

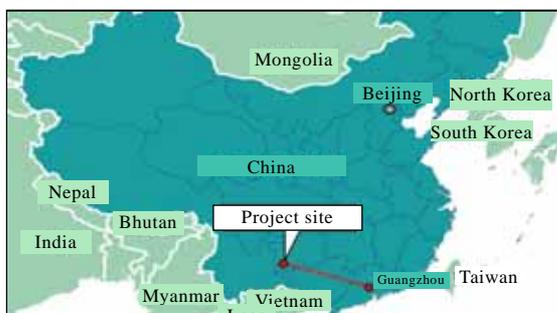
China

## Tianshengqiao First Hydropower Project (1)-(4)

External Evaluator: Mitsue Mishima (OPMAC)

Field Survey: September 2004

### 1. Project Profile and Japan's ODA Loan



Project site location map

(Power station: located on the border of Anlong County, Guizhou Province and Jianglin County, Guangxi Zhuangzu Autonomous Region. Transmission lines extend from Tianshengqiao to Guangzhou, Guangdong Province)



Tianshengqiao No.1 Hydropower Station

#### 1.1 Background

In the 1980s, power generation in China increased by 7.5% on an annual average and the average increase rate in the latter 5 years was 8.5%. The “10-Year Plan for National Economic and Social Development” and the “Eighth 5-Year Plan” adopted in April 1991 set the target of increasing power generation by 5.6% on an annual average from 1991 to 1995 and 6.3% from 1996 to 2000.

In Guangdong Province where 3 Special Economic Zones, Shenzhen, Zhuhai, and Shanton, and 2 Coastal Open Cities, Guangzhou and Zhanjiang, are located, power demand increased by 12.0 % on an annual basis in the 1980s and further increase was expected with the economic growth. However, the power supply capacity was limited, and there was concern that power shortages might occur especially in the dry season.

About 83.9% of the power source in the province was occupied by thermal power generation (hydropower generation: approximately 16%), mostly coal thermal power generation. However, as 73% of the coal was provided by the one in other provinces, there were concerns about the securing coal resources, the loading capacity of the ports , and the ports for unloading in the province.

As a measure to expand hydroelectric facilities using the abundant water in the southern region to replace coal thermal power generation, the Chinese Government developed “Hongshui River Comprehensive Use Plan” for the development of the Hongshui River, one of the major rivers. Under the plan, it was decided to construct 10 power stations (total output: 11,120MW) including those constructed in this project. This

project was important in that it was to secure a power supply source outside of Guangdong Province and also was expected to help stabilize power generation at other hydropower stations located along lower reaches of the Hongshui River (e.g. Tianshengqiao No.2 Power Station) by constructing a hydropower plant at the upper most reach of the river.

### 1.2 Objective

This project's objective was to construct a hydropower station with an output of 1200MW (300MW × 4) on the Nanpan River, a part of the Hongshui River system located on the border of Guangxi Province and Guizhou Province, and to construct transmission lines between Ma Wo and Guangzhou in order to increase power supply to Guangdong Province and Guangxi Province, thereby easing the tight demand-supply situation of electric power in these regions and contributing to the development of regional economy.

### 1.3 Borrower/Executing Agency

Government of the People's Republic of China/Ministry of Energy (as of appraisal time),

### 1.4 Outline of Loan Agreement

Project	(1)	(2)	(3)	(4)
Loan Amount/	4,367 million yen/	6,683 million yen/	16,647 million yen/	12,930 million yen/
Disbursed Amount	4,063 million yen	6,175 million yen	15,462 million yen	11,230 million yen
Exchange of Notes/ Loan Agreement	September 1991/ October 1991	October 1992/ October 1992	August 1993/ August 1993	January 1995/ January 1995
Terms and Conditions				
- Interest Rate	2.6%	2.6%	2.6%	2.6%
- Repayment Period (Grace Period)	30 years (10 years)	30 years (10 years)	30 years (10 years)	30 years (10 years)
- Procurement	General untied	General untied	General untied	General untied
Final Disbursement Date	November 2000	November 1999	September 2000	February 2004
Main Contractor	South China Hydropower Construction Association, Siemens A. G. GFR			
Consultants	Teshmont Consultants Inc., Electric Power Development Co., Ltd., Nippon Koei Co., Ltd.			
Feasibility Study (F/S), etc.	1984 F/S (Chinese Government) 1986 Basic design (Chinese Government)			

## 2. Results and Evaluation

### 2.1 Relevance

#### 2.1.1 Relevance at the time of appraisal

The Eighth 5-Year Plan (1991-1995) called for active development of power sources in the regions covered by this project (Guangdong Province and Guangxi Province) in order to cope with the predicted increase in power demand in the latter half of the 1990s at a rate of 8.4%, higher than the predicted increase rate of 6.3% for all of China. In Guangdong Province, which was predicted to suffer particularly serious power shortages, hydropower generation occupied only 16% of the total power generation, and as for the coal thermal power generation, the primary power source, it was feared that adequate coal resources might not be secured in the future. Therefore, receiving a power supply from outside the province was regarded as an important solution. This project was to construct a 1,200MW dam-type hydropower station on the Hongshui River located on the border between Guangxi Province and Guizhou Province to enable power transmission to Guangdong Province and therefore was of high priority at the time of appraisal.

#### 2.1.2 Relevance at the time of ex-post evaluation

The power demand in China is predicted to increase by 5% on average in the Tenth 5-Year Plan (2001-05), while Guangdong Province's Tenth 5-Year Plan for Energy Development (2010-2015) predicts that power consumption in Guangdong Province, where about 85% of the electricity generated at the power station constructed under the project is supplied, will increase at a rate over 5% on an annual average. Therefore, it remains important to secure a stable power supply for the future. As the structure of power sources in the province still relies on thermal power generation (70.3% of the total; hydropower generation: 21.6%), and it is difficult to meet the power demand only by the power sources in the province, receiving a stable power supply from outside the province is essential. In this regard, a high emphasis is placed on the West-to-East Power Transmission Program<sup>1</sup> including this project, and the plan to increase the power transmission capacity from Western China to Guangdong Province (during the period of Tenth 5-Year Plan (2001-05)) is currently under way. This project implemented the West-to-East Power Transmission Program prior to other projects and therefore maintains high priority.

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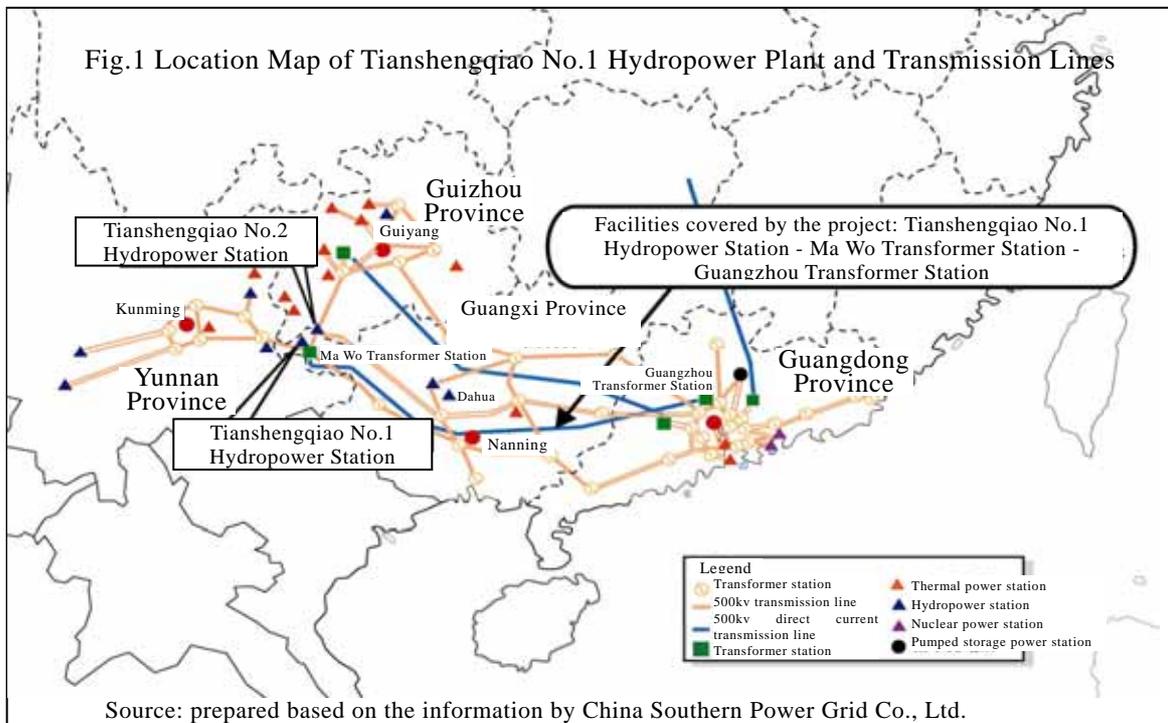
<sup>1</sup> A program to develop power sources in Western China and send electricity to Eastern China, which is regarded as a national project of high priority

## 2.2 Efficiency

### 2.2.1 Output

The output planned at the appraisal time was achieved almost according to the plan. In order to enhance the efficiency of power transmission by establishing the transformer station closer to the demand area, the location of it was changed from Jiangmen to Guangzhou, and the length of transmission lines was extended.

Plan	Actual
1. Construction of a 1,200MW dam type hydropower station	1. As planned
2. Construction of transmission lines: 934km	2. Construction of transmission lines: 984km
3. 2 AC to DC transformer stations (Ma Wo and Jiangmen Transformer Stations)	3. 2 AC to DC transformer stations (Ma Wo and Guangzhou Transformer Stations)



### 2.2.2 Project Period

The whole project period planned at the appraisal time (reckoning from the date of the signing of the Loan Agreement (L/A)) was 98 months from October 1991 to December 1999, whereas actually it took 116 months (118% of the initially planned period) from October 1991 to June 2001. Factors that caused the delay in the implementation were: 1) delay in the civil engineering work for the dam construction due to more complicated soil conditions than expected; and 2) delay in the start of the work due to rebid for some equipment for transmission lines.

### 2.2.3 Project Cost

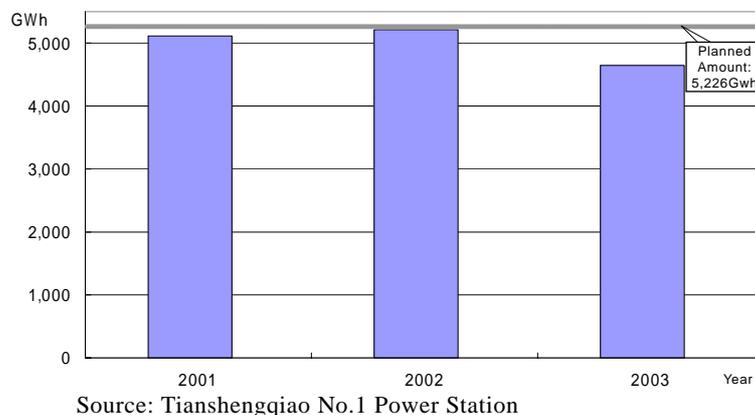
The total project cost was 174.704 billion yen, almost the same as the planned 174.948 billion yen at appraisal time.

## 2.3 Effectiveness

### 2.3.1 Power generation and power transmission

After all generators started operation at the end of 2000, the power station has generated 5,114Gwh at the sending end in 2001 and 5,212Gwh in 2002, nearly achieving the planned amount of 5,226Gwh<sup>2</sup> (Fig.2). The plant load factor rate and the availability factor rate have been around 45-50%<sup>3</sup> and 80-90% respectively. Thus the power station has been working without any operational problem (Table 1). Since the completion of transmission lines and transformer stations in June 2001, the transmission loss rate has been maintained at the level of 6.5% (as of 2003; transmission loss rate in Japan: 5.5%). However, net electric energy production in 2003 was 4,645Gwh because the reservoir water level was low<sup>4</sup> due to drought. As the one in 2004 also decreased, affected by drought, we need to pay attention to the future situation.

Fig.2. Net Electric Energy Production of Tianshengqiao No.1 Hydropower Station



<sup>2</sup> The amount computed in the basic design prepared by the Chinese side, assuming the plant load factor rate at 49.7%.

<sup>3</sup> Those of Japanese hydropower stations are usually within the range of 45-60%.

<sup>4</sup> The annual total of the reservoir inflow volume in 2002 was 19.217 billion m<sup>3</sup> whereas that in 2003 was 16.072 billion m<sup>3</sup>.

Table 1. Plant Load Factor and Availability factor of  
Tianshengqiao No.1 Hydropower Station

Year	2001	2002	2003
Plant Load factor <sup>1)</sup> (%)	48.6%	49.6%	44.5%
Availability Factor <sup>2)</sup> (%)		85.5%	78.4%

Source: Tianshengqiao No.1 Hydropower Station

Note 1): =Annual power generation (Mwh)/amount of electricity that would have been generated if the generators were fully operational throughout the year (1,200MW×24 hours×365days)(Mwh)

Note 2): =Total annual actual operation time (h)/operation time that would have been achieved if the generators were fully operational throughout the year (24hours×365 days)(h)

### 2.3.2 Financial and Economic Internal Rate of Return

Financial Internal Rate of Return (FIRR) was not calculated at the time of appraisal. Recalculation of FIRR using the actual data based on the following assumption resulted in 6.7%. Economic Internal Rate of Return (EIRR) calculated at the time of appraisal was 8.1%. Recalculation of EIRR for this evaluation based on the same assumptions as the appraisal resulted in 12.7% due to the increase in the cost of the replaced coal thermal power station.

(Assumptions for recalculation of FIRR)

Project life: 50 years from completion

Benefits: income from sale of electricity

Costs: cost of investment in this project + maintenance cost + taxes

(Assumptions for recalculation of EIRR)

Project life: 50 years from completion

Benefits: construction cost of alternative coal thermal power station + cost of coal fuel + maintenance cost

Costs: cost of investment in this project + construction cost of the second Tianshengqiao project + maintenance cost

## 2.4 Impact

### 2.4.1 Easing of tight demand-supply situation of electric power

As shown in Table 2, Guangdong Province and Guangxi Province continued increasing power generation by expanding power generation installations in preparation for the expected increase in power demand (Table 3). About 85% of the electric power generated under the project is supplied to Guangdong Province and the remaining 15% is supplied to Guangxi Province, which respectively accounts for 2-3% of the total power supply in

Guangdong Province and 2% of that in Guangxi Province<sup>5</sup> in the 2000-2002 period. Also, considering the fact that the project contributes to the increase in power generation in the dry season at the power stations on downstream sites<sup>6</sup>, it can be said that the project contributed to easing tight power supply-demand situations in these regions where power shortages have been continuing in recent years.

Table 2. Power Generation Installation and Power Generation Volume in Guangdong Province and Guangxi Province

Item		Power Generation Installation (ten thousand kw)			Power Generation Volume (hundred million kwh)		
		Guangdong	Guangxi	Total	Guangdong	Guangxi	Total
1995	All Power Sources	<b>2,272</b>	<b>558</b>	<b>2,830</b>	<b>821</b>	<b>217</b>	<b>1,038</b>
	Hydropower Generation	466 (21%)	340 (61%)	1408 (37%)	131 (16%)	138 (64%)	500 (34%)
1999	All Power Sources	<b>3,033</b>	<b>635</b>	<b>3,668</b>	<b>1,140</b>	<b>253</b>	<b>1,393</b>
	Hydropower Generation	655 (22%)	402 (63%)	1756 (35%)	111 (10%)	154 (61%)	530 (27%)
2000	All Power Sources	<b>3,190</b>	<b>742</b>	<b>3,932</b>	<b>1,353</b>	<b>289</b>	<b>1,642</b>
	Hydropower Generation	702 (22%)	416 (56%)	1849 (35%)	156 (12%)	169 (58)	632 (28%)
2001	All Power Sources	<b>3,360</b>	<b>734</b>	<b>4,094</b>	<b>1,433</b>	<b>297</b>	<b>1,730</b>
	Hydropower Generation	730 (22%)	424 (58%)	1895 (34%)	191(13%)	179 (60%)	682 (28%)
2002	All Power Sources	<b>3,587</b>	<b>752</b>	<b>4,339</b>	<b>1,610</b>	<b>317</b>	<b>1,927</b>
	Hydropower Generation	778 (22%)	436 (58%)	2041 (34%)	169 (10%)	186 (59%)	701 (25%)
Average Yearly Increase Rate 1995-2000		7%	6%	7%	11%	6%	10%
Increase Rate 2000-01		5%	-1%	4%	6%	3%	5%
Increase Rate 2001-02		7%	2%	6%	12%	7%	11%

Source: China Electric Power Yearbook 1995-2003

Note: Parenthesized figures are percentage ratios against the total.

Table 3. Power Consumption in Guangdong Province and Guangxi Province

Year	Guangdong	Guangxi	Total
1995	640	202	842
1999	952	252	1,204
2000	1,160	281	1,441
2001	1,283	291	1,574
2002	1,638	311	1,949
Average Yearly Increase Rate 1995-2000	13%	7%	11%
Increase Rate 2000-01	11%	4%	9%
Increase Rate 2001-02	28%	7%	24%

Source: China Electric Power Yearbook 1996-2003

<sup>5</sup> Population of major beneficiary areas of this project: Guangdong Province: 2.38 million; Guangxi Province: 0.97 million

<sup>6</sup> According to China Hydroelectric Yearbook (vol.7), as an effect of this project, Tianshengqiao No.2, Yantan, Dahua and other power stations on downstream sites ensure 1.69 times as much output as that achieved without the project. It states that stable power generation is realized as a result of the reduction in the difference in power generation between the dry season and the season when water is swollen, and at the same time the peak time adjustment capacity has been improved, and thus 73% of the annual power generation is ensured.

#### 2.4.2 Contribution to economic activities

The GRDP growth rate in real terms of Guangdong Province has been over 10% since 2000, and that of Guangxi Province for 2003 was 10.2%, exceeding the growth rate of all of China<sup>7</sup>. This fact indicates that this project supported economic activities in the target regions by alleviating power shortages<sup>8</sup>.

#### 2.4.3 Impact on environment and society

Regarding the natural environment, an environmental impact assessment was conducted at the time of appraisal in which the project's impact on natural life, water quality and water temperature, historical or cultural heritage, etc. was surveyed and examined. In the inspection by the State Environmental Protection Administration of China in March 2004 after project completion, the project was evaluated as "achieving the targets set forth in the environmental impact assessment report and other documents of permission" and passed the inspection. In the field survey, recovery of cultivated land and relocation of historic structures were confirmed.

Relocation of residents was carried out as shown in Table 4. While the relocation was planned to be completed by 1998 at the appraisal time, it took longer and was completed in 2003 due to the delay in construction work and the increase in relocated residents, which included those affected by the landslide that happened at the time of waterlogging in the reservoir(1999). The number of relocated residents increased from the initial approximate of 45,000 to about 57,000 because the result of the project plan reaffirmation survey conducted from 1992 to 1996 was taken into account, and because the residents affected by the above-mentioned landslide were added.<sup>9</sup>

We took the example of Guizhou Province where nearly 50% of the relocated residents live, and conducted interviews with immigration offices<sup>10</sup>, inspection of the resettlement areas, and brief interviews with residents in order to know the present situation of the relocated residents. In the brief interviews, we spoke to 6 residents in 2 resettlement areas in Xingyi City and 1 site in Anlong County. The result of the brief interviews indicates that all of the interviewed residents think that their living environment and living standard

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<sup>7</sup> China's GRDP growth rate in real terms was 8.0% for 2000, 7.5% for 2001, 8.3% for 2002, and 9.1% for 2003.

<sup>8</sup> According to China Southern Power Grid Co., Ltd. during this period, economic activities were activated by investment from overseas (electronic industries of Taiwan, etc.) in the Zhu Jiang Delta Region (an area in the southern part of Guangdong Province where many factories are located, including Shenchuan, Guangzhou, Zhaoqing, Zhuhai, Aomen, and Hong Kong), which is the load center, and power demand was particularly high.

<sup>9</sup> The amount of compensation to the residents increased from the initially estimated 460 million yuan (in 1989) to 2,250 million yuan in 1997 taking into account the advancement of the relocation process and the review of the basic design. It was further increased to 2,500 million yuan when the residents affected by the landslide were added.

<sup>10</sup> The Immigration office of Guizhou Province, Qian Xinan Buyizu Miaozu Autonomous Prefecture, and immigration offices of Xingyi City and Anlong County, the relocation destinations

have improved since the resettlement and they are satisfied with the procedure and the result of the resettlement. As they were relocated to more urban areas, they think that their living environment has improved: 1)convenience of transportation has improved; 2)basic infrastructure is better in the resettlement are as; 3)structure of residences has improved (wooden brick-built); and 4)employment opportunities in other industries than agriculture increased. Although they belong to minority groups, their customs have mostly been integrated into those of the surrounding regions. Also, they were relocated within the same city or county. Therefore, there seems to be no significant change in the living environment. As far as the result of this survey is concerned, though limited, there was no report on disadvantages inflicted on the relocated residents<sup>11</sup>.

Table 4. Area of Acquired Land and Number of Relocated Residents  
by Province (Plan and Actual)

Province	Item	Plan	Actual <sup>(1)</sup>
Guangxi	Acquired Land (ha)	7,519.5	5,882.1
	Relocated Residents (persons)	20,543	24,511
Guizhou	Acquired Land (ha)	7,445.2	5,990.7
	Relocated Residents (persons)	21,947	28,460
Yunnan	Acquired Land (ha)	1,160	860.2
	Relocated Residents (persons)	2,215	4,034
Total	Acquired Land (ha)	16,124.7	12,733
	Relocated Residents (persons)	44,732	57,005

Source: South China Electric Power Joint Venture Corporation (as of appraisal in 1994) for the planned figures and Tianshengqiao No. 1 Hydropower Corporation for the actual figures.

Note: 1) As of March 2003. At the time of the field survey (September 2004), official statistical data on immigration in Guanxi, Yunnan, and Guizhou were not available because the official inspection and certification by the central government had not been completed yet. The additional portion of resident relocation was carried out in accordance with "Document of Permission for Dangerous Areas Involved in Tianshengqiao Class 1 Power Generation Project and Subsequent Support" issued by the National Development Plan Committee in 2002.

<sup>11</sup> When we asked about objections made by some residents from July to August 1997, the immigration office of Qian Xinan (Buyizu Miaozi) Autonomous Prefecture answered that since the amount of compensation was reviewed and additional compensation was paid, no complaints have been made.

## 2.5 Sustainability

### 2.5.1 Executing Agency

#### 2.5.1.1 Technical Capacity

Every year, both organizations provide training programs for employees in line with the training plan developed at the beginning of the year, and employees qualified by examinations are assigned to the chief of each workplace. The technical levels of specialized engineers (in welding, gauge test, crane operation, etc.) are also verified by examinations. In addition, performance evaluation of all employees and technical evaluation of maintenance staff are conducted every year. There is a system whereby employees whose evaluated technical capacity is inadequate leave their posts to receive training and return to work after passing the examination.

#### 2.5.1.2 Operation and Maintenance System

As a series of structural reforms of the State Power Corporation<sup>12</sup> have been mostly completed, an appropriate personnel assignment and the improvement of organizational efficiency were implemented in the departments in charge of operation and maintenance. Their structures have no problem with the operation and maintenance of this project.

At present, power generation and power transmission are carried out by different organizations under the separation policy promoted in China. Tianshengqiao No.1 Hydropower Station constructed under the project is owned, operated, and maintained by Tianshengqiao No.1 Hydropower Corporation(established in 1999) and transmission lines are owned, operated and maintained by Transmission Company<sup>13</sup> (established in 2003).

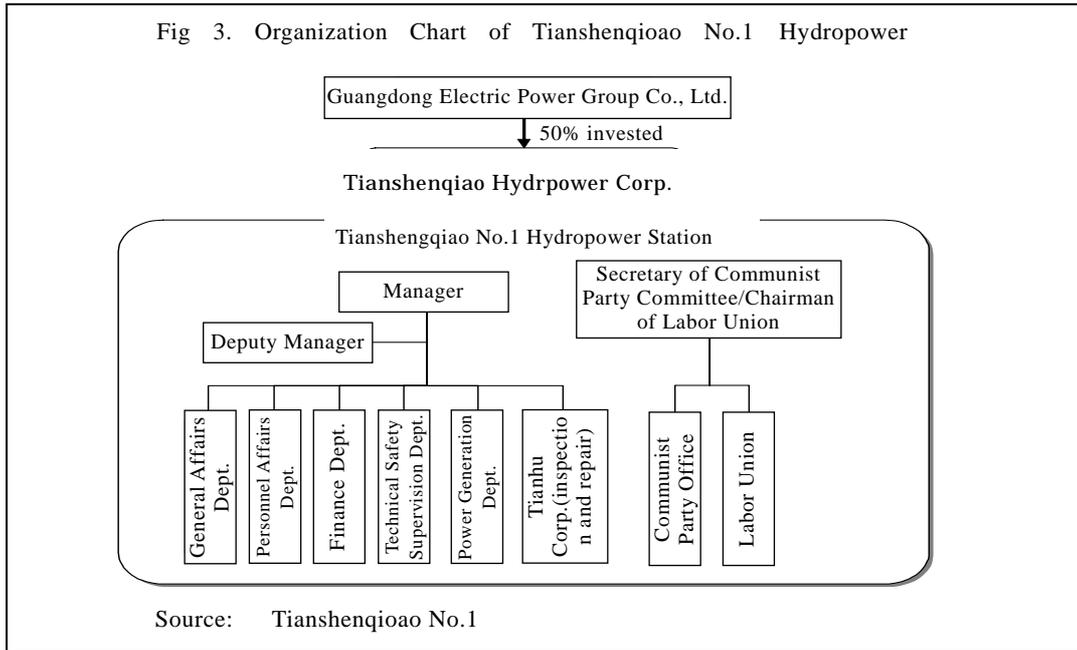
As shown in Fig.3, Tianshengqiao No.1 Hydropower Corporation is composed of General Affairs Department, Personnel Affairs Department, Finance Department, Technical Safety Supervision Department, and Power Generation Department, which are respectively in charge of financial management for construction works, operation and maintenance of facilities, sales of electricity, resident relocation for dam construction, and production safety management, etc. The Power Generation Department has 67 employees and Tianhu Corporation in charge of inspection and repair has 112 employees. Among them, about 80 employees engage in the maintenance of the power stations.

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<sup>12</sup> In China the electric power industry as a whole used to be managed by the central government. After State Power Company was established in 1997 and took over the business management function of the Ministry of Electric Power Industry, the company owned the power generation assets and transmission assets and operated businesses. Following the reform of the electric power system in April 2002, power generation business and power transmission business were separated and are now operated by several entities.

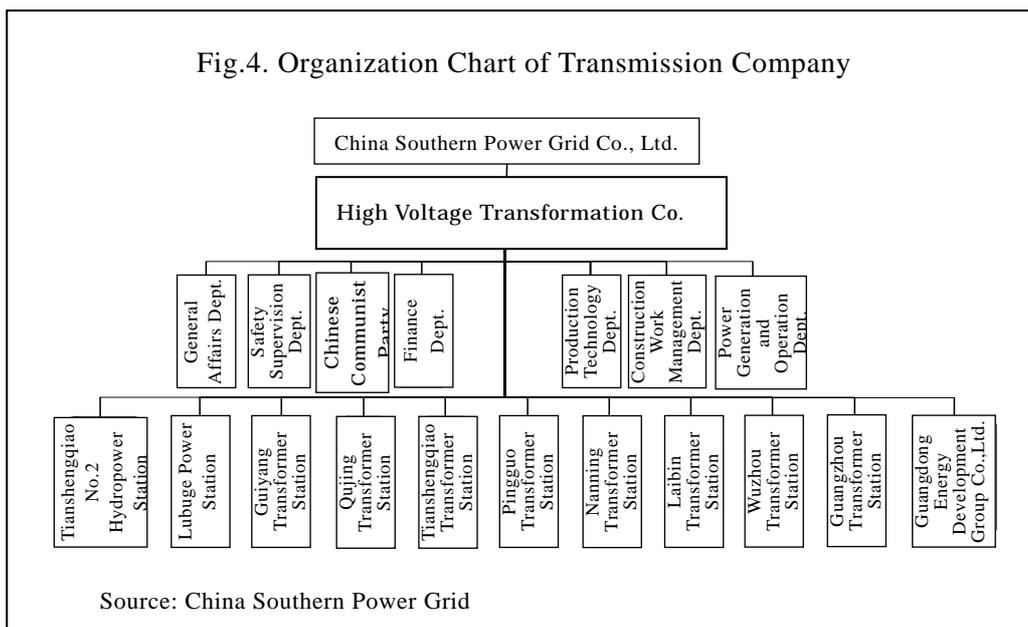
<sup>13</sup> Transmission Company took over most businesses (including the “West-to-East Power Transmission Project”) of State Power Southern Company (a company under the control of State Power Corporation) and engages in the construction and operation of the inter-province trunk transmission network while operating and maintaining Tianshengqiao No.2 Hydropower Station.

Fig 3. Organization Chart of Tianshenqiao No.1 Hydropower



As shown in Fig.4, Transmission Company has seven departments, General Affairs, Personnel Affairs, Finance, Production Technology, Safety Supervision, Construction Work Management, Power Generation and Operation, and Communist Party at the headquarters and owns and operates 8 transformer stations and 2 power stations (Tianshengqiao No.2 Hydropower Station and Lubuge Power Station with an installed capacity of 1920 MW) (total number of employees: about 1,600). The company introduces advanced technology to realize efficient operation requiring 2 employees for the maintenance of 100km of transmission line, less than the standard in China (3 employees/100km).

Fig.4. Organization Chart of Transmission Company



### 2.5.1.3 Financial Status

Financial statements of Tianshenqiao No.1 Hydropower Corporation and Transmission Company were not furnished. As for Tianshenqiao No.1 Hydropower Corporation, the figure of “income from sales of electricity - cost for sales of electricity” has had a surplus since 2002 (Table 5). China Electric Power Yearbook (2003) positively evaluated China Southern Power Grid Co., Ltd. as a whole as of 2002 before the reorganization stating that the company was operated appropriately and making efforts to enhance financial management. With consideration of these things, there seems to be no problem with their financial status.

### 2.5.2 Operation and Maintenance Status

No accident has been reported relating to the power station or transmission lines and they seem to be maintained in good condition. According to the report submitted at the completion of the power station, some problems including minor water leakage at several points were pointed out immediately after the start of operation. When we inquired about the present condition, they said that inspection, repair, and reinforcement work were implemented and those problems were solved. At the power station, regular inspection is conducted once a year in addition to daily maintenance activities. Overhaul was conducted one year after the completion and is scheduled to be conducted once every 6-8 years.

## 3. Feedback

### 3.1 Lessons Learned

None

### 3.2 Recommendations

None

### Comparison of Original and Actual Scope

Item	Plan	Actual
Output		As planned
1) Construction of a hydropower station with four 300MW generators	<ul style="list-style-type: none"> <li>• Dam, reservoir (concrete faced rock-fill dam)</li> <li>• Outdoor-type power station</li> <li>• Installed capacity: 1,200MW (300MW × 4)</li> <li>• Intake tower, headrace, penstock, switch yard, etc.</li> </ul>	
2) Construction of transmission lines	<ul style="list-style-type: none"> <li>• Length of transmission lines: 934 km</li> <li>• 2 AC to DC transformer stations (transformation capacity: 1,800MW for each)</li> </ul>	Length of transmission lines: 984km
3) Consulting service	419M/M	334M/M
Project Period	Oct. 1991-Dec. 1999 (98 months)	Oct. 1991- Jun. 2001 (116 months)
Project Cost		
Foreign Currency	45.898 billion yen	36.886 billion yen
Local Currency	129.05 billion yen (4,925.57 million yuan)	154.04 billion yen (10,317.49 million yuan)
Total	174.948 billion yen	190.926 billion yen
ODA Loan Portion	45.898 billion yen	36.886 billion yen
Exchange Rate	1US\$=137yen 1yuan=26.2yen (As of June 1991)	1 yuan=14.93yen  (weighted average for 1991-2001)