China’s Energy

— Challenges and Strategy

Prof. Ni Weidou

Tsinghua University

Chairman of Steering Committee of

Tsinghua-BP Clean Energy Research and Education Centre

Member of Chinese Academy of Engineering

Chairman of Science and Technology Commission of Ministry of Education
If today’s trend of utilization of fossil fuel will continue (BAU technology), we are running out of atmosphere faster than we’re running out of fossil fuels.

Terrorism doesn’t threaten the viability of the heart of our high technology life-style, but energy really does.
Five challenges China is facing

- Enormous energy demand
- Shortage of liquid fuels
- Severe environmental pollution
- Greenhouse gas emissions
- Rural energy supply
GDP per capita comparison of countries

( Unit: US dollars)

Japan: 42318
Germany: 31707
America: 30845
France: 28959
Singapore: 26071
Korea: 12068
The average: 5462
China: 1000

Notes: Prices of 1995
Sources: 《日本能源经济统计手册》（2002）
Per capita energy consumption

Notes: Data in 1999.

Sources: 《日本能源经济年鉴》 (2000)
In 2003, total production 1.603 billion tce, 11% of world total, rank 3rd

NG
35 billion m³, 1.3% of world total, rank 17th

Oil
170 million ton, 4.6% of world total, rank 5th

Hydro
280 billion kWh, 10.8% of world total, rank 4th

Raw coal
1.667 billion ton, 33.5% of world total, rank 1st
## Production of Raw Coal

(Units: $10^8$ ton)

<table>
<thead>
<tr>
<th>Year</th>
<th>1980</th>
<th>1990</th>
<th>2003</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total</strong></td>
<td>6.2</td>
<td>10.8</td>
<td>16.67</td>
</tr>
<tr>
<td><strong>State-owned Key Mines</strong></td>
<td>3.5</td>
<td>4.8</td>
<td>8.3</td>
</tr>
<tr>
<td><strong>State-owned Local Mines</strong></td>
<td>1.6</td>
<td>2.0</td>
<td>2.9</td>
</tr>
<tr>
<td><strong>Small Mines</strong></td>
<td>1.1</td>
<td>4.0</td>
<td>5.47</td>
</tr>
</tbody>
</table>

Annual increase **45 mil. ton**, average increase rate **4.4%**
Production of Oil

Average increase rate 14.4%

Unit: 10^4 t
Production of NG

Average increase rate 16.3%

Unit: billion m³
From 1996, total installed capacity ranked 2nd in the world. 2005, about 430 GW
By the end of 2003, Installed capacity **391GW**

**Power Mix of China in 2003**

- **Coal fired**
  - 290GW, 74.1%
- **Hydro**
  - 94.89GW, 24.23%
- **Renewables**
  - 550MW, 0.14%
- **Nuclear**
  - 6.19GW, 1.58%
The supply of energy is the big problem

From 2000, shortage of energy supply becomes more and more severe. Though the domestic average energy production increase rate – 14.35%, and oil import increase rate – 11.7%, the supply of energy is still the big problem.
Coal (China) = Oil + NG (World)

Oil + NG (China) = Coal (World)

Consequently, serious pollution and low efficiency
The constituent of Power Sector

2001 World Power Mix
- Coal – 1636 GW, 47%
- Gas – 690 GW, 20%
- Nuclear – 361 GW, 10%

2003 China Power Mix
- Coal – 29000, 74.05%
- Hydro – 95 GW, 24%
- Nuclear – 619, 1.58%
- Renewables – 55, 0.14%

(Unit: 100GW)
(Unit: 10MW)
Improvement of technology

Specific Consumption

Internal utility needs

Transmission loss

471 \(\rightarrow\) 381 gce / kWh

8.8% \(\rightarrow\) 6.15%

9.64% \(\rightarrow\) 7.5%
The main problems China is facing

- Constraints of domestic resources (reserves)
- Huge investment (up to 2020, about 1000 billion $)
- Energy security
- Low efficiency
- Severe environment impact
Constraints of Domestic Resources (Reserves)

**Coal**

Though the resource is abundant, but at present resource suitable for exploitation only about 100 billion ton
Constraints of Domestic Resources (Reserves)

**Oil**

**In 2004**
- Domestic production – 170 mil. t (3.4 mil. bbls/d)
- Consumption – 290 mil. t
- Reserve / exploitation ratio 12~15, very critical (World average ~40)
- Import 120 mil. t (2.4 mil. bbls/d), import dependence – 40%

**By the year 2020**
- Domestic production – 200 mil. t
- Consumption – 400~500 mil. t
- Import dependence – more than 60%
Hydro Power

- Resource – rank 1st in the world, ~500GW
- Location – mainly in remote west-south areas, far from load centers
- Ecological uncertainty
Constraints of Domestic Resources (Reserves)

The exploitation of hydraulic resources by areas

- East: Development rate: 61%
- Central: Development rate: 35.7%
- West: Development rate: 12.6%

Unit: 10MW

Exploitable Installed Capacity

0 5000 10000 15000 20000 25000 30000 35000

East Central West
Constraints of Domestic Resources (Reserves)

Production target by the year 2010 and 2020

Unit: 10^8 tce

<table>
<thead>
<tr>
<th>Resource</th>
<th>2003</th>
<th>2010</th>
<th>2020</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coal</td>
<td>11.91</td>
<td>14.6</td>
<td>16.4</td>
</tr>
<tr>
<td>Oil</td>
<td>2.43</td>
<td>2.72</td>
<td>2.86</td>
</tr>
<tr>
<td>NG</td>
<td>0.46</td>
<td>0.998</td>
<td>1.6</td>
</tr>
<tr>
<td>Hydro</td>
<td>0.15</td>
<td>0.355</td>
<td>0.996</td>
</tr>
<tr>
<td>Nuclear</td>
<td>1.08</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Renewables</td>
<td></td>
<td>1</td>
<td>2</td>
</tr>
</tbody>
</table>
Energy Mix by the year 2010 and 2020

2003
- Coal: 59%
- Oil: 21%
- NG: 9%
- Nuclear: 1%
- New Energy: 4%

2010
- Coal: 67%
- Oil: 23%
- NG: 3%
- Nuclear: 1%
- Hydro: 6%

2020
- Coal: 51.0%
- Oil: 20.7%
- NG: 8.6%
- Nuclear: 3.2%
- Hydro: 10.0%
- New Energy: 6.5%
Constraints of Domestic Resources (Reserves)

**Speed up the Nuclear power**

Nuclear Power

- 2003 – 6.2 GW
- 2020 – 40 GW
- More than 2 GW increase annually
- Development of domestic 1000 MW unit (advanced PWR)
**Constraints of Domestic Resources (Reserves)**

*Speed up the NG exploitation and import of LNG*

- West to east pipeline – 12 billion Nm³
- 2003, total production 35 billion Nm³
- 2020, domestic production 120 billion Nm³, consumption 200 billion Nm³
- Already signed contract with GE, MHI and Siemens for purchasing 45 units of F-class gas steam combined cycles (380 MW each). Total consumption of NG – 16 billion Nm³. Is it the right way for NG utilization?
Constraints of Domestic Resources (Reserves)

**Renewable energy**

- China is abundant in renewable energy – wind, solar and biomass...

- Wind energy, in shore – 254 GW, off-shore – 700 GW

- Biomass – 500~600 mil. tce (but highly scattered)
Constraints of Domestic Resources (Reserves)

**Renewable energy (Wind)**

- Installed capacity of wind power – 700 MW
- 170 thousand small wind mills, total capacity about 20 MW
- By the year 2020 – 20 GW, about 30 times increase
- Domestic production: 600, 750 kW units have been installed in large scale; 1.2 MW units are being tested now.
Constraints of Domestic Resources (Reserves)

**Renewable energy (Solar)**

- Solar heat collectors – high technology, 92~95% absorption rate
- 52 mil. m², 40% of world’s total
- Dominant in the world market
- Huge potential of energy conservation (In combination with heat pump technology)
Constraints of Domestic Resources (Reserves)

The Energy Production Scenarios

(Unit: 10^8 tce)

- Renewable
- Nuclear
- Hydro
- NG
- Oil
- Coal

Primary energy
Energy security

- The per capita energy reserves of China are much lower, especially for the oil and natural gas.
- Oil will reach the peak production around 200Mt in 2020, after which the production will decrease.
- 60% oil and natural gas in 2020 will depend on import.
- 1000Mt coal production new capacity will be set up before 2020, it is a very tough task (reserves, capital investment, ecology...).
Energy security

Increasing Dependence on Oil Import

- Demand
- Domestic production
Energy efficiency

- The energy consumption intensity of GDP of China in 2000 was 0.89kgoe/$US, 3.34 times of world average level and 4.63 times of OECD average.

- 4% of world GDP consume 10% of the world electricity.

- 4% of world GDP consume 30% the world iron and steel and 40% of the world cement.

- In developed countries – industry, construction and transportation each consumes roughly 1/3 of the total energy. But in China, industry consumes about 70% (Iron steel, cement, aluminum – about 60% of the industrial energy use).

Structure Change needed!
Energy efficiency

- Comprehensive energy efficiency – 33%, about 10 points percentage lower than OECD countries

- Power, Iron and Steel, Nonferrous metals, petroleum chemistry, Construction materials, Chemical engineering, Light industry and textile – 8 industrial sectors, their unit product consumption is about 40% higher than OECD countries

- Iron and Steel, Cement, Paper – specific energy consumptions – 21%, 45% and 120% in comparison with advanced level respectively

- Efficiency of vehicles – 25% lower than in Europe and 20% than in Japan

- Specific energy consumption for building heating is about 2〜3 times higher than the developed countries at the same latitude
Energy efficiency

*Enormous potential of energy conservation and efficiency improvement*

In this concern, not only technology, more important is the institutional issues – government policy and regulations, taxation, financial incentive of the parties (sectors)
Severe Pollution

- In 2020 the SO$_2$ and NO$_x$ pollutant could be 40Mt and 35Mt and exceed 16Mt and 19Mt of the pollutant limits respectively, if no additional control measures will be taken.

- About 40% of the territory of China is suffering acid rain.

- China is the second largest CO$_2$ emission country, it will increase in the future.
Severe Pollution

Forecast of CO₂ emission from different countries
General Conclusions

- According to the projection of energy demand and supply, coal will still play the dominant role (50%~60% in 2050).

- Coal utilization will contribute about 70%~75% of CO₂ in China (at present 76.8%), and SO₂, NOₓ, PM₅, Hg as well.

- Coal mainly will be used for power generation in future (up to 80%, at present about 45~50%), It means coal fired power plants will contribute 60% or more CO₂ of total.
Large scale mitigation of shortage of liquid fuel could be realized only by coal-derived alternatives (F-T synthetic fuel, Methanol, DME), Biodiesel and ethanol from corn and cellulose could only solve small part of the shortage problem.

Capture CO₂ from flue gas of power plants is investment intensive and with unaffordable large (per unit CO₂) energy consumption.

“Hydrogen Economy” with renewable derived hydrogen is still a long way to go (20~30 years).
What is the way out?

Except to speed up the development of nuclear and renewable energy

- Sustainable utilization of coal or modernized coal utilization beyond direct combustion

- Coproduction of Power, liquid fuel, chemicals, heat and gas via coal (or petrol coke) gasification and once-through chemical reactors.

That is: POLYGENERATION
What is the way out?

Integrated Resource-Energy-Environment System

Air

- Air Separation
  - N₂, Ar

Coal

- Gasification
  - O₂

- Steam

- Shift
  - CO₂ + H₂
  - CO₂
  - H₂

- Syngas

NG

- Heat/power/cool cogeneration

Commercial building

- Residential

- IGCC or GCC

- Chemical products

- Liquid fuel

- Others

- Fuel cell

- Sequestration

- Dry ice

- Fertilizer

- Algae plant growth

- Enhancement of CBM

Heat/power/coal cogeneration

Large-scale power generation

Commercial building

residential

enhancement of CBM
What is the way out?

Integrated Gasification Combined Cycle
What is the way out?

Simplified illustration of Polygeneration
What is the way out?

- Polygeneration is the sustainable, technically consistent, technologically realistic, economically beneficial, and ecologically friendly way for CO\textsubscript{2} mitigation, capture, and further sequestration. It is really the most important strategy in China, even in the world.
What is the way out?

- Polygeneration
  - It doesn’t need specific technology breakthroughs, consistent to the existing technologies
  - Concentrated CO$_2$ could be easily captured along with the natural technological processes, that is, polygeneration has the nature easy for CO$_2$ capture
  - This is the strategic way for CO$_2$ mitigation in China
With more and more stringent environmental regulation, the advantages of coal gasification polygeneration will be more and more economically significant.
Urgent actions should be taken (1)

Scenario study (MARKAL model)

Total Primary Energy Supply

Exajoules


Base Technologies

Advanced Technologies

SO2, 30% Oil&Gas, 66 Gt C Caps

EFFICIENCY
RENEWABLES
NUCLEAR
CBM
NGAS
OIL
COAL Gasification
COAL Combustion
Urgent actions should be taken (2)

The effect of Advanced Technologies Scenario

• Provides the same energy services at about the same cost as the Base technologies strategy

• SO$_2$ emissions are reduced from 23.7 Mt in 1995 to 16.2 Mt in 2020 and 8.8 Mt in 2050

• Imports of oil and natural gas are limited to 30% of consumption of oil and gas over the long-term

• 66 Gt C caps
Urgent actions should be taken (3)

Projection for Coal Power Plant Capacity

- Post-2000 New Capacity
- Pre-2000 Capacity
Urgent actions should be taken (4)

Delaying the start of the transition to coal gasification based polygeneration technology would significantly increase:

- the costs to China of air pollution damages
- the costs of oil imports
- the costs of reducing GHG emissions
Conclusions

• China needs an integrated, but divided into long term (20~50 years), intermediate term (8~15 years) and short term (3~8 years) energy strategy.

• Any significant change in energy system needs a long period (large inertial system with big time constant).

- Step on the peel of watermelon (or banana), slipping anywhere without definite direction.

- When head aches – treat only headache, when leg aches – treat only leg ache.

Are not the way for China’s energy.
Thank You!