Current Status and Outlook of SC&USC Power Generation Technology in China

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Electric Power Planning and Engineering Institute
Contents

- The Status Quo of China’s Electric Power Industry
- Development of SC&USC Power Generation Technology in China
- Outlook of SC&USC Power Generation Technology in China
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By the end of 2010, the total installed capacity nationwide hit 962GW.

With an increase of 118% during the past 7 years, i.e. from 2004 to 2010.
The installed capacity of China has increased by 80% during the period from 2004 to 2008.

While the growth rate of other BRICS countries in the same period was respectively:
- 14.5% in Brazil,
- 2.7% in Russia,
- 27.3% in India,
- and 5.2% in South Africa.
In spite of the rapid growth and large amount of the total installed capacity, China is still lagging in installed capacity per capita.

The Installed Capacity per capita in 2008 (kW/person)

- USA: 3.32 kW/person
- Germany: 1.74 kW/person
- Japan: 2.17 kW/person
- South Korea: 1.64 kW/person
- China: 0.60 kW/person
Relatively Low Electricity Consumption per capita

- **Electricity Consumption** - kWh per Capita
- **Household Electricity Consumption** - kWh per capita

<table>
<thead>
<tr>
<th>Country</th>
<th>USA</th>
<th>Germany</th>
<th>Japan</th>
<th>South Korea</th>
<th>China</th>
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<tr>
<td>Electricity Consumption</td>
<td>12937</td>
<td>6682</td>
<td>7746</td>
<td>8488</td>
<td>2154</td>
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<tr>
<td>Household Electricity Consumption</td>
<td>4681</td>
<td>1774</td>
<td>2310</td>
<td>1171</td>
<td>333</td>
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(Statistics in 2008)
As the economy in China grows rapidly, the demand and supply of electricity in China will keep growing fast.
Among the electric power generated in 2010, thermal power capacity was 73.4%; the portion of electricity generated by thermal power plants was 80.8%.
Among the electric power generated by thermal power plants in 2010, coal-fired power capacity was 92%; the portion of electricity generated by coal-fired power plants was 95.2%.
The government in China has actively carried out the environmental protection policies by phasing out the obsolete low and medium pressure, small capacity thermal generating units and developing large capacity and high efficiency units. These policies have led to the enlarged capacity of single thermal unit, higher overall net efficiency of the thermal power plant and a year-on-year decrease of pollutant emissions.
The capacity of single thermal power unit is enlarged.

During the “11th Five-Year Plan” (the period from 2006 to 2010), a large number of out of date and small-capacity (lower than 200MW) thermal power units, with a total capacity of approximately 72000MW, have been shut down.
Improving year by year in overall net thermal efficiency of the thermal power plants

Thermal power efficiency improvements vs. time

Year
2004 2005 2006 2007 2008 2009 2010

Thermal power efficiency
32% 33% 34% 35% 36% 37% 38%

- 32.7%
- 33.2%
- 33.6%
- 34.5%
- 35.6%
- 36.1%
- 36.7%
China is still lagging behind many developed countries in the overall thermal power efficiency.
The pollutant emissions from thermal power units are on a decrease.
The electric power is generated mainly by coal-fired power plants in China. By the end of 2010, the coal-fired power capacity was 67.5% of the total installed capacity; the electricity generated by the coal-fired power units accounts for 76.8% of the total electricity generation.

Coal consumed by coal-fired power plants accounts for approximately 47% of the total raw coal supply in China.

The development of advanced coal-fired power generation technology has an important significance for improving the efficiency of coal-fired power plants to alleviate the problem of environment pollution and carbon emissions.
Contents

- The Status Quo of China’s Electric Power Industry
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- Outlook of SC&USC Power Generation Technology in China
Development route of thermal power generation technology in China: large capacity, high steam conditions and high efficiency
The SC power plants with large capacity in China were constructed in the 1980s with imported technologies.

The 600MW SC power plants were constructed in the early 1990s with imported technologies.

The first 1000MW and 600MW USC units in China were constructed with imported technologies and cooperative manufacturing in the 21st century.

Through technology introduction and absorption, China has realized the localization of USC technology. By the end of 2011, there have been 35 sets of 1000MW USC units in operation in China, with a total installed capacity of 35280MW. SC & USC technologies have become the main development direction of China's thermal power units.
Among the thermal power generation units, the proportion of the SC & USC capacity is increasing.

SC & USC units proportion in thermal power vs. time

Year | Capacity percentage
--- | ---
2004 | 3.7%
2005 | 4.5%
2006 | 9.2%
2007 | 14.2%
2008 | 17.5%
2009 | 21.7%
2010 | 24.5%
The proportion of SC & USC units in coal-fired power plants in 2009

- **USA**: 30%
- **Germany**: 21%
- **Japan**: 70%
- **South Korea**: 71%
- **China**: 23.6%
Shidongkou-II Power Plant:
2 × 600MW SC coal-fired units with imported technology

- Commercial operation: 1992
- Steam conditions:
  24.2MPa/538/566℃
- Boiler supplier: CE, USA
- Steam turbine and generator supplier: ABB, Switzerland
Suizhong Power Plant:
2×800MW SC coal-fired units with imported technology from Russia

- Commercial operation: 2000
- Steam conditions: 23.54MPa/540/540°C
- Boiler, steam turbine and generator imported from Russia
Qinbei Power Plant:  
the first localized 600MW SC coal-fired unit in China

- Commercial operation: 2004
- Capacity: 2×600MW
- Steam conditions: 24.2MPa/566/566°C
- Boiler supplier: Dongfang Electric Corporation (DEC), China
- Steam turbine and generator supplier: Haerbin Electric Corporation (HEC), China
Yuhuan Power Plant:
the first localized 1000MW USC coal-fired unit in China

- **Commercial operation:** 2006
- **Capacity:** $4 \times 1000$MW
- **Steam conditions:** 26.25MPa/600/600°C
- **Boiler supplier:** Haerbin Electric Corporation (HEC), China
- **Steam turbine and generator supplier:** Shanghai Electric Corporation (SEC), China
Yingkou Power Plant: the first localized 600MW USC coal-fired unit in China

- Commercial operation: 2007
- Capacity: 2 × 600MW
- Steam conditions: 25MPa/600/600°C
- Boiler, steam turbine and generator suppliers: Haerbin Electric Corporation (HEC), China
Waigaoqiao III Power Plant:
the highest efficiency USC coal-fired units in China

- Commercial operation: 2008
- Capacity: 2×1000MW
- Steam conditions: 27MPa/600/600℃
- Boiler, steam turbine and generator suppliers: Shanghai Electric Corporation (SEC), China
- Net efficiency: 43.9%(LHV)
### Information of Waigaoqiao III power plant units

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<tr>
<td><strong>Gross power output</strong></td>
<td>1000MW</td>
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<td><strong>Net power output</strong></td>
<td>953MW</td>
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<td><strong>Auxiliary power consumption rate</strong></td>
<td>4.7%</td>
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<td><strong>Designed net efficiency</strong></td>
<td>43.57% (LHV)</td>
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<td><strong>Operating net efficiency</strong></td>
<td>43.9% (LHV)</td>
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<tr>
<td><strong>Feed water heating system</strong></td>
<td>4LP + deaerator + 3HP</td>
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<tr>
<td><strong>Feed water temperature</strong></td>
<td>297°C</td>
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<tr>
<td><strong>Condenser back-pressure</strong></td>
<td>Double backup pressure: 4.19/5.26kPa</td>
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<td><strong>NOx abatement systems</strong></td>
<td>SCR</td>
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<tr>
<td><strong>NOx emission</strong></td>
<td>&lt; 80mg/Nm³</td>
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<td><strong>SO2 abatement systems</strong></td>
<td>FGD</td>
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<tr>
<td><strong>SO2 emissions</strong></td>
<td>&lt;110mg/Nm³</td>
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<tr>
<td><strong>Particulates removal system</strong></td>
<td>ESP</td>
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<tr>
<td><strong>Particulates emissions</strong></td>
<td>14.32 mg/ Nm³</td>
</tr>
<tr>
<td><strong>Specific capital cost</strong></td>
<td>Approximately $ 600 USD/kW</td>
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</table>
The development of USC technology in China went through the following stages: introduction of foreign advanced technologies, cooperative manufacturing, innovation and improvement, and finally the realization of local production.

The imported technologies include:

- **SEC**: boiler technology from Siemens and steam turbine from Alstom
- **DEC**: boiler and steam turbine technologies from Hitachi
- **HEC**: boiler technology from Mitsubishi and steam turbine from Toshiba

(SEC = Shanghai Electric Corporation, DEC = Dongfang Electric Corporation, HEC = Haerbin Electric Corporation)
Main equipment suppliers in China have formed the ability of batch manufacturing of domestic 600MW and 1000MW USC coal-fired power generation equipment. Some suppliers have reached the annual production capability of over 30000MW.
Reliability index and operating index of 1000MW USC coal-fired power generation units in China (in 2010)

- **Average reliability index (statistics of 20 units):**
  - AH (hours/year): 8061.2
  - EAF: 92.3%
  - UOT (times/year): 0.74
  - EFOR: 0.42%

  *AH = Available hours*
  *EAF = Equivalent available factor*
  *UOT = Unplanned outage times*
  *EFOR = Equivalent forced outage rate*

- **Average operating index (statistics of 27 units):**
  - Net efficiency: 42%
  - Particulates emissions: 0.08 g/kWh
  - SO2 emissions: 0.25 g/kWh
  - NOx emissions: 0.8 g/kWh
China has achieved the independent design of SC and USC power plant, and 3D modeling design tools have been broadly utilized in power plant design work.
Contents

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SC/USC technologies in China will be developed in the future to further increase the capacity and net efficiency of single unit, options including:

- 1000MW double-reheat USC unit with tandem compound turbine
- 1200MW single-reheat USC unit with tandem compound turbine
- 1350MW double-reheat USC unit with cross compound turbine
- 700℃ Advanced USC technology
1000MW double-reheat USC unit with tandem compound turbine

- Steam conditions: 30~35MPa/600/610~620/610~620°C
- Net efficiency: 44.4%(LHV)
- Adoption of reliable boiler and steam turbine engineering techniques, utilization of reliable high-temperature materials, and integration of several energy saving and emission reduction technologies
- Application of technology optimizations such as flue gas heat recovery to improve thermal efficiency
1200MW single-reheat USC unit with tandem compound turbine

- Steam conditions: 28MPa/600/610~620℃
- Utilization of reliable high-temperature materials
- High technical reliability, with the boiler, steam turbine and generator developed basing on 1000MW USC technology
1350MW double-reheat USC unit with cross compound turbine

- Steam conditions: 30~35MPa/600/610~620/610~620°C
- Net efficiency: 44.4% (LHV)
- Adoption of reliable boiler and steam turbine engineering techniques, utilization of reliable high-temperature materials, and integration of several energy saving and emission reduction technologies
- Placing the inlet of high pressure block of steam turbine at the level next to the exit of super-heater of boiler, in which way the length of the high temperature pipe is shortened, and the cost is deducted
700℃ Advanced USC technology

- China was involved in the 700℃ Advanced USC technology R&D in 2010

- Development goals:
  - **EU:** 35MPa/700℃/720℃, net efficiency of 50~53% (LHV);
  - **USA:** 35MPa/732℃/760℃, net efficiency of 51~53% (LHV);
  - **Japan:** 35MPa/700℃/720℃/720℃ (double reheat), net efficiency of 50~52% (LHV);
  - **China:** 35MPa/700℃/720℃, net efficiency over 50% (LHV)
China 700°C USC Alliance

On July 23, 2010, the National Energy Administration (NEA) announced the kick-off of the national 700 °C USC coal-fired power generation technology innovation alliance in Beijing.
Mission Statement of the Alliance

- To make full use of the resources in the Alliance;
- To carry out the research on 700°C USC power generation technology;
- To achieve technological breakthroughs through joint efforts;
- To master the technology know-how and to achieve the independent manufacturing of 700°C USC power generation equipment;
- To promote the development of other relevant industries in China;
- To contribute significantly to the energy conservation and emission reduction of electric power industry.
Nature of the Alliance

- Initiated by the government;
- Voluntary participation of entities engaged in the USC power technology application and research, e.g. electric power research and design institutes, equipment manufacturers, operators, etc.;
- A non-profit technology innovation cooperative organization approved by the government;
- By signing a legally binding Agreement, members of the Alliance will share the benefits and risks, as well as complement each other’s advantages;
- With no legal personality.
Main Tasks of the Alliance

- Carrying out the research focusing on the general studies and core technology development of USC coal-fired power generation technology; making technological breakthroughs; mastering the technology know-how and achieving the independent manufacturing of 700℃ USC power generation equipment;
- Promoting domestic and international technology cooperation and exchange on 700℃ USC power generation and accelerating the transformation of innovation achievements and engineering application;
- Promoting the development of related domestic industries and improving the technical level of USC power generation.
Members of the Alliance

**NEA** = National Energy Administration  
**EPPEI** = Electric Power Planning and Engineering Institute  
**SEC** = Shanghai Electric Corporation  
**HEC** = Haerbin Electric Corporation  
**DEC** = Dongfang Electric Corporation  
**CHNG** = China Huaneng Group  
**CDT** = China Datng Group  
**CHD** = China Huadian Group  
**CGDC** = China Guodian Group  
**CPI** = China Power Investment Group

**CFHI** = China First Heavy Industries  
**Erzhong** = China National Erzhong Group Co.  
**CISRI** = China Iron & Steel Research Institute Group  
**Baosteel** = Baosteel Group Corporation  
**DSSC** = Dongbei Special Steel Group Co.  
**TPRI** = Thermal Power Research Institute  
**IMR** = Institute of Metal Research, Chinese Academy of Sciences  
**SPERI** = Shanghai Power Equipment Research Institute
China 700 ℃ USC Technology R&D Roadmap (Draft)

- Learning from the experience of other countries in developing 700℃ USC unit; constructing the R&D platform of China 700℃ USC power generation technology on the base of the R&D and application achievements in 600℃ USC units; mastering the technology know-how and achieving the independent manufacturing of 700℃ USC power generation equipment;
- Proposing the overall technical plan and key equipment design plan of 700℃ USC unit.
China 700 °C USC Technology R&D Roadmap (Draft)

- Selecting, developing, assessing and optimizing metal materials used in high temperature components, determining the series of high temperature materials for China 700℃ USC unit;
- Developing the production technology of key high temperature materials and the Manufacturing Technology of key equipment, and forming the production capability.
China 700 °C USC Technology R&D Roadmap (Draft)

- Constructing the verification test platform, and taking performance test for critical components;
- Constructing the demonstration projects of 700°C USC unit, and comprehensively grasping the core technology of 700°C USC coal-fired power generation technology.
# Action Plan of China 700°C USC R&D (Draft)

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<td>Overall design</td>
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<td>Development of high temperature materials</td>
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<td>3</td>
<td>Development of key components of main equipment and high temperature pipe</td>
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<td>High temperature pipe</td>
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<td>Verification test of key components of boiler and construction of the test platform</td>
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<td>5</td>
<td>Demo power plant</td>
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<td>Operation and experiences feedback</td>
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* FH = First Half of the year, SH = Second Half of the year
Vision

- To achieve the high-efficiency and clean development of thermal power by strengthening the R&D of USC power technologies in China
Thanks for your attention