Power System Development and Nationwide Grid Interconnection in China

Xiaoxin Zhou
Electric Power Research Institute, China
Qinghe, Beijing 100085
xxzhou@epri.ac.cn
INTRODUCTION

CURRENT STATUS AND DEVELOPMENT OF POWER SYSTEM IN CHINA

PURPOSE AND FUNCTION OF THE NATIONAL GRID INTERCONNECTION

BASIC STRUCTURE OF THE NATIONWIDE INTERCONNECTED GRID

SOME KEY PROJECTS

TECHNICAL PROBLEMS

CONCLUSION
INTRODUCTION

• China power industry: 1882
• First 220kV line: 1943
• First 330kV line: 1972
• First 500kV line: 1981
• First 500kV HVDC line: 1989
• Nationwide grid interconnection: from now to 2015-2020
CURRENT STATUS AND DEVELOPMENT OF POWER SYSTEM IN CHINA

Generation

- The total generation capacity: 298.8GW by the end 1999; reached 300GW April 2000. Estimate 327GW, 1430 TWh the end of 2001. Annual increasing rate 6%~6.5%.
- Generation capacity: about 75% from thermal power, nearly 24% is from hydro. Two nuclear power plants with total capacity of 2.1 GW, 1% of the total.
- Energy production: about 70% from coal fired, 20% from hydro, 10% from others.
Transmission

- AC transmission system: 500 kV line: 22,400 km; Northwest Power Network: 330 kV.
- HVDC +/- 500 kV, 1,200MW, 1,043km transmission project, from Gezhouba Hydro Power Plant to Shanghai was put in operation in 1989.
- A new HVDC transmission project, TSQ project from Tianshengqiao Hydro Power Plants to Guangzhou with +/- 500 kV, 1,800MW long distance transmission is under commissioning.
- The feasibility studies of other two HVDC projects with 3,000MW each, one from Gueizhou to Guangdong, one from the Three Gorges to Guangdong have been approved. These two projects will be put in operation in 3-4 years.
Grids (1)

- Six inter-provincial regional power grids: East China, North China, Northeast China, Central China, Northwest China, South China
- Six independent provincial level power grids: Shandong, Fujian, Sichuan and Chongqing, Xinjiang, Tibet
- The East China interconnected with the Central China by a HVDC line (1,044 km, 1,200 MW)
Regional Grids Interconnection in 1999

Hydropower station

- DC
- Under construction DC
- Under construction AC
Grids (2)

- A 500 kV AC interconnection between North China Network and Northeast China Network will be in operation the middle of this year 2001.
- Shangdong to North China, Fujian to East China will be in operation the end of 2001 or 2002.
Regional Grids Interconnection in 2001-2002
Three Gorges Project

- Overview
- Chronicle of Events
- Power Station
- Supply Area
- Transmission System
## Chronicle of Events

<table>
<thead>
<tr>
<th>Time</th>
<th>Events</th>
</tr>
</thead>
<tbody>
<tr>
<td>on April 3, 1992</td>
<td>Approval by the National People’s Congress</td>
</tr>
<tr>
<td>on December 14, 1994</td>
<td>Official beginning to be built</td>
</tr>
<tr>
<td>on November 8, 1997</td>
<td>successfully blocked</td>
</tr>
<tr>
<td>in August 2003</td>
<td>Operation of the first generating unit</td>
</tr>
<tr>
<td>in June 2002</td>
<td>Commission of the first pole of HVDC from the TGHS to Changzhou</td>
</tr>
<tr>
<td>in 2006</td>
<td>Completion of Left Bank Power Station</td>
</tr>
<tr>
<td>By 2009</td>
<td>Completion of whole project</td>
</tr>
</tbody>
</table>
Power Station

- Total generation capacity 18.2GW, annual production 84.7 billion kWh.
- 26 generation units, 700MW each.
- Left bank plant: 14 units, Right bank plant: 12 units; additional 6 unit sites for future expansion.
- The first unit will start generation in year 2003, the total installation 2009.
Supply Area

- Highly seasonal hydroelectric output. 50% energy output during June-September. Minimum output constrained by navigation.

- Need large supply area and thermal power for compensation and utilization of large seasonal hydroelectric power.

- Supply power for Central China, East China, Sichuan-Chongqing(Chuanyu) power systems.
Transmission System

- Two stations, four independent busbars, fifteen 500kV transmission circuits, AC and DC transmission.

- To Central China, 12GW, 500kV AC lines; to East China, 7.2GW, three +/- 500kV DC lines; to Chuanyu, 2GW, two circuits of 500kV lines.

- Three Gorges Power Grid: 3 regional power grids, 8 provinces, 2 metropolitan cities. 200GW in capacity by the year 2010.
PURPOSE AND FUNCTION OF THE NATIONAL GRID INTERCONNECTION

Energy Transmission: West to East

- Energy resources distribution geographically unbalance. 82% of coal deposits are in the north and southwest. 67% of exploitable hydropower are concentrated in the southwest.

- 70% of energy consumption concentrate in the central and coastal areas. In order to make up the deficits of energy in the central and coastal.

- It is imperative to transmit energy in large amount and long distance. It is necessary to develop cross-regional power systems interconnection.
Hydropower Transmission

- The Three Gorges Transmission System. A strong network along the Yangtze River will be formed by 2010.

- JinShaJiang River Hydropower will be sent to Central China, East China and South China regions after 2010. Higher AC voltage transmission system or HVDC transmission system becomes significance for the further bulk power transmission.

- Lancang River Hydropower sent to Guangdong with HVDC lines.
Hydropower Transmission in China

- Yellow River Hydropower
- TSQ Hydropower
- Three Gorges Transmission
- Planned Hydropower (JinShaJiang, LanCangJiang)
Coal Fired Power Transmission

- North of Inner Mongolia to Liaoning
- Shanxi and West of Inner Mongolia to Beijing, Tianjin and Tangshan (JJTPG)
- Shanxi-Inner Mongolia-Shanxi to North China
- Henan-Shanxi to Central China
- South Shanxi to North Jiangsu
- Shanxi to Shandong
Coal Fired Power Transmission in China
Interconnection Benefits

- Reducing total installed capacity.
- Increasing reliability and ensuring supply quality.
- Merging and levelling of load peaks
- Hydro-thermal coordination.
- Cross river-valley compensation.
BASIC STRUCTURE OF THE NATIONWIDE INTERCONNECTED GRID

Nationwide Interconnection

- Three Gorges Power System (2010) will be the major part of the national power grid.
- Three interconnected sections: North Section, Central Section, South Section
North Section

- North Section: NCPN, NEPN, NWPN and Shangdong grid will be connected.
- NEPN and NCPN being connected to share the interconnection benefits.
- NCPN and NWPN interconnected along with the development of "Sanxi" thermal power base.
- Interconnection of NEPE with Russia power system to import electricity need further study.
- The proposed interconnection with countries in Northeast Asia should be studied and considered to share benefits of interconnection.
Central Section

- Central Section: CCPN, ECPN, CYPG and Fujian grid.
- This section will be basically established when the first generating unit of Three Gorges Power Plant commissioned.
- Three Gorges Power System (2010) will be the major part of the section.
South Section

- South Section: Guangdong, Guangxi, Guizhou and Yunnan provincial power grid.
- In the South Section, large amount of electricity will be transmitted to Guangdong from the west provinces mainly by HVDC/HVAC transmission lines.
- In future, Hainan provincial grid will be interconnected with Guangdong provincial grid by HVDC marine cable.
- Yunan will export electricity to Thailand.
Regional Grids Interconnection in 2005
Regional Grids Interconnection in 2010

Possible International connection
AC
DC
Regional Grids Interconnection in 2015-2020
Table 1  The routes from North to South

<table>
<thead>
<tr>
<th>Sending system</th>
<th>Receiving system</th>
<th>Transmission power (MW)</th>
<th>Assumed transmission schemes</th>
</tr>
</thead>
<tbody>
<tr>
<td>South Shanxi*</td>
<td>North Jiangsu</td>
<td>4000</td>
<td>500 kV AC with SC</td>
</tr>
<tr>
<td>Shanxi</td>
<td>Hubei</td>
<td>3000</td>
<td>±500 kV DC</td>
</tr>
<tr>
<td>Ningxia</td>
<td>East Hubei</td>
<td>1200-2400</td>
<td>±500 kV DC</td>
</tr>
<tr>
<td>Shanxi</td>
<td>Sichuan</td>
<td>2400</td>
<td>± 500 kV DC</td>
</tr>
<tr>
<td>Shanxi</td>
<td>CCPN</td>
<td>About 300</td>
<td>Back-to-back DC</td>
</tr>
</tbody>
</table>

*: Remote thermal plant, the first stage of the project is completed.
<table>
<thead>
<tr>
<th>Sending system</th>
<th>Receiving system</th>
<th>Trans. power (MW)</th>
<th>Alternatives of transmission</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydro power stations in Jingsha River</td>
<td>CCPN</td>
<td>6,000</td>
<td>±600 kV DC or UHVAC</td>
</tr>
<tr>
<td>(Xiluodu, xiangjiaba)</td>
<td>ECPN</td>
<td>10,000</td>
<td>±800 kV DC or UHVAC</td>
</tr>
<tr>
<td>Hydropower stations in Lancang River</td>
<td>Guangdong</td>
<td>7,000-8,000</td>
<td>±500 kV DC or ±600 kV DC</td>
</tr>
<tr>
<td>(Xiaowan, Dacaoshan, Nuozhadu, etc.)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
TECHNICAL PROBLEMS

- Transient stability. NEPN and NCPN interconnection
- Low frequency oscillation. Most cases with week interconnection
- HVAC/HVDC operation. South China
- Multi HVDC inverters operation. Three Gorges and South China
- The possible application of UHVAC (1,000kV-1,150kV) and FACTS
GRID INTERCONNECTION IN NORTHEAST ASIA

What is the purpose?

- Power transmission: e.g. Russia to North China
- General mutual benefits
- Solving the problem of small network with large generator operation: sample in China
GRID INTERCONNECTION IN NORTHEAST ASIA

Technique issues

- AC or DC
- Single point connection or multi point connection
- Low frequency oscillation with AC weak interconnection, transient and voltage stability
- Operation problem: frequency and voltage control
GRID INTERCONNECTION IN NORTHEAST ASIA

Financial, economic problems

- Investment for transmission system
- Electricity price and mutual benefits
- Need detailed studies
CONCLUSION

- In 2015-2020, the nationwide interconnected grid will be basically established. The construction of Three Gorges Hydropower Project will push forward the implementation of nationwide interconnection program of China.

- The nationwide interconnected grid will cover most of existent regional and independent provincial power grids. Total installed capacity will reach 750GW by the year 2020. Three sections in the early stage, the North, Central and South Section. The central and south section will likely merge into one.
CONCLUSION

- Power flow is mainly from west to east and there is power exchange in direction from north to south. It is guessed that the north section will be connected to the central by HVDC.
- Some technical problems should be studied and paid attention, such as AC/DC, transient stability, low frequency oscillation, voltage stability, etc.
- Various issues and problems of Northeast Asia grid interconnection should be further detailed studied.
Thank you!