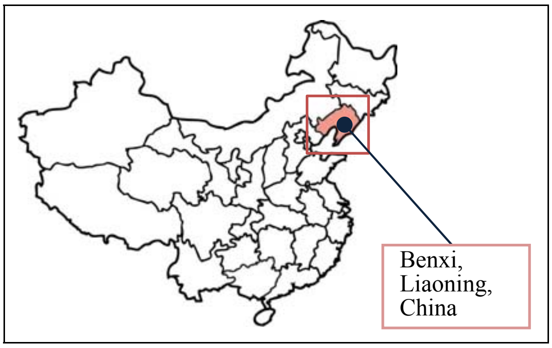
People's Republic of China

Ex-Post Evaluation of Japanese ODA Loan Project

Benxi Environmental Improvement Project Phase (1) (2) (3)

External Evaluator: Machi KANEKO, Earth and Human Corporation

1. Project Description



Project Location

Beitai Iron & Steel Group (Left: coke oven environmental pollution control facilities, right: facilities for utilization of emission gas)

1.1 Background

In China, while the national economy grew steadily, industrialization and population growth increased environmental pollution from the 1980s. As the country depended on coal for industrial materials and fuel for power generation and heating, air pollution with sulfur dioxide (SO_2) and Total Suspended Particles[1] (TSP) generated by coal combustion was especially serious. Moreover, although the demand of water for both domestic and industrial use was growing, the construction of wastewater treatment facilities was slow. Therefore, the river water quality also deteriorated.

The city of Benxi, where this project was carried out, is located in a mountainous area of southeast Liaoning Province and is one of the major heavy industry cities in China. In Benxi, basic material industry such as iron and cement manufacturing developed from the 1940s and the economy rapidly grew mainly in the iron manufacturing from 1980s. On the other hand, the air pollution in the city became so serious that the city was called "a city invisible from the satellite", partially because of the geographic condition that it is surrounded by mountains. Moreover, the Taizi River, a major river in Benxi that flows through the city for 27 km, was also seriously polluted as most of the city's domestic and industrial wastewater flew into it. The Taizi River was a drinking water source and the water safety was also a concern.

[1] Total Suspended Particles (TSP): Particulate matters suspended in the atmosphere that are equal to or smaller than 100 micrometers in diameter. The city of Benxi has been using "Inhalable particles (particulate matters smaller than 10 µm: PM10)" as a substitute index for TSP since 2005.

Under these circumstances, the city of Benxi established a long-term plan (till 2000) and started taking measures for environmental improvement. As part of such efforts, this project was carried out for comprehensive improvement of the environment.

1.2 Project Outline

To contribute to the environmental improvement of the city of Benxi, where water and air pollution caused by rapid economic growth became serious issues, by improving air and water quality through the following actions:

- Equipment renewal and installation of pollution control facilities at factories that discharge contaminants
- Construction of a water intake station
- Construction of an environmental observation center

Approved Amount / Disbursed Amount	Phase I: 4,110 million yen/4,076 million yen Phase II: 3,237 million yen/3,082 million yen Phase III: 1,160 million yen/1,159 million yen Total: 8,507 million yen/8,317 million yen
Exchange of Notes Date/ Loan Agreement Signing Date	Phase I: September 1997/September 1997 Phase II: December 1998/December 1998 Phase III: March 2000/March 2000
Terms and Conditions	Phase I: Interest rate: 2.1% Repayment period: 30 years (Grace period: 10 years) General untied Phase II: Interest rate: 0.75% Repayment period: 40 years (Grace period: 10 years) Partially untied Phase III: Interest rate: 0.75% Repayment period: 40 years (Grace period: 10 years) Bilateral tied loan
Borrower / Executing Agencies	Government of People's Republic of China / People's Government of Benxi Municipality
Final Disbursement Date	Phase I: April 2003 Phase II: July 2004 Phase III: July 2005
Main Contractor (Over 1 billion yen)	-
Main Consultant (Over 100 million yen)	-
Feasibility Studies, etc	F/S: Benxi Environmental Protection Center, etc. August 1989 – June 1996 SAPROF: JBIC 1995-1996
Related Projects	Grant aid: Sino-Japan Friendship Center for Environmental Protection

2. Outline of Evaluation Study

2.1 External Evaluator

Machi KANEKO, Earth and Human Corporation

2.2 Duration of Evaluation Study

The ex-post evaluation was conducted in the following periods:

Duration of the Study: December 15, 2009 – October 29, 2010

Duration of the Field Study: February 28, 2010 – March 23, 2010

May 6, 2010 – May 29,2010

2.3 Constraints during the Evaluation Study

It was difficult to check the effectiveness of the whole project as it consisted of 20 subprojects. Therefore, we checked these 20 subprojects in terms of achievement level of the outputs, operation and effect indicators for effectiveness, and also evaluated the whole program from a panoramic perspective. Although each evaluation item is described per subproject as much as possible, relevance, impact and sustainability are evaluated as a whole.

3. Results of the Evaluation (Overall Rating: B)

3.1 Relevance (Rating: a)

3.1.1 Relevance with the Development Plan of China

At the time of appraisal, the Chinese government established 'The Ninth Five-Year Plan for National Environmental Protection and Long-Term Targets for 2010,' placing priority on "water and air pollution source control" and "urban environment improvement". Regarding these two major tasks, the government also planned such concrete measures as full compliance with emission standards at the water and air pollution sources, closure or transformation of production process at small old-type plants, conversion to city gas and promotion of greening. In response to such policy of the central government, the city of Benxi also established 'The Seven-Year Plan for Environmental Improvement' and promoted environmental conservation projects.

At the time of the ex-post evaluation, environmental protection was still an important policy and 'The 11th Five-Year Plan (2006-2010)' (hereinafter the "11.5 plan"), which defined the national policy for environmental protection, presented the basic principle of shifting its focus to environmental protection and economic growth. The 11.5 plan also set a numeric goal to reduce sulphur dioxide emission and chemical oxygen demand by 10% each by 2010. Moreover, 'The 11th Five-Year Plan 2006-2010' of the city of Benxi also stated treatment of air pollution, water pollution and sold waste as major ongoing challenges.

In light of the above, it is deemed that the relevance of this project with government policies was high both at the time of appraisal and the time of ex-post evaluation.

3.1.2 Relevance with the Development Needs of China

(1) Development Needs at the Time of Appraisal

In 1995 the annual average SO_2 concentration was 0.15 mg/Nm^3 and the annual average TSP concentration was 0.41 mg/Nm^3 in Benxi. These numbers exceeded the national ambient air quality standard grade 3 [2] (annual average SO_2 concentration: 0.10 mg/Nm^3, TSP concentration: 0.30 mg/Nm^3), a standard applied only to industrial areas, and there was a concern about the public health effects of air pollution. To respond to this situation, the city of Benxi, designated as "sulfur dioxide pollution control area[3]" by the State Council in February 1998, planned to enhance measures for pollution control.

(2) Development Needs at the Time of Ex-post Evaluation

Benxi is located in Liaoning Province, the largest economy among the three northeast provinces[4], and the GDP of the city reached 68 billion yuan in 2009 (15.81 billion yuan in 2000). Moreover, belonging to the "Central Liaoning City Cluster[5]", the province's new regional development strategy, the city has been growing with a large steel complex and other various manufacturing industries including as metallurgy, machinery, building material, pharmaceutical, chemical and spinning.

The city has also been actively tackling environmental issues, and the water quality of the Taizi River, a water source for Benxi, has achieved the national surface water quality standard grade 2 in 2008. As for the air quality, the SO_2 level achieved the national ambient air quality standard grade 2 (annual average) in 2005 and the level of inhalable particulate matters (PM10[6]) has achieved grade 2 (annual average) in 2008. Both air and water quality has significantly improved.

As the total industrial production is expected to continue to grow in the future, ensuring a balance between environmental protection and economic growth is still a major development challenge for the city.

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2 National ambient air quality grade 3 is applied to industrial areas. The threshold for effects on health of long-term residents is grade 2.

3 Cities with a high level of SO_2 emission where the annual average of SO2 concentration exceeds the national ambient air quality standard grade 2 and the daily average exceeds grade 3

4 Three northeast provinces: three provinces in northeast China (Liaoning, Jilin and Heilongjiang)

5 Central Liaoning City Cluster: seven cities of Shenyang, Anshan, Fushun, Benxi, Yingkou, Liaoyang and Tieling, one of the areas where the economy is most remarkably growing in the northeastern China

6 Inhalable particulate matters (particulate matters smaller than 10 µm, PM10): Atmospheric particulate matters suspended in the atmosphere that are smaller than 100 micrometers in diameter. The city of Benxi has been using PM10 as a substitute index for TSP since 2005.

In light of the above, the development needs in Benxi are high.

3.1.3 Relevance with Japan's ODA Policy

The ODA Charter in 1992 stated that environmental protection was one of ODA fundamental principles and Japan expressed its intention to increase environmental ODA significantly in five years from 1992 to 1996 externally on such occasions as UN meetings.

Japan's assistance policy for China in those days also placed the following as a key issue: "to provide assistance that will contribute to economic infrastructure development mainly in the form of loan assistance and pay more attention to the assistance for inland regions where the space for development is relatively large". It also takes environment as one of focal areas and intends to make use of its experiences and technologies to assist improvement of energy efficiency, waste recycling, smoke treatment and flue-gas desulfurization for air pollution prevention and measures to prevent water contamination such as sewerage development. Moreover, the "Japan China Environmental Cooperation toward the 21^{st} Century" was agreed on at a Japan-China summit meeting in September 1997.

The project was implemented as one of environmental yen-loan projects for China that are the key of environmental cooperation for China that was launched in full scale in the late 1990s and thus it was consistent with Japan's aid policy at the time of appraisal.

3.1.4 Selection of Subprojects

Affected by the reform of state-owned enterprises in China that started in 1998, the management environment of the executing agencies has significantly changed since the time of appraisal; e.g., over 70% of the executing agencies have been privatized. Moreover, as the economic liberalization required privatized companies to improve technical capabilities, market competitiveness and profitability, some companies have ended up with production stoppage, bankrupt or downsizing. In addition, as part of the efforts to enhance its environmental policy, the government tends to further tighten regulations on environmentally harmful companies.

In the situation described above, although the project planned to carry out 20 subprojects, some of them were not able to cope with such environmental changes and production was stopped. However, it is deemed that there was no problem in the selection of each project because the enhancement of environmental measures and privatization of enterprises were carried out to remedy environmental issues and management issues of state-owned enterprises.

Considering the above, this project has been highly relevant with the country's development plan, development needs, as well as Japan's ODA policy, therefore its relevance is high.

3.2 Efficiency (Rating: b)

3.2.1 Project Outputs

Before evaluating the outputs of this project, we would like to mention the following two major changes from the original plan.

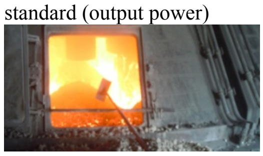
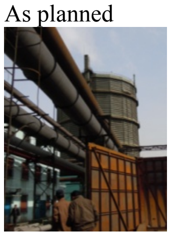
1) Two of the 20 subprojects were cancelled because of the “closedown due to land readjustment” and “the Chinese government’s policy change and decision not to guarantee repayment after privatization”. These cancellations were deemed unavoidable and approved through consultation via L/A alteration decision request on December 3, 1999. Therefore, the two subprojects should be excluded from the efficiency, effectiveness and sustainability evaluation.
2) In three of the 18 subprojects that have acquired a loan, the production has been stopped (virtually bankrupt).

We have individually checked the outputs of each subproject and confirmed that the inputs were provided as planned in 14 subprojects out of the total 18. As for the remaining four subprojects, changes were made after the time of the appraisal but these changes were made to deal with changes in the market needs or the government’s design criteria. Therefore such changes are deemed to be a kind of force majeure events for the business units; inputs to these four subprojects were also appropriate.

Table 1　Comparison between Original Plan and Actual Outputs

Phase I

Original Plan	Actual Outputs	Notes
1) Emission Gas and Wastewater Treatment at Benxi Electrical Equipment Plant (executing body: Benxi Electrical Equipment Plant)		
① Introduction of electrostatic spraying equipment ② Introduction of wastewater treatment equipment ③ Introduction of desulfurizing and dust collection equipment to 2 boilers	Cancelled	Excluded from evaluation
2) Converter Emission Gas Control at Second Plant of Benxi Iron & Steel (executing body: Benxi Iron & Steel Group Co., Ltd.)		
① Enclosure of a converter ② Introduction of equipment to treat emission gas when the converter opens and closes ③ Converter gas control ④ Improvement of a primary dust collection system: Annual processing capacity 240 mil. m^3 Fan room 12 m x 72 m, 2-story, building area 1,910 m^2 ⑤ New construction of a secondary dust collection system: Fan room 15 m x 42 m, single-story, building area 932 m^2	① Enclosure of a converter ② Introduction of equipment to treat emission gas when the converter opens and closes ③ Converter gas control ④ Improvement of a primary dust collection system: Annual processing capacity 240 mil. m^3 Fan room 12 m x 72 m, 2-story, building area 1,910 m^2 ⑤ New construction of a secondary dust collection system: Fan room 15 m x 42 m, single-story, building area 932 m^2	As planned  Converter dust collection system
3) Relocation and Improvement of DMSO Plant of Benxi Rubber Chemical (executing body: Benxi Fine Chemical Co., Ltd.)		
① Relocation of a rubber chemical plant of Benxi (plot area 22,000 m^2, building area 3,791.4 m^2) ② Construction of a DMSO plant with new emission and wastewater treatment equipment	① Relocation of a rubber chemical plant of Benxi (plot area 22,000 m^2, building area 3,791.4 m^2) ② Construction of a DMSO plant with new emission and wastewater treatment equipment	As planned  Emission and wastewater treatment equipment
4) Dust Proofing at Benxi Cement Factory (executing body: Benxi Cement Factory)		
① Construction of coal silos with dust removal equipment (diameter 15 m x height 30 m, 3 silos)	Cancelled	Excluded from evaluation
5) Emission Gas and Wastewater Treatment of W & Mo Production Process at Alloy Plant in Benxi (executing body: Benxi Abundance Tungsten & Molybdenum Co., Ltd.)		
① Introduction of SO_2, HCI, NH_2 and dust treatment equipment ② Introduction of acid and alkaline discharge treatment equipment ③ Conversion of the existing technology for molybdenum refinement	① Introduction of SO_2, HCI, NH_2 and dust treatment equipment Equipment: Purification towers Scale/specs: 7 units, BF-10 ② Introduction of acid and alkaline discharge treatment equipment Equipment: Neutralizing ponds Scale/specs: 2 ponds, 2 m x 10 m	[Plan changed] Reasons: - The budget was run over due to rising yen and equipment could no be procured as planned. - Equipment was not procured as planned due to the molybdenum market contraction. - Neutralization ponds were downsized due to lack of space in the plant.

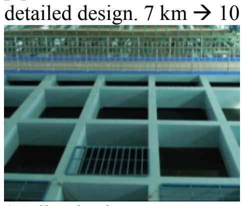
6) Emission Control of Carbide Production Process at Mineral Chemistry Plant in Benxi (executing body: Carbide Plant of Benxi Fubisheng Calcium Carbide Co., Ltd.)		
① Semi-enclosure of a carbide furnace ② Introduction of a dust collector Equipment: Pulse-jet dust collector, PPC-96-8 ③ Construction of a 10,000 kVA closed carbide furnace	① Semi-enclosure of a carbide furnace ② Introduction of a dust collector Equipment: Pulse-jet dust collector, PPC-96-8 ③ Construction of a 12,500 kVA closed carbide furnace	[Plan changed] Reason: Change of government standard (output power)  Closed carbide furnace
7) Expansion of Environment Observation Center (executing body: Benxi Environment Observation Center)		
① Automatic air monitoring system ② Mobile air and water quality monitoring system ③ Automatic monitoring system (video-surveillance of environmentally sensitive areas) ④ Regular monitoring system ⑤ Renovation and expansion of the office/auxiliary building of the center	① Automatic air monitoring system ② Mobile air and water quality monitoring system ③ Automatic monitoring system (video-surveillance of environmentally sensitive areas) ④ Regular monitoring system ⑤ Renovation and expansion of the office/auxiliary building of the center	As planned  Atomic analysis equipment: Measures heavy metals in the air
8) Utilization of Blast Furnace Gas at Steel Plant of Beitai Iron & Steel (executing body: Beitai Iron & Steel Group Co., Ltd. in Benxi)		
① A 75 t/h gas boiler ② A 12 MW single bleeder turbine power generation unit ③ Installation of other related facilities	① A 75 t/h gas boiler ② A 12 MW single bleeder turbine power generation unit ③ Installation of other related facilities	As planned  Emission gas utilization equipment
9) Construction of Water Intake Station (executing body: Benxi Waterworks Department)		
① Construction of a water intake station with an intake capacity of 350,000 m^3/day ② Installation of conductive tubes (double tubes) - 13.5 km, DN1400 (1,400 mm in diameter)	① Construction of a water intake station with an intake capacity of 350,000 m^3/day ② Installation of conductive tubes (double tubes) - 13.5 km, DN1400 (1,400 mm in diameter)	As planned  Inside of the water intake station (intake pumps)
10) Comprehensive Utilization of Coal Ash (executing body: Material Plant of Benxi Water Supplies Department)		
① Introduction of sprinklers ② New construction of a building material plant - Produces 50,000 m^3/year of ALC blocks with a high fly-ash content	① Introduction of sprinklers ② New construction of a building material plant - Produces 50,000 m^3/year of ALC blocks with a high fly-ash content	Production shutdown → Equipment provided as planned
11) Emission Gas and Wastewater Treatment at Copper Processing Plant in Benxi (executing body: Benxi Jinyuan Copper Foil Co., Ltd.)		
① Introduction of emission gas treatment equipment Equipment: Acidic mist purifier, combustion enhancement equipment Scale/specs: ≥ 95-98%, 5,000 m^3/h ② Improvement of water purification technologies Improvement: Integration of water treatment systems ③ Integration of a heat exchanging system	① Introduction of emission gas treatment equipment Equipment: Acidic mist purifier, combustion enhancement equipment Scale/specs: ≥ 95-98%, 5,000 m^3/h ② Improvement of water purification technologies Improvement: Integration of water treatment systems ③ Integration of a heat exchanging	As planned  Copper foil surface treatment equipment

and a filter system (wastewater treatment systems to neutralize or detoxify SO_3 mist, sulfuric acid, hydrochloric acid, copper and chromium generated in the electrolytic copper foil production process) ④ Improvement of copper foil surface treatment technologies Improvement: Adoption of automatic micro-control	system and a filter system (wastewater treatment system to neutralize or detoxify SO_3 mist, sulfuric acid, hydrochloric acid, copper and chromium generated in the electrolytic copper foil production process) ④ Improvement of copper foil surface treatment technologies Improvement: Adoption of automatic micro-control	
12) Wastewater Treatment at Pharmaceutical Plant in Benxi (executing body: Benxi Haida Pharmaceutical Co., Ltd.)		
① Introduction of an automatic process control system ② Introduction of wastewater treatment equipment Equipment: Air compressor, plate frame filter press Scale/specs: 450 t/day ③ Installation of a temperature regulator and a biological treatment facility to reduce COD and BOD generated in wastewater at the yeast production process ④ Introduction of deep well aeration - fluid bed type, activated sludge process, secondary treatment technologies ⑤ Construction of a receiving basin, a distributing basin, a deep well facility, a biological fluid bed	① Introduction of an automatic process control system ② Introduction of wastewater treatment equipment Equipment: Air compressor, plate frame filter press Scale/specs: 450 t/day ③ Installation of a temperature regulator and a biological treatment facility to reduce COD and BOD generated in wastewater at the yeast production process ④ Introduction of deep well aeration - fluid bed type, activated sludge process, secondary treatment technologies ⑤ Construction of a receiving basin, a distributing basin, a deep well facility, a biological fluid bed	As planned  Wastewater treatment facility
13) Renovation of Caustic Soda Production Process at Plastic Chemical Plant in Benxi (executing body: Benxi Dongfang Chlor-Alkali Co., Ltd.)		
① Construction of production equipment with an annual capacity of 20,000 tons ② Updating of a production process Before → After Fusion method → Ion diaphragm method ③ Introduction of emission gas and wastewater treatment equipment ④ (New construction of a secondary salt water purifying system, a pure and salt water chlorine removal system, a water purifying system and a pure acid production system)	① Construction of production equipment with an annual capacity of 20,000 tons ② Updating of a production process Before → After Fusion method → Ion diaphragm method ③ Introduction of emission gas and wastewater treatment equipment ④ (New construction of a secondary salt water purifying system, a pure and salt water chlorine removal system, a water purifying system and a pure acid production system)	As planned  Caustic soda production system with ion diaphragm

Phase II

Original Plan	Actual Outputs	Notes
1) City Gas Supply Phase 5 (executing body: Benxi Wanhua Gas Co., Ltd.)		
① Construction of a coke-oven gas supply station (for storage and distribution of LPG) (Gaotaizi gas liquefaction process) ② Construction of 2 LPG supply stations (for gas mixing) (Caitun/Dayu gas mixing processes) ③ Gas piping (Zhuanshan gas system) ④ Construction of an LP gas cylinder supply station (for storage and distribution of gas) (Zhuanshan gas system)	① Construction of a coke-oven gas supply station (for storage and distribution of LPG) (Gaotaizi gas liquefaction process) ② Construction of 2 LPG supply stations (for gas mixing) (Caitun/Dayu gas mixing processes) ③ Gas piping (Zhuanshan gas system) ④ Construction of an LP gas cylinder supply station (for storage and distribution of gas) (Zhuanshan gas system)	As planned  Coke oven gas supply station

2) Converter Emission Gas Control at Beitai Iron & Steel (executing body: Beitai Iron & Steel Group Co., Ltd.)		
① A 50,000 m^3 rubber-sealed dry type gas tank 2 electrostatic converter gas dust collectors ② Construction of an electrostatic dust collection system ③ Construction of a coal gas pressurising station (2 units of gas pressurising equipment) ④ Construction of automatic control gauges (2 sets each for combustion equipment, heat conduction equipment, gas bleeding dust collecting equipment, blower, control system and material supply equipment) ⑤ Construction of compressed slag ball production equipment with a capacity of 20,000 t/year	① A 50,000 m^3 rubber-sealed dry type gas tank 2 electrostatic converter gas dust collectors ② Construction of an electrostatic dust collection system ③ Construction of a coal gas pressurising station (2 units of gas pressurising equipment) ④ Construction of automatic control gauges (2 sets each for combustion equipment, heat conduction equipment, gas bleeding dust collecting equipment, blower, control system and material supply equipment) ⑤ Construction of compressed slag ball production equipment with a capacity of 20,000 t/year	As planned  Equipment related to emission gas utilization
3) Pollution Control at Chemical Plant (executing body: Benxi Fine Chemical Co., Ltd.)		
① Installation of desulfurization equipment at DMDS plant ② Relocation to a block of chemical engineering area (25,000 m^3) within an existing chemical engineering site ③ Construction of a plant of a new process with wastewater treatment and other environmental protection facilities that produces 1,000 tons of dimethyldisulphide per year	① Installation of desulfurization equipment at DMDS plant ② Relocation to a block of chemical engineering area (25,000 m^3) within an existing chemical engineering site ③ Construction of a plant of a new process with wastewater treatment and other environmental protection facilities that produces 1,000 tons of dimethyldisulphide per year	Production shutdown → Equipment installed as planned
4) Pollution Control at Solvent Plant (executing body: Auxiliaries Plant in Benxi)		
① Establishment of a soft calcium carbonate plant ② Production process improvement and installation of desulfurization equipment at an anti oxidant plant - To reduce 20 tons of ammonia nitrogen per year - To reduce 0.14 tons of asphalt per year - To reduce 42.4 tons of SS per year ③ Installation of a dust collector ④ Installation of a settling basin and other environmental control equipment	① Establishment of a soft calcium carbonate plant ② Production process improvement and installation of desulfurization equipment at an anti oxidant plant - To reduce 20 tons of ammonia nitrogen per year - To reduce 0.14 tons of asphalt per year - To reduce 42.4 tons of SS per year ③ Installation of a dust collector ④ Installation of a settling basin and other environmental control equipment	Production shutdown → Equipment installed as planned
5) Pollution Control at Lubricant Plant (executing body: Benxi Huante Petrochemical Co., Ltd.)		
① Improvement of production processes at a molybdenum sulfide plant, a lube oil plant and a grease plant ② Construction of production and auxiliary facilities for molybdenum disulfide powder (300 tons/year), molybdenum disulfide based oil products (5,000 tons/year) and molybdenum disulfide lube oil (5,000 tons/year) ③ Construction of environmental protection facilities with Public Construction Commission ④ Installation of environmental control equipment such as SO_2 collecting unit, oil recovery unit and wastewater treatment unit	① Improvement of production processes at a molybdenum sulfide plant, a lube oil plant and a grease plant (Renewal of roasting furnaces: 2 closed rotary kilns and 2 pyrolysis kilns) ② Construction of production and auxiliary facilities for molybdenum disulfide powder (300 tons/year), molybdenum disulfide based oil products (5,000 tons/year) and molybdenum disulfide lube oil (5,000 tons/year) ③ Construction of environmental protection facilities with Public Construction Commission ④ Installation of environmental control equipment such as SO_2 collecting unit, oil recovery unit and wastewater treatment unit	As planned  Grease production equipment

6) Taizi River Drinking Water Pollution Control (executing body: Benxi Waterworks Department)		
① Purified water supply equipment: 80,000 m^3/day ② Distribution pipe network: 7 km	① Expansion of a water purifying plant Processing ability: 80,000 m^3/day ② Improvement of distribution pipes Length: 10 km	Plan changed] Reason: The length of the drain pipe was extended as a result of detailed design. 7 km → 10 km  Settling basin

Phase III

Original Plan	Actual Outputs	Notes
1) Beitai Iron & Steel Coke Oven Pollution Control (executing body: Beitai Iron & Steel Group Co., Ltd.)		
① Construction of two sets of 38-hole stamp charging coke production facilities (JNO38-2; coal preparation, coke production, gas collection and purification system and wastewater treatment) with a production capacity of approx. 560,000 tons/year ② Construction of ancillary facilities including a substation and other facilities for production aid, management and environmental improvement (total lot area 261, 000 m^3)	① Construction of a 65-hole JN43-804 coke oven and coke production facilities with a production capacity of approx. 450,000 tons/year (Coal preparation, coke production, gas collection and purification system and wastewater treatment) ② Construction of ancillary facilities including a substation and other facilities for production aid, management and environmental improvement	[Plan changed] Reason: As a result of detailed calculation of required production capacity, specs of the coke oven were changed.  Coke oven

3.2.2 Project Inputs

3.2.2.1 Project Period

The planned and actual project periods are as follows. There is a delay in general.

Phase I	Planned period:	October 1997 – December 2001 (51 months)
	Actual period:	October 1997 – December 2002 (63 months)
Phase II	Planned period:	December 1998 – March 2002 (40 months)
	Actual period:	December 1998 – July 2004 (68 months)
Phase III	Planned period:	July 2000 – March 2002 (21 months)
	Actual period:	July 2000 – June 2002 (24 months)

The period of each subproject is as shown in Table 2 below. In Phase I, the actual period of five subprojects out of 11 were longer than planned because there were so many subprojects and the city government and executing agencies were not accustomed to the procedures and project management. In Phase II, two subprojects out of the total 6 were much longer (150%-) than planned due to the slow process of privatization and delay of funding in the executing agencies. (The executing agencies of these two subprojects are practically bankrupt now.) Two other projects were slightly longer than planned (100%-) due to the delay of equipment procurement. In Phase III, there was only one subproject, which was delayed for three months due to the delay of equipment procurement.

We first evaluated each subproject and then the whole project. It was evaluated as follows:

3-level evaluation based on the difference between the original plan and actual results (the actual period was a: not exceeding 100% of the plan, b: longer than 100% and not exceeding 150% of the plan, and c: longer than 150% of the plan), addition of 2 points for a, 1 for b, and 0 for c, and overall rating of (a) when the total of the points is over 80 percent, (b) when it is more than 50 percent and under 80 percent, and (c) when it is 50 percent or less. (See the right-hand column of Table 2.)

As a result, as shown in Table 3, the actual period was shorter than planned or mostly as planned (not exceeding 100%) in eight subprojects, longer than planned (100%-150% of the plan) in eight subprojects and much longer (150%-) in two subprojects. As a result of the calculation described above, the project period is rated as (b) “longer than planned”.

Table 2 Original Plan and Actual Results of Each Subproject Period

Subproject Name	Original (at appraisal)			Actual (at ex-post evaluation)			Difference (%)(Actual / Original)	Evaluation
	Launched	Completed	Period (month)	Launched	Completed	Period (month)		
Phase I								
1)Emission gas and wastewater treatment at Benxi electrical equipment plant	October 1997	December 2001	51	-	-	-	-	Cancelled
2)Converter emission gas control at second plant of Benxi Iron & Steel	October 1997	December 2001	51	October 1997	December 2002	63	124	b
3)Relocation and improvement of DMSO plant of Benxi rubber chemical plant	October 1997	December 2001	51	October 1997	September 2002	60	118	b
4)Dust proofing at Benxi cement factory	October 1997	December 2001	51	-	-	-	-	Cancelled
5)Emission gas and wastewater treatment of W & Mo production process at alloy plant in Benxi	October 1997	December 2001	51	October 1997	July 2002	58	114	b
6)Emission control of carbide production process at mineral chemistry plant in Benxi	October 1997	December 2001	51	October 1997	December 2001	51	100	a
7)Expansion of Environment Observation Center	January 1998	December 2001	48	January 1998	November 2000	35	73	a
8)Utilization of blast furnace gas at steel plant of Beitai Iron & Steel	October 1997	December 2001	51	October 1997	November 2000	38	75	a
9)Construction of water intake station	October 1997	December 2001	51	October 1997	October 2002	61	120	b
10)Comprehensive utilization of coal ash	October 1997	December 2001	51	October 1997	December 2000	39	76	a
11)Emission gas and wastewater treatment at copper processing plant in Benxi	October 1997	December 2001	51	October 1997	June 2002	57	112	b
12)Wastewater treatment at pharmaceutical plant in Benxi	October 1997	December 2001	51	October 1997	December 2000	39	76	a

Subproject Name	Original (at appraisal)			Actual (at ex-post evaluation)			Difference (%)(Actual / Original)	Evaluation
	Launched	Completed	Period (month)	Launched	Completed	Period (month)		
13)Renovation of caustic soda production process at plastic chemical plant in Benxi	October 1997	December 2001	51	October 1997	September 2001	48	94	a
Phase II								
1)City gas supply Phase 5	December 1998	March 2002	40	December 1998	December 2002	49	123	b
2)Converter emission gas control at Beitai Iron & Steel	April 1999	March 2002	36	April 1999	December 2001	33	92	a
3)Pollution control at chemical plant	January 1999	March 2002	39	January 1999	July 2004	67	172	c
4)Pollution control at solvent plant	January 1999	March 2002	39	January 1999	November 2003	59	151	c
5)Pollution control at lubricant plant	January 1999	March 2002	39	January 1999	November 2001	35	90	a
6)Taizi River drinking water pollution control	December 1998	March 2002	40	December 1998	October 2002	47	118	b
Phase III								
1)Beitai Iron & Steel coke oven pollution control	July 2000	March 2002	21	July 2000	June 2002	24	114	b

Table 3 Evaluation of Project Period

	(a) Evaluation Shorter than planned [2 points]	(b) Evaluation Longer than planned [1 point]	(c) Evaluation Much longer than planned [0 point]	Total	Evaluation result
Subproject Quantity	8	8	2	18	
Point [maximum: 36]	16 points	8 points	0 point	24 points	67% = (b)

3.2.2.2 Project Cost

The planned and actual project costs are as shown below. The total project costs of all phases were lower than planned.

Phase I Plan: Total 9,918 million yen (Japanese ODA loan portion 4,110 million yen)
Actual: Total 9,652 million yen (Japanese ODA loan portion 4,076 million yen)

Phase II Plan: Total 6,564 million yen (Japanese ODA loan portion 3,237 million yen)
Actual: Total 5,916 million yen (Japanese ODA loan portion 3,082 million yen)

Phase III Plan: Total 5,362 million yen (Japanese ODA loan portion 1,160 million yen)
Actual: Total 1,980 million yen (Japanese ODA loan portion 1,159 million yen)

As for the cost of each subproject, the actual cost was higher than planned in 10 subprojects out of the total 18, as shown in the following Table 4. It was mainly because the sum of all prices slightly exceeded the estimated cost as a result of competitive bidding.

The project cost was also evaluated first by subproject and them as a project in its entirety as it was in the case of project period. It was evaluated as follows: 3-level evaluation based on the difference between the plan and actual results (the actual result was a: not exceeding 100% of the plan, b: more than 100% and below 150% of the plan, and c: 150% or more of the plan), with addition of 2 points for a, 1 for b, and 0 for c, and overall rating of (a) when the total of the points is over 80 percent, (b) when it is more than 50 percent but under 80 percent, and (c) when it is 50 percent or less. (See the right-hand column of Table 4.)

As a result, as shown in Table 5, the actual cost was lower than planned or mostly as planned (not exceeding 100%) in eight subprojects, and higher than planned (100%-150% of the plan) in 10 subprojects. Based on the calculation described above, the sub-rating of the project cost is (b) “higher than planned”.

Table 4 Comparison of Original Plan and Actual Project Cost

(Unit: million yen)

Subproject Name	Plan		Actual		Difference (Actual / Original)	Evaluation
	Project Cost	Yen Loan in Project Cost	Project Cost	Yen Loan in Project Cost		
Phase I						
1)Emission gas and wastewater treatment at Benxi electrical equipment plant	188	61	-	-	-	Excluded
2)Converter emission gas control at second plant of Benxi Iron & Steel	1,345	499	1,376	475.2	102%	b
3)Relocation and improvement of DMSO plant of Benxi rubber chemical works	985	502	998	558.1	101%	b
4)Dust proofing at Benxi cement factory	231	114	-	-	-	Excluded
5)Emission gas and wastewater treatment of W & Mo production process at alloy plant in Benxi	486	200	497	200	102%	b
6)Emission control of carbide production process at mineral chemistry plant in Benxi	658	298	663	295.9	101%	b
7)Expansion of Environment Observation Center	292	151	297	151.3	102%	b
8)Utilization of blast furnace gas at steel plant of Beitai Iron & Steel	2,019	819	1,903	806.3	94%	a
9)Construction of water intake station	1,578	503	1,609	494.6	102%	b
10)Comprehensive utilization of coal ash	186	101	189	101.3	101%	b

Subproject Name	Plan		Actual		Difference (Actual / Original)	Evaluation
	Project Cost	Yen Loan in Project Cost	Project Cost	Yen Loan in Project Cost		
11)Emission gas and wastewater treatment at copper processing plant in Benxi	618	228	631	221.6	102%	b
12)Wastewater treatment at pharmaceutical plant in Benxi	231	140	240	140.3	104%	b
13)Renovation of caustic soda production process at plastic chemical plant in Benxi	1,101	494	1,249	613.6	114%	b
Phase I Total	9,918	4,110	9,652	4,058		
Phase II						
1)City gas supply Phase 5	1,725	573	1,523	466.4	88%	a
2)Converter emission gas control at Beitai Iron & Steel	890	442	832	442.4	94%	a
3)Pollution control at chemical plant	992	640	883	640.5	89%	a
4)Pollution control at solvent plant	526	382	447	382.5	85%	a
5)Pollution control at lubricant plant	1,191	551	1,025	558	86%	a
6)Taizi River drinking water pollution control	1,241	649	1,205	597.3	97%	a
Phase II Total	6,565	3,237	5,916	3,087		
Phase III						
1)Beitai Iron & Steel coke oven pollution control	5,362	1,160	1,980	1,159.4	37%	a
Phase III Total	5,362	1,160	1,980	1,159		
Project Total	21,845	8,507	17,547	8,305		

Table 5 Evaluation of Project Cost

	(a) Evaluation Lower than planned [2 points]	(b) Evaluation Higher than planned [1 point]	(c) Evaluation Much higher than planned [0 point]	Total	Evaluation result
Subproject Quantity	8	10	0	18	
Point [maximum: 8]	16 points	10 points	0 point	26 points	72% = (b)

As shown above, both project period and project cost exceeded the plan; therefore efficiency of the project is fair.

3.3 Effectiveness (Rating: b)

3.3.1 Quantitative Effects

3.3.3.1 Results from Operation and Effect Indicators

The achievement level of operation and effect indicators of each subproject is as shown in the following table. The right-hand column of the table has “a” in case the achievement level is over 80%, “b” in case the achievement level is over 50% and under 80%, and “c” in case the achievement level is 50% or below or the production is shut down.

Table 6 Targets and Actual Results of Operation and Effect Indicators

Phase I

Subproject	Target values (2000)	Actual results (2009)	Evaluation
1) Emission gas and wastewater treatment at Benxi electrical equipment plant	Cancelled	-	Excluded
2) Converter emission gas control at second plant of Benxi Iron & Steel	Flue dust concentration: 120 g/m^3 → 0.1 g/m^3 (99.92% reduced)	Flue dust concentration: 0.035 g/m^3 (99.97% reduced compared to 1996)	a
3) Relocation and improvement of DMSO plant of Benxi rubber chemical works	DMSO production scale: 2,000 t/year Annual reduction of SO_2 emission: 43.9 t (reduction rate 50.8%) CDO concentration in wastewater: to be reduced to 15.58 mg/L COD reduction rate: 87.5% Reduction of solid waste: 17.84 t/year DMSO collection rate: 60% → 90%	DMSO production scale: 3,339 t/year (Target in 2009: 4,000 tons) Annual reduction of SO_2 emission: 45 tons CDO concentration in wastewater: reduced to 15.6 mg/L COD reduction rate: 88% Reduction of solid waste: 18.1 t/year DMSO collection rate: 91%	a
4) Dust proofing at Benxi cement factory	Cancelled	—	Excluded
5) Emission gas and wastewater treatment of W & Mo production process at alloy plant in Benxi	- Annual reduction of SO_2: 223.1 tons (Reduction rate 100%) - Reduction of solid waste: 24.9 tons (Reduction rate 100%) - Standards for discharged SO_2, hydrochloric acid mist, ammonia gas and waste liquid: Discharged waste liquid (alkaline) PH>9 → PH=7 (improved amount 420 t/year) Discharged waste liquid (acidic) PH2-2.5 → PH=7 (improved amount 3,840 t/year) - Annual production of ammonium molybdate: 400 tons - Increased production of hot rolled steel plates and cold rolled steel plates: to be increased by 45t /year	- Annual reduction of SO_2: 0 ton - Reduction of solid waste: 0 ton - Standards for discharged SO_2, hydrochloric acid mist, ammonia gas and waste liquid: Discharged waste liquid (alkaline) PH>9 → PH=7 (improved amount 700 t/year) Discharged waste liquid (acidic) PH2-2.5 → PH=7 (improved amount 8,000 t/year) - Annual production of ammonium molybdate: 1,544 t/year - Annual production of molybdenum: 34 t/year - Increased production of hot rolled steel plates and cold rolled steel plates: 0 ton (because equipment was not procured as planned) Note: Reduction of SO_2 and solid waste was not the effect of equipment installation but of the production process change (outsourcing of molybdenum oxide production).	b
6) Emission control of carbide production process at mineral chemistry plant in Benxi	- Dust emission: 100 mg/m^3 or below - Utilization of recycled water: Recycled water to be used for all production processes - Production of formic acid with use of CO generated as by-product of a carbide furnace	Dust emission: 80 mg/m^3 - Utilization of recycled water: Recycled water to be used for all production processes - Production of cement with use of by-product of a carbide furnace (Cement materials produced instead of formic acid according to the needs of the market) : 10,406 t/year - Dust collection: 1,460 t/year - Real output of carbide: 22,076 t/year	a
7) Expansion of Environment Observation Center	- Environmental monitoring ability: achievement of national ambient air quality standard grade 3 - Full-scale automatic air monitoring, regular monitoring of all water systems and major dams in the city,	- Environmental monitoring ability: Achieved national ambient air quality standard grade 3 and passed the laboratory-level examination conducted by the parent department.	a

Subproject	Target values (2000)	Actual results (2009)	Evaluation
	and full-scale control of major water sources in the city		
8) Utilization of blast furnace gas at steel plant of Beitai Iron & Steel	- Standard quantity of alternative to coal: 3.99 t/year - Annual SO_2 emission reduction: 1,640-1,760 tons - Flue dust reduction: 1,340 tons - Annual power feed: 144.4 million kWh	- Standard quantity of alternative to coal: 148,800 t/year - Annual SO_2 emission reduction: 1,840 t/year - Flue dust reduction: 1,240 t/year - Annual power feed: 147.6 million kWh (up 89% from 2002)	a
9) Construction of water intake station	Environmental effect: To supply daily life water to 400,000-500,000 people living in the central part of the city; to improve the water supply coverage for 800,000 people to more than 99%; to improve the quality of tap water to meet the standard	- Real number of beneficiaries: 830,000 - Water quality: achieved grade 2 standard	a
10) Comprehensive utilization of coal ash	Environmental effects To control fly ash pollution at a Bengang plant and generate positive economic and social effects Production: 50,000 m^3/year of ALC blocks with a high fly-ash content	Production shutdown	c
11) Emission gas and wastewater treatment at copper processing plant in Benxi	Copper concentration: 0.5 mg/L Copper emission: 0.27 t/year Chrome concentration: 0.05 t/year Chrome discharge: 0.03 t/year Reduction of wastewater: 320,000 t/year *To collect 13 tons of copper per year Acid mist concentration in working area: 200 mg/m^3 or below	Copper concentration: 0.45 mg/L Copper emission: 0.26 t/year Chrome concentration: 0.049 mg/L Chrome discharge: 0.03 t/year Reduction of wastewater: 330,000 t/year Acid fog concentration in working area: 150 mg/m^3 or below Real output of electrolytic copper foils: 1,333 tons (up 22% from 2000)	a
12) Wastewater treatment at pharmaceutical plant in Benxi	COD concentration (mg/L): 10,000 → 50 (99%) COD discharge (t/year): 1,280 → 8 BOD concentration (mg/L): 4,500 → 30 (99%) BOD discharge (t/year): 575 → 4.8 SS reduction rate: 97.5% Wastewater treatment: 450-500 t/day	COD concentration (mg/L): 80-90 COD discharge (t/year): 4 BOD concentration (mg/L): 32 BOD discharge (t/year): 3 (down 23% from 1977) SS reduction rate: 97% Wastewater treatment: 100 t/day Note: Although the target values of COD and BOD concentration have not been achieved, all the other indicators have been mostly achieved. However, it is not the effect of the provided equipment but mainly because of the downsizing of production. (Drug materials and drugs cannot be produced in the same plant due to the tightened government regulations on pharmaceutical companies.)	b
13) Renovation of caustic soda production process at plastic chemical plant in Benxi	Annual COD reduction: 337.6 tons Annual BOD5 reduction: 47.1 tons Annual SS reduction: 350.6 tons Annual SO^2 reduction: 114 tons Annual TSP reduction: 16.3 tons	Annual COD reduction: 827 tons (2007) Annual BOD5 reduction: 416 tons (2007) Annual SS reduction: 2,072 tons (2007) Annual SO^2 reduction: 254.2 tons (2007) Annual TSP reduction: 25 tons (2007) Caustic soda production: 50,000 tons (2007) Note: Although the target values were achieved in 2007, the production scale was downsized in 2008 and was stopped in 2009 due to decreased market needs.	b

Phase II

Subproject	Target values (2000)	Actual results (2009)	Evaluation
1) City gas supply Phase 5	Coal consumption reduction: 126,000 t/year SO_2 emission reduction: 3,600 t/year TSP discharge reduction: 9,900 t/year	Coal consumption reduction: 130,000 t/year SO_2 emission reduction: 3,550 t/year TSP discharge reduction: 10,000 t/year Coke gas supply: 100,000 m^3/day Liquefied petroleum gas supply: 6,000 t/year Gas users: 54,000 households Users of liquefied petroleum gas cylinders: 6,000 households Users of liquefied petroleum gas pipeline: 14,000 households	a
2) Converter emission gas control at Beitai Iron & Steel	SO_2 emission reduction: 160 t/year CO gas emission reduction: 32,369 t/year Flue dust reduction: 90 t/year --> 122 t/year Solid waste reduction: 5,690 t/year --> 7,587 t/year Dust reduction: 966 t/year Steel converter slag reduction: 200,000 t/year Reduction of dust collector sludge: 20,000 t/year	SO_2 emission reduction: 165 t/year CO gas emission reduction: 30,520 t/year Flue dust reduction: 114 t/year Solid waste reduction: 6,586 t/year Dust reduction: 1,013.33 t/year Steel converter slag reduction: 200,000 t/year Reduction of dust collector sludge: 18,000 t/year Iron products output: 2,471,316 tons (up 25% from 2002)	a
3) Pollution control at chemical plant	SO_2 emission reduction: 154 t/year → 38 t/year SO_2 concentration: 15.9 mg/m^3 → 10.5 mg/m^3 COD discharge: 3.3 t/year COD concentration: 1,000 mg/L → 97mg/L Other: To eliminate almost all environmental impact of methanethiol, sulfur ether and other malodorous substances	Production shutdown (The company went bankrupt.)	c
4) Pollution control at solvent plant	SO_2 reduction: 148 t/year TSP reduction: 90 t/year Environmental effect: To improve low-level production technologies; to reduce pollution; to achieve emission standards	Production shutdown (The company went bankrupt.)	c
5) Pollution control at lubricant plant	SO_2 reduction: 373 t/year BOD reduction: 2.8 t/year Sulfurated hydrogen reduction: 65 t/year SS reduction: 24 t /year Ammonia nitrogen reduction: 1.7 t/year Oil reduction: 10.5 t/year	SO_2 discharge: 0 t/year BOD discharge: 0 t/year Sulfurated hydrogen discharge: 0 t/year SS discharge: 0 t/year Ammonia nitrogen discharge: 0 t/year Oil discharge: 0.5 t/year Note: Although the target values have been achieved, it was not the effect of the provided equipments but mostly because of significant downsizing of production compared with the original plan.	b
6) Taizi River drinking water pollution control	Drinking water quality standard: Class II achieved Maximum water supply capacity: daily processing capacity 80,000 m^3 → 160,000 m^3	Served population for water supply: 830,000 (up 17% from 1997) Water supply: 140,000 m^3/day (up 100% from 1997) Facility utilization rate Leakage rate: 25% (down 10 points from 1997) Water intake: 330,000 m^3/day (up 38% from 1997) Water quality standard: Class II achieved Water supply coverage rate: 100% (up 10 points from 1997) Maximum daily processing capacity: 160,000 m^3 (up 100% from 1997)	a

Phase III

Subproject	Target values (2000)	Actual results (2009)	Evaluation
1) Beitai Iron & Steel coke oven pollution control	SO_2 emission reduction: 334 t/year TSP emission reduction: 1,052 t/year COD discharge reduction: 19 t/year Petroleum oil discharge reduction: 3 t/year	SO_2 emission reduction: 770 t/year TSP emission reduction: 2,420 t/year COD discharge reduction: 136 t/year Petroleum oil discharge reduction: 13.11 t/year	a

As shown in the table above, out of the total 18 subprojects, it was given a rating of "a" to 11 subprojects that achieved the target values. A rating of (b) was given to Phase I: "5) Emission gas and wastewater treatment of W & Mo production process at alloy plant in Benxi", "12) Wastewater treatment at pharmaceutical plant in Benxi", "13) Renovation of caustic soda production process at plastic chemical plant in Benxi" and Phase II: "5) Pollution control at lubricant plant", because their target achievement was not made by the introduction of equipment but mainly by production cut or change of production processes. Moreover, Phase I: "10) Comprehensive utilization of coal ash", Phase II: "3) Pollution control at chemical plant" and "4) Pollution control at solvent plant" received a rating of "c", because production was shut down in those projects and the actual results could not be checked. The major reasons for production shutdown were updating of a production process or a slow process of privatization.

The effectiveness of the whole project was also evaluated based on the sum of the ratings of all subprojects. 2 points were given for the rating of "a", 1 point for "b" and 0 point for "c". Then a rating of (a) was given when the total score was over 80% , (b) when over 50% up to 80%, and (c) when under 50% or less. The evaluation result based on this rule is as shown in the following Table 7. The total score was 72% of the highest score. Therefore, the effectiveness of the whole project was (b).

Table 7 Evaluation of Operation and Effect Indicators

	(a) Evaluation Indicator achievement level 80% or more	(b) Evaluation Indicator achievement level 50% to 79%	Rating (c) Indicator achieved less than 49% or no operation	Cancellation (Excluded from evaluation)	Total
Subproject Quantity	11	4	3	2	20
Point [maximum: 36]	22 points	4 points	0 point	-	26 points 72%= (b)

3.3.1.2 Results of Calculations of the Internal Rate of Return

Financial Internal Rate of Return (FIRR) values of Phase I and Phase II were not calculated at the time of appraisal and will not be calculated because it was difficult to obtain necessary information from the Chinese side. FIRR of the "Beitai Iron & Steel Coke Oven Pollution Control" of Phase III was calculated with coke sale revenue. However, at the time of ex-post evaluation, it was found out that coke was not sold but was consumed in the course of steel production. Moreover, it was pointed out that the facilities used for subproject evaluation were only part of the coke production facilities and that it was difficult to calculate the maintenance and operation cost and other expenses only for this portion. Therefore, FIRR will not be calculated for Phase III, either.

Economic Internal Rate of Return (EIRR) benefit indicators could be health improvement made by air quality improvement and amount of money people would like to pay for improved public service. However, comparison with similar benefit indicators cannot be conducted because EIRR was not calculated at the time of appraisal, and no other similar benefit indicators is not available for evaluation. It is also difficult to obtain data of the time. Therefore, EIRR is not calculated in this evaluation.

3.3.2 Qualitative Effects

The primary qualitative effect of this project is that “with reduction of air and water contaminants and supply of safe drinking water, local people become aware of improvements of air and water quality”.

As shown in the following table, over 90% of the respondents of the beneficiary survey are aware that the air quality in Benxi has improved compared with 10 years ago. Many respondents pointed out “plant relocation”, “reduction of plant smoke concentration with the use of advanced technologies”, “tightened control” and “increase of households supplied with gas” as major improvement factors.

Table 8 Residents’ Recognition of Air Quality Improvement

Changes in air quality in comparison with 10 years ago	Total (%)
Improved very much	90.8
Rather improved	8.3
Not changed much	0.8
Rather deteriorated	0
Deteriorated very much	0
Don’t know	0

(Of responses “Improved or rather improved”) Main causes of improvement [multiple answers allowed]	Total (%)
Plants relocated to suburbs	81.7
Flue gas concentration from plants reduced by the advanced technologies	74.2
Municipal government control was strengthened	73.3
Gas is used at home	68.3
Improved financial strength of the city	55.0
Promotion of public works in local cities	25.0

Note: Result of a beneficiary survey conducted during the ex-post evaluation (survey of 120 residents of the city in May 2010)

As for the water quality of the Taizi River, the water source of Benxi, over 90% people responded that it has improved compared with 10 years ago, and many of them pointed out "relocation of intake sources to the upstream", "tightened control" and "plant relocation", all conducted in this project, as major improvement factors.

Table 9 Residents' Awareness about Water Quality of the Taizi River
(Result of Beneficiary Survey)

Water quality of the Taizi River compared with 10 years ago	Total (%)
Improved very much	76.7
Rather improved	20.0
Not changed much	1.7
Rather deteriorated	0
Deteriorated very much	0
Don't know	1.7

Major factors that improved water quality (Multiple answers of respondents who marked "Improved" or "Generally improved")	Total (%)
Relocation of intake sources to the upstream	86.7
Municipal government control was strengthened	57.5
Promotion of public works in local cities	46.7
Improved financial strength of the city	43.3
Relocation of plants to suburbs	40.0
Flue gas concentration from plants reduced by the advanced technologies	30.8

Note: Result of a beneficiary survey conducted during the ex-post evaluation (survey of 120 residents of the city in May 2010)

These effects were developed through the effective cooperation with and supplement to the environmental improvement activities that the Chinese parties had been carrying out on their own. Therefore, the project was not the only contributor to these effects, but its overall contribution seems significant.

As described above, the achievement level of the operation and effect indicators and qualitative effects of the whole project show that this project has largely achieved its objectives, therefore its effectiveness is high.

3.4 Impact

3.4.1 Intended Impacts

Although the environmental improvement of the whole city of Benxi is largely attributed to the efforts outside this project, such as long-term environmental measures and advances in contaminant processing technologies, the environmental indicators of the whole city and the result of the beneficiary survey indicate that the project has a major impact on the improvement of the local people's living environment.

Benxi had such serious environmental issues that it was called "a city invisible from the satellite" at the time of appraisal. Therefore, implementation of various environmental measures in this project, including measures for companies that had a negative impact on the environment (Beitai Iron & Steel Group and Benxi Iron & Steel Group) and measures to improve drinking water and city gas supply that have a significant impact on the public life, is deemed to have made no small contribution to the environmental improvement of the whole city.

(1) Improvement of Air and Water Quality in Benxi

As shown in Table 10, the air quality index of the city of Benxi dramatically improved from 2001 to 2005. In 2005 the average SO_2 concentration achieved the national ambient air quality grade 2 (0.06 mg/ m^2) for the first time, and in 2008 the level of PM10 also achieved grade 2 (0.054 mg/m^2). Moreover, after the relocation of the Dayu water source from an urban district to 13.5 km upstream in Phase I "9) Construction of Water Intake Station", the water quality of the water source has achieved the water quality standard grade 2 and the downstream water quality has also been improving.

Table 10 Indicators of Air Quality in Benxi (annual average)

(mg/m^3)

Index	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
TSP/ PM10	0.47	0.41	0.41	0.39	0.346	0.288	0.282	0.280	0.119	0.110	0.108	0.092	0.090
SO_2 concentration	0.15	0.11	0.09	0.09	0.071	0.068	0.060	0.060	0.059	0.044	0.047	0.046	0.050
NO_x concentration	0.03	0.05	0.05	0.05	0.033	0.036	0.039	0.032	0.036	0.028	0.031	0.034	0.032
Total particle emissions (t)	39.6	38.4	36.9	35.7	28.5	27.3	26.0	25.0	22.9	22.0	21.4	21.1	20.3

Note 1: PM10 replaced TSP in 2005.

Note 2: The SO_2 and TSP values from 2006 to 2009 include pollutants from area-wide observation and cannot be simply compared with the values before 2006, which were obtained only through fixed-point observation.

*Reference: Benxi Environment Year Book

Table 11 Indicators of Water Quality in the Downstream of the Taizi River in Benxi (annual average)

(mg/L)

Index	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
BOD	4.06	4.34	5.42	5.12	3.52	4.35	4.86	4.75	4.63	4.75	4.05	3.52	4.62
COD	42.9	30.0	37.8	29.6	20.5	23.0	21.7	32.7	27.3	22.3	20.8	16.9	17.8

Note : The BOD and COD values from 2006 to 2009 include pollutants from area-wide observation and cannot be simply compared with the values before 2006, which were obtained only through fixed-point observation.

*Reference: Benxi Environment Year Book

(2) Improvement of the Local People's Living Environment

According to the result of the beneficiary survey described in the following table, many citizens are aware that their living environment and the level of their life have been improved thanks to the enhanced air and water quality in Benxi.

Many respondents especially pointed out "reduction of dirt on clothes" and "reduction of cough and soreness in the eyes" as beneficial effects of the air quality improvement.

Table 12 Public Awareness about Living Environment Improvement

Beneficial effects of air quality improvement [multiple answers]	Total (%)
Reduction of clothing contamination by dust	89.2
Reduction of cough and soreness in the eyes	81.7
Able to hang laundry outside	60.0
No need to use masks and sunglasses for dust protection any more	24.2
Others	0.8

Note: Result of a beneficiary survey conducted during the ex-post evaluation (survey of 120 residents of the city in May 2010)

(3) Improvement of the Level of Life with the Development of Urban Infrastructures

As shown in the following table, over 90% of the citizens are aware of the "qualitative improvement of the life" with the development of city gas and water infrastructures. Especially regarding the water project, the level of satisfaction is high in terms of water supply quantity, water pressure and water quality. Therefore, it is assessed that the level of the public life has improved.

Table 13 Public Awareness about Improvement of Life
(Result of Beneficiary Survey)

Beneficial effects of city gas supply [multiple answers]	Total (%)
Much contributed to the qualitative improvement of life	63.3
Contributed to the qualitative improvement of life	31.7
Did not contribute to the qualitative improvement of life	4.2
Not sure	0.8

Effect of water source relocation and water supply [multiple answers]	Total (%)
Much contributed to the qualitative improvement of life	85.8
Contributed to the qualitative improvement of life	11.7
Did not contribute to the qualitative improvement of life	0.8
Not sure	1.7

Note: Result of a beneficiary survey conducted during the ex-post evaluation (survey of 120 residents of the city in May 2010)

(4) Strengthened Environmental Measures of the City of Benxi

Improvement of equipments in the environment observation center was conducted as one of the subprojects. Therefore, the monitoring ability of the city of Benxi has been enhanced and the municipal government is encouraged to take environmental measures more actively.

Moreover, according to the result of a hearing with the environmental protection agency, although, right after this project was started, their environmental preservation program[7] was not making much progress due to fund shortage and the air pollution issues were still considered as major issues, 20 projects selected by the agency were later implemented as subprojects of this project. The agency understands that, as a result, these subprojects had good effects and promoted understanding of investment and loan in the environmental field, and therefore helped the subsequent structural enhancement.

3.4.2 Other Impacts

1) Impacts on the Natural Environment

The EIA was ratified before the start of this project, and no negative impact on the natural environment was found, according to the hearing with the environmental protection agency.

2) Land Acquisition and Resettlement

There has been no relocation of residents as planned during the appraisal. On the other hand, 22,000 m^2 of land has been acquired for the Phase I subproject "3) Relocation and Improvement of Benxi Rubber Chemical DMSO Plant" in an industrial area far from residential areas with no problem. Although it was heard that local residents made many complaints about emission gas and wastewater from the plant before the relocation, no such issues were identified in the beneficiary survey conducted after the relocation.

3) Unintended Positive/Negative Impacts

The results of the hearing with the environmental protection agency and the beneficiary survey do not show any issues of noise and vibration.

In light of the above, it is concluded that this project significantly improved the quality of the environment in Benxi and has a positive impact on the daily life of the local residents. Therefore the impact of the project is large.

3.5 Sustainability (Rating: b)

3.5.1 Structural Aspect of Operation and Maintenance

There are a total of 12 executing bodies involved in currently ongoing subprojects and eight of them were privatized during or after construction in connection with the reform of state enterprises. All these privatized companies except the city gas supply company (merged with a Hong Kong capital company), seven companies out of eight, were small-to-midsize material

[7] This municipal program started in the latter half of the ninth five-year plan and the seven-year environmental development plan of the municipal government. The environment protection agency planned as much as 50 environmental development plans but faced severe financial problems. Against the backdrop, the fund pumped into this project at project Phase I accounted for about 40% of total environmental investment in the city.

manufacturers. As a result of efforts for business efficiency improvement (personnel reduction in production departments and increase of professional engineers) to cope with increased competition in domestic and international markets, they have a stronger operation and management structure than assumed. However, some small and medium-sized companies cut back production after the financial crisis in 2008, and the result of the hearing with the officials of the environmental protection agency implies that this trend will continue. Moreover, as for the small and medium-sized companies that are environmentally harmful, the possibility that such companies will be eliminated by political selection is also pointed out.

On the other hand, the two companies that still keep the form of state enterprise are Benxi Iron & Steel Group Co., Ltd. and Beitai Iron & Steel Group Co., Ltd. These companies are major leading companies in the iron manufacturing industry, which support the steady economic growth of Benxi, and do not seem to have any problems as they have taken sufficient measures for operation and management in aspects of organization and human resources. As for the iron manufacturing, as the central government has declared its policy to promote corporate consolidation on a national basis, there may be changed in the management form in the future. However, it is believed that the operation and management structure will not be affected.

In addition, no problem has been observed in the two organizations that belong to the municipal government, the Environment Observation Center and the Benxi Waterworks Department, with a proper operation and management structure constructed under the control of the municipal government. Also in the city gas supply company, a proper operation and management structure has been established under the control the municipal government, so that city gas is supplied in a safe and stable manner.

In light of the above, it is deemed that, although currently there is no problem observed with the operation and management structure, some subproject executing agencies have unstable factors for the future.

3.5.2 Technical Aspects of Operation and Maintenance

As for the subprojects where equipment has been introduced and are in operation, there is no technical problem in particular with the operation and maintenance of such installed facilities and materials. Safety control and staff training about technical matters are given priority especially in gas and water projects, as such projects are highly public and beneficial to a large number of people and therefore safe operation is required.

It is said that small and medium-sized manufacturers pay close attention to daily checks of equipment and actions after checks as the achievement of the target production volume affects business management. Moreover, some companies also actively try to support young engineers, providing technical training on their own.

In light of the above, no problem has been observed in technical aspects.

3.5.3 Financial Aspects of Operation and Maintenance

According to the explanation of the executing agencies, public utility corporations (city gas and water service) and large state-owned corporations do not seem to have any financial problems as they are well managed and have enough funds for operation and management. Small and medium-sized companies that are continuously run in a stable manner are seeking to enhance profit-earning capacity through privatization and loans are properly repaid. However, in response to the tightened environmental standards, some small and medium-sized companies have been already showing a trend toward production reduction, which is an unstable factor about the future company management.

3.5.4 Current Status of Operation and Maintenance

As for the facilities, equipment and materials, there is no problem related to daily operation, maintenance, and actions against failure, trouble and repair. The result of the inspection of each subproject shows that the operation and maintenance of facilities and equipments introduced are generally conducted in a proper manner. In the companies that had malodor or noise issues at the beginning, the conditions have been improved with plant relocation, introduction of enclosed facilities and other measures.

To a question about supply of city gas and water asked as part of the beneficiary survey, the majority of the respondents answered that they are satisfied with the current status and there is no problem with the operation. According to the environmental protection agency, the air quality improvement in Benxi is largely attributed to the introduction of emission gas treatment systems to plants of Benxi Iron & Steel Group and Beitai Iron & Steel Group. It is considered that the proper operation and maintenance of the facilities and equipment introduced through this project contribute to the air quality improvement.

In light of the above, it seems that currently there is no problem with the maintenance of this project in terms of organization, technology and financial status. Though some problems have been observed in terms of future organizational and financial conditions in several subprojects, sustainability of this project is fair.

4. Conclusion, Lessons Learned and Recommendations

4.1 Conclusion

Although the relevance and effectiveness of this project are high, the project management is difficult with as many as 18 subprojects. Therefore, the efficiency is moderate. As for the sustainability, some subprojects show unstable factors related to the future company management.

In light of the above, this project is evaluated to be (B) satisfactory.

4.2 Recommendations

4.2.1 Recommendations to the Executing Agencies

Executing agencies of some subprojects emit pollutants that are very harmful to the environment. Therefore, the environmental protection agency should strengthen monitoring while sharing information with the financial agency so that pollutants can be properly treated in case the business environment should suddenly deteriorate. Moreover, the executing agencies should collect proper information and perform monitoring, because they are required to provide information to JICA based on the viewpoint of General Terms and Conditions Article 6.01 (b), if a target enterprise becomes bankrupt.

4.3 Lessons Learned

In the beginning of this project, it was very difficult to conduct activities in the field of environmental protection sector due to the lack of understanding of the Chinese side about financial input into the environmental sector and enhancement of environmental measures. In this situation, the implementation of this project did not only resolve fund shortage, but promoted understanding about investment and loan in the environmental field and contributed to the enhancement of the implementation system. Promotion of understanding about environmental measures among municipal government officials and company personnel especially accelerated the improvement of environmental measures of the city of Benxi.

Although the environmental measures of the Chinese side did not show much progress, as a result of giving support to the implementation of high-priority subprojects selected by the environment protection agency, the sense of responsibility was increased in the agency and many subprojects have been continued until now despite rapidly changing economic circumstances and environmental policies. Therefore, selecting high-priority subprojects in cooperation with the government of the recipient country (executing agencies) with full understanding of the current status and issues in the target areas and sectors improves the sense of ownership of the recipient country, which then contributes to the improvement of the sustainability of the whole project.

Comparison of the Original and Actual Scope of the Project

Item	Original	Actual
1. Project Outputs Phase I 1) Emission gas and wastewater treatment at Benxi electrical equipment plant	① Introduction of electrostatic spraying equipment ② Introduction of wastewater treatment equipment ③ Introduction of desulfurizing and dust collection equipment	Subproject cancelled
2) Converter emission gas control at second plant of Benxi Iron & Steel	① Enclosure of a converter ② Introduction of equipment to treat emission gas when opening and closing ③ Converter gas control ④ Improvement of a primary dust collection system ⑤ New construction of a secondary dust collection system	① Enclosure of a converter ② Introduction of equipment to treat emission gas when opening and closing ③ Converter gas control ④ Improvement of a primary dust collection system ⑤ New construction of a secondary dust collection system
3) Relocation and improvement of DMSO plant of Benxi rubber chemical works	① Relocation of a rubber chemical plant of Benxi (plot area 22,000 m^2, building area 3,791.4 m^2) ② Construction of a DMSO plant with new exhaust and wastewater treatment equipment	① Relocation of a rubber chemical plant of Benxi (plot area 22,000 m^2, building area 3,791.4 m^2) ② Construction of a DMSO plant with new exhaust and wastewater treatment equipment
4) Dust proofing at Benxi cement factory	① Construction of coal silos with dust removal equipment (diameter 15 m x height 30 m, 3 silos)	Subproject cancelled
5) Emission gas and wastewater treatment of W & Mo production process at alloy plant in Benxi	① Introduction of SO_2, HCI, NH_3 and dust treatment equipment ② Introduction of acid and alkaline discharge treatment equipment ③ Conversion of the existing technology for molybdenum refinement	① Introduction of SO_2, HCI, NH_3 and dust treatment equipment ② Introduction of acid and alkaline discharge treatment equipment
6) Emission control of carbide production process at mineral chemistry plant in Benxi	① Semi-enclosure of a carbide furnace ② Introduction of a dust collector ③ Construction of a 10,000 kVA closed carbide furnace	① Semi-enclosure of a carbide furnace ② Introduction of a dust collector ③ Construction of a 12,500 kVA closed carbide furnace
7) Expansion of Environment Observation Center	① Automatic air monitoring system ② Mobile air and water quality monitoring system ③ Automatic monitoring system ④ Regular monitoring system ⑤ Renovation and expansion of the office/auxiliary building	① Automatic air monitoring system ② Mobile air and water quality monitoring system ③ Automatic monitoring system ④ Regular monitoring system ⑤ Renovation and expansion of the office/auxiliary building
8) Utilization of blast furnace gas at steel plant of Beitai Iron & Steel	① Gas boiler ② Single bleeder turbine power generation unit ③ Installation of other related facilities	① Gas boiler ② Single bleeder turbine power generation unit ③ Installation of other related facilities
9) Construction of water intake station	① Construction of a water intake station ② Installation of conductive tubes (double tubes)	① Construction of a water intake station ② Installation of conductive tubes (double tubes)
10) Comprehensive utilization of coal ash	① Introduction of sprinklers ② New construction of a building	① Introduction of sprinklers ② New construction of a building material

	material plant	plant
11) Emission gas and wastewater treatment at copper processing plant in Benxi	① Introduction of emission gas treatment equipment ② Improvement of water purification technologies ③ Introduction of a heat exchanging system and a filter system ④ Improvement of copper foil surface treatment technologies	① Introduction of emission gas treatment equipment ② Improvement of water purification technologies ③ Introduction of a heat exchanging system and a filter system ④ Improvement of copper foil surface treatment technologies
12) Wastewater treatment at pharmaceutical plant in Benxi	① Introduction of an automatic process control system ② Introduction of wastewater treatment facilities ③ Installation of a temperature regulator and a biological treatment facility for yeast production process ④ Deep well aeration ⑤ Construction of a receiving basin, deep well equipment, a biological fluid bed	① Introduction of an automatic process control system ② Introduction of wastewater treatment facilities ③ Installation of a temperature regulator and a biological treatment facility for yeast production process ④ Deep well aeration ⑤ Construction of a receiving basin, deep well equipment, a biological fluid bed
13) Renovation of caustic soda production process at plastic chemical plant in Benxi	① Construction of production equipments with an annual capacity of 20,000 tons ② Updating of a production process (Ion diaphragm method) ③ Introduction of emission gas and wastewater treatment facilities ④ New construction of a secondary salt water purifying facility, pure and salt water chlorine removal system, a water purifying system etc.	① Construction of production equipment with an annual capacity of 20,000 tons ② Updating of a production process (Ion diaphragm method) ③ Introduction of emission gas and wastewater treatment facilities ④ New construction of a secondary salt water purifying facility, pure and salt water chlorine removal system, a water purifying system etc.
Phase II 1) City gas supply Phase 5	① Construction of a coke-oven gas supply station ② Construction of 2 LPG supply stations ③ Gas piping ④ Construction of an LP gas cylinder supply station	① Construction of a coke-oven gas supply station (Gaotaizi liquefied gas process) ② Construction of 2 LPG supply stations ③ Gas piping ④ Construction of an LP gas cylinder supply station
2) Converter emission gas control at Beitai Iron & Steel	① A 50,000 m^3 rubber-sealed dry type gas tank 2 electrostatic converter gas dust collectors ② Construction of an electrostatic dust collection system ③ Construction of a coal gas pressurising station (2 units of gas pressurising equipment) ④ Construction of automatic control gauges ⑤ Construction of compressed slag ball production equipment with a capacity of 20,000 t/year ⑥ Establishment of drum type equipment to steam converter steel slag	① A 50,000 m^3 rubber-sealed dry type gas tank 2 electrostatic converter gas dust collectors ② Construction of an electrostatic dust collection system ③ Construction of a coal gas pressurising station (2 units of gas pressurising equipment) ④ Construction of automatic control gauges ⑤ Construction of compressed slag ball production equipment with a capacity of 20,000 t/year ⑥ Establishment of drum type equipment to steam converter steel slag
3) Pollution control at chemical plant	① Installation of desulfurization equipment at DMDS plant ② Relocation of existing chemical engineering plants to allotted blocks within chemical engineering area (25,000 m^3) ③ Construction of a plant with a new	① Installation of desulfurization equipment at DMDS plant ② Relocation of existing chemical engineering plants to allotted blocks within chemical engineering area (25,000 m^3) ③ Construction of a plant with a new

	production process with wastewater treatment and other environmental protection facilities	production process with wastewater treatment and other environmental protection facilities
4) Pollution control at solvent plant	① Establishment of a soft calcium carbonate plant ② Production process improvement and installation of desulfurization equipment at an anti oxidant plant ③ Installation of a dust collector ④ Installation of a settling basin and other environmental control facilities	① Establishment of a soft calcium carbonate plant ② Production process improvement and installation of desulfurization equipment at an anti oxidant plant ③ Installation of a dust collector ④ Installation of a settling basin and other environmental control facilities
5) Pollution control at lubricant plant	① Improvement of production processes at a molybdenum sulphide plant, a lube oil plant and a grease plant ② Construction of production and auxiliary facilities ③ Construction of environmental protection facilities with Public Construction Commission ④ Installation of environmental control equipment such as SO_2 collecting unit, oil recovery unit and wastewater treatment unit	① Improvement of production processes at a molybdenum sulphide plant, a lube oil plant and a grease plant ② Construction of production and auxiliary facilities ③ Construction of environmental protection facilities with Public Construction Commission ④ Installation of environmental control equipment such as SO_2 collecting unit, oil recovery unit and wastewater treatment unit
6) Taizi River drinking water pollution control	① Purified water supply equipment 80,000 m^3/day ② Distribution pipe network 7 km	① Expansion of a water purifying plant Processing ability: 80,000 m^3/day ② Improvement of distribution pipes Extension length: 10 km
Phase III 1) Beitai Iron & Steel coke oven pollution control	① Construction of coke production facilities (coal preparation, coke production, gas collection and purification system, and wastewater treatment) ② Construction of ancillary facilities including a substation and other production aid facilities and management and environmental improvement facilities (total lot area 261,000 m^3)	① Construction of a coke oven and coke production facilities (coal preparation, coke production, gas collection and purification system, and wastewater treatment) ② Construction of ancillary facilities including a substation and other production aid facilities and management and environmental improvement facilities
2. Project Period	Phase I: Oct 1997 – Dec 2001 (51 months) Phase II: Dec 1998 – Mar 2002 (40 months) Phase III: July 2000 – Mar 2002 (21 months)	Phase I: Oct 1997 – Dec 2002 (63 months) Phase II: Dec 1998 – July 2004 (68 months) Phase III: July 2000 – June 2002 (24 months)
3. Project Cost Amount paid in Foreign Currency Amount paid in Local Currency Total Japanese ODA Loan Portion Exchange Rate	Phase I Foreign Currency: 4,110 million yen Local Currency: 5,808 million yen Total: 9,918 million yen Japanese ODA Loan Portion: 4,110 million yen Exchange Rate: 1 yuan = 12 yen Publication Phase II	Phase I Foreign Currency: 4,058 million yen Local Currency: 5,594 million yen Total: 9,652 million yen Japanese ODA Loan Portion: 4,076 million yen Exchange Rate: 1 yuan = 14.13 yen (Average between 1997 and 2002)

	Foreign Currency: 3,237 million yen Local Currency: 3,327 million yen Total: 6,564 million yen Japanese ODA Loan Portion: 3,237 million yen Exchange Rate: 1 yuan = 12 yen (January 1996) Phase III Foreign Currency: 1,160 million yen Local Currency: 4,202 million yen Total: 5,362 million yen Japanese ODA Loan Portion: 1,160 million yen Exchange Rate: 1 yuan = 12 yen (January 1996)	Phase II Foreign Currency: 3,082 million yen Local Currency: 2,829 million yen Total: 5,916 million yen Japanese ODA Loan Portion: 3,237 million yen Exchange Rate: 1 yuan = 13.93 yen (Average between 1998 and 2004) Phase III Foreign Currency: 1,160 million yen Local Currency: 820 million yen Total: 1,980 million yen Japanese ODA Loan Portion: 1,159 million yen Exchange Rate: 1 yuan = 13.85 yen (Average between 2000 and 2002)