

People's Republic of China

Ex-Post Evaluation of Japanese ODA Loan Project

Liuzhou Environmental Improvement Project

External Evaluator: Machi KANEKO, Earth and Human Corporation

1. Project Description



Project Location



Gas Supply Project

1.1 Background

Since its shift to a course of reform and liberalization in 1987, China has experienced steady economic growth to achieve remarkable economic development. However, its excessive dependence on coal in primary energy consumption, especially as fuel for power plants and as industrial materials, has caused serious air pollution. A number of damage caused by acid rain has been reported recently and environmental problems caused by industrialization are serious issues that require attention, while achieving a good balance with development.

Liuzhou that is the project site is an industrial city in Guangxi Zhuang Autonomous Region in southwest China. Air pollution, acid rain pollution in particular, caused by coal combustion has become a serious problem. In addition, the amount of garbage is increasing each year mainly due to the rapid economic development in recent years and the city also faces an urgent need to solve the waste disposal problem.

Against the backdrop, a decision was made to implement the project in order to promote a gas supply project, waste treatment plant construction, and environmental improvement at non-public plants, in Liuzhou City.

1.2 Project Outline

Increase in gas supply, construction of a waste disposal site and installation of exhaust treatment systems at plants in order to reduce air pollution and improve water quality as well as urban health will contribute to the betterment of living environment in Liuzhou City.

Approved Amount / Disbursed Amount	2,300 million yen / 2,299 million yen
Exchange of Notes Date / Loan Agreement Signing Date	December, 1996 / December, 1996
Terms and Conditions	Interest Rate: 2.1%; Repayment Period: 30 years (Grace Period: 10 years); Conditions for Procurement: General Untied Loan
Borrower / Executing Agencies	Guarantor: Government of People's Republic of China / People's Government of Liuzhou Municipality
Final Disbursement Date	January, 2003
Main Contractor (Over 1 billion yen)	-
Main Consultant (Over 100 million yen)	-
Feasibility Studies, etc.	F/S: JICA study for Liuzhou Environmental Improvement Project, December 1995 SAPROF: 1995 to 1996
Related Projects	JICA technical assistance: Environmental Program in Liuzhou (M/P production)

2. Outline of the 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

Because the project consists of four subprojects, it was difficult to examine the effectiveness of the project in its entirety. Thus, the project was evaluated based on the examination of expected outputs and achievement level of operation and effect indicators of effectiveness of each subprojects as well as the overall project 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 project appraisal, the Chinese government formulated 'The Ninth Five-Year

Plan for National Environmental Protection and Long-Term Targets for 2010' and announced the policy to include an environment plan in 'The National Five-Year Plan' (ninth five-year plan 1996 to 2000). The environment plan contains two strategic projects—the "Total Pollutant Discharge Control Policy" and "Trans-Century Green Project". The plan specified an increase in investment in environment, implementation of total pollutant discharge control, and priority in pollution to be placed on water and air pollution in order to implement the strategic projects.

At the time of ex-post evaluation, the Chinese government has expressed in the basic principle of 'The 11th Five-Year Plan 2006-2010' (hereinafter referred to as "11.5 plan") its shift of the focus on emphasis both on environmental protection and economic growth, based on the evaluation stating that many of environmental issues did not improve during the period of the previous policy, 'The 10th Five-Year National Environmental Protection Plan 2001-2005'. The 11.5 plan also specifies the numerical targets to reduce the sulfur dioxide emissions and chemical oxygen demand by 10 percent each by 2010, indicating that the prevention of the expansion of acid rain is also a priority issue. Liuzhou is designated as one of 113 key cities for environmental protection in the 11.5 plan and intends to make qualitative improvement of air conditions with the focus on comprehensive prevention and treatment of air pollution.

The municipal government also has stated that it will emphasize a good balance between industry and environmental protection in the course of economic development in its "Outline of 10.5 plan for people's economy and social development of Liuzhou" and "Outline of 10.5 plan for environmental protection of Liuzhou and the long-term targets for 2015". It has expressed its policy to work on the creation of energy-efficient society and enhancement of environmental protection and the need to realize development that allows harmony between humans and nature.

Therefore, the project has been highly relevance with the policy of the recipient country at the times of the project appraisal and ex-post evaluation, respectively.

3.1.2 Relevance with the Development Needs of China

(1) Development Needs at Project Appraisal

Liuzhou is an industrial city in Guangxi Zhuang Autonomous Region in southwest China and coal has been widely used for industrial and consumer use. Coal that had been used widely in the city was low-quality coal (3000 kcal/kg) with very high content of sulfur (4% to 7%) and ash (50%). This caused serious air pollution in the city to the level of annual average SO₂ concentration at 0.217 mg/Nm³ in 1993, 3.6 times higher than the national environmental standards grade 2 (0.06 mg/Nm³). Average pH of acid rain was 4.18 to 4.76¹ and the frequency was 86 percent to 98 percent, which shows that the city was one of Chinese cities

¹ The pH is around 5.6 because carbon dioxide in the air is in the rain even when it is not polluted. Thus, rain with the pH of 5.6 or below is considered acid rain.

with the most serious acid rain pollution.

The city also had a serious garbage increase problem in accordance with steady economic growth. The population of Liuzhou reached 800,000 by 1994, while there was only one small landfill. It was estimated to be filled in mid 1998. The city also had environmental and public health problems related to the garbage issue as conventional disposal facilities were not equipped with leachate treatment equipment and other facilities for public health maintenance.

(2) Development Needs at Ex-post Evaluation

Liuzhou has developed as the biggest industrial city in Guangxi Zhuang Autonomous Region. The gross industrial production of state-run enterprises and non-state-run enterprises with annual sales of five million yuan or more reached 55 billion yuan in 2007. On the other hand, the city has invested huge funds to strengthen corporate pollutant emissions control and worked hard on river wastewater treatment and solid waste treatment in the urban zone for the last several years in an attempt to solve the serious acid rain problem caused by air pollution and river pollution caused by industrial waste. As a result, air quality has significantly improved—the national air quality standards were achieved in 360 days in FY2008. The acid rain problem also improved—its frequency in 1995 was 84.6 percent (average pH=4.19) and it improved to 43.4 percent (average pH=5.07) in 2008.

As the gross industrial production is likely to continue to grow, further reduction of acid rain frequency by carrying out thorough air pollution countermeasures remains to be a major issue Liuzhou needs to tackle. Due to rapid urbanization and population increase, garbage generated by consumers is on the rise and thus waste treatment remains to be also a serious issue.

Therefore, achieving a good balance between environmental protection and economic growth remains to be a key development issue and development needs remain high, although the environment of the target city is improving.

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.

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

The Liuzhou municipal government has committed itself to environmental issues. For example, it closed 10 small and medium-sized enterprises (including a spinning and dyeing factory) that were serious sources of pollution in 2007. It has also been working hard to develop model companies in order to encourage large companies that consume a big volume of energy to tackle environmental problems in an attempt to realize reduction of coal consumption and pollutant discharge more steadily. For example, Liuzhou Steel Plant Group Corporation that is one of the plants where a subproject was conducted began a full-scale investment in environmental issues in 2001 upon request from the Liuzhou municipal government and is considered as one of model companies.

Four subprojects were implemented in the project. Against the above backdrop, one pollutant treatment facility that was introduced in the project was renewed into a facility with higher treatment capacity as a result of the Liuzhou municipal government setting the target level of pollutant reduction for companies higher than the national standards. On the other hand, specifications of one of the introduced facilities did not satisfy the needs due to production increase and sharp rise in raw material prices and the facility was renewed or the plan was changed.

However, because such alteration were made in order to enhance environmental measures and respond to changes in market needs, the selection of subprojects itself was reasonable.

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

Several conditions of the China side have changed significantly since the appraisal, which are described below in order to evaluate the outputs of the projects.

- 1) At the time of appraisal, two subprojects, "3) Liuzhou chemical fertilizer plant emissions treatment" and "4) Liuzhou Steel Plant coke combustion gas desulfurization" were expected to be implemented through the two-step loan procedure. However, the procedure was eventually cancelled in response to the following requests made by the China side:

- * These two subprojects are regarded as non-public work, while any kinds of projects in China are generally supervised by the municipal government. Thus, the People's Government of Liuzhou Municipality shall be the executing agency of the two subprojects, in Lieu of the Export-Import Bank of China.
 - * The project should be implemented as a comprehensive environment improvement measure. However, if those "non-public" subprojects cannot benefit from the preference interest rate for special environmental projects that is applicable only to public work projects, they will face stiffer loan conditions and the project will lose its significance. Therefore, application of the two-step loan procedure shall be reconsidered.
- 2) There was a gap between the introduced facility and current needs in three of four subjects and the facility has been renewed in whole or in part funded by the executing bodies.

As shown in Table 1 below, all the four subprojects had some changes in specifications of facility and materials and equipment from the original plan. Particularly, 1) Gas supply project plan was changed significantly in response to sharp crude oil price rise and changes in market needs. It was reasonable to make the changes because best measures were examined and implemented as needed as the circumstances changed in order to implement a highly-public gas supply project. As for 2) Waste disposal site construction, it was also a measure to respond to construction standards changes by the government and thus it was force majeure for the project executor.

Table 1 Comparison between Original Plan and Actual Results

1) Gas supply project (executing body: Liuzhou Zhongran City Gas Development Company)		
Original Plan	Actual Results	Note
① City gas supply grid: 110km ② 27 gas pressure regulation stations ③ For liquefied petroleum gas 4 storage tanks: 400 m ³ each Mixing equipment (mix liquefied gas with air) ④ For coke gas 2 storage tanks: 54,000 m ³ each	① City gas supply grid: 110 km ② 27 gas pressure regulation stations ③ For liquefied petroleum gas <u>Panlongshan gas storage station</u> 4 storage tanks: 100 m ³ each Mixing equipment (mix liquefied gas with air) Loading device <u>Banliyuan gas storage station</u> 2 storage tanks: 2000 m ³ each ④ For coke gas <u>Liubei gas storage station</u> 2 storage tanks: 50,000 m ³ each	Significant changes in specifications and installation locations; reasons and changes are described below. <u>Original plan:</u> Supply both liquefied petroleum gas (LPG) and coke gas (drawn from Liuzhou Steel) to residents in the city. <u>Change 1:</u> Although coke gas was originally planned to be drawn from Liuzhou Steel in accordance with JICA's intention, it was determined that it is difficult to secure a stable amount of gas and all facility plans were changed to be those for LPG and the construction began.

		<p><u>Change 2:</u> LPG price rise continued as a result of crude oil price hike and residents' demand dropped sharply. As a result, it was determined that continued injection in LPG would not be financially viable and later construction was suspended.</p> <p>Use of liquefied natural gas (LNG) that is cheaper than LPG was decided and facility was partially used while supply and sales for residents began.</p> <p><u>Change 3:</u> Because stable supply of coke gas from Liuzhou Steel Plant became possible, the "Liubei coke gas storage station plan" was formulated, its construction officially began in May 2008 and it was completed and city gas supply for residents began in November 2009.</p>
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2) Waste disposal site construction (executing body: Bureau of City Appearance Environmental and Sanitation of Liuzhou Municipality)

Original Plan	Actual Results	Note
① Waste disposal site construction: rockfill dam embankment (Installation of drainage landfill dam and flood control wall) ② Construction of accessory facilities (leachate catchment, gas release treatment facility, etc.) ③ Management building construction: 800 m ² ④ Installation of environmental monitoring facility ⑤ 10 garbage delivery vehicles Rear Loaded Compressed 7-8 t	① Waste disposal site construction: rockfill dam embankment (Installation of drainage landfill dam, flood control wall and sheet to prevent leachate) ② Construction of accessory facilities (leachate catchment, gas release treatment facility, etc.) ③ Management building construction: 800 m ² ④ Installation of environmental monitoring facility ⑤ 10 garbage delivery vehicles Rear Loaded Compressed 7-8 t	Because of the introduction of new national standards for waste treatment facilities, redesign and acquisition of construction permit (installation of sheet to prevent leachate into soil, etc.) were needed. This prolonged the project term. The construction permit after the design change was obtained in January 2001.

3) Liuzhou Chemical fertilizer plant emissions treatment (executing body: Liuzhou Chemical Industry Group Corporation)

Original Plan	Actual Results	Note
Installation of facility to treat emissions from Liuzhou Chemical fertilizer plant (emissions denitration facility of NO.1 nitric acid production plant (18,000 Nm ³ /h))	Installation of facility to treat emissions from Liuzhou Chemical fertilizer plant (emissions denitration facility of NO.1 nitric acid production plant (21,000 Nm ³ /h))	It was discovered in the detailed design that the emissions denitration facility (18000 Nm ³ /h) in the original plan would not be able to satisfy the future demand and the facility was changed to one with higher treatment capacity (21,000 Nm ³ /h).

4) Liuzhou Steel Plant coke combustion gas desulfurization (executing body: Liuzhou Steel Plant Group Corporation)

Original Plan	Actual Results	Note
Installation of coke combustion gas desulfurization facility at Liuzhou Steel Plant	Installation of desulfurization facility for coke combustion gas at Liuzhou Steel Plant [Specifications] 1. Desulfurization facility Capacity: 27,000 m ³ /h 2. Surplus gas storage tank: 50,000 m ³ 3. Wet naphthalene washing facility Capacity: 27,000 m ³ /h (Diesel oil for naphthalene washing is collected and reused.)	It was discovered in the detailed design that the emissions desulfurization facility in the original plan would not be able to satisfy the future demand and the facility was changed to one with higher treatment capacity.

3.2.2 Project Input

3.2.2.1 Project Period

The project period was planned to be 63 months from October 1996 to December 2001. However, its completion delayed substantially—it took 158 months to complete it, beginning in October 1996 and ending in November 2009.

The project period per subproject is shown in Table 2 below. Although the completion of 1) Gas supply project and 2) Waste disposal site construction required much longer period than the plan, other two projects were completed before the end of scheduled project period.

Table 2 Original Plan and Actual Results of Each Subproject Period

Subproject Name	Original			Actual			Difference (Actual /Original)	Evaluation
	Launched	Completed	Period (month)	Launched	Completed	Period (month)		
1) Gas supply project	October 1996	January 2000	40 months	October 1996	November 2009	158	395%	c
2) Waste disposal site construction	October 1996	August 1998	23 months	October 1996	November 2004	98	426%	c --> a
3) Liuzhou Chemical fertilizer plant emissions treatment	October 1996	December 2001	63 months	October 1996	October 2000	49	78%	a
4) Liuzhou Steel Plant coke combustion gas desulfurization				October 1996	April 2000	43	68%	a

Based on above, the project period was evaluated first by subproject and then as a project in its entirety. 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. The subproject 2) Waste disposal site construction delayed in order to respond to the new construction standards. Because it is considered as force majeure for the project executing body, it did not affect the evaluation negatively (c evaluation → a evaluation).

As a result, as shown in Table 2 above, the project period of two subprojects were below 100 percent and two other subprojects were more than 150 percent of the plan.

The overall evaluation result is (b) exceeding the plan as shown in Table 3 below.

Table 3 Evaluation of Project Period

	(a) <u>Evaluation</u> Shorter than planned [2 points]	(b) <u>Evaluation</u> Longer than planned [1 point]	(c) <u>Evaluation</u> Much longer than planned [0 point]	Total	Evaluation result
Subproject Quantity	3	0	1	4	
Point [maximum: 8]	6 points	0 point	0 point	6 points	75% = (b)

3.2.2.2 Project Cost

Although the total project cost was planned to be 4,168 million yen (2,300 million yen of which is yen loan), the actual cost was 11,762 million yen (2,300 million yen of which was yen loan).

The cost per subproject is shown in Table 4 below. As the table shows, all of them cost more than the original plan; 1) Gas supply project and 2) Waste disposal site construction cost 50 percent more than the original plan, 3) Liuzhou Chemical fertilizer plant emissions treatment and 4) Liuzhou Steel Plant coke combustion gas desulfurization cost between 0 percent and 50 percent more than the plan. It is mainly because of the following reasons and executing bodies took following action:

- 1) Gas supply project:

The design was changed three times due to sharp price increase of raw materials and changes in market needs, which resulted in the increase in the project cost. The surplus was borne by the executing body.

- 2) Waste disposal site construction:

Because of the introduction of new national standards for waste disposal sites, redesign and acquisition of construction permit (installation of sheet to prevent leachate into soil, etc.) were needed. Construction permit was obtained in January 2001 after design change, and funding from the Chinese side (Liuzhou municipal government fund and

central western loans) was increased before the construction began.

- 3) Liuzhou Chemical fertilizer plant emissions treatment and 4) Liuzhou Steel Plant Liuzhou Steel Plant coke combustion gas desulfurization:

It was assessed in the detailed design that the emissions treatment facility in the original plan would not be able to satisfy the future demand and the facility was changed to one with higher treatment capacity. Although the change required additional cost, the surplus was borne by the executing body.

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		
1) Gas supply project	2,416	1,116	4,033	1,350	167%	c
2) Waste disposal site construction	1,045	477	6,945	456	665%	c --> a
3) Liuzhou Chemical fertilizer plant emissions treatment	707	707	785	494	111%	b
4) Liuzhou Steel Plant coke combustion gas desulfurization			(214)	(111)		
Total	4,168	2,300	11,762	2,300		

Based on above, the project cost was also evaluated first by subproject and then 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. As for the subproject 2) Waste disposal site construction, the reason for the cost increase is changes in government standards and it is considered as force majeure for the project executing body and thus it did not affect the evaluation negatively (c evaluation → a evaluation).

As a result, as shown in Table 4 above, the project cost of one subproject was equal to or less than 100 percent of the plan, two were between 100 percent and 150 percent, and the remaining one was over 150 percent of the plan.

The overall evaluation result is (b) exceeding the plan as shown in Table 5 below.

Table 5 Evaluation of Project Cost

	(a) <u>Evaluation</u> Lower than planned [2 points]	(b) <u>Evaluation</u> Higher than planned [1 point]	(c) <u>Evaluation</u> Much higher than planned [0 point]	Total	Evaluation result
Subproject Quantity	1	2	1	4	
Point [maximum: 8]	2 points	2 points	0 point	4 points	50% = (b)

As shown above, the project cost and period both 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

Table 6 below shows the operation effect indicator of each subproject. 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 it cannot be observed because the facility is removed. Changes in the circumstances of each subproject are also described in the table.

Table 6 Targets and Actual Results of Operation Effect Indicators

Subproject	Target values (no target year)	Actual results (at ex-post evaluation)	Evaluation
1) Gas supply project	<ul style="list-style-type: none"> •Coke-oven supply volume at existing gas plant (Liuzhou Steel Plant) 156,000 m³/day gain •Liquefied petroleum gas (LPG) supply volume: 7,000 m³/year gain (400 m³/day) •Number of gas consuming household: 120,000 •Reduction of pollutants: SO₂ 6,220 t/year TSP 7,700 t/year 	<ul style="list-style-type: none"> •Coke gas supply volume (Pipeline for coke gas installed from Liuzhou Steel Plant) 62,000 m³/day (daily maximum supply capacity: 100,000 m³) •LPG supply volume: 38,000 m³/day •Number of gas consuming household 100,000 Liquefied natural gas (56,000 households) Coke gas (44,000 households) •Reduction of pollutants •SO₂ 7,680 t/year •TSP 9,507 t/year 	a
<<Changing circumstances around subproject>>	LPG gas supply for consumers was suspended due to a sharp increase of crude oil price. However, later LNG gas supply began instead. Because stable supply of coke gas from Liuzhou Steel became possible, the project plan was reexamined and funds of the corporation were injected in order to supply less expensive coke gas. The supply began in November 2009.		

Subproject	Target values (no target year)	Actual results (at ex-post evaluation)	Evaluation
2) Waste disposal site construction	<ul style="list-style-type: none"> • Remaining years of the disposal site: 36 years • Landfill volume: 8 million m³ • Leachate catchment: 600 m³/day • Maximum wastewater treatment capacity: 1,059 m³/day 	<ul style="list-style-type: none"> • Remaining years of the disposal site: 17 years (use began in 2004) • Landfill volume: 8 million m³ • Leachate catchment: 600 m³/day • Maximum wastewater treatment capacity: 1,059 m³/day • Garbage generated by consumers in Liuzhou: 339,500 t/day • Number of users: 1.0184 million (2008) 	a
<<Changing circumstances around subproject>>	<p>Although no original target figure was set up, design change due to introduction of new standards is likely to have enhanced soil pollution prevention effect. The increase rate of garbage generated by consumers exceeded the estimate due to urbanization and population increase and the remaining years decreased to 17 years from 36 years in the original plan. Liuzhou is now constructing a new disposal site in the upper area of the existing site as one of garbage handling efforts for the future.</p>		
3) Liuzhou Chemical fertilizer plant emissions treatment	NOx emissions concentration: 905 mg/N m ³ NOx reduction volume: 181.2 t/year	<u>In 2003</u> <ul style="list-style-type: none"> • NOx emissions concentration: 360 mg/N m³ • NOx reduction volume: 47.6 t/year (Both emissions and reduction achieved the national standards grade 2 as of July 2002.) <u>At ex-post evaluation</u> No data available because facility was renewed.	c
<<Changing circumstances around subproject>>	<p>With the leadership of the Liuzhou municipal government, the pollutant reduction volume for key pollution-causing companies was increased significantly. Although the exhaust NOx treatment unit introduced in the project satisfied the national emissions standards, operation of the facility was suspended in 2003, because tougher environmental measures were sought in response to the demand from the residents², and installation of new facility was completed in 2005.</p>		
4) Liuzhou Steel Plant coke combustion gas desulfurization	SO ₂ emissions concentration: 60 mg/N m ³ SO ₂ reduction: 1,849 t/year	<u>2001 to 2005</u> <ul style="list-style-type: none"> • SO₂ emissions concentration: 0.084 mg/m³ (annual average concentration inside plant) • SO₂ reduction volume: 1,817.8 tons (annual average) • H₂S (hydrogen sulfide) concentration: 11.53 mg/m³ (annual average concentration and removal rate at the outlet of desulfurization unit: 99.74%) • Total of coke gas supply volume: For industrial use: 1,312 million tons For household use: 108 million tons <u>At ex-post evaluation</u> <ul style="list-style-type: none"> • Naphthalene washing volume: 280 tons (2009) • Diesel oil collection and recycle volume: 301,435 L (2009) 	c
<<Changing circumstances around subproject>>	<p>Upon request from the Liuzhou municipal government, Liuzhou Steel Group Corporation began full-scale investment in environmental issues in 2001 and it now serves as a model company for creating recycling-oriented economy. On the other hand, coke gas production of the company increased significantly thanks to good business operation and the coke gas desulfurization system (capacity: 27,000 m³/h) introduced in the project was no longer able to satisfy the demand. Thus, the system was partially removed (desulfurization unit) and a new coke gas desulfurization system (capacity: 100,000 m³/h) was introduced in 2004. Of the desulfurization system introduced in the project, the gas tank to store surplus gas and wet naphthalene washing unit are still in operation.</p>		

² Although the exhaust NOx treatment unit introduced in the project satisfied 200 ppm or less that is the national emissions standard, the exhausts are yellow and residents in the area called the smoke “yellow dragon”.

As shown in the table above, subprojects “1) Gas supply project” and “2) Waste disposal site construction” were evaluated as “a” because they achieved the target level. However, the remaining years of the “2) Waste disposal site” decreased significantly from 36 years to 17 years and such measures as charging garbage collection fees and environmental education need to be examined as efforts for reduce domestic garbage. As for subprojects “3) Liuzhou Chemical fertilizer plant emissions treatment” and “4) Liuzhou Steel Plant Liuzhou Steel Plant coke combustion gas desulfurization”, as described in the table, the facilities introduced in the project was removed and new facility was built with funds from the Chinese side in order to enhance environmental measures and cope with sharp demand increase. Thus, the equipment installed through the yen loan is not so much related to the indicator achievement levels; the effect is inevitably deemed low at present, and “c” is given as evaluation.

The effectiveness of the whole project were 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) <u>Evaluation</u> Indicator achievement level 80% or more	(b) <u>Evaluation</u> Indicator achievement level 50% to 80%	(c) <u>Evaluation</u> Indicator achievement level 50% or below, or data not available because the facility is not operating	Total
Subproject Quantity	2	0	2	4
Point [maximum: 8]	4 points	0 point	0 point	4 50%= (b)

Effectiveness of the project have the following characteristics: subprojects “1) Gas supply project” and “2) Waste disposal site construction” that are highly public showed high effectiveness, while it was impossible to confirm in the ex-post evaluation the effectiveness of “3) Liuzhou chemical fertilizer plant emissions treatment” and “4) Liuzhou Steel Plant coke combustion gas desulfurization”, which were implemented for private enterprises, as a result of their response to changes in the circumstances. However, because the effect of the project that had emerged in the beginning induced the enhancement of additional environmental measures, it is evaluated as an impact.

3.3.1.2 Results of Calculations of Rates of Return(IRR)

Among four subprojects, Financial Internal Rate of Return (FIRR) of subprojects “1) Gas supply project” and “2) Waste disposal site construction” had been obtained at the appraisal

time. However, because of three major changes in “1) Gas supply project” before the launch of the subproject, the basis for FIRR calculation changed completely.

As for “2) Waste disposal site construction”, garbage treatment fees were originally posted as income in the FIRR calculation. However, it was discovered when we confirmed at the ex-post evaluation that no garbage treatment fee is collected and that all the cost for the facility is managed by the municipal government.

Thus, FIRR is not obtained in the evaluation.

Although Economic Internal Rate of Return (EIRR) can be estimated with the willingness to pay as the indicator as a result of health and public services improvement as a result of air pollution improvement as benefits. However, the benefit indicators cannot be used for comparison because no EIRR was obtained at the project appraisal. Because it is also impossible to obtain data at the appraisal, EIRR is not calculated in the evaluation.

3.3.2 Qualitative Effects

The primary qualitative effect of the project is residents’ recognition of improvement of air quality and reduction of discarded waste as a result of the reduction of air pollutants and expansion of waste disposal site.

As shown in the table below, more than 90 percent of the respondents of beneficiary survey recognized the improvement of air quality in Liuzhou compared to 10 years ago. About 60 percent of respondents pointed out “reduction of flue gas concentration from plants by the advanced technologies” and “use of gas at home” as main causes of the improvement.

Table 8 Residents’ Recognition of Air Quality Improvement (beneficiary survey result)

Changes in air quality in comparison with 10 years ago (number of days of acid rain and smog)	Total (%)	(Of responses “Improved or rather improved”) Main causes of improvement [multiple answers allowed]	Total (%)
Improved very much	45	Plants relocated to suburbs	73
Rather improved	52	Gas is used at home	60
Not changed much	3	Flue gas concentration from plants reduced by the advanced technologies	57
Rather deteriorated	0	Government’s environmental projects were promoted	43
Deteriorated very much	0	Economic force of the city as a whole improved	34
Don’t know	0	Municipal government control was strengthened	18

Note: Beneficiary Survey Result in Ex-Post Evaluation (150 residents of the city were surveyed in May 2010.)

Eighty-eight percent of those surveyed said that discarded waste reduced compared to 10 years ago. About half of them said that it is mainly because of the “expansion of disposal site” and “number of garbage collection vehicles” related to the project (waste disposal site

construction), while only 30 percent said it is because of “increased awareness of garbage treatment among residents”. About 15 percent said it is because of “tightened control by the municipal government”. Thus, the environmental protection agency is expected to take such action as promotion of environmental education for the residents.

Table 9 Residents’ Recognition of Reduction of Discarded Waste

Change in discarded waste in comparison with 10 years ago	Total (%)	(Of responses “Improved or rather improved”) Main causes of improvement [multiple answers allowed]	Total (%)
Improved very much	37	Garbage collection vehicles increased	60
Rather improved	51	Government’s environmental improvement projects were promoted	49
Not changed much	11	Disposal site expanded	48
Rather deteriorated	0	City's economic force improved	39
Deteriorated very much	0	Awareness of garbage treatment among residents increased	32
Don’t know	1	Municipal government's control strengthened	15

Note: Beneficiary Survey Result in Ex-Post Evaluation (150 residents of the city were surveyed in May 2010.)

The effects emerged as a result of effective collaboration and complement with China’s its own efforts for environmental improvement. Therefore, they are not solely of the project itself, though its contribution is estimated to be large in general.

Therefore, this project has somewhat achieved its objectives, therefore its effectiveness is fair.

3.4 Impact

3.4.1 Intended Impacts

Because the Liuzhou municipal government tackled various environmental problems actively when the project was implemented, the impacts were not necessarily those of the project. However, it is estimated to have had significant impact on the improvement of people’s living environment and beautification of the city, based on the environmental indicators and beneficiary survey of the city. The project that includes environmental measures of Liuzhou Steel Plant Group Corporation and Liuzhou Chemical Industry Group Corporation that are major private companies in Liuzhou is considered to have helped deepen the recognition of the importance that major companies should take a leadership role in taking environmental measures in order to achieve the target level for environmental improvement set by the municipality and, as a result, concrete measures by the municipal government has been further

promoted.

(1) Air quality improvement in Liuzhou

Achievement level of air quality indicators of Liuzhou has improved since the beginning of the project as shown in Table 10. For example, the national air quality standards were achieved 360 days in 2008. According to the municipal environmental protection agency, environmental indicators in Table 10 cannot be compared simply with past data because of the improved accuracy of measuring devices and increase in the measurement points. According experts of the agency, conditions of air quality and acid rain in the city have improved significantly than those at the beginning of the project, although environmental measures need to be enhanced in order to achieve the environmental standards.

Table 10 Environmental Indicators of Liuzhou (annual average)

Indicator \ Year	1996	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Number of Days when National Air Quality Standards are Achieved (Note 1)	-	-	-	-	-	289	339	313	351	360	-
TSP/PM ₁₀ (Notes 2), 3)	0.190	0.207	0.194	0.158	0.206	0.101	0.064	0.055	0.040	0.037	0.054
SO ₂ Concentration (mg/m ³) (Note 4)	0.152	0.092	0.073	0.070	0.070	0.104	0.072	0.094	0.071	0.071	0.061
NO ₂ Concentration (mg/m ³) (Note 4)	0.036	0.038	0.030	0.028	0.030	0.036	0.033	0.038	0.030	0.031	-
COD (t/year) (Note 5)	51,068	37,737	76,802	47,461	129,334	51,068	103,900	105,800	101,900	97,700	-

Note 1) China's national environmental air quality standards are categorized into three grades and grade 2 applies to residential area, mixed areas of commercial, transport and residential districts, cultural areas, general industrial areas and rural areas. The concentration limit to be counted as days of achievement of grade 2 is 0.15 mg/ m (daily average) for SO₂ and 0.15 mg/m² (daily average) for PM10.

Note 2) TSP stands for Total Suspended Particulate, particulate matters suspended in the air with a diameter of 100 μm or less in atmospheric dynamics.

Note 3) PM10 stands for "Particular Matter less than 10 μm" suspended in the air with a diameter of 10 μm or less in atmospheric dynamics. In Liuzhou, PM10 has been used as the indicator instead of TPS since 2005.

Note 4) The concentration limits of the national air quality grade 2 are 0.06 mg/m² (annual average) for SO₂ and 0.054 mg/m² for PM10.

Note 5) Because a new COD observation method was introduced in 2005, comparison of COD values before and after 2005 is difficult.

* Source: Liuzhou official environment report

As shown in Table 11 below, the annual average frequency of acid rain has also improved significantly since the beginning of the project, from 84.6 percent (average pH=4.19) in 1995 to 43.4 percent (average pH=5.07) in 2008.

Table 11 Acid Rain Indicator in Liuzhou

Year \ Indicator	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
pH Annual average	4.19	4.61	4.94	4.97	5.17	5.20	5.17	5.40	5.66	-	4.69	4.95	5.09	5.07
Frequency of acid rain (%)	84.6	54.4	65.1	44.4	31.0	30.0	27.2	19.4	15.0	47.6	57.1	52.4	42.8	43.4

Note) Rain of pH=5.6 or less is generally categorized as acid rain.

* Source: Liuzhou official environment report

(2) Improvement of citizens' living environment and livelihood

As shown in Table 12, more than 90 percent of respondents of the beneficiary survey recognized the improvement of air quality and reduction of acid rain in Liuzhou.

As shown in the table on the left side below, many residents pointed out the improvement of their daily living that includes the “reduction of contaminated clothing” as an effect of air quality improvement. As shown in the right-side table below, about 70 percents pointed out the “improvement of water quality of water source” as an effect of improvement of acid rain and more than 50 percent pointed out the reduction of “physical stimulation”.

Ninety-five percent of respondents recognized the “improvement of efficiency of household duties” as a result of the city gas development, which shows the improvement of people's living environment and livelihood.

Table 12 Citizens' Recognition of Improvement of Living Environment

Effect of Air Quality Improvement [multiple answers allowed]	Total (%)	Effect of Acid Rain Improvement [multiple answers allowed]	Total (%)
Reduction of clothing contamination by dust	63	Water quality improvement of water source Liujiang River	67
Able to hang laundry outside	57	Reduction of physical (eyes, skin, hair, etc.) stimulation in rain	53
No need to use masks and sunglasses for dust protection any more	29	Improvement of living environment of creatures in rivers and lakes	47
Health improvement	62	Slowing in deterioration of historical structures and buildings	36
Others	0	Defoliation in forests reduced	28
		Others	0

Note: Beneficiary Survey Result in Ex-Post Evaluation (150 residents of the city were surveyed in May 2010.)

(3) City beautification and improvement of public health

As shown in Table 13 below, more than 70 percent of those surveyed pointed out the “city beautification” and “reduction of foul odor” as effects of waste treatment improvement. Ninety-five percent of respondents recognized the improvement of garbage treatment service that includes increase in frequency of garbage collection. This shows that people recognize the improvement of public health environment.

Table 13 Citizens' Recognition of Improvement of Waste Treatment
(beneficiary survey result)

Effect of Improvement of Waste Treatment [multiple answers allowed]	Total (%)
Progress of city beautification	79
Reduction of foul odor from discarded garbage	75
Reduction of illegal dumping in city and rivers	51
Water quality improvement of water source Liujiang River	43
Reduction of pest in city	24

Note: Beneficiary Survey Result in Ex-Post Evaluation (150 residents of the city were surveyed in May 2010.)

3.4.2 Other Impacts

1) Impacts on the Natural environment

The EIA was approved before the launch of the project and no special impact on natural environment is recognized according to an interview with the environmental protection agency.

2) Land Acquisition and Resettlement

The project did not involve any relocation of residents and the land of 64 hectares for the waste disposal site construction was acquired smoothly. Foul odor and leachate that had been problems of the conventional waste disposal site were not recognized in the result of beneficiary survey.

3) Enhancement of environmental measures by Liuzhou municipal government

According to the interview with concerned Liuzhou municipal government agencies (finance agency, environmental protection agency and executing bodies), they often said that the implementation of the project before the city government took full-scale environmental measures had a significant meaning. They consider that the project had positive impacts on the improvement of the municipal government's awareness of environmental issues. In particular, although the facility introduced as part of "3) Liuzhou chemical fertilizer plant emissions treatment" and "4) Liuzhou Steel Plant coke combustion gas desulfurization" in the project was removed after several years of operation, it accelerated the environmental measures for companies as those for Liuzhou Steel Plant Group Corporation and Liuzhou Chemical Industry Group Corporation that represent the city were taken at an early stage.

4) Unintended Positive/Negative Impacts

No noise or vibration problem was expressed in the interview with the environmental protection agency or in the beneficiary survey.

Thus, the project significantly improved the environmental quality of Liuzhou and had significant positive impacts on daily living of local people.

3.5 Sustainability (Rating: a)

3.5.1 Structural Aspects of Operation and Maintenance

Subprojects “1) Gas supply project” and “2) Waste disposal site construction” are regarded as key projects for the creation of environmentally-friendly city in its “Outline of 10.5 plan for people’s economy and social development of Liuzhou” and “Outline of 10.5 plan for environmental protection of Liuzhou and the long-term targets for 2015” of the municipal government. The municipal government clearly expressed its intention to assist smooth operation of the projects. Thus, although, as for subproject “1) Gas supply service” that used to be provided by state-run enterprise was privatized, there is an established structure for proper operation, maintenance and management based on the municipal government policy so that the former state-run city gas company that is the only one of its kind in Liuzhou will be able to operate itself safely and supply gas in a stable manner. As for “2) Waste disposal site”, its operation, maintenance and management is conducted under the supervision of the municipal government and there is no organizational or human resources problem.

As for “3) Liuzhou chemical fertilizer plant emissions treatment”, although the business environment has changed greatly because of its privatization, its operation, maintenance and management system is enhanced more than expected as a result of the improvement of management efficiency (reduction of human resources in production and increase in engineers) as a result of privatization. As for “4) Liuzhou Steel Plant coke combustion gas desulfurization”, there is no problem in its operation, maintenance and management system as business operation of the Liuzhou Steel Plant Group Corporation has been going well.

3.5.2 Technical Aspects of Operation and Maintenance

As for equipment and machinery that were introduced in “1) Gas supply project” and “2) Waste disposal site construction”, there is no technical problem related to operation and maintenance of facilities and materials and equipment. As for “3) Liuzhou chemical fertilizer plant emissions treatment”, because the facility that was introduced in the project was removed, verification cannot be performed. As for “4) Liuzhou Steel Plant coke combustion gas desulfurization”, the equipment and machinery in operation is maintained properly and there is no technical problem.

Details are described below.

- 1) Gas supply project: They observe inspection standards stipulated in laws and are committed to safety measures so that they will be able to respond to occurrences of problems. Thus, safety management and technical training is provided regularly for its

employees, according to the survey.

- 2) Waste disposal site construction: According to employees who work at the waste disposal site, they pay full attention to operation of the wastewater treatment unit and conducts daily monitoring thoroughly in order to keep values under the standards stipulated in laws. In addition to the daily inspection, they also provide training for engineers regularly in order to develop human resources for maintenance.
- 3) Liuzhou chemical fertilizer plant emissions treatment: The facility installed in this subproject was removed; sustainability cannot be verified.
- 4) Liuzhou Steel Plant coke combustion gas desulfurization: Although desulfurization unit was removed, the naphthalene washing unit and diesel oil collection unit are maintained properly by engineers in charge, according to the survey.

3.5.3 Financial Aspects of Operation and Maintenance

As for “1) Gas supply project”, according to the executing body, efforts for operation efficiency and profitability improvement has been enhanced rapidly, using other similar projects as reference, after the merger with a Hong Kong capital enterprise that operates city gas business in China. As for coke gas supply, it has concluded a gas supply contract with about 20,000 households. Upon the completion of pipe-work, it is planned to begin supply of gas. As a result of user increase, the growth of profit is also expected.

Although “2) Waste disposal site” provides waste treatment service as free public service, however according to the employees of the site, sufficient operation and maintenance fund is secured and replacement parts are provided properly due to the good financial condition of the municipal government.

Although the facility installed in “3) Liuzhou chemical fertilizer plant emissions treatment” was removed, Liuzhou Chemical Industry Group Corporation’s business operation is going well and it has continued fund injection in environmental protection measures. As for “4) Liuzhou Steel Plant coke combustion gas desulfurization”, Liuzhou Steel’s business operation is also going well and there is no financial problem.

3.5.4 Current Status of Operation and Maintenance

According to the beneficiary survey results, majority of citizens are satisfied with the gas supply and waste treatment services, and thus it is fair to say that there is no problem in their operation.

- 1) Gas supply project: The date and time of inspections and the name of inspectors were clearly indicated at each facility when we visited the site and thus it is fair to conclude that regular inspections are carried out properly by maintenance personnel. According to the interview with the environmental protection agency, there has been no accident or problem

and the facility has been operated safely since the launch of gas supply service.

- 2) Waste disposal site construction: No foul odor or noise was observed in the neighborhood at the time of the field visit. Because a sufficient maintenance budget is secured, they have no difficulty in handling failures or purchasing wastewater treatment chemicals and spare parts, according to the interview.
- 3) Liuzhou chemical fertilizer plant emissions treatment: The facility introduced in this subproject was removed; however, no yellow smoke that had been the cause of complaints from residents in the neighborhood was observed at the time of the field visit, which shows that the environmental standards are achieved well.
- 4) Liuzhou Steel Plant coke combustion gas desulfurization: Although the desulfurization unit was removed when we visited the facility, its accessory equipment, the naphthalene cleaning unit and diesel oil collection unit, were in operation. In particular, they place importance on daily maintenance of the naphthalene washing unit, because the unit is essential for the operation of the renewed desulfurization system, according to the interview.

Thus, no major problems have been observed in the operation and maintenance system, therefore sustainability of the project is high.

4. Conclusion, Lessons Learned and Recommendations

4.1 Conclusion

Although the project is highly relevant, its effectiveness and efficiency are moderate because the pollutant treatment facilities introduced in the project were removed in whole or in part because of changes in circumstances of the subprojects. There is no notable problem in its sustainability. In light of the above, this project is evaluated to be satisfactory (B).

4.2 Recommendations

4.2.1 Recommendations for Executing Agencies

- 1) While plant regulations and waste treatment services are improved, environmental education for residents is not provided sufficiently. Because further urbanization and population increase are expected to continue in Liuzhou, the city needs to enhance its efforts to raise residents' awareness of environmental issues, especially of waste volume, through such measures as publicity and environmental education. It also needs to create a system to collect fees for waste treatment from residents in order to handle ever-increasing waste treatment work in future.
- 2) Liuzhou has taken measures to tackle pollutants problems that can be carried out easily,

which include the installation of the pollutant treatment unit in the end of production processes at plants, as part of environmental pollution countermeasures of the municipal government. For further reduction of pollutant emissions, more drastic measures need to be taken, including the relocation of pollution-causing companies to outside of the city and conversion of energy source of coal-dependent major companies into energy that imposes less environmental burden.

4.3 Lessons Learned

Although environmental issues need to be tackled by the region as a whole, the project focused on Liuzhou Steel Group Corporation and Liuzhou Chemical Industry Group Corporation, both major companies in Liuzhou, as leading companies that are committed to environmental issues, which promoted the efforts by the city as a whole to take environmental measures. Because both companies are designated as key environmentally-friendly companies in Liuzhou, the project progress was introduced in the official annual environment report issued by the environmental protection agency and the “10.5 plan for environmental protection of Liuzhou 2001-2005”, which led concerned parties to learn about the outputs of the yen-loan project.

Areas where manufacturing companies and power plants concentrate tend to suffer serious environmental problems. It is important to prioritize business entities that will play a leadership role in tackling local environmental problems in selecting the target through discussions with the partner government. It is also important to promote the efforts of the business entities by regularly informing ministries, agencies and corporate personnel concerned, of the achievement status of environmental indicators of the whole area.

Comparison of the Original and Actual Scope of the Project

Item	Original	Actual
1.Project Outputs 1) Gas supply project	<p>City gas supply grid: 110 km</p> <ul style="list-style-type: none"> • 27 gas pressure regulation stations • 2 tanks (400 m³ each) for liquefied petroleum gas • 3 tanks (54,000 m³ each) for coke gas 	<ul style="list-style-type: none"> • City gas supply grid: 110 km • 27 gas pressure regulation stations • For liquefied petroleum gas <ul style="list-style-type: none"> 4 storage tanks (100 m³ each) 2 storage tanks (2000 m³ each) Mixing unit (mix liquefied gas and air) Loading device • For coke gas <ul style="list-style-type: none"> 2 storage tanks (50,000 m³ each)
2) Waste disposal site construction	<ul style="list-style-type: none"> • Waste disposal site construction: rockfill dam embankment (installation of drainage landfill dam and flood control wall) • Construction of accessory equipment (leachate catchment, gas release treatment facility, etc.) • Management building construction: 800 m² • Installation of environmental monitoring facility • 10 garbage delivery vehicles Rear Loaded Compressed 7-8t 	<ul style="list-style-type: none"> • Waste disposal site construction: rockfill dam embankment (installation of drainage landfill dam and flood control wall) • Construction of accessory equipment (leachate catchment, gas release treatment facility, etc.) • Management building construction: 800 m² • Installation of environmental monitoring facility • 10 garbage delivery vehicles Rear Loaded Compressed 7-8t
3) Liuzhou Chemical fertilizer plant emissions treatment	<p>Installation of facility to treat emissions from Liuzhou Chemical fertilizer plant (emissions denitration facility of NO.1 nitric acid production plant (18,000 Nm³/h))</p>	<p>Installation of facility to treat emissions from Liuzhou Chemical fertilizer plant (emissions denitration facility of NO.1 nitric acid production plant (21,000 Nm³/h))</p>
4) Liuzhou Steel Plant coke combustion gas desulfurization	<p>Installation of coke combustion gas desulfurization facility at Liuzhou Steel Plant</p>	<p>Installation of coke combustion gas desulfurization facility at Liuzhou Steel Plant</p>
2.Project Period	<p>October 1996 — December 2001 (63 months)</p>	<p>October 1996 — November 2009 (158 months)</p>
3.Project Cost		
Amount Paid in Foreign currency	2,300 million yen	2,300 million yen
Amount Paid in Local currency	1,868 million yen	9,462 million yen
Total	4,168 million yen	11,762 million yen
Japanese ODA loan portion	2,300 million yen	2,300 million yen
Exchange rate	<p>1 yuan = 12 yen (As of January 1996)</p>	<p>1) Gas supply business: 1 yuan = 14.27 yen (Average between 1996 and 2009)</p> <p>2) Waste disposal site construction: 1 yuan = 14.24 yen (Average between 1997 and 2004)</p> <p>3) Liuzhou Chemical fertilizer plant emissions treatment: 1 yuan = 13.36 yen (Average between 1999 and 2000)</p> <p>4) Liuzhou Steel Plant coke combustion gas desulfurization: 1 yuan = 13.36 yen (Average between 1999 and 2000)</p>