

Power System Development and Nationwide Grid Interconnection in China

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- ❑ 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

INTRUDUCTION

- 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

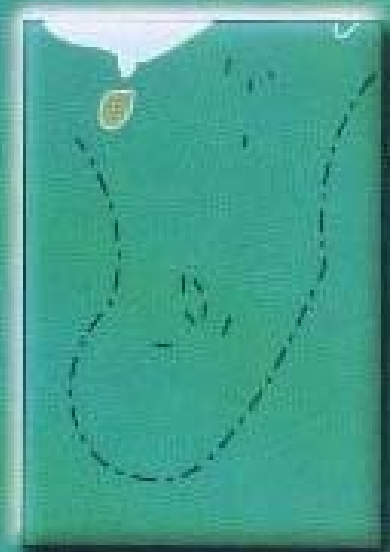
- The total generation capacity: 298.8GW by the end 1999; reached 300GW April 2000. Estimate 327GW, 1430 TWh the end of 2001. Annual increasing rate 6%~6.5% .
- Generation capacity: about 75% from thermal power, nearly 24% is from hydro. Two nuclear power plants with total capacity of 2.1 GW, 1% of the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

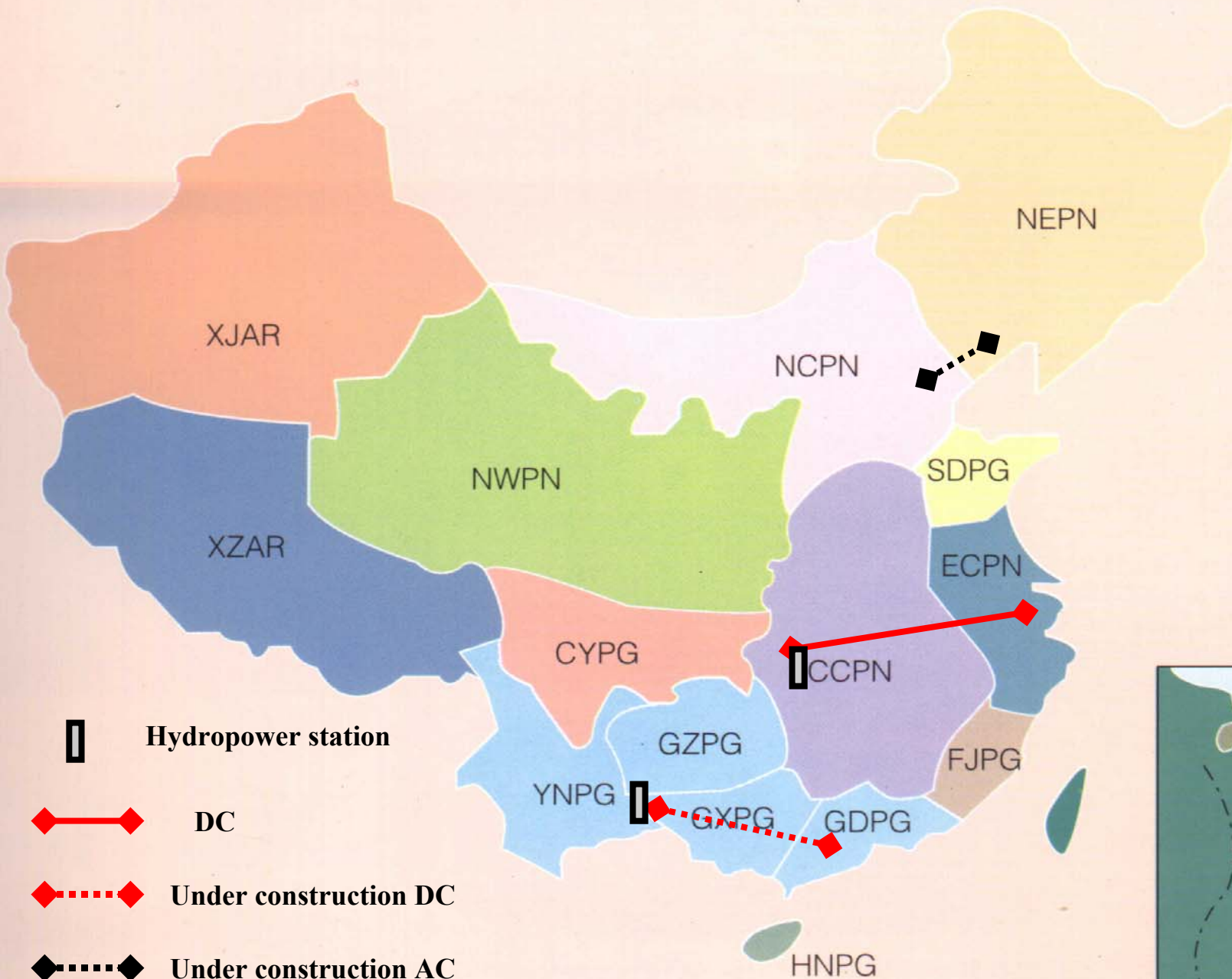
Transmission


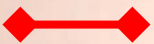


- ❑ AC transmission system: 500 kV line: 22,400 km; Northwest Power Network :330 kV.
- ❑ HVDC +/- 500 kV, 1,200MW, 1,043km transmission project, from Gezhouba Hydro Power Plant to Shanghai was put in operation in 1989.
- ❑ A new HVDC transmission project, TSQ project from Tianshengqiao Hydro Power Plants 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 6 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)





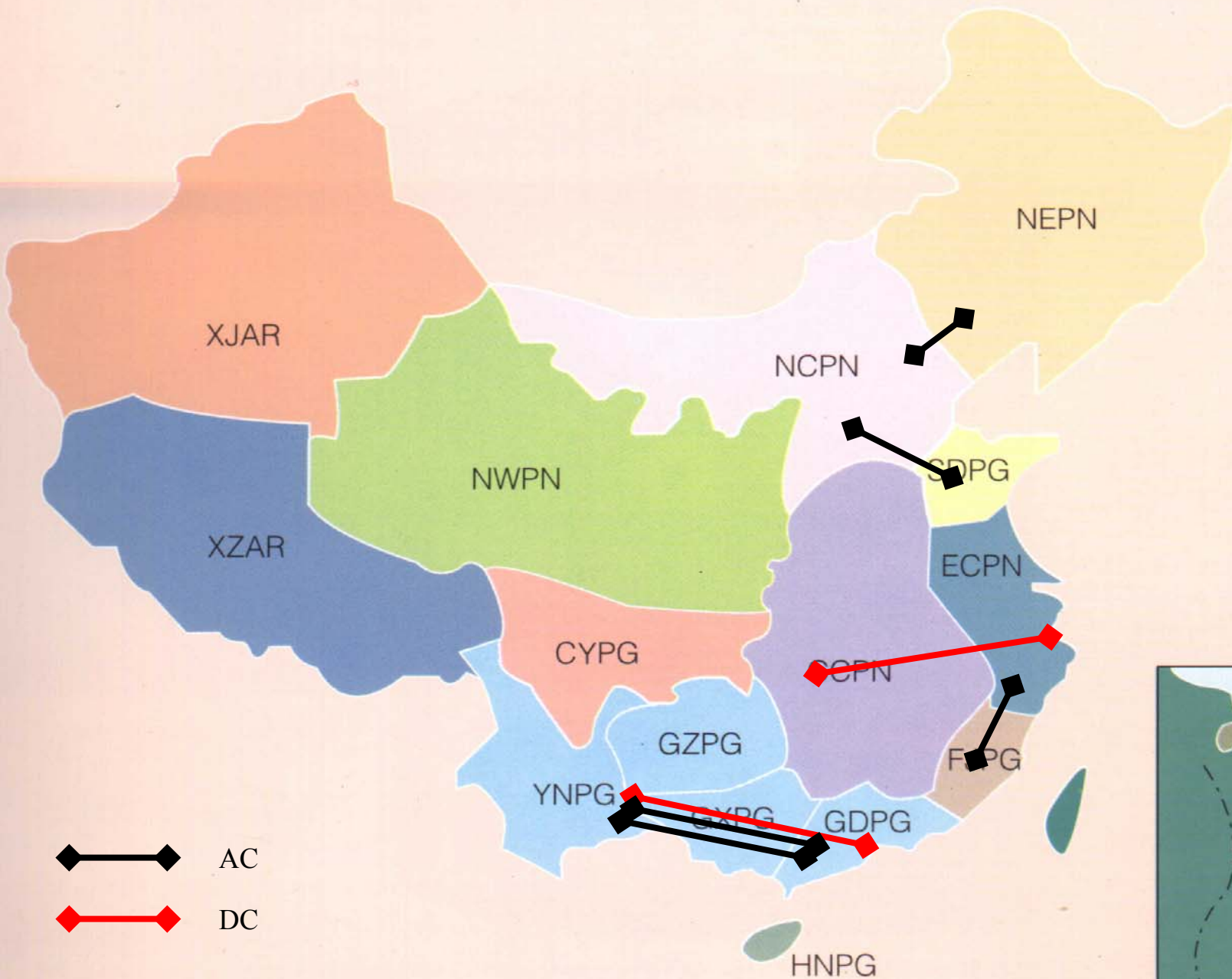
-  **Hydropower station**
-  **DC**
-  **Under construction DC**
-  **Under construction AC**



Regional Grids Interconnection in 1999

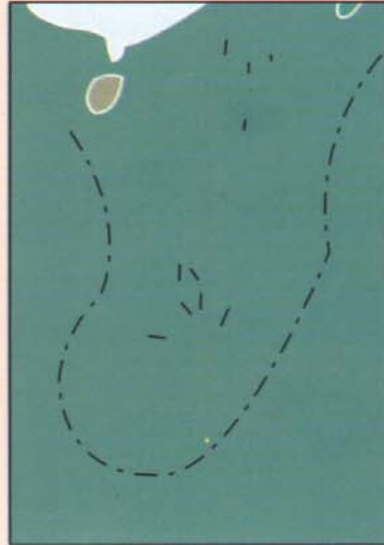
Grids (2)

- 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.



 AC
 DC

Regional Grids Interconnection in 2001-2002



Three Gorges Project

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





Beijing

Hwang Ho

CHINA

Three Gorges

Wuhan

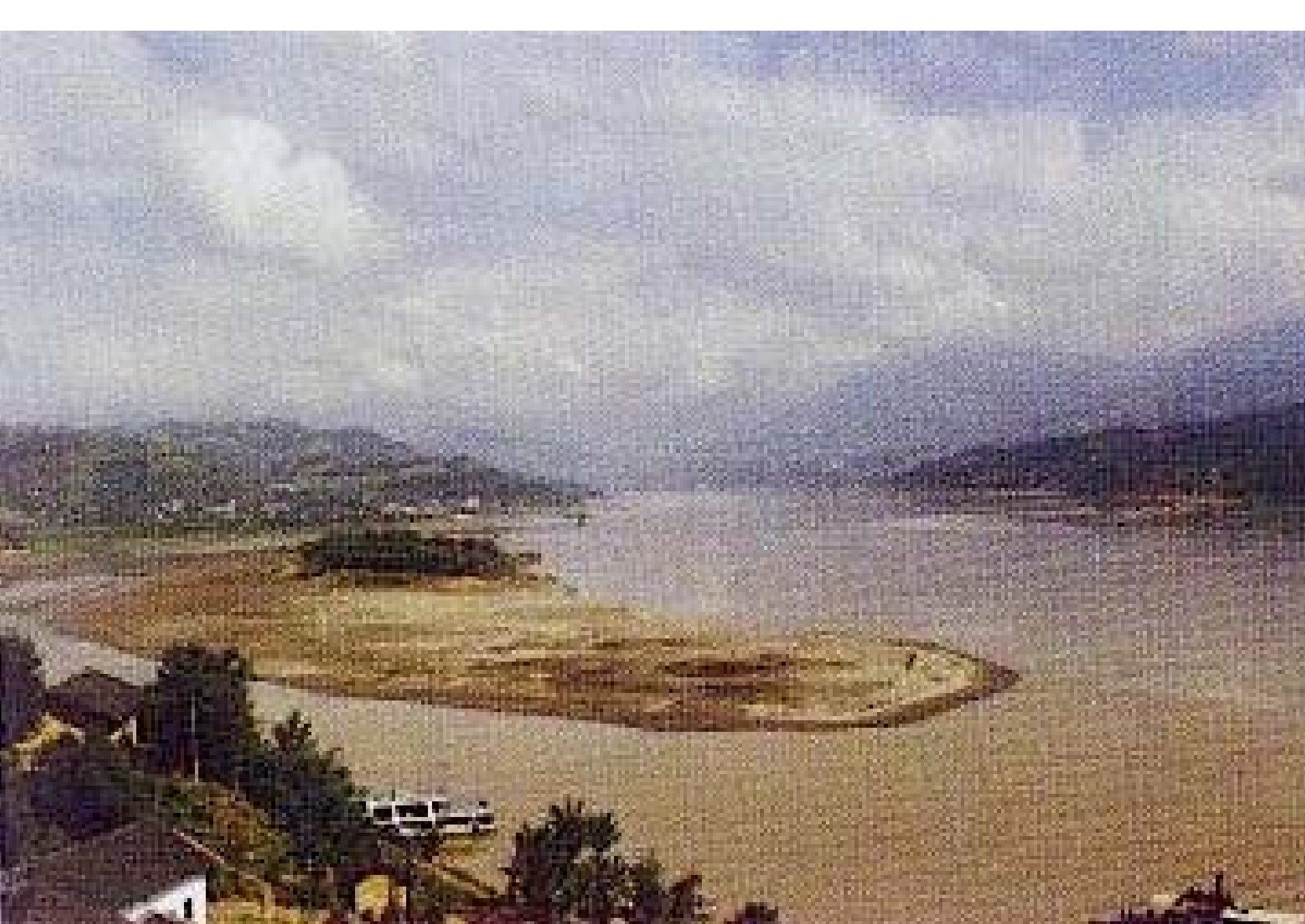
Shanghai

Parzhiua

Yangtze

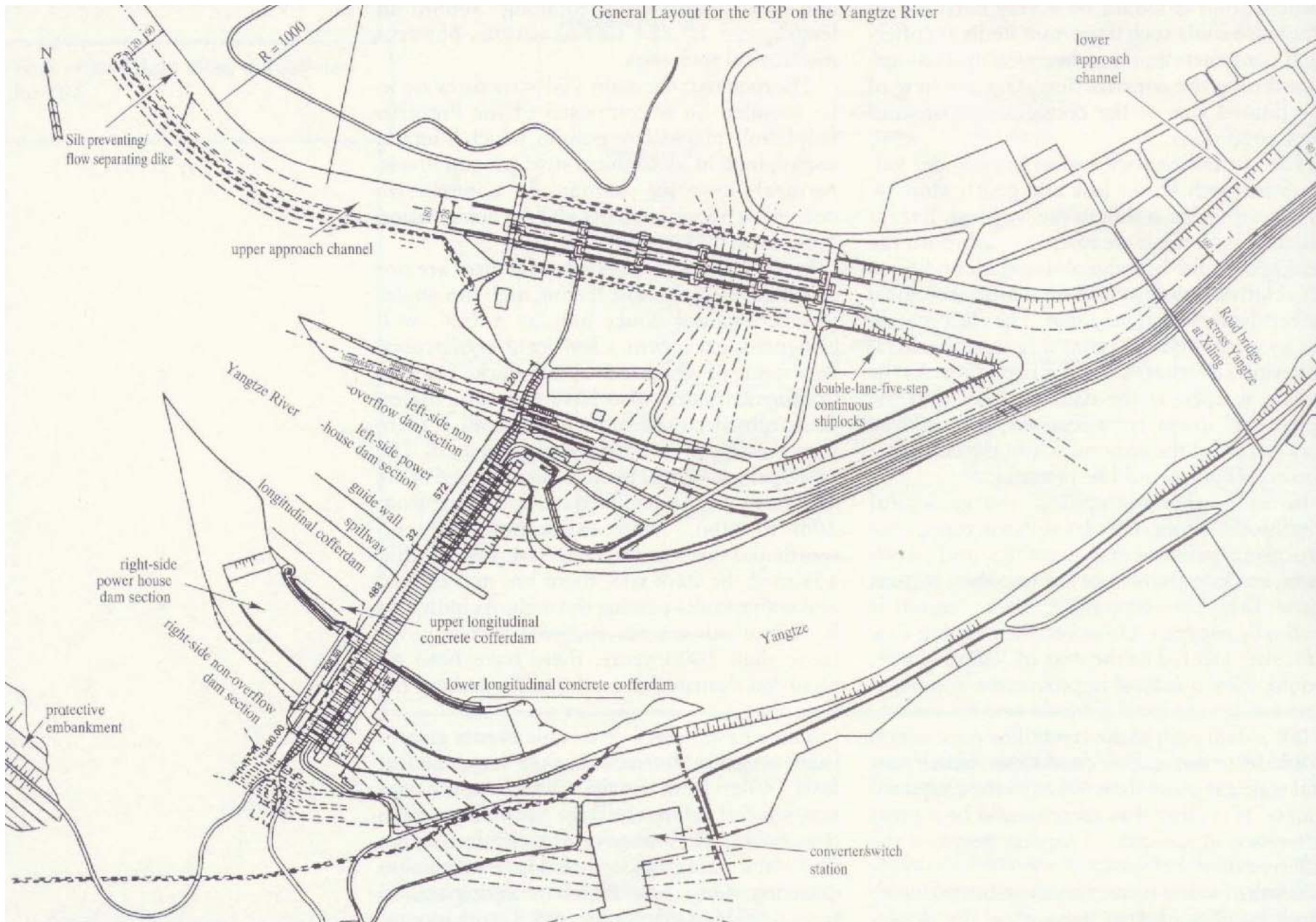
Hsikiang

Hong Kong





General Layout for the TGP on the Yangtze River





Chronicle of Events

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

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

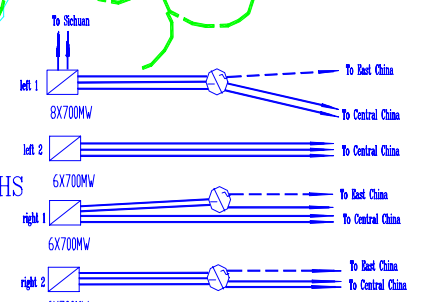
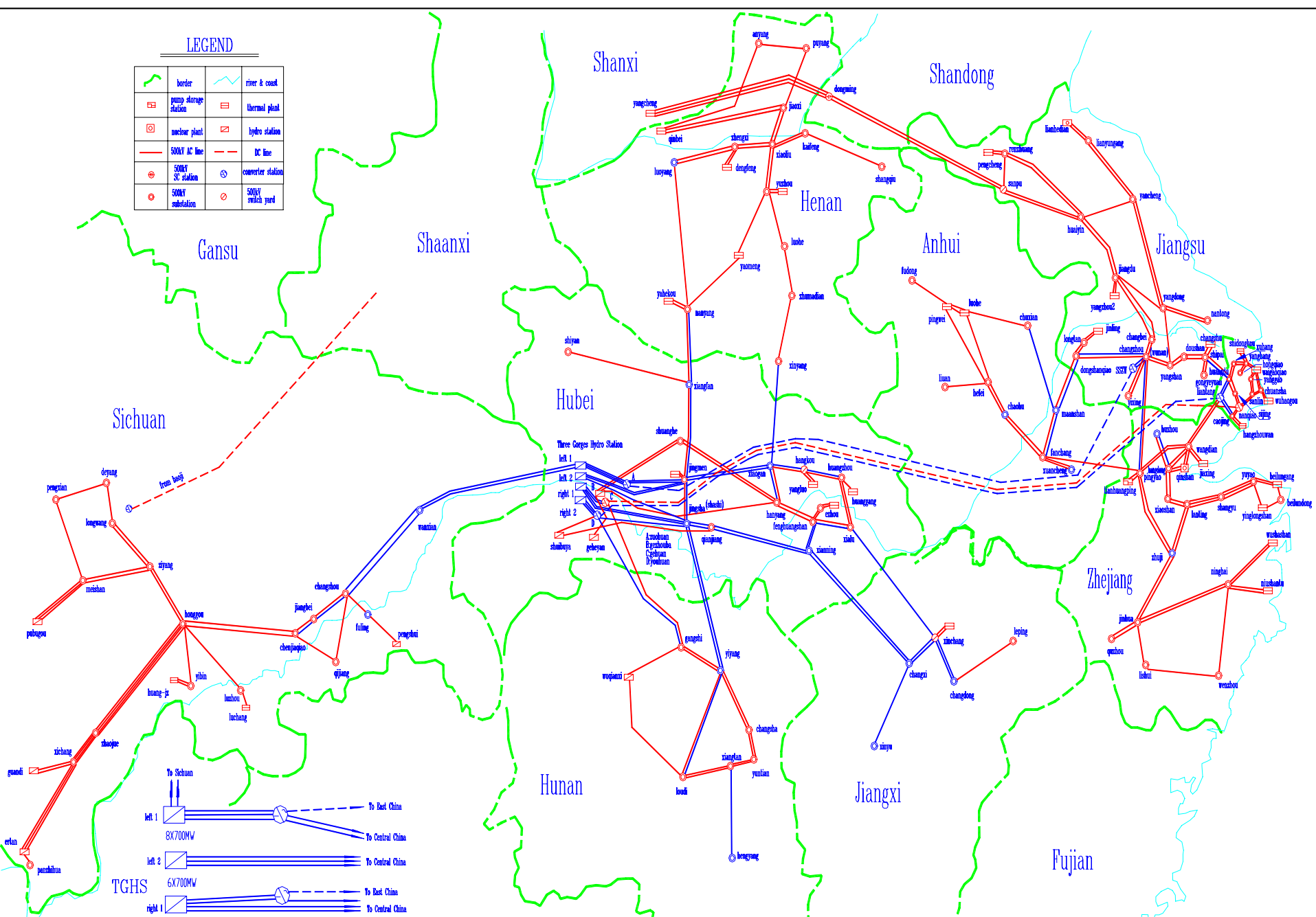
- ❑ Highly seasonal hydroelectric output. 50% energy output during June-September. Minimum output constrained by navigation.
- ❑ Need large supply area and thermal power for compensation and utilization of large seasonal hydroelectric power.
- ❑ Supply power for Central China, East China, Sichuan-Chongqing(Chuanyu) 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.

LEGEND

	border		river & coast
	pump storage station		thermal plant
	nuclear plant		hydro station
	500kV AC line		DC line
	500kV SC station		converter station
	500kV substation		500kV switch yard



Geographic Diagram of Three Gorges Power System in 2010

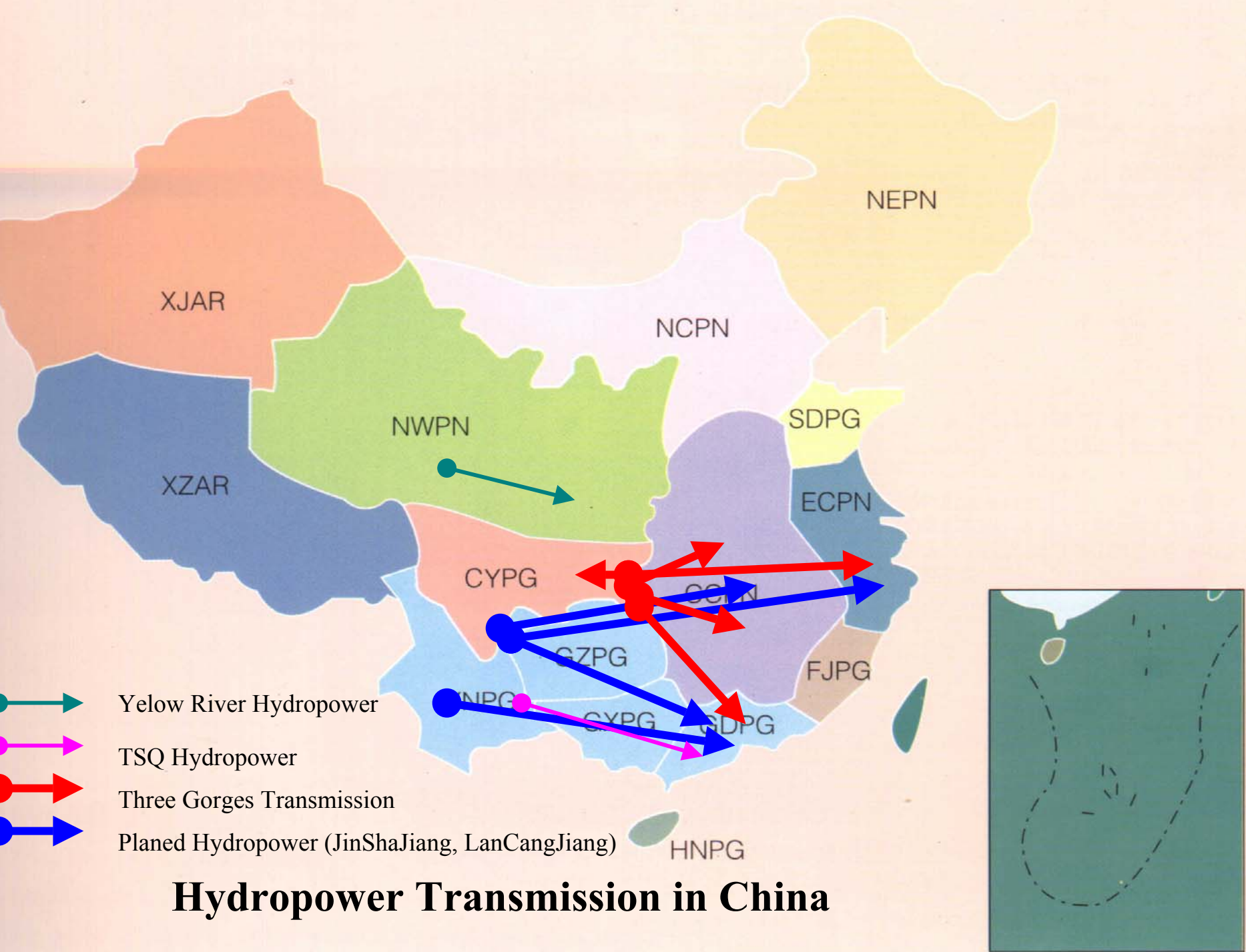
PURPOSE AND FUNCTION OF THE NATIONAL GRID INTERCONNECTION

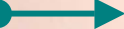



Energy Transmission: West to East

- 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.

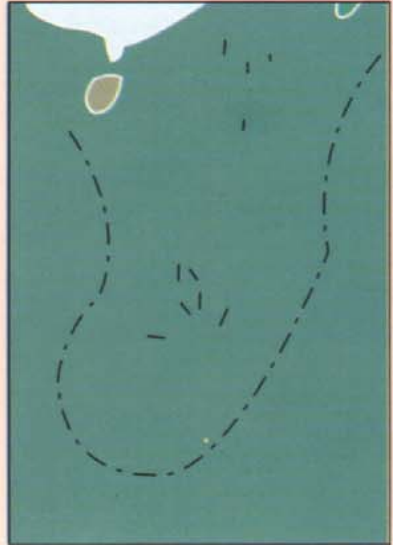
Hydropower Transmission

- ❑ 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.



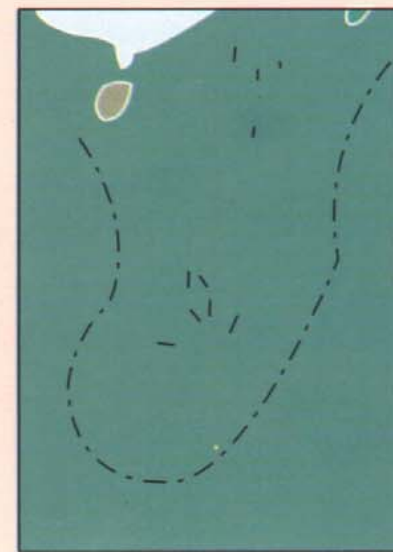
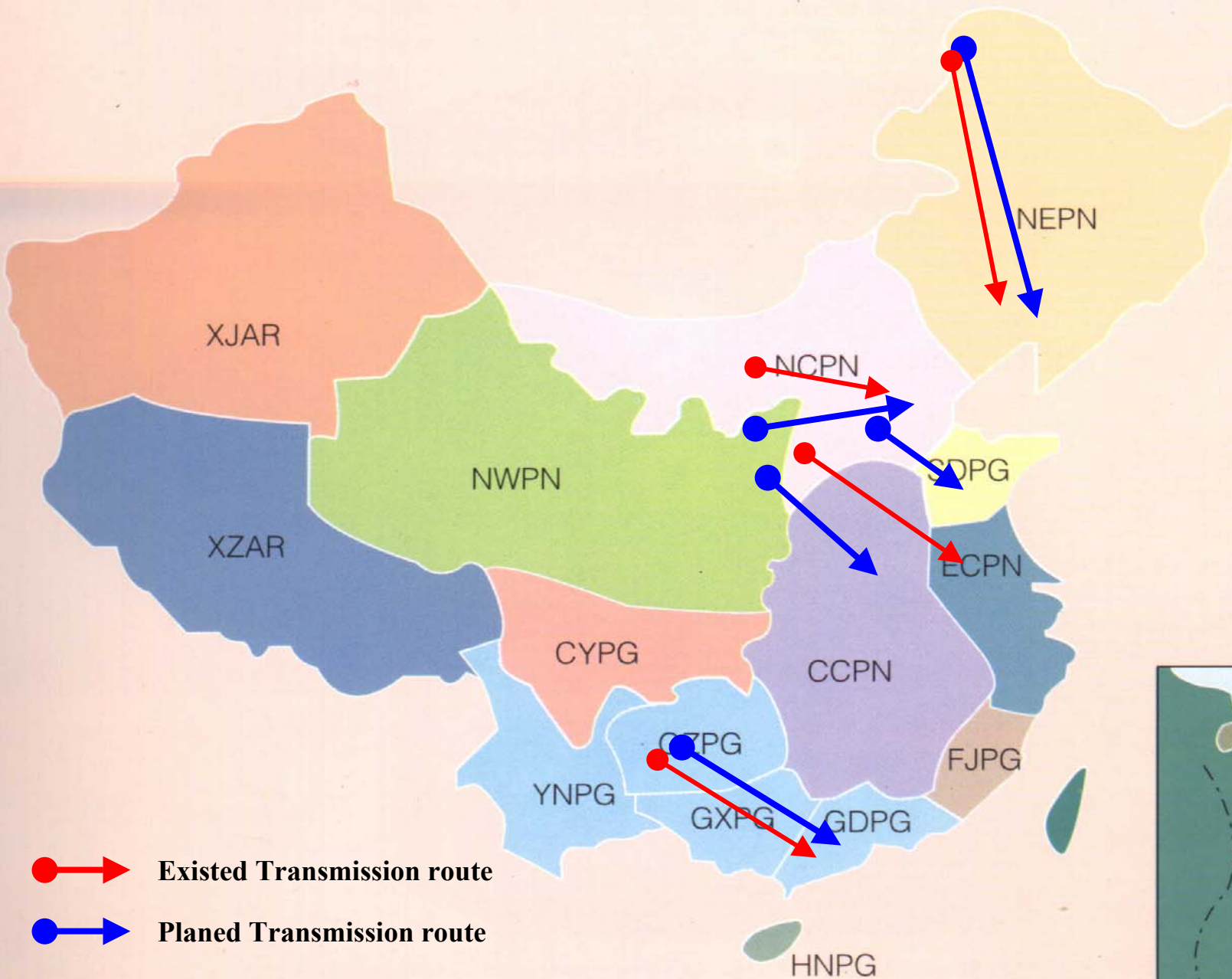
-  Yellow River Hydropower
-  TSQ Hydropower
-  Three Gorges Transmission
-  Planed Hydropower (JinShaJiang, LanCangJiang)

Hydropower Transmission in China



Coal Fired Power Transmission

- ❑ North of Inner Mongolia to Lianning
- ❑ 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 NATIONAWIDE INTERCONNECTED GRID

Nationwide Interconnection

- ❑ Nationwide interconnection: first phase- 2005; Major phase-2010-2015.
- ❑ 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

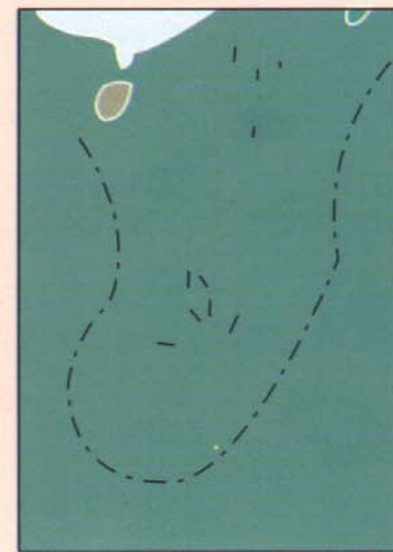
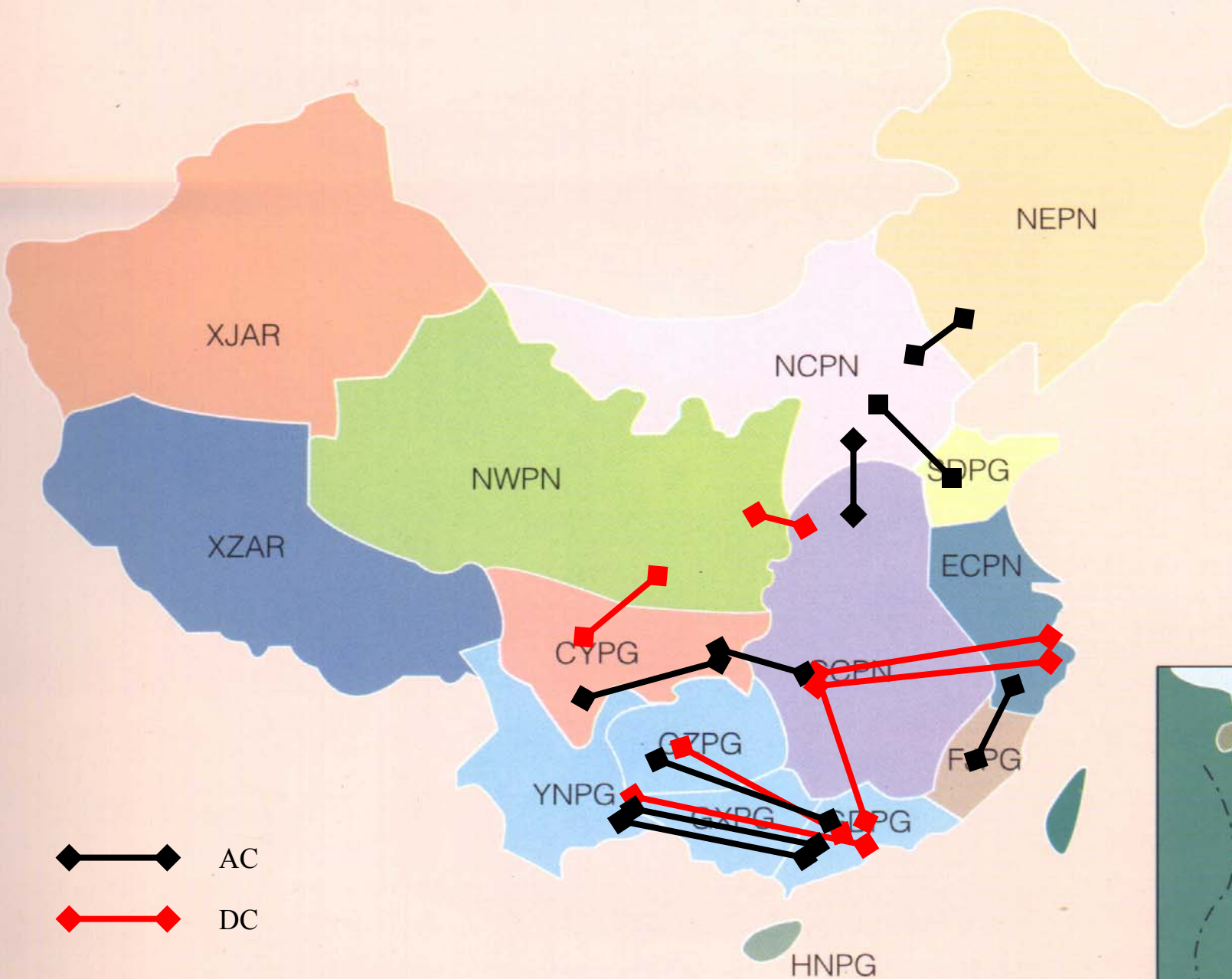
- ❑ North Section: **NCPN, NEPN, NWPN** and **Shangdong** grid will be connected.
- ❑ NEPN and NCPN being connected to share the interconnection benefits.
- ❑ NCPN and NWPN interconnected along with the development of "**Sanxi**" thermal power base.
- ❑ Interconnection of NEPE with **Russia** power system 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

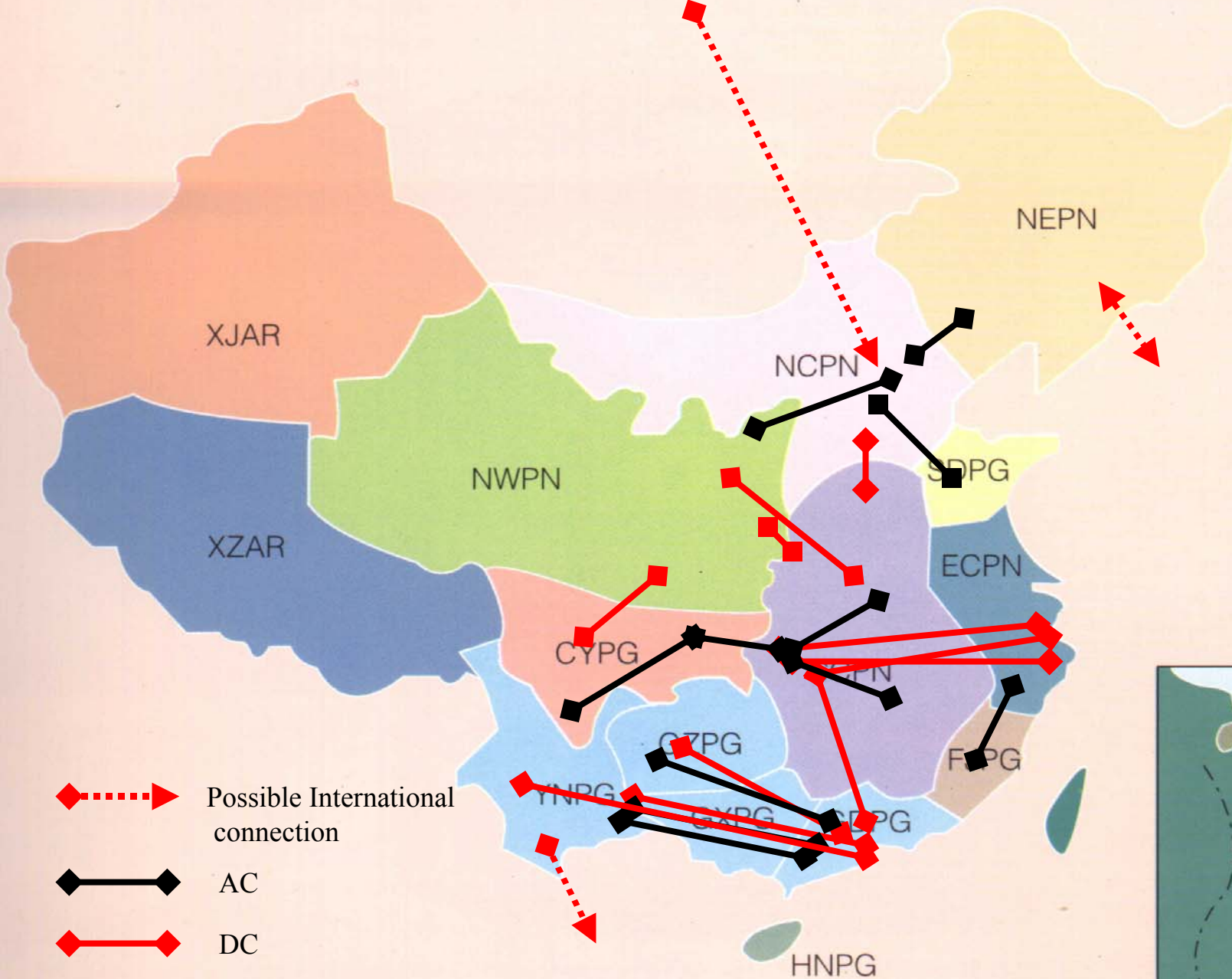
- ❑ Central Section: CCPN, ECPN , CYPG and Fujian grid.
- ❑ This section will be basically established when the first generating unit of Three Gorges Power Plant commissioned.
- ❑ Three Gorges Power System (2010) will be the major part of the section.




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.

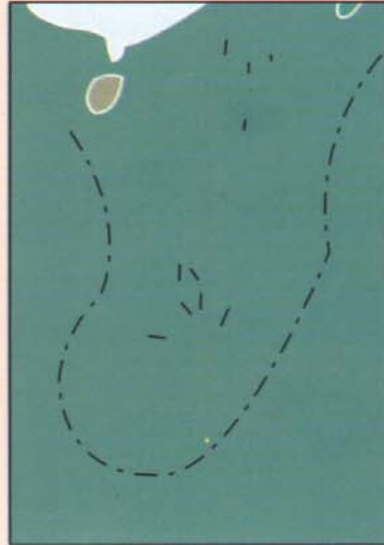


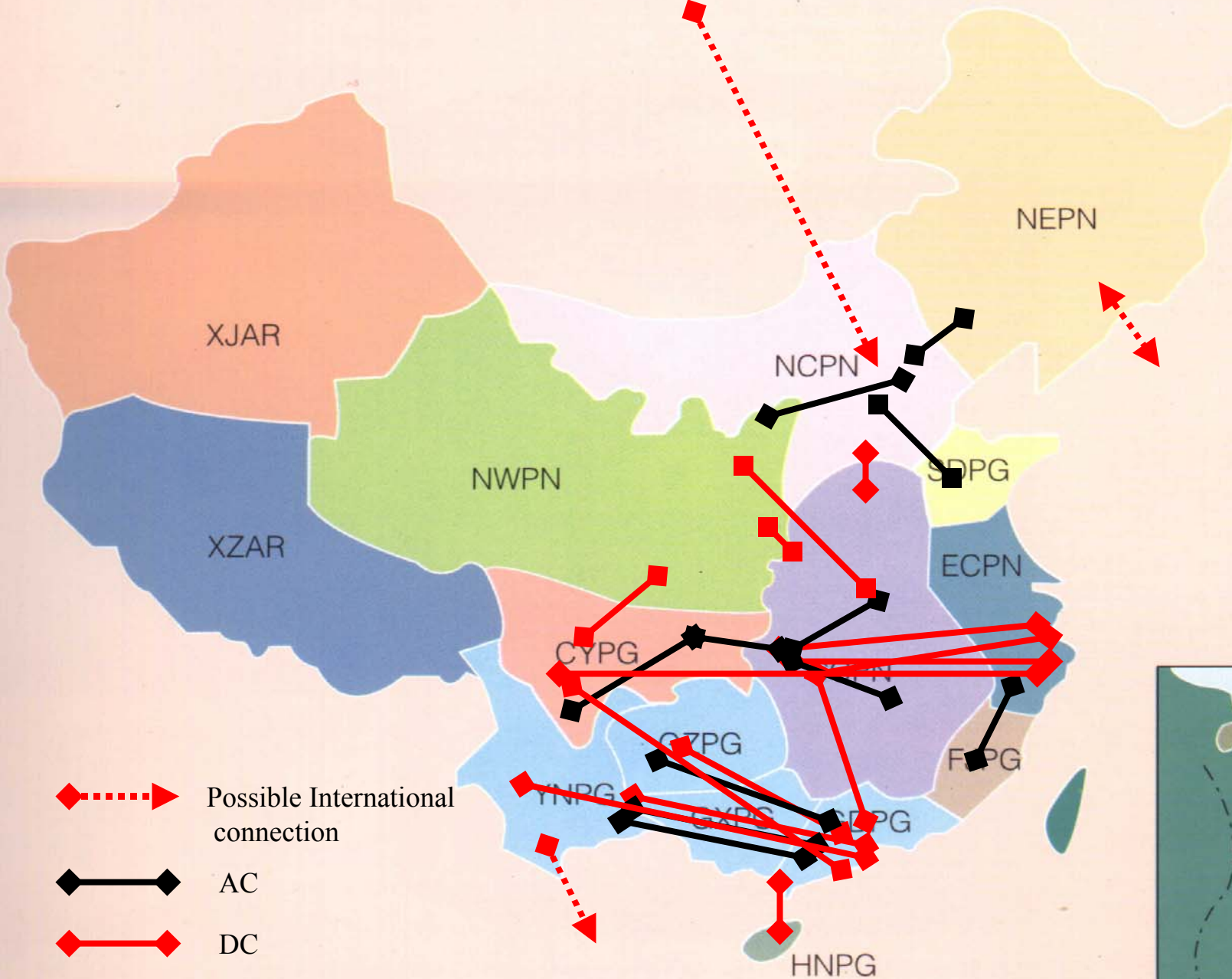
Regional Grids Interconnection in 2005






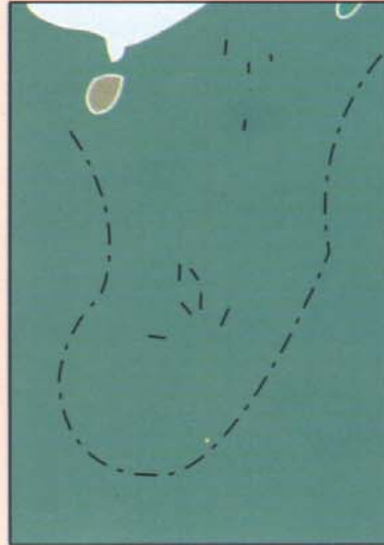
-  Possible International connection
-  AC
-  DC

Regional Grids Interconnection in 2010





-  Possible International connection
-  AC
-  DC



Regional Grids Interconnection in 2015-2020

Table 1 The routes from North to South

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

*: Remote thermal plant, the first stage of the project is completed.

Table 2 The routes from southwest to East

Sending system	Receiving system	Trans. power (MW)	Alternatives of transmission
Hydro power stations in Jingsha River (Xiluodu, xiangjiaba)	CCPN	6,000	± 600 kV DC or UHVAC
	ECPN	10,000	± 800 kV DC or UHVAC
Hydropower stations in Lancang River(Xiaowan, Dacaoshan, Nuozhadu, etc.)	Guangdong	7,000- 8,000	± 500 kV DC or ± 600 kV DC

TECHNICAL PROBLEMS

- ❑ Transient stability. NEPN and NCPN interconnection
- ❑ Low frequency oscillation. Most cases with weak 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!

