CHINA

Project of Construction of Hydroelectric Power Plant in Wuqiangxi(I)～(Ⅴ)

Report Date: September, 2002
Field Survey: July, 2001

1. Project Profile and Japan's ODA Loan

Site Map: to west of Changsha, provincial capital in the Hunan province

Site Picture: the Wuqiangxi hydroelectric power plant dam

1.1 Background

1) The power generating capacity in Hunan province was 3,610MW as of the end of 1987, out of which 2,000MW was generated by hydroelectric power plants and 1,610MW by thermal power plants, and the ratio of hydroelectric and thermal generation was 55:45. The amount of the generated power in the same year was 14.55 billion kWh, out of which 6.9 billion kWh was generated by hydro electric and 7.65 billion kWh by thermal electric power, and the ratio was 47:53. Demand (net output) minus losses from gross output was 13.02 billion kWh. On the other hand, as of 1987, the demand (power consumption) in the province was 18.5 billion kWh, out of which 5.48 billion kWh exceeding its capacity, was provided by other provinces. Although increasing both hydro- and thermal power generating capacity had been planned in the province, it was regarded as impossible for them to satisfy the power demand for industrial and consumer use that was estimated to increase 8 to 9 % on annual average. If this project had not been carried out, the power shortage would have amounted to 8.09 billion kWh in 1995 and further to 13.9 billion kWh in 2000.
2) The down stream region of the Yuanshui River forms a great stretch of lowlands, and despite banks constructed on the both sides of the river, every year 1.22 million of residents and 1,193km^2 agricultural lands are subject to the danger of inundation during the May to July rainy season. Every year the damage caused by flood has reached 33 million RMB, equivalent to 1.1 billion yen. In this context, construction of the Wuqiangxi dam was thought to help adjust the water volume and then prevent it from causing such considerable damages.
3) The Yuanshui River is a main trunk road for the waterborne transport with lots of ship traffic in the western Hunan province. Meanwhile, a lot of shoals impeded free waterway traffics during the dry season. After completion of the Wuqiangxi, all the shoals of the upper stream regions would be submerged to allow all ships to travel freely. Also, the minimum volume of the down stream regions of the dam would increase during the dry season, which would contribute to a substantial improvement in the free waterway traffic, too.

1.2 Objectives

Easing of the tight position of power supply, flood prevention and improvement in traffic situation in Hunan province are the objectives to construct a dam type power plant with a maximum output of

1,200MW and annual power generation of 5.37 billion kWh, together with the related facilities, on the lower reaches of the Yuanshui River, a tributary of the Changjiang river, situated about 300km to west of Changsha, the capital of the Hunan province.

1.3 Project Scope

Construction of a gravitation type concrete dam that has the height of 87.5m and the total water storage capacity of 4.2 billion m^3,construction of a traveling ｆacility with 61m long lift and triple locks, building a hydroelectric power plant of 240MW×5/laying of power lines (Wuqiangxi～Gang shi 500kv, 90km, Wuqiangxi～Loudi 500kv, 180km and Wuqiangxi～Yuntian 500kv, 120km), construction of transformer substation (Gang shi 360MVA, Loudi 500MVA and Yuntian 750MVA), and also consulting services.

1.4 Borrower / Executing Agency

The People's Republic of China/ National Electric Power Company ,former Ministry of Water Supply of the People's Republic of China and Hunan Power Company

1.5 Outline of Loan Agreement

Refer to the following table, 25.1 billion yen loan was offered to this project from first yen loan in 1988 to fifth yen loan in 1992(Loan disbursed amount is 24.8 billionn)

Item	First (1988)	Second (1989)	Third (1990)	Fourth (1991)	Fifth (1992)
Loan Amount	2,470million yen	6,020milllion yen	3,100milllion yen	8,100milllion yen	5,400milllion yen
Loan Disbursed Amount	2,470million yen	6,003milllion yen	3,100milllion yen	7,925milllion yen	5,333milllion yen
Exchange of Notes	July, 1988	May , 1989	November , 1990	September , 1991	October , 1992
Loan Agreement	August,1988	May , 1989	January , 1991	October, 1991	October , 1992
Teams and Conditions				2.6%	
Interest Rate	2.5%	2.5%	2.5%	30years	2.6%
Repayment Period	30years	30years	30years	（10 years）	30years
(Grace Period)	（10 years）	（10 years）	（10 years）	general untied	（10 years）
Procurement	general untied (consultant partially untied)	general untied	general untied		general untied (consultant partially untied)
Final Disbursement Date	August1995	May, 1996	March, 1992	November, 1997	November, 1997

2. Results and Evaluation

2.1 Relevance

The objectives of this project are to ease the tightened power supply position, prevent flood, and improve river traffic, to ensure that industrial and agricultural production be promoted in the Hunan province. Thus, the objectives can be deemed to comply consistently with the Chinese government policies and its development plans since the time of appraisal.

"More improvement in infrastructure" is one of the important goals in the Chinese 10th Five Year Plan published in March 2001And water transportation facilities, traffic system and energy related to this project, it is strongly required not only to formulate in a scientific method and proceed comprehensively with a master plan to construct national water transportation facilities and a plan for major river-basins, but also develop positively water transportation of inland rivers area and hydroelectric power generation.

2.2 Efficiency

（2.2.1） Project scope

This project was implemented as planned.

（2.2.2） Implementation Schedule

In carrying out this project, despite fluctuation of exchange rate and inflation etc., the construction

was implemented as planned at the time of appraisal. According to Wuling company belonging to the implementing organization, as is rare for a large-scale construction project like this, various troubles that might be feared in process of fund raising and equipment procurement could be prevented effectively from happening, because the company took a proactive measure by concentrating their intensive efforts consistently on the whole processes of implementation, especially not only advantageous procurement of equipment, severe supervision and management, but also securing necessary local fund. Additionally, another reason is that suppliers of required equipment observed faithfully the conditions and terms of this contract, including shipment.

（2.2.3） Project Cost

Table1 shows the breakdown of the comparison between the plan and result. The domestic currency cost experienced 83 % increase (in terms of domestic currency) because of the following two main factors: firstly, cost of various materials used mainly for constructing works and labor charges ballooned because of inflation, but the more important reason is that the project period was just overlapped with the period of Chinese transition from planned economic system to a market economy, which triggered a sharp increase in all prices of the above items. Secondly, the compensations for residents' relocation amounted to more than doubled, as a result of an increase in number of emigrating residents. The reason that manyresidents moved is that owing to Wuqiangxi dam destruction caused by a major flood in 1996, newly additional land became necessary to implement the repair engineering and new shore protection works of the dam which resulted in relocation of more residents.

Table 1: Comparison of operation cost between project plan and its result

	Plan						Result					
	Foreign currency		Domestic currency		Total sum		Foreign currency		Domestic currency		Total sum	
	Total (million yen)	Japan's ODA Loan (million yen)	Total (10,000 RMB)	Japan's ODA Loan	Total (million yen)	Japan's ODA Loan (million yen)	Total (million yen)	Japan's ODA Loan (million yen)	Total (10,000 RMB)	Japan's ODA Loan	Total (million yen)	Japan's ODA Loan (million yen)
Hydroelectric generation Construction machinery	2,348	2,348	11,461	—	5,030	2,348	1,906	1,906	13,113	—	5,154	1,906
Constructing works	3,190	3,190	140,907	—	36,162	3,190	3,149	3,149	393,229	—	100,552	3,149
Turbine・generator	11,200	11,200	34,137	—	19,188	11,200	12,108	12,108	66,846	—	28,666	12,108
Power plant・switching station	2,808	2,808	3,450	—	3,615	2,808	3,105	3,105	10,484	—	5,702	3,105
Power lines	1,855	1,855	32,837	—	9,548	1,855	1,490	1,490	51,380	—	14,217	1,490
Transformer substation	2,490	2,490	38,930	—	11,599	2,490	3,110	3,110	32,771	—	11,227	3,110
Consulting service	210	210	10	—	213	210	220	220	1,962	—	706	220
Compensation for residents relocation	—	—	70,000	—	16,380	—	—	—	167,298	—	41,440	—
Price escalation	425	425	25,209	—	6,324	425	—	—	—	—	—	—
Reserve fund	564	564	45,704	—	11,258	564	—	—	—	—	—	—
Total	25,090	25,090	402,681	—	119,317	25,090	25,090	25,090	737,083	—	207,665	25,090

Note: 1) As for cost of the plan, the exchange rate is based on the rate of 1992 (RMB1=JP¥23.4)

2) As for cost of the result, the exchange rate is based on the rate of 1991 (RMB1=JP¥24.77)

3) There is 259 million yen diffrence between Result foreign currency total 25,090 million yen and Loan Disbursed Amount 24,831 million yen. Result foreign currency is reported by executing agency. The reason of difference is the exchange rate which was used by executing agency.

2.3 Effectiveness

Generation capacity and output

As the table 2 shows, the total output of generation capacity has increased from 7,755MW to 7,111MW (9.1 %) in 1995 over the previous year, and increased to 8,898MW (14.7 %) in 1996 as completion of the prject. And the output has risen to 33.1 billion kwh (13.2 %) in 1995 over the previous year, and after 1996 output achieved 342～355 billion kwh. Among the the total generation output, the output of this

project was about 40～53 billion kwh and accounting for 12%to15%. In the meanwhile, it was about 75～88% compared output of this project with the output that was planned at appraisal, but demand in Hunan province was alleviated because of enhancement of the generation capacity include other power plants.

Table 2: Trend of power generating facilities and output in the Hunan province

		1988	1989	1990	1991	1992	1993	1994	1995	1996 complete	1997	1998	1999	2000
Generation Capacity(MW)	Plan	N.A	N.A.	5,020	N.A.	N.A.	N.A.	N.A.	8,030	N.A.	N.A.	N.A.	N.A.	10,940
	r e s u l t	N.A.	N.A.	5,440	6,405	6,524	6,658	7,111	7,755	8,898	9,097	9,920	10,264	N.A
Output A (100 million kwh)	Plan	N.A.	N.A.	N.A.	N.A.	N.A.	N.A	N.A.	N.A.	N.A.	N.A.	N.A.	N.A	N.A
	r e s u l t	N.A.	N.A.	201.4	211.3	244.7	272.7	292.3	331.0	341.6	347.1	350.0	348.4	355.5
Output B by Wuqiangxi plant B (100million kwh)	Plan	—	—	—	—	—	—	—	32.5	48.8	53.7	53.7	53.7	53.7
	R e s u l t	—	—	—	—	—	—	—	32.6	52.6	42.8	40.1	40.7	47.2
B/A (%)	Plan	—	—	—	—	—	—	—	N.A.	N.A	N.A.	N.A.	N.A	N.A
	r e s u l t	—	—	—	—	—	—	—	9.8	15.4	12.3	11.5	11.7	13.3

Resource： JBIC and Wiling company

Damages caused by flood

The damage index which reflects the extent of flood damages, inundation area, the damage amount and the number of victims around the Wuqiangxi dam, has stood at zero since the project was completed in 1997. The index proved that the dam that has function to adjust the water volume flowing to lower reaches, can play a significant role in flood prevention.

Table3: Trend of inundation area, damages, number of victims (1988 to 2000)

	1993	1994	1995	1996 complete	1997	1998	1999	2000
Inundation area (square km)	25.18	0	42.50	48.95	0	0	0	0
Amount of damage(10,000 RMB）	57,700	0	97,400	112,100	0	0	0	0
Number of victims	67,600	0	136,200	144,000	0	0	0	0

Resource：Wuling company

Changes in river traffic restriction during the dry season

Since the naviagtion in the Yuanshui River used to be restricted during the dry season,all the shoals in upper reaches of the dam were expected to be submerged after the completion of the Wuqiangxi dam, which would produce an increase in waterway traffic. However, contrary to the initial predictions, the waterborne traffic of the Yuanshui River has declined as shown in Table 5. This is because the volume of land transportation has increased, as a result of the development of roads on the both sides of the Yuanshui River accompanied by the construction of the dam and hydroelectric power plant.

Table5: Trend of waterborne traffic volume at the Wuqiangxi dam

(unit: t/year)

	1993	1994	1995	1996 complete	1997	1998	1999	2000
Result	664.822	451,509	299,949	298,615	265,775	224,541	212,049	234,083

Resource：Wuling company

Financial internal return rate (FIRR)

Recalculated FIRR based on the results and estimates, FIRR stands at 7.7 % for 50 years-project life, indicating smaller number than the one at the time of appraisal (13.8 % for 50 years). As described above, the reason for this is that utilization factor and availability factor have stayed low because the sales volume has been less than planned.

Economic internal return rate (EIRR)

Recalculated EIRR based on the results and estimates, EIRR stands at 7.8 % for 50 years of project life, indicating smaller number than the estimate at the time of appraisal (18.1 % for 50 years). The reason for the lower number of EIRR is that maintenance costs became higher and the investment cost became larger than the estimate at the time of appraisal.

2.4 Impact

Effects on the natural and social environment

According to the implementing organization, the quality of water has not been deteriorated. Also, greenery activities around the area were carried out since the beginning of this project. On the other hand, valuable cultural assets such as historic remains and burial mounds around the area were relocated beforehand in accordance with the related national bills and regulations to avoid damages. In addition, it was expected that about 84,600 residents would be relocated at the appraisal, but actually about 115,800 residents was relocated. According to National Electric Power Company and Hunan Power Company which conducted hearings, problem related to relocation of residents at the implementation of the project have not been reported. And to evaluate about the impacts on residential relocation,,it had been needed the continual follow-up by department of Hunan province related with residencial relocation.

2.5 Sustainability

Operation and Maintenance

An organization responsible for O&M is the Hunan hydroelectric development company, Inc. that was jointly established in 1994 by three companies, namely, the Hunan Power company, the Hunan Economic, Construction, Investment Company, and the Chinese Electricity Groups Company. The ratio of their investment among them is 56:32:12. The Hunan power company is the largest shareholder.

The structure of the Hunan Wuling hydroelectric development company Inc. is as shown in chart 1. The president, who takes responsibility for all the management, supervises seven control sections and four production sections, under the control of the board of directors and the chairman with the help of vice president, the vice chairman of Committee of Communist Party of China, and so called the " Three Leaders of the Company", namely, the general production leader, the general accounting leader, and the general engineering leader

Also, of the four production sections that are under direct control of the president, the Wuqiangxi and Lingjin electricity factories are responsible for two of the hydroelectric power plants, namely, the Wuqiangxi and Lingjin plants. At the Wuqiangxi power plant, the one of the above two, which is related with this project, there are currently 120 workers assigned to its size of 1.2 million kw, equivalent to 10,000 kw per person on average, in accordance with the standards set by the government.

According to the implementing organization, the maintenance of this project has been going well under

such a system, and there have been no particular problems so far. The Hunan Wuling hydroelectric development company had an honor to be awarded a title of "`A First Rate Power Company"` by The National Power Company

Technology Capacity

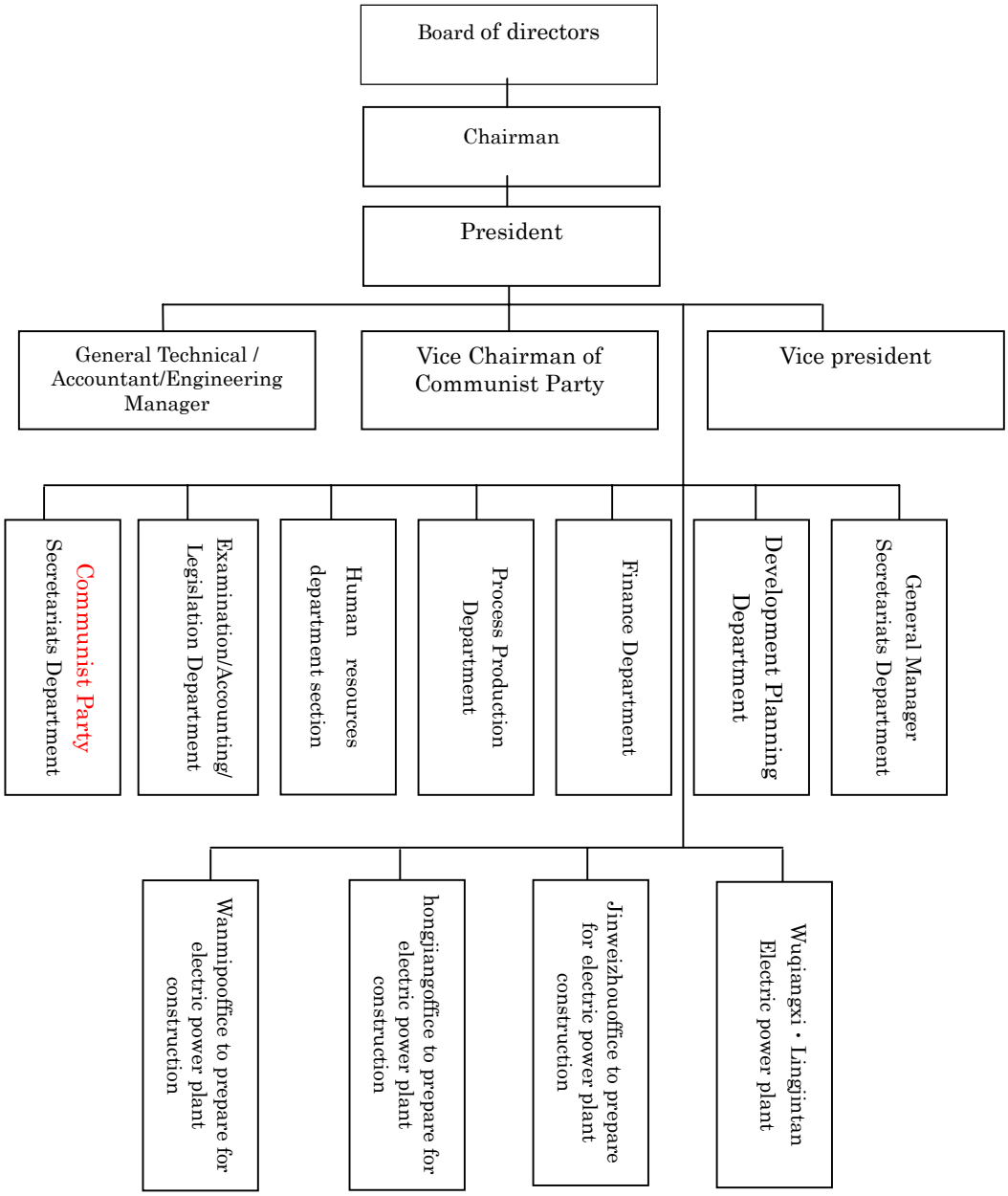
As for fostering skills of workers, "Provisional method with regard to development of post/skill and maintenance" (hereinafter, called "Provisional method") has been applied.

The critical points are specified as follows.

1. While the Human Resources Department of the power plant manages trainings concerning instructions, inspections, supervision, and tests for development of skills required for each post, the practice of development training itself is entrusted to the training center of the Wuling Company.
2. During the training, every worker's minimum hours shall be 15 hrs/month/person and180 hrs/year/person.
3. The content of the training shall be in accordance with "Handbook for Development of Post/Skill" and training plans of each section of the year.
4. Evaluation of the skills is done in the form of writing tests and interview, etc. after the training. Each worker is obligated to acquire at least 100 credits every year. Acquirement of credits related to post is compulsory, while others are optional.
5. The result of the tests (score) shall be retained in the file of the worker. Table 7 shows correlations between scores and payment of each worker and the section he or she belongs to.

As is shown in the above, the training method to develop skill to operate and maintain facilities has been systematized to apply this to all employees, and further evaluation of the result that employees acquired skills through this method shall be reflected directly on their compensation and promotion. This system seems, thus, to be working very effectively. Also it can be assured that this will lead to an enhancement in skill concerning operation and maintenance of this project.

Chart 1 : The structure of The Hunan Wuling hydroelectric development company, limited.



Resource：Wuling company

Table5: Gearing of skill evaluation to compensation of the Wuqiangxi power plant workers

Content of Evaluation	Standard index	Frequency	Index related to payment	Effects of evaluation results on payment
Post, skills	Passing rate≧ 90%	Yearly	Passing rate ＜90%	1 % shortage leads to 1% reduction in variable part of the payment of the section of the month when fiscal year ends
Status of qualification, promotion	Promotion rate ≧ 25%	Yearly	Promotion rate ＜25%	5% reduction in variable part of the total compensation for the section of the month when fiscal year ends
Acquirement status of credit as a whole department	Acquirement rate□ 100%	Quarterly	Acquirement rate ＜100%	1 % shortage leads to 1% reduction in variable part of the total compensation for section of the month when the quarter ends
Completion status of article on specified field	Completion amount≧ 1 essay/person	Yearly	Completion amount ＜ 1 essay/person	0.5% reduction in variable part of the total compensation for the section of the month when the fiscal year ends
Acquirement status of individual credit	≧100%	Yearly	Actual score	Credit acquirement rate measured by actual score compensation standards decided in accordance with post skills＝ net compensation

Resource：Wuling company

Financial Status

According to the the profit and loss statement and cash flow statement of the company obtained from Wuling company, responsible for the operation and maintenance of this project, the net sales profit ratio stayed stagnant from 1996 to 1999, but it improved substantially to 17.7 % in 2000 from 2.1 % in the previous year. Behind this is the improvement of factor load and capacity utilization of this project since 2000, as described above. As a result, the ratio of net profit and depreciation expense recorded a substantial improvement from 4.7 %: 95.3 % in 1999 to 32.6 %:67.4 % in 2000, which indicates recovery from decreasing trend of net profit to relatively healthy financial condition as to the relation profit and depreciation.

Substantial cash inflows obtained through business activities allow the company to retain relatively considerable amount of cash and cash equivalents, after covering a huge capital outflows by investment/financial activities to enlarge the operations of this project. Therefore, the data of cash flow draws a conclusion that there is no problem about the financial soundness of the company.

Table6： 1998 to 2000 Trend of major financial data of Wuling company

Financial data	1996	1997	1998	1999	2000
Sales(million RMB)	1,078.13	1,274.98	1,163.06	1,178.57	1,265.88
Net profit (million RMB)	22.63	22.60	11.30	25.20	223.47
Depreciation expense(million RMB)	348.20	390.36	391.23	511.73	461.26
Cash flow by business activities(million RMB)	—	—	936.32	782.08	1,106.58
Cash flow by investment(million RMB)	—	—	-955.82	-419.52	-550.89
Cash flow by financial activities(million RMB)	—	—	40.50	-232.79	-471.70
Balance of cash and cash equivalent (million RMB)	—	—	21.00	150.77	234.76
Net sales profit rate （%）	2.1	1.8	1.0	2.1	17.7
Net profit/ （net profit＋depreciation expense）（%）	6.1	5.5	2.8	4.7	32.6
Depreciation expense/（net profit＋depreciation expense）（%）	93.9	94.5	97.2	95.3	67.4

Resource： Wuling company

3. Recommendations

It is required that continued efforts to follow up the life condition of the relocated regidents because of this project in the midium and long term by department of Hunan province related with residencial relocation.

Comparison of Original and Actual Scope

Items	Plans	Result
1.Project Scope		As same as the left description
(1)Hydroelectric power generation facilities： Gravitation-style concrete dam	Height 87.5m The total reserving capacity 4.2 billion ㎥	
Turbine generator	Total output 1200mw（240mw×5） Annual amount of generated power 5.37 billion kWh	
(2)Waterway traffic facility （Lock system）	Triple locks・length 61m	
(3) Transmission facilities： Power line	Wuqiangxi～Gangshi 500kv、90km	
	Wuqiangxi～Loudi 500kv、180km	
	Wuqiangxi～Yuntian 500kv、120km	
500kv Transformer substation	Gangshi 360MVA (500/220kv)	
	Loudi 500MVA (500/220kv)	
	Yuntian 750MVA (500/220kv)	
Consulting service	Foreign consultants： Hydroelectric power generation 30M/M Power transmission 30M/M Total 60M/M	
2. Implementation Schedule		As same as the left description
Pre-works	～1989 the fourth quarter	
Drilling works	～1992 the first quarter	
Construction works of the dam	1990 the third quarter～1995 the first quarter	
Works for waterway traffic lock/system	1991 the fourth quarter～1995 the second quarter	
Works for installation of generator	1990 the fourth quarter～1991 the fourth quarter	
Bid and contract	1992 the first quarter～1993 the third quarter	
Manufacture and transportation	1992 the third quarter～1996 the fourth quarter	
Installation, acceptance（usable）		
The first unit	December,1994	
The second unit	August, 1995	
The third unit	December, 1995	
The fourth unit	June, 1996	
The fifth unit	December,1996	
Works for power lines	1991 the fourth quarter～1995 the fourth quarter	
3. Project Cost		
ForeignCurrency	25,090million yen	25,090million yen
LocalCurrency	94,227million yen (4,026,810,000 RMB)	182,575million yen (7,370,830,000 RMB)
Total	119,317million yen	207,665million yen
ODA Loan Portion	25,090million yen	25,090million yen
Exchange Rate	RMB1=JP¥23.4（1992 rate）	RMB1=JP¥24.8（1991 rate）