007: 2.65btce

2008: ~180Mtce increase (estimated)
Coal flow in China@2006

China’s Coal Flow Chart 2006
(100 million tce)

- **Exports**: 0.49 million tce
- **Domestic Production**: 16.95 million tce
- **Supply**: 16.81 million tce
- **Consumption**: 17.08 million tce
- **Transformation**: 12.48 million tce, 73%
- **Power Generation**: 7.95 million tce, 64%
- **Coking**: 3.30 million tce, 26%
- **Industry**: 3.59 million tce, 78%
- **Residential**: 0.61 million tce
- **Other end-use**: 0.40 million tce

Data Source: China Energy Statistical Yearbook 2007
History of power generation capacity

<table>
<thead>
<tr>
<th>Year</th>
<th>Total Capacity (GW)</th>
<th>Coal-based Capacity (GW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1980</td>
<td>66.5</td>
<td>66.5</td>
</tr>
<tr>
<td>1990</td>
<td>138</td>
<td>110</td>
</tr>
<tr>
<td>2000</td>
<td>319</td>
<td>209</td>
</tr>
<tr>
<td>2007</td>
<td>713</td>
<td>254</td>
</tr>
<tr>
<td>2008</td>
<td>792.5</td>
<td>601.3</td>
</tr>
</tbody>
</table>
Scale distribution of newly installed capacity in 2007

More than 150 SC and USC units larger than 600 MW are established or ordered.

Typical steam parameters are:
- SC: 24.2/566/566, 600MW
- USC: 26.25/600/600, 1GW
Efficiency improvement in China’s Power Sector

Energy efficiency of different size of coal power unit in China in 2006

<table>
<thead>
<tr>
<th>Unit Size (MW)</th>
<th>Coal consumption of power supply (gce/kWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>600</td>
</tr>
<tr>
<td>12</td>
<td>550</td>
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<td>25</td>
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<td>100</td>
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<td>600</td>
<td>299</td>
</tr>
<tr>
<td>600</td>
<td>292</td>
</tr>
<tr>
<td>1000</td>
<td>285.6</td>
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</tbody>
</table>

Coal Consumption of Power Supply (gce/kWh)

Circulating Fluidized Bed (CFB) Combustion

- China started CFB R&D since early 1980’s
- Application of CFBC covers the steam generation range of 75t/h, 130 t/h, 220t/h, 410t/h with no reheat
- ~200 reheat CFB units of 410～450t/h high pressure or 440～480t/h super high pressure are in operation in China
- Currently, large utility CFB boilers are applied in Chinese power industry. For the time being, the largest capacity is 300 MW.
- 600MW supercritical CFB is under development
Design of 600 MW supercritical CFB boiler

Steam parameters:
1-24.2/571/571, $\eta=43.18\%$
2-27.3/604/604, $\eta=43.66\%$
Efficiency potential of coal steam power plants

Advances in Hard Coal Fired Power Plants

Net power plant efficiency

Materials Development

Component Optimization

Output: 700 MW
Condenser Vacuum: 40 mbar
Entrained flow coal gasification in China

Shell

Texaco

GSP

OMB CWS

HT-L

Two stage dry feed

Two stage oxygen feed
Opposite Multiple Burner Gasification technology has been widely disseminated.
Two-stage oxygen feed gasifier developed in Tsinghua University

Staged Entrained Flow Coal Gasification—from concept to industrialization
分级气流床煤气化-从概念到工业化

CFB

500 t/d gasifier applied in 100K t/y Methanol production

Desulphurization
GreenGen: 250 MW IGCC demonstration in Tianjin
Direct CTL plant: 1Mt/a for the first train of first phase

规划规模: 500万吨油品/年（分二期建设）
示范规模: 100万吨油品/年（一期工程第一条生产线）
建设地点: 内蒙古自治区鄂尔多斯市
神华百万吨煤直接液化项目进展 Progress of DCTL Project

- 自2008年12月30日14时46分投煤试车起，至2009年1月6日14时46分，神华煤直接液化百万吨级示范工程打通全流程，产出合格产品，已连续稳定运行168小时。
- Successful start on December 30th, 2008
- Continuous operation for ~300 hrs
- Controlled shut down for study and optimization
- A 100,000 tons EOR CCS demonstration has put on agenda
- A 1 Mt aquifer CCS project is under discussion
Indirect coal liquefaction

700t/a pilot FT synthesis plant

Successful test operation in Shanxi Lu’an was reported in the end of 2008

160kt CTL plant under construction in Inner-Mongolia.
Thinking on the scale of alternative coal-derived fuel (AF)

**Avoided loss from AF**
- SPR cost: facility/O&M/capital
- GDP loss by oil price increase
- GDP loss by supply disruption

**Cost for AF development**
- Investment of production plant
- O&M cost
- Subsidy for low oil price

Oil import

Total oil demand - indigenous oil

AF

**Key question**
Where is the Optimal fraction?

Source: Tsinghua BP CEC

Essentially, this is a problem to compromise the benefit of energy security and financial & environmental cost for the development of alternative fuels.
China’s first post-combustion CO₂ capture demonstration

- The demonstration project is located in Beijing Thermal Power Plant of CHNG.
- The project has been into operation since July, 2008 with a capacity of 3000t/a CO₂ capture.
- The product CO₂ is refined to a purity of 99.997% and meets the requirement for food making.
CO2 injection test in oil field for the purpose of EOR
Carbon sequestration pilot test by PetroChina

4. Pilot test program of block Hei79, Hei59, Hong87-2, Qian’an were formulated.

Pilot test program of miscible flooding in Hei79 and Hei59
Immiscible flooding pilot test program in Hong 87-2
Pilot test program in Qian’an
Launch of China-US CCS Regulatory Guideline
Project_081218@THCEC
1. Alternative oil imports lead to higher fossil fuel use and carbon emissions.

2. Development of non-fossil energy helps reduce fossil fuel use and carbon emissions.

3. Carbon capture and storage helps reduce carbon emissions but increases fossil fuel use.

- 1=15% non-fossil fuel in total mix
- 2=30% non-fossil fuel in total mix
- 3=2+30% power with CCS
Low carbon economy is the direction 低碳经济是发展方向

President Hu proposed five measures on climate change issue on 27 June 2008. 胡主席等领导人重视日益增长的CO₂排放问题，提出了五项举措

- To develop the recycling economy and low carbon economy, and insist on the basic national policy of resource conservation and environmental protection
  发展循环经济、低碳经济，坚持节约资源和保护环境的基本国策

- To enhance the ability to address climate change issue, and continue constructing ecological protection projects 增强适应气候变化能力，继续开展生态保护重点工程建设

- To strengthen the foundation research, technological development and international science & technology cooperation for addressing climate change issues 发挥科技进步和创新的作用，加强应对气候变化的基础研究、技术研发和国际合作

- To improve the mechanisms for addressing to climate change, improve laws and regulations, and enhance the capabilities of early warning, disaster reduction 健全应对气候变化的体制机制，完善法律法规，提高预警能力、抵御能力、减灾能力

- To enhance the consciousness and ability of entire society to address climate change issue 提高全社会参与的意识和能力，营造全民应对气候变化的良好环境

Clean and low carbon energy technologies are critical for the realization of low carbon economy

- 清洁和低碳能源技术是实现低碳经济的关键
Look at CO₂ reduction from energy system evolution

- Coal CCS Chain
  - Coal conversion plant / anthropological CO₂ sources
    - Direct coal firing PP
    - IGCC / Poly-generation
    - Coal-chemical plant
    - Oxy-fuel/chemical looping
  - CO₂ transportation
  - CO₂ sink
    - EOR
    - Aquifer
    - Other
  - Natural CO₂ resources
  - Expensive
  - Uncertainty

- GOAL
  - CO₂ Reduction

- Alternative energy & energy saving
  - Energy saving
    - Nuclear
    - Hydropower
    - Renewable
  - Expensive
  - Reliable
Low carbon power  低碳电力

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<table>
<thead>
<tr>
<th>建筑物</th>
<th>建筑面积</th>
<th>能耗（kWh/m²·a）</th>
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<tbody>
<tr>
<td>清华学堂</td>
<td>4650m²</td>
<td>34kWh/m²·a</td>
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<tr>
<td>清华美术学院</td>
<td>6.4万m²</td>
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<td>北京政府办公楼A</td>
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<tr>
<td>北京政府办公楼B</td>
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<td>6425m²</td>
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<tr>
<td>法国里昂政府办公楼</td>
<td>1.7万m²</td>
<td>165kWh/m²·a</td>
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能源消费水平：需要合适的总体定位，不能盲目追求西方模式

Energy consumption level positioning: should not following western countries

来源：借鉴清华大学江亿院士报告

Right position level for China

发达国家

Developed country

我国比能耗现状

China
Special importance of energy conservation for China -- current decisions and activities will result in pathway locking

- When GDP per capita is $10000, energy consumption per capita of each country will be more than 4 tce.
- The energy consumption per capita in China is 1.71 tce in 2005, lower than the world average level 2.42 tce per capita (2004), and even lower than that of the OCED countries.
- The energy consumption per capita of rural residents in China is less than 29% of the urban.

Note: 117GJ=4 tce
Thank you for your attention!

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