Electric Power Industry in China

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- Power network in China
- Power supply and demand
- Causes of 2002-2005 power shortage
- Future power development plan and challenges
- Power industry reform
Power network in China

- 500kV: Xinjiang, Tibet, Northeast
- 330kV: Xinjiang, Tibet, Northwest
- 220kV: Northeast, North, Central, East, South

Power network coverage 96.4%
Grid interconnection

- **Northeast**
  - 500KV AC(2)
    - 2001 / 05
    - 1200 MW

- **North China**
  - 500KV AC(3)
    - 2001
    - 1900 MW
  - 500KV DC(1)
    - 2004 / 02
    - 3000 MW

- **Northwest**
  - 500KV AC(2)
    - 2006 / 06
    - 1200 MW

- **South China**
  - 500KV DC(1)
    - 1989 / 2003 / 2207
    - 7200 MW
  - 500KV AC(2)
    - 2006 / 06
    - 1200 MW

- **Central China**
  - 120KV DC(1)
    - 2005 / 06
    - 360 MW

- **Tibet**
  - 500KV AC(1)
    - 2003 / 09
    - 800 MW

- **East China**
  - 500KV AC(3)
    - 2001
    - 1900 MW

- **Taiwan**
  - ±500KV DC(1)
    - 2004 / 02
    - 3000 MW

- **State Grid Corporation**
The capacity of each corridor will reach about 20GW in 2020.
Power supply and demand

Growth of GDP, energy and electricity use
China’s installed capacity and power generation output are second largest in the world’s electricity industry following the United States.

By 2005, installed capacity reached 508 GW.

By 2005, power generation reached 2,475 TWh.

Source: China Electricity Council (http://www.cec.org.cn/cec-en/index.htm)
Electricity intensity per capita is 1/10 that of U.S. and less than half of the world’s average.

<table>
<thead>
<tr>
<th></th>
<th>China</th>
<th>U.S.</th>
<th>World total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Installed capacity (GW)</td>
<td>356.6</td>
<td>979.6</td>
<td>3,372.8</td>
</tr>
<tr>
<td>(% of world total)</td>
<td>(9.6%)</td>
<td>(26.4%)</td>
<td>(100%)</td>
</tr>
<tr>
<td>Power generation (TWh)</td>
<td>1,654.2</td>
<td>3,858.5</td>
<td>15,614.1</td>
</tr>
<tr>
<td>(% of world total)</td>
<td>(10.6%)</td>
<td>(24.7%)</td>
<td>(100%)</td>
</tr>
<tr>
<td>Power generation per capita (KWh/person)</td>
<td>1,288</td>
<td>13,120</td>
<td>2,578</td>
</tr>
</tbody>
</table>

2002 Data

2002 Per Capita Generation in KWh per person
Coal is the major generation supply fuel.
Coal-fueled installed capacity mix in 2003 by unit size. The total installed capacity is 289,770MW
Power supply and demand

Industry electricity use dominates other sectors

China’s 2002 elec. use

Share of total 2002 electricity use by sector in 4 countries

Power supply and demand

**Business consumption growth dominates total growth**

<table>
<thead>
<tr>
<th>Year</th>
<th>Total</th>
<th>Agriculture, forestry, ranching and fishery</th>
<th>Industry and construction</th>
<th>Transportation, communication, commercial and others</th>
<th>Residential</th>
<th>Rate of increase relative to the previous year</th>
</tr>
</thead>
<tbody>
<tr>
<td>2002</td>
<td>14,979</td>
<td>780</td>
<td>10,619</td>
<td>1,600</td>
<td>1,980</td>
<td>10.4%</td>
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<tr>
<td></td>
<td></td>
<td>5.2%</td>
<td>70.87%</td>
<td>10.71%</td>
<td>13.22%</td>
<td></td>
</tr>
<tr>
<td>2003</td>
<td>18,633</td>
<td>559</td>
<td>13751.2</td>
<td>2,422.2</td>
<td>1,900.8</td>
<td>24.4%</td>
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<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>3%</td>
<td>73.8%</td>
<td>13%</td>
<td>10.2%</td>
<td></td>
</tr>
<tr>
<td>2004</td>
<td>21,762</td>
<td>687.5</td>
<td>16,301</td>
<td>2,329.5</td>
<td>2,444</td>
<td>16.3%</td>
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<tr>
<td></td>
<td></td>
<td>3.16%</td>
<td>74.9%</td>
<td>10.7%</td>
<td>11.24%</td>
<td></td>
</tr>
<tr>
<td>2005</td>
<td>24,690</td>
<td>740</td>
<td>18,480</td>
<td>2,630</td>
<td>2,840</td>
<td>13.5%</td>
</tr>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>3%</td>
<td>74.85%</td>
<td>10.65%</td>
<td>11.5%</td>
<td></td>
</tr>
<tr>
<td>‘02-’05 annual growth</td>
<td>18%</td>
<td>-2%</td>
<td><strong>20%</strong></td>
<td><strong>18%</strong></td>
<td><strong>13%</strong></td>
<td></td>
</tr>
</tbody>
</table>

Electricity consumption (2002-2005)
Power supply and demand

- Power shortages were being caused by need for more generation capacity (Trillion Yuan = $130B)

Since 2002, severe power shortages has occurred nationwide

- In 1997, balance between power demand and supply was first maintained

- Economy loss around 1 trillion Yuan

- 2002: 12 Provinces (Autonomous, Municipalities)
- 2003: 22 Provinces (Autonomous, Municipalities)
- 2004: 24 Provinces (Autonomous, Municipalities)
- 2005: 26 Provinces (Autonomous, Municipalities)
Power supply and demand

- Power shortages occurred in three major regions.

Demand exceeded supply
Balance
Supply exceeded demand

The number of provincial grids with curtailments in the peak period:
12 (2002)
22 (2003)
24 (2004)
26 (2005)
Causes of power shortages

- Climatic variability (droughts and heat waves)
- Economy, and therefore energy use, is growing faster than electric generation capacity can be built.
Causes of power shortages

- Coal supply shortages and transport bottle-necks
- Escalating coal prices and decreased energy content of coal. Differences in price trends of “regulated power prices” and “unregulated coal prices”.

Blue indicates supply sources and red indicates major load centers.
Addressing power supply shortages

- **Generation sector**
  - Developing coal-fired generation – high boiler pressure, high capacity, and environmentally friendly – is the direction.
  - Accelerating development of hydropower, nuclear power, and gas-fired power generation.
  - Introducing renewable energy (solar, wind, …)

- **Network sector**
  - Strengthening the grid.
  - Intensifying energy conservation efforts and improving energy efficiency.
Environmental challenges

China’s carbon dioxide emissions from consumption of fossil fuels are expected to increase from 3,000 million tons in 2000 to 5,700 million tons in 2020.

Source: International Energy Association 2004
Environmental challenges

- China is experiencing rising SO2 and NOX.

<table>
<thead>
<tr>
<th></th>
<th>Emission</th>
<th>Removal</th>
<th>Efficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>SO2</td>
<td>8.01Mt</td>
<td>0.97Mt</td>
<td>10.8%</td>
</tr>
<tr>
<td>Smoke dust</td>
<td>3.13Mt</td>
<td>120.8Mt</td>
<td>97.5%</td>
</tr>
</tbody>
</table>

Efficiency of SO2 and smoke dust emission reduction systems (2003)

Emission trends
Improving generation and delivery efficiency

Greater generation and delivery efficiency is reducing rates of internal use of electricity, transmission losses, and coal consumption.

<table>
<thead>
<tr>
<th>Year</th>
<th>Internal use of electricity (%)</th>
<th>Power transmission losses (%)</th>
<th>Coal consumption (g/kWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2005</td>
<td>5.82</td>
<td>7.18</td>
<td>374</td>
</tr>
<tr>
<td>2020</td>
<td>5.1</td>
<td>6.2</td>
<td>320</td>
</tr>
</tbody>
</table>
Strategies for overcoming coal supply and delivery challenges

- **Alliances between coal mining companies and power generation companies**
  - Shenhua model: simultaneous stock holding and building of power stations
  - Shanxi coking coal co. model: building of power station by coal mines
  - Luneng model: building of coal mines by power enterprises
  - Huainan model: joint venture to establish the new coal mines and power stations

- **Mine-mouth power plants substituting electric transmission for coal transportation**
Hydro-power development

- Hydro
  - Resources: 500GW
  - By the year 2005:
    - Installed capacity 120GW (including 34.1GW from small hydro plants).
    - 395TWH, 15% of the total annual generation.
12 Major Hydropower Locations (unit: $10^4$KW)
Nuclear power

KEY
- NPP in operation
- NPP under construction
- NPP being proposed

SHANDONG
Hayang 2x1000 MW

JIANGSU
Tianwan (Lieryuancang)
2x1000 MW
Tianwan Phase II 2x1000 MW

ZHEJIANG
Qinshan phase I 300 MW
Qinshan phase II 2x600 MW
Qinshan Phase III 2x770 MW
Qinshan phase IV 2x1000 MW

Fujian
Hui An 2x1000 MW

Guangdong
Daya Bay 2x354
Ling Ao 2x954 MW
Ling Ao Phase II 2x1000 MW
Yangjiang 6x1000 MW

China Map showing nuclear power plants and their locations.
Potential wind power resource > 3000 GW

green=great, pink=good, blue=ok, yellow=poor
(offshore & coastal potential not shown)
Wind power

By the year 2005:
- 59 wind power plants, with total installed capacity of 1266MW.
- 200,000 small wind units, located in rural areas, with total installed capacity of 30MW.
- Mass production of 750KW (and below) units; units at MW level is still in the trial phase.
- Key technology dependent on imports. However, design expertise growing in China.

By the year 2020 – 40GW
Solar power resource

- Theoretically 1.7 trillion ton coal equivalent/year
- 2/3 of the land with daylight hours surpassing 2,200 hours/year, equaling 5,000 mega joule/m²
- Most abundant in western regions
Solar power

- **PV**
  - Installed capacity: 70 MW, mainly in the rural areas. (including “sending electricity to townships” project: 17MW).
  - On-grid ceiling PV: Shenzhen 1MW project.
  - Industrial capacity: 300MW units/year, but silicon materials depend on import.

- **Solar water heaters**
Renewable energy policy


- Establishing national targets
- Grid connection priorities
- Classifying tariffs for RE electricity
- Sharing cost at national level
- Special fund for renewable energy
- Favorable credit and favorable tax treatment
Long-term target generation mix

Target generation mix in 2020

installed capacity (GW)

2004  2020

coal  325  560
hydro  108  246
gas    40   10
nuclear 10    40
new     64   0

30% coal  65% hydro  7% gas  3% nuclear  3% new
Power industry reform objectives

- To establish a power market system that will introduce competitive incentives, improve efficiency, lower cost, improve power pricing, optimize resource allocation, promote electric power development, and advance nationwide grid construction.

- This market system should encompass fair competition, orderly transition, and efficient development using separation of government functions from enterprise functions.
Reform goals

Goals of “Article Five” during the “10th Five-year Plan”

- A: Separation of generation from grid (completed)
- B: Corporate separation of non-core functions (such as planning, designing, construction, etc.)
- C: Direct access to market by large users
- D: Formulation of competitive regional power market
- E: Bidding for access to grids
- F: Make retail tariffs more market-driven
## Power industry reform history

<table>
<thead>
<tr>
<th>Year</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>1997-1998</td>
<td>State Power Corp. (SPC) established</td>
</tr>
<tr>
<td>1998</td>
<td>Dissolved Ministry of Electricity</td>
</tr>
<tr>
<td>2002</td>
<td>Power Regime Reform formally approved by the State Council</td>
</tr>
<tr>
<td>2002-2004</td>
<td>SPC restructured</td>
</tr>
<tr>
<td>2002-2004</td>
<td>Separation of gen. assets from transmission assets</td>
</tr>
<tr>
<td>2004-2004</td>
<td>East China starts pilot regional power market operation.</td>
</tr>
</tbody>
</table>
To “introduce competition and break the market monopoly” generation and grid sectors were separated.

**Restructuring of the State Power Corporation of China**

December 2002
Power industry reform

Comparison of the installed capacity of different types of players (2004)

- Big 5 Generation Groups: 36%
- State-owned enterprises other than Big 5 groups: 46%
- Local, government-owned enterprises: 5%
- Generation owned by Grid Group: 9%
- State-owned Nuclear Group: 1%
- Private generators from China: 2%
- International private generators: 1%
Restructuring pilot program

- East China: the most developed area; electricity consumption ranks first; installed capacity $\geq 100,000$MW in 2005.
- One of two pilot regional power markets in China.
- May 18, 2004: East China’s first simulated bidding process for the next month.
- October 2005: simulated operation of China’s first day-ahead power market.
- April 2006: trial operation of day-ahead power market.
Restructuring pilot program

Generation units in East China:⭐
Category A: coal-fired units with capacity over 100MW (216 units registered by the end of 2005, generation capacity ≥58,818MW = 56.7% of total generation capacity in East China area). Participation Required.
Category B: gas-fuel units, oil-fuel units, hydro units, nuclear power units, etc. Participation Not Required

Trading modes:
Bilateral Transactions (between neighboring provinces and municipality)
Yearly Generation Contract
Monthly Contract Bidding
Day-ahead Market
Real-time Balance Market
Thanks !