CHP & Distributed Energy in China

China5e.com

Falcon Pioneer Technology Ltd
2004 5 5/2004
China5e.com
China CHP Development

CHP Annul increase in capacity

<table>
<thead>
<tr>
<th>Year</th>
<th>CHP</th>
<th>Capacity (GW)</th>
<th>Increase (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1997</td>
<td>230</td>
<td>294.412</td>
<td>1.28</td>
</tr>
<tr>
<td>1998</td>
<td>84</td>
<td>296.75</td>
<td>3.53</td>
</tr>
<tr>
<td>1999</td>
<td>90</td>
<td>322.06</td>
<td>3.578</td>
</tr>
<tr>
<td>2000</td>
<td>95</td>
<td>174.7</td>
<td>1.05</td>
</tr>
<tr>
<td>2001</td>
<td>108</td>
<td>233.55</td>
<td>2.163</td>
</tr>
<tr>
<td>2002</td>
<td>331</td>
<td>519.511</td>
<td>1.57</td>
</tr>
<tr>
<td>2003</td>
<td>184</td>
<td>625.51</td>
<td>3.4</td>
</tr>
</tbody>
</table>
## 6000

**Signal Unite with the capacity above 6MW in China**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>6000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Capacity</td>
<td>10MW</td>
<td>4369</td>
<td>3743</td>
<td>3224</td>
<td>2990.</td>
<td>2815</td>
<td>2493</td>
</tr>
<tr>
<td>5</td>
<td></td>
<td>262</td>
<td>223</td>
<td>187</td>
<td>172</td>
<td>161</td>
<td>140</td>
</tr>
<tr>
<td></td>
<td>10MW</td>
<td>2270</td>
<td>1831</td>
<td>1583</td>
<td>14701</td>
<td>1374</td>
<td>1137</td>
</tr>
<tr>
<td>2.5~</td>
<td>5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>high pressure</td>
<td></td>
<td>140</td>
<td>142</td>
<td>119</td>
<td>112</td>
<td>120</td>
<td>120</td>
</tr>
<tr>
<td></td>
<td>10MW</td>
<td>360</td>
<td>365</td>
<td>301</td>
<td>282</td>
<td>301</td>
<td>301</td>
</tr>
<tr>
<td></td>
<td></td>
<td>97</td>
<td>77</td>
<td>96</td>
<td>88</td>
<td>81</td>
<td>70</td>
</tr>
<tr>
<td></td>
<td>10MW</td>
<td>252.</td>
<td>200</td>
<td>247</td>
<td>227</td>
<td>210</td>
<td>182</td>
</tr>
<tr>
<td>1.2~</td>
<td>2.5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>29</td>
<td>27</td>
<td>18</td>
<td>15</td>
<td>14</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td>10MW</td>
<td>39</td>
<td>37</td>
<td>25</td>
<td>20</td>
<td>18</td>
<td>18</td>
</tr>
<tr>
<td></td>
<td></td>
<td>712</td>
<td>631</td>
<td>538</td>
<td>499</td>
<td>455</td>
<td>426</td>
</tr>
<tr>
<td></td>
<td>10 MW</td>
<td>907</td>
<td>798</td>
<td>672</td>
<td>618.</td>
<td>564</td>
<td>525</td>
</tr>
<tr>
<td>0.6~</td>
<td>1.2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>872</td>
<td>828</td>
<td>646</td>
<td>610</td>
<td>570</td>
<td>541</td>
</tr>
<tr>
<td></td>
<td></td>
<td>532</td>
<td>504</td>
<td>392</td>
<td>369.</td>
<td>345</td>
<td>327</td>
</tr>
</tbody>
</table>

Total Capacity: 10MW
<table>
<thead>
<tr>
<th>Year</th>
<th>Value 1</th>
<th>Value 2</th>
<th>Value 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>2003</td>
<td>16.03</td>
<td>3.91</td>
<td>1.91</td>
</tr>
<tr>
<td>2020</td>
<td>16.67</td>
<td>2.44</td>
<td></td>
</tr>
<tr>
<td></td>
<td>9.5</td>
<td>20</td>
<td>6.3</td>
</tr>
<tr>
<td></td>
<td>4.5</td>
<td></td>
<td>6.1</td>
</tr>
<tr>
<td></td>
<td>3000</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>2.45</td>
<td>5000</td>
</tr>
<tr>
<td></td>
<td>4000</td>
<td>2000</td>
<td></td>
</tr>
</tbody>
</table>
2003

China CHP Development in 2003

2121  6000

4369

14.84

15.69

11.16

22

66

3000
China CHP Development forecasting in 2020

2020

2020 CHP CAPACITY:

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>2001</td>
<td>1.6</td>
<td>1.3</td>
</tr>
<tr>
<td>30</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

Residential CHP

6500

Industrial CHP

2001  4200

1.3
Distributed Energy in China
Trend of installation scale of world power generation facilities

- From small to large
- From near to far
- From large to small
- From far to near

Back to distributed style
Key part of 21st century energy system

Normal thermal power plant, hydro power plant and nuclear power plant have been challenged biologically and environmentally, along with the development of energy technology and reformation in energy structure, distributed energy shall serve mankind by forming a stronger energy network with traditional large grid power supply with its advantages of environmental friendly, highly efficient, energy saving and flexible, etc.
CCHP Of Distributed Energy

New wave of 21st century

Historical Dialectic

Result of technological progress

Environmental & High utilization rate of energy

Energy facilities From large to small --from Far to near
Advantages Of Distributed Energy

Low emission, high environmental protection

Nox  25ppm  CO2

The Nox emission from the gas turbine can be as low as to below 250ppm, and the emission of CO2, sulfur ride and power is low.

Highly efficient utilization of energy in a comprehensive way

75%

With CCHP, the comprehensive utilization of energy can be above 75%.

Intelligent & Flexible

Controlled automation, information, managed grid, remote control, free of man duty
Advantages Of Distributed Energy

Enhance the safety of power utilization

Be directly placed nearby customers, work with large grid and so significantly enhance the safety of power utilization

Improve economic benefit of city grid and natural gas pipeline

Supply cooling air in summer, supply heat in winter, improve the utilization rate of power grid and natural gas pipeline
Necessity of promoting CCHP technologies in China
2001
Huge Development Potential of China Electric Power Industry

1/10
Average installed capacity per head is less than 1/10 of that in the US

Average generation/utilization of power per head is less than 1/10 of that in the US
2003-2004
Power Outage and Shortage in the summer of 2003-2004

26 (2003 19)
24 provinces of China are heavily short of power (19 provinces in 2003)

2003 7 8 during June and July in 2003
14
Cumulatively, more than 140,000 lines/time were shut down to restrict the power supply
19 kwh
Cumulatively, about 1.9 billion kwh power were estricted

4000 kw
The maximum restricted power load in one day exceeded 400 billion kwh.
Electric power development fails to keep up with the rapid and continuous growth of national economy

During the first half of 2004, the economy of China grew with 9.5% while the power consumption of whole society for the same period increased by 14.9%. However, the growth rate of average installed capacity targeted by 15th Plan is only 3.6%.

The maximum load of the grid of Beijing, Tianjin and Tangshan increased up to 22.04 million kwh, 2.67 million kwh over that of the last year.

The specific weight of the load caused by cooling of air conditioning in the grid of East China, South China and Central China has exceeded 30%, and near 40% in individual provinces.
Nature Gas Pipe Line
Completion of the second Sanxi to Beijing Natural Gas Pipeline

By 2008, the gas utilization volume shall be 5 billion cubic meter

<table>
<thead>
<tr>
<th>Project</th>
<th>2002</th>
<th>2005</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Å¢è</td>
<td>Å¢è</td>
</tr>
<tr>
<td>Ïî   Ä¿  Pr oj ect</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ñ..ÓãŒ«¹ «Residents, Public servants</td>
<td>55918</td>
<td>80491</td>
</tr>
<tr>
<td>Å²µIndustry</td>
<td>55918</td>
<td>53548</td>
</tr>
<tr>
<td>ÒÉº¬Cooling</td>
<td>94885</td>
<td>145759</td>
</tr>
<tr>
<td>ÖÄäHeating</td>
<td>4400</td>
<td>5842</td>
</tr>
<tr>
<td>ÖÈ¼ú Direct gas engine</td>
<td>842</td>
<td>5842</td>
</tr>
<tr>
<td>Ï¼ÄSubtotal</td>
<td>100127</td>
<td>151601</td>
</tr>
<tr>
<td></td>
<td>31.28</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>31.28</td>
<td>13</td>
</tr>
<tr>
<td></td>
<td>(94.77)</td>
<td>(96.)</td>
</tr>
<tr>
<td></td>
<td>(4.39)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.84)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>56</td>
<td>37</td>
</tr>
</tbody>
</table>
Situation of natural gas utilization volume of various consumers in Beijing

50
6

Natural gas used for heating accounts for more than 50% of the total of whole year, and the difference between winter and summer is 6 folds

(M³)
Grid annual load curve of Beijing, Tianjin and Tangshan & Beijing natural gas annual load curve
Shanghai has piloted the project

Huangpu Central Hospital

- 20
  - Use Solar Saturn 20 gas turbine unit
  - 1,100kW
  - Generate 1,100kw power
- Satisfies the needs of power, heat, cooling, hot water and disinfect steam of whole hospital.
Shanghai has piloted the project

<table>
<thead>
<tr>
<th>Pudong International Airport</th>
<th>Minhang Central Hospital</th>
</tr>
</thead>
<tbody>
<tr>
<td>Use Solar Centaur 50 gas turbine</td>
<td>400kW</td>
</tr>
<tr>
<td>Generate 4,000kw power</td>
<td>Jiantai 400kw gas engine</td>
</tr>
<tr>
<td>Satisfied the needs of power, heating and cooling of part of the airport</td>
<td>400kW</td>
</tr>
<tr>
<td>Generate 4,000kw power</td>
<td>Generate 400kw power</td>
</tr>
<tr>
<td>Satisfied the needs of power, heat, cooling, hot water and disinfect steam of part of hospital.</td>
<td>Satisfied the needs of power, heat, cooling, hot water and disinfect steam of part of hospital.</td>
</tr>
</tbody>
</table>
Shanghai PuDong Inter’l Airport

- Gas turbine  3.5MW
- Exhaust heat boiler  9.7t/h

- Vapor Generated:  0.9Mpa
- Overall efficiency  77%
CCHP Policy Of Shanghai

- Government coordinates the interconnection of Co-Gen project.
- Imported equipment is exempted from VAT and import duty
- Assist enterprise in doing feasibility study, setting up project, organize, review and approve project
- Provide financial support low interest loan research budget
- 2.1-2.4 / / : 1.9 /
- Favorable natural gas price 2.1-2.4 RMB/cubic meter; 1.9 RMB / cubic meter for co-gen
- Reduce or exempt natural gas resources package fee
- Actively promote pilot project Organize abroad visit, etc.
Testing being actively performed in Beijing

Already constructed and being commissioned

- 1 480kw + 1 725kw
  1 set of 480kw + 1 set of 72kw gas engine
- 1 BZ100 + 1 BZ200
  1 set of BZ100 + 1 set of BZ200 Waste Heat direct gas turbine

- Guarantee power consumption of the basically, the shortage shall be supplemented by the grid
- Satisfies the heating, cooling, and hot water of the building
Beijing Gas Monitoring & Controlling Center

- **Equipment:**
  - 725 KW gas engine + 2 million Kcal DFA
  - 480KW gas engine + 1 million Kcal DFA

- **Construction Area:**
  - 32,800 m²

- **Maximum Load:**
  - Electrical: 1640 Kw
  - Cooling: 3148.8 Kw
  - Heating: 2296 Kw
Comprehensive building of Beijing Ciqumen Natural Gas Station
Already constructed and commissioned successfully

1 TG80 80kw
1 set of British Bowman TG80 80kw micro gas turbine

1 20
1 set of China Yuanda 200,000 mega pscal waste heat direct engine;

- Satisfy the needs of power, heating, cooling and water of the office building

Extra power be interconnected (system testing project)
CiQu Gas Pump Station BCHP

- A gas pump station
- Floor area 2900 m²
- Electrical power: 80KW
  Bowman Microturbine
- Exhaust heat DFA: 66USRT
- DFA: 66USRT
Zhongguancun Software Park
During design stage

1 1200kw
1 set of 1200kw gas turbine

1 $500 \times 10^4$ kcal/h
1 set of $500 \times 10^4$ kcal/h waste heat direct gas engine

Satisfy power consumption partially, support safe power utilization

Satisfy the heating, cooling and hot water of the square
### ZhongGuanCun Software Park
#### Financial analysis

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Estimated total investment: RMB</td>
<td>39 million</td>
</tr>
<tr>
<td>Estimated incremental investment compared with using DFA only: RMB</td>
<td>13.6 million</td>
</tr>
<tr>
<td>Energy-net: RMB</td>
<td>10 million</td>
</tr>
<tr>
<td>Project owner: RMB</td>
<td>29 million</td>
</tr>
<tr>
<td>Estimated project IRR</td>
<td>12.46%</td>
</tr>
<tr>
<td>Payback period</td>
<td>7.16 years</td>
</tr>
</tbody>
</table>
Project of CCHP with Qinghua University Sterlin outer combustion turbine
Successfully commissioned and operate normally

- 20kW  35.5kW
  20kw Sterlin generator, 35.5kw heating supply
- 30  53
  30% power generation efficiency, 53% heating supply efficiency
- 55  250
  Outlet hot water temperature is 55 degree C, exhaust gas
temperature is 250 degree C
- Extreme low equipment emission
- 8ppm  1/15
  Nitrogen Oxide is 8ppm, 1/15 of
ZhongGuanCun Medical Park

- Northwest Beijing
- Total occupied area: 119.66 hectare

- Cooling: $5,633 \times 10^4$ kcal/h
- Heating: $4,501 \times 10^4$ kcal/h
- Electricity: 43.608 MW
- Hot water: $168 \times 10^4$ kcal/h
- Steam: 40 t/h
China World Trade Center
Phase 3 BCHP

Construction area:

540 000 m²

Total investment:

800 million USD

Commercial use date:

the end of 2007
GGuangzhou University City DE Projects
have been set up and being tendered

LNG LNG is main fuel;
2 Form up 2 sets Gas-steam gas turbine combined cycle CCHP unit;
126 Mw 52.1%
generation capacity: 126MW, combined cycle power generation
Heating supply capacity
120t/h 3.5Mpa 130°C
80%
120t/h 3.5Mpa high temperature and high pressure steam, total
efficiency of energy utilization of 130 degree Clow temperature flue
gas recovery such as free from living water system is above 80%;
2005
Phase 1 of University City (before 2005)
18 / 18 square kilometer
25 / 250,000 population

Phase 2 University City
43 / 43 square kilometer
30 / 300,000 population

/ Medium sized cities

Largest university city in the country
Difficulty faced by promoting the application of CCHP in Buildings

- Hard to interconnect
- Restrictions from fire-fighting rules
- Too high gas price
- Restrictions on power sales
- Restrictions of Beijing emission rules
- Too expensive and less localized on the main equipment
Difficulty of interconnection

- Currently, Beijing power bureau believes that the grid will be affected if interconnected by small capacity power source. However, technically, the interconnection of generator that conforms with national standards with the grid is a matured technology.

- Indeed there is certain difficulties in dispatching and managing the interconnection. However, the difficulties can be solved technically.

**Solution:** The difficulties can be solved technically. The issue lies in mind.
Restrictions of fire-fighting rules

• 2kg  5kg  15kg

Current fire-fighting rules restrict the gas with pressure higher than 2kg from entering into household though the pressure of gas turbine is usually between 5kg and 15kg.

• 10kg

• The pressure of the gas that is allowed to enter into household in Japan and US is usually above 10kg. But both countries have formulated a complete set of corresponding managerial and technical measures to solve the problem resulted from the high pressure gas rather than inhibiting the application of such gas.

Solution: Along with the technical development, corresponding rules and measures should be formulated in terms of different new technologies and equipment. Otherwise, it will be the obstacle to the technical progress.
Gas price is too high

- CCHP

The high gas price has been the main reason that has been inhibiting the application of CCHP and other industries. Chinese gas price is one fold higher than that of US and Russia.

Suggestions: Governmental agencies to formulate a reasonable price, balance the interests of various agencies, or provide favorable treatment and support to the application of such highly efficient energy. Beijing Gas Group has granted certain favorable treatments to CCHP projects though not enough.
Restrictions on power sales

- For the time being, the domestic power market is still a monopolized one. Although the reformation designed to break such monopoly has started, still far away from being marketed.

- CCHP

CCHP is only allowed to sell power to its own customers, and is restricted from selling power to neighboring customers through the grid. And even it is allowed, the tariff is unreasonable which affected the economy of distributed energy.

- CCHP

Suggestions: Rules should be formulated to allow CCHP to sell neighboring customers through grid at a reasonable and relatively low wheeling fee to grid.
Restrictions of Beijing Emission Rules

- **NO\textsubscript{X}** 200mg/m\textsuperscript{3}  
- **NO\textsubscript{X}** 200mg/m\textsuperscript{3}

The standards of Beijing to the emission of Nox of boiler is restricted below 200mg/cubic meter, and that the Nox emission of gas turbine is below 200mg/cubic meter. However, it is extremely difficult for gas engine to satisfy this standards.

- **NO\textsubscript{X}** 250mg/m\textsuperscript{3}

Gas engines have been widely used in abroad, the Nox emission is controlled below 250mg/cubic meter. In addition, Gas engine is completely different from boiler in terms of operation principle. If boiler standards are used to regulate gas engine or other equipments, it is obvious improper.

**Suggestions:** Corresponding rules should be formulated with respect to different technologies and rules so as to guarantee that the advanced technologies get fully and effectively applied.
Too expensive and less localized on the main equipment

- **CCHP**

  The main equipment of CCHP are gas turbine and gas engine, and these two equipments are almost vacant domestically, I.e. must be imported from abroad which results high price accounting for more than half of the investment which eventually cause the high investment in CCHP project.

- **863**

  Both gas turbine and micro-gas turbine are part of state 863 program.

**Suggestions:** The development of CCHP is fully integrated with the localization of equipment, and the active development of CCHP shall promote related domestic industries which will in turn promote the development of CCHP.
China5e.com

Thanks