

0. Summary

The objective of the project was to reduce pollutants, thereby contributing to improvement of the environment in Guiyang City, an environment model city.

The project matches the priority sectors in China's development plan and Japan's aid policy, and development needs are high. Therefore, the relevance of the project is high as a whole. Although some subprojects greatly contributed to reduction of pollutants, the effects of reducing environmental pollutants is moderate because of such factors as the suspension of operations. The efficiency is fair because it is hard to say that the outputs of the project were good. Although the project cost was lower than planned, the project period was significantly longer than planned. With regard to the sustainability of the effects of the project, there is no problem concerning Guiyang Gas-Transportation and Distribution Extension Project and Guiyang Monitoring Project, excluding dismantled or discontinued subprojects, and no major problems have been observed in terms of institutional and technical aspects of the operation and maintenance. Taking into account the future financial uncertainty of Guiyang Steel Plant, which is in the process of relocation, sustainability of the project effect is fair.

In light of the above, it is fair to say that this project is partially problematic.

1. Project Description



Project Location

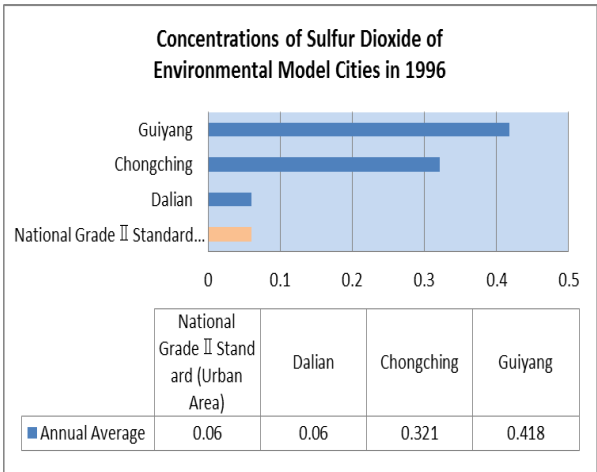


City gas tank in Guiyang City

1.1 Background

In China, with smooth economic growth from the 1980s, environmental pollution worsened because of industrialization and an increase in population. Air pollution became serious because of substances generated from incineration of coal, a main energy source, including sulfur dioxide (SO₂),

total suspended particulate (TSP)¹ and nitrogen oxides (NO_x). Against such a background, the environment model city plan was proposed at the Japan-China summit meeting in September 1997. The purpose of the plan was to carry out intensive environmental measures for giving support in coping with serious environmental pollution in China, designating Dalian, Chongqing, and Guiyang as model cities, and to apply successful cases to other cities. As one of the three model cities, Guiyang preferentially and intensively carried out an environmental pollution prevention project, including measures for dealing with powder dust and SO₂ and eliminating water pollution (Figure 1 shows the concentrations of sulfur dioxide in the three cities).



Source: China Environment Yearbook 1999

Figure 1: Air Pollution in the Environment Model Cities

1.2 Project Outline

The objective of the project is to eliminate air pollutants and river pollutants by (1) change of energy for small boilers from coal to city gas, (2) installation of dust collectors and change to gas in the iron works, (3) installation of equipment for dealing with powder dust in the cement plant, (4) remodeling of existing boilers and change of acetic acid production processes in the organic chemical factory, (5) installation of equipment for removing sulfur from emitted smoke in the power plant, and (6) construction of a clean coal factory, and to strengthen control of air quality by (7) establishment of a system for automatically monitoring air quality, thereby contributing to improvement of the environment in Guiyang City.

¹ Total suspended particulate is a particulate matter such as soot dust. While soot dust is emitted through burning, powder dust is usually generated through crushing or sorting of things.

| | |
|---|--|
| Loan Approved Amount/ Disbursed Amount | 1st phase: 6,266 million yen; 2nd phase: 8,169 million yen 1st phase: 3,979 million yen; 2nd phase: 4,200 million yen |
| Exchange of Notes Date/ Loan Agreement Signing Date | 1st phase: Mar. 27, 2000; 2nd phase: Mar. 30, 2001 / 1st phase: Mar. 28, 2000; 2nd phase: Mar. 30, 2001 |
| Terms and Conditions | <ul style="list-style-type: none"> • Interest Rate: 0.75% • Repayment Period: 40 years (Grace Period: 10 years) • Conditions for Procurement: Bilateral tied |
| Borrower/ Executing Agency | Government of the People's Republic of China / Provincial Government of Guizhou |
| Final Disbursement Date | 1st phase: Jan. 12, 2011; 2nd phase: Jan. 27, 2011 |
| Main Contractor (Over 1 billion yen) | Chiyoda Corporation (Japan) |
| Main Consultant | None |
| Feasibility Studies, etc. | <ul style="list-style-type: none"> • Guiyang Gas-Transportation and Distribution Extension Project F/S (Guiyang City Gas Thermodynamic Planning and Design Institute) Jun. 1999; Guiyang Steel Plant Air Pollution Treatment Project F/S (Beijing Steel Design Institute) Dec. 1998; Guiyang Cement Plant Powder Dust Treatment F/S (Guizhou Construction Materials Science and Design Institute) Jun. 1999; Guizhou Crystal Organic Chemical Plant Mercury Pollution Treatment Project F/S (Guizhou Chemical Technology and Pharmacy Planning and Design Institute) Mar. 1999; Guizhou Crystal Organic Chemical Plant Mercury Pollution Treatment Project F/S (Guizhou Construction Design and Chemistry Research Institute) Mar. 2003; Guizhou Crystal Organic Chemical Plant Mercury Pollution Treatment Project F/S (Guizhou Chemical Technology and Pharmacy Rules and Design Institute) Mar. 2003; Guiyang Power Plant F/S (Guizhou Electricity Design Research Institute) Dec. 1998; Lindong Clean Coal Project F/S (Guizhou First Industrial Design Institute) Feb. 2000 • Guiyang Monitoring Project Air Pollution Control Measures (SAPROF) Feb. 2000 • Guiyang City Air Pollution Control Measures Planning Study (Development Study) 2004 |
| Related Projects | <ul style="list-style-type: none"> • Sino- Japan Friendship Center for Environmental Protection Project (Phase III: 2002–2006; extension: April 2006–March 2008) • China Pollution Control Manager System (JICA Training Program) |

Although the project consists of several subprojects, some were not in operation at the time of the ex-post evaluation for various reasons. The following shows the outline of each subproject and the status at the time of the ex-post evaluation:

| Subproject name ² | Subproject outline | Status of operation at the time of ex-post evaluation |
|---|---|--|
| <1st phase> | | |
| 1) Guiyang Gas-Transportation and Distribution Extension Project | Total cost ³ : 1.29 billion yen Extension of city gas supply pipes, installation of storage tanks, etc. | In smooth operation |
| 2) Guiyang Steel Plant Air Pollution Treatment Project | Total cost: 1.22 billion yen Installation of dust collectors, shift of fuel to city gas | After beginning of operation, temporarily suspended at the time of the ex-post evaluation: completed in 2004, operated until 2010. In May 2010, the steel plant was in the process of relocation under a government order at the time of the ex-post evaluation. |
| 3) Guizhou Cement Plant Dust Comprehensive Control Project | Total cost: 1.65 billion yen Introduction of dry-type kiln, installation of dust collectors | After operating for several years, suspended at the time of the ex-post evaluation: completed in 2004, operated until 2010. In May 2010, the factory's operation was suspended under a government order. |
| 4) Guizhou Crystal Organic Chemical Plant Mercury Pollution Treatment Project | Total cost: 9.38 billion yen Change in acetic acid production processes, remodeling of boilers | Discontinuance (not operated although trial run was done) |
| <2nd phase> | | |
| 5) Guiyang Power Plant Air Pollution Treatment Project | Total cost: 12.57 billion yen Construction of generation equipment, installation of equipment for removing sulfur from emitted smoke | After operating for several years, suspended at the time of the ex-post evaluation: completed in 2004, operated until 2010. In May 2010, the station's operation was suspended under a government order. |
| 6) Guiyang Monitoring Project | Total cost: 250 million yen Development of an automatic air quality monitoring system | In smooth operation |
| 7) Lindong Clean Coal Project | Total cost: 1.35 billion yen Construction of a clean coal production factory | Operated after completion, but suspended soon after |

² These subproject names are used hereafter in the report.

³ Total amount of yen loans and China's own payment

2. Outline of the Evaluation Study

2.1 External Evaluator

Noriyo Aoki, IC Net Limited

2.2 Duration of Evaluation Study

The study for the ex-post evaluation was carried out as follows:

Duration of the Study: August 2012 - January 2014

Duration of the Field Study: February 24 - April 4, 2013; May 28 - June 8, 2013

2.3 Constraints during the Evaluation Study

In some subprojects of the project, suspension of operation, relocation, or dismantling was carried out after operation for a certain period. Moreover, because of delay in some subprojects or cancellation, the ex-post evaluation was carried out seven to nine years after the beginning of operation of the other subprojects. With regard to the suspended subprojects, because operation was carried out for a certain period after completion, and environmental improvement effects produced during that period played a great role in improvement of environment in Guiyang City, the effectiveness of the project is evaluated based on not only the effects at the time of the ex-post evaluation but also certain effectiveness of the subprojects when they were in operation before suspension.⁴

⁴ As it was difficult to collect information on these subprojects for the ex-post evaluation, the evaluation was carried out based on information in the “Sino-Japan Friendship Environment Model City (Guiyang) Project Report” (Guiyang Environment Protection Bureau, 2006) and Project Completion Report in 2010.



Figure 2: Subproject Location

3. Results of the Evaluation (Overall Rating: C⁵)

3.1 Relevance (Rating: ③⁶)

3.1.1 Relevance to the Development Plan of China

3.1.1.1 Development Plan at the time of the appraisal

1) Policy at the national level

In the 9th Five-Year National Plan (1996–2000), China specified the target for total volume control - reduction of total emissions of main pollutants to the 1995 level by 2000. In the 10th Five-Year National Plan (2001–2005), China declared that it would reduce the total emissions of main pollutants by 10% compared with 2000, for air pollution became more serious while the economy developed smoothly. In addition, in the 9th Five-Year National Environmental Protection Plan (1996–2000), the Government specified objectives, such as reduction of total emissions of main pollutants to the 1995 level and achievement of the standard emission level at industrial pollution sources. The Government revised the Air Pollution Control Law of 1995⁷ to

⁵ A: Highly satisfactory; B: Satisfactory; C: Partially satisfactory; D: Unsatisfactory

⁶ ③: High; ②: Fair; ①: Low

⁷ In China, the basic framework for air pollution control measures is established under the Air Pollution Control Law. The law was enacted in 1987 and amended in 1995 and 2000. The control of air pollutant emissions is based on concentration control over sources of pollutant emissions. The State Council has established national environmental standards for air quality.

introduce “SO₂ pollution control zones” and “acid rain⁸ control zones” and intensively carried out antipollution measures by designating areas in 1998. Guiyang City was designated as a double control zone.⁹

In the 10th National Environmental Protection Five-Year Plan (2001–2005), to improve the environment, the Government aimed to reduce the emissions of SO₂, soot and powder dust by around 10% by 2005, compared with 2000 levels. The Government declared that it would carry out positive measures for implementing plans for the reduction and thereby improving the environmental control capabilities, such as promotion of creation of an environment model city and construction of a system for monitoring air quality in priority cities.

2) Guiyang City’s environmental policy

In its 9th Five-Year Environmental Plan (1996–2000), Guiyang City specified objectives, such as reduction of total emissions of main pollutants to the 1995 level, and achievement of the standard emission level concerning industrial pollution sources. In the 10th Plan (2001–2005), the City planned to implement total volume control gradually according to its total volume control plan, taking into consideration the current status of pollutant emissions, the current level of pollution prevention technology, and the status of production management. The City strengthened the executing system for total volume control and clarified the objectives at the ward, city, and county levels. In addition, as an environmental conservation city, Guiyang aimed to improve industrial production technology for the promotion of cleaner production¹⁰, suspend or discontinue old-fashioned businesses and equipment that emitted a large quantity of pollutants, and prevent wasting energy and resources through the strengthening of production management.

3.1.1.2 Development plan at the time of the ex-post evaluation

1) National-level plan

In the 12th Five-Year National Plan (2011–2015), the Government of China showed a policy to strengthen its environmental protection efforts further. With regard to air pollution control measures concerning the total emissions of main pollutants, the Government set a target of 8–10% reduction compared with 2010: 8% reduction of SO₂ and 10% reduction of NO_x. In the 12th Five-Year Environmental Protection Plan (2011–2015), the Government planned to take the following measures to achieve the above target: strengthening of control in priority pollution

To achieve the standards, it has also established national standards for emissions. The local governments are allowed to establish local standards for matters not specified in the national standards. They are allowed to make such standards stricter than the national standards.

⁸ “Acid rain” means rain with a low pH that occurs by incorporating sulfuric acid and nitric acid generated by reaction of SO_x and NO_x in the air. SO_x and NO_x are generated when fossil fuels are burnt. Acid rain includes not only rain but also mist and snow (wet deposition). It also includes deposition in the form of gas and aerosol (dry deposition). Usually, rain with a hydrogen-ion concentration (pH) of up to 5.6 is called “acid rain.”

⁹ An area that falls under both “SO₂ pollution control zone” and “acid rain control zone” is called a “double control zone.”

¹⁰ “Cleaner production” is the general term for efforts to control occurrence of pollutants during production activities through excellent technology and equipment, such as desulfurization equipment, and improvement of management technology. In January 2003, the Cleaner Production Promotion Law was enacted.

zones; construction of an energy-saving society for promotion of recycling economy development; strengthening of ecological protection; adjustment of energy structure for solving air pollution problems; and improvement of the environmental monitoring system.

2) Guiyang City's plan

In its 12th Five-Year Environmental Plan (2011-2015), Guiyang City aimed to set the total emissions of main pollutants, promote the development of a recycling economy and a low-carbon economy, and formulate a production method that can contribute to resource-saving and environmental conservation. The measures for such total volume control had been regarded binding objectives¹¹ with legal force equivalent to laws since the 11th Five-Year Plan. In the 12th Plan, they continued to be regarded as such binding objectives. In the 12th Five-Year Plan, Guiyang City established the 12th Five-Year Ecological Culture City Plan as an ecological culture model city and instructed polluting companies to relocate from the City or discontinue their businesses.

Therefore, the project aims to improve environmental pollution as one of the priority sectors in the development plans at national as well as Guiyang City levels, and is highly relevant with the development plans both at the time of the appraisal and at the time of the ex-post evaluation.

3.1.2 Relevance to the Development Needs of China

1) Condition of air pollution in Guiyang City at that time

When the project was being planned, air pollution was serious because of coal burning by heavy chemical plants in the central part of basin-shaped Guiyang City. The concentration of SO₂ in particular was much higher than the grade II of national air environment standard, which is applied to urban residential zones. Acid rain accounted for 21% of annual precipitation because of SO₂ and NO_x emitted mainly from factories, and Guiyang City was regarded as an acid rain city.

Table 1: Air pollution in Guiyang City (annual average concentration) (unit: mg/m³)

| Indicator | 1995 | 1996 | 1997 | 1998 | National Grade II level |
|-------------------|-------|-------|-------|-------|-------------------------|
| SO ₂ | 0.42 | 0.42 | 0.37 | 0.35 | 0.06 |
| NO _x | 0.047 | 0.045 | 0.033 | 0.031 | 0.05 |
| TSP ¹² | 0.35 | 0.37 | 0.33 | 0.30 | 0.20 |

Source: JICA appraisal documents

¹¹ Binding objectives are separated from predictive objectives and have the same effects as laws. They were first introduced in the 11th Five-Year Plan.

¹² The standard for TSP was applicable until 1999.

Table 2 Result of PM10 Measurement¹³ in Elementary Schools around
Pollution Sources

| | PM10 (µg/m ³) | Remarks |
|---------------------------|---------------------------|----------------------------|
| Nanjiao Elementary School | 223.5 | Around Guiyang Steel Plant |
| Daci Elementary School | 147.7 | Around Guizhou Power Plant |
| Yutian Elementary School | 84.6 | Around Guiyang Station |

Source: JICA internal documents

The factories covered by the subprojects - especially Guiyang Steel Plant, Guizhou Cement Plant, and Guizhou Crystal Organic Chemical Plant Mercury Pollution Treatment Project - were designated as priority air pollution sources by the Government of China, for they caused serious pollution within the companies and around the factories. In addition, because Guiyang City's air pollution monitoring method at that time was chemical laboratory analysis, frequency of sampling was low. Moreover, an analysis of the relation between total volume of pollutants and location or pollution sources was not sufficient. It was not possible to manage pollution sources by environmental control.

Guiyang City was required to take measures because it was designated as one of the 47 priority cities in China and an acid rain control zone under the Air Pollution Prevention Law. As the plans of the project were implemented to satisfy these needs, the necessity for the measures was high.

2) Situation of the subprojects

The status of operation of the subprojects which were carried out under the project can be classified into the following three types. As described in the summary table at the beginning of the report, four of the seven subprojects under the project were not in operation at the time of the ex-post evaluation.

- Type 1: Subprojects that have continued to be in operation after completion: 3 subprojects¹⁴
Subprojects: Guiyang Gas-Transportation and Distribution Extension Project; Guiyang Steel Plant Air Pollution Treatment Project; Guiyang Monitoring Project
- Type 2: Subprojects that suspended after operation for five to six years following completion: 2 subprojects
Subprojects: Guizhou Cement Plant Dust Comprehensive Control Project; Guiyang Power Plant Air Pollution Treatment Project
- Type 3: Subprojects that are discontinued or suspended production right after the beginning of operation: 2 subprojects

¹³ PM10 is particles with a trapping efficiency of 50% if the aerodynamic diameter is 10 µm (50% cutoff particle diameter is 10 µm). The Support Effect Promotion Team measured PM10. At that time, China was monitoring air quality by TSP.

¹⁴ Although the operation of the Steel Plant was temporary suspended because of relocation, the Steel Plant was classified as a factory in operation because it was to be reopened after the relocation.

Subprojects: Guizhou Crystal Organic Chemical Plant Mercury Pollution Treatment Project; Lindong Clean Coal Project

The subprojects fell into these conditions because the environmental policy became stricter and market needs changed during the period between the beginning of the project and the ex-post evaluation.

1. Changes in the policy environment

To achieve the above-described objectives of the National Development Plan, the Government of China made the environmental standards stricter and, if factories could not satisfy the standards and were regarded as pollution sources, forced them to close, suspend operation, or relocate to suburbs. When the Air Pollution Control Ordinance was enacted in 2006, the Government's orders to close or relocate polluting factories became highly binding. Under the situation, Type-2 and -3 subprojects in particular operated smoothly for a certain period after the completion, achieving the effects of improving environment, but operation was suspended after that. In relation to Lindong Clean Coal Project of Type -3 subprojects, due to the strict environmental standard, in spite facilities were able to produce, the operation ended without full-scale production.

2. Coping with changes in market needs

The following two subprojects of Type-3 was either operated for a certain period after completion or suspended without having operated after the completion, because the above-described changes in the policy environment and changes (decrease or loss) in the market needs for the products of the covered factories. Details are as follows:

Table 3: Background of Suspension of Operation

| Subproject name | Details about suspension of operation |
|--|--|
| Lindong Clean Coal Project | Because of the Government’s strengthening of control, it was provided that clean coal should have a sulfur content of up to 1%. Although the factory was completed, this requirement could not be satisfied by the use of the introduced technology, resulting in suspension before the start of production of clean coal. |
| Guizhou Crystal Organic Chemical Plant Mercury Pollution Treatment Project | As it was necessary to cope with the Government of China’s strengthening of the environmental policy, an installation of additional equipment for waste was greatly delayed. Although the equipment was completed, the trial run was discontinued for various technical reasons. The resumption of the test run required a considerable cost of repair and purchase of chemicals. However, because it became possible to produce and procure acetic acid at low prices in the market during the delay in the subproject (in 2011), the economic reasons for the completion of the project disappeared. As a result, this subproject became discontinued. |

In accordance with the interviews to the executing organization and the related personnel, at the time of planning of the project, it was extremely low possibility for the related personnel of both sides of the countries who involved in the planning of the project to prospect the mid and long term sustainability, based on elimination of other factories, strengthening of regulations and market need (whether its possibility of foreseeability at the time of the planning). As far as it was confirmed with the related persons of both countries, in relation to examination of finance, management culture, and organizational management of state-owned enterprises whether it was responsive to future organizational changes or not, it was responded that at the time of the planning, the appropriate required detailed studies were conducted.

During the implementation process of the project, in response to changes of market needs and strengthened environmental policy, the Japanese side, in collaboration with the other technical cooperation project, conducted a series of guidance for the three model cities, gave a piece of advice for promoting improvement of environment to the Environment Protection Bureau of the three cities, and implementing the study of Guiyang City Air Pollution Control Planning Study (2003) and so forth, in order to support the project even they were out of the scope of the project. Thus, it can be concluded that it was fully examined and taken action to the selection of the subprojects and changes of policy environment at the time of planning and implementation of the project.

On the other hand, as the stated above, some of the subprojects that constitute this project ended without playing expected roles because of changes in the originally expected needs and consistency with technologies. In particular, such projects for environmental measures as this project, it is necessary to consider unforeseeable rapid changes of policy environment, technology innovation, and their large influences on implementation of the subprojects as the risk of the planning to

implementation. It becomes the lessons for future projects for environmental measures in developing countries and newly emerging countries like China,

However, as described in the section concerning effectiveness, during a certain period just after implementing of each subproject, these measures had a great effect of reducing air pollutants. From these results, it can also be evaluated that the selection of the subprojects at that time had some relevance from the viewpoint of consistency with needs.

3.1.3 Relevance to Japan's ODA Policy

When the project was planned, JICA regarded environmental assistance as one of the priority sectors for Japanese ODA loans to China under its Medium-Term Policy for Overseas Economic Cooperation Operations. According to the Country Assistance Strategy for China, JICA regarded environmental problems in China as global problems and recognized them as matters of the utmost urgency. Therefore, JICA decided to promote support through air pollution control measures.

Japan has various experiences in contributing to China's environmental improvements, such as environment model city projects with the support of Japanese ODA loans and other comprehensive environmental improvement projects. The support is highly relevant also from the viewpoint of technical superiority in the sector of air pollution control measures.

Therefore, this project is fully consistent with China's development plan and Japan's assistance policy. This project is highly relevant as a whole because urgency for selection of the covered projects is high and the development needs requires a prompt response. In light of the above, its relevance can be rated as high.

3.2 Effectiveness¹⁵ (Rating: ②)

3.2.1 Quantitative Effects

3.2.1.1 Operation and Effect Indicators

As described in the section concerning the relevance, the subprojects under the project can be classified into the following three types:

- Type 1: Subprojects that have continued to be in operation after completion: 3 subprojects
Subprojects: Guiyang Gas-Transportation and Distribution Extension Project; Guiyang Steel Plant Air Pollution Treatment Project; Guiyang Monitoring Project
- Type 2: Subprojects that operated for five to six years after completion and then were suspended
Subprojects: Guizhou Cement Plant Dust Comprehensive Control Project; Guiyang Power Plant Air Pollution Treatment Project

¹⁵ Sub-rating for Effectiveness is to be done with consideration of Impact.

Type 3: Subprojects that are discontinued or suspended production just after the beginning of operation: 2 subprojects
Subprojects: Guizhou Crystal Organic Chemical Plant Mercury Pollution Treatment Project; Lindong Clean Coal Project

The effectiveness of the project is evaluated in terms of effects of the subprojects from the beginning to the ex-post evaluation (2013) by comparison between plan and results at the time of the ex-post evaluation. The effectiveness of the project seems low from a viewpoint of status of emergence of effects at the time of the ex-post evaluation because, as described above, only three of the seven subprojects are now in operation. However, it has been confirmed that Type-2 subprojects, which operated for a certain period after completion, had a great effect on improvement of air environment in Guiyang City. As the objective of the project is “improvement of air environment in Guiyang City,” the subprojects not in operation at the time of the ex-post evaluation should be evaluated in terms of the effect on improvement of air environment in Guiyang City between the beginning of the subprojects and the ex-post evaluation (2000–2013). The method for each type is as follows:

Type-1 subprojects are evaluated from available data in terms of operation between the beginning and the ex-post evaluation. With regard to Type-2 subprojects, because their operation has already discontinued and detailed data could not be confirmed at the time of the ex-post evaluation, they are evaluated from the project report prepared in 2006 by Guiyang City’s Environment Protection Bureau.¹⁶ The concrete procedure is as follows: comparison between plans and results at the time of beginning of operation recorded by monitoring indicators (2005); confirmation of emergence of effects; and evaluation of a degree of contribution to improvement of air environment in Guiyang City so far based on length of operation period. With regard to Type 3, because some subprojects have no operation results or have not reached full production just after beginning of operation, it is concluded that they have no effectiveness. Lastly, the project as a whole is comprehensively evaluated in terms of situation of emergency of effects in accordance with each type, and the duration having effects.

Table 4 analyzes the effects of each type as of 2005 based on the project report prepared in 2006:

¹⁶ Sino-Japan Friendship Environment Model City (Guiyang) Project Report, 2006

Table 4: Reduction of Air Pollution by Each Subproject (as of 2005)

| Indicator | Standard emission level (1999) | Reduction target (1) | Reduction result (2005) (2) | Target/result |
|--|--------------------------------|----------------------|-----------------------------|---------------|
| <Type 1> | | | | |
| Guiyang Gas-Transportation and Distribution Extension Project | | | | |
| SO ₂ emissions | 18,500 tons/year | 18,200 tons/year | 18,400 tons/year | 101% |
| Soot/powder dust emissions | 9,800 tons/year | 9,100 tons/year | 9,700 tons/year | 106% |
| Guiyang Steel Plant Air Pollution Treatment Project ¹⁷ | | | | |
| SO ₂ emissions | 11,200 tons/year | 8,500 tons/year | 9,600 tons/year | 113% |
| Soot/powder dust emissions | 4,600 tons/year | 4,500 tons/year | 4,300 tons/year | 95% |
| <Type 2> | | | | |
| Guizhou Cement Plant Dust Comprehensive Control Project | | | | |
| SO ₂ emissions | 4,700 tons/year | 3,900 tons/year | 4,000 tons/year | 103% |
| Soot/powder dust emissions | 10,000 tons/year | 9,400 tons/year | 9,600 tons/year | 102% |
| Guiyang Power Plant | | | | |
| SO ₂ emissions | 110,000 tons | 102,800 tons/year | 100,000 tons/year | 97% |
| Soot/powder dust emissions | 35,900 tons | 33,000 tons/year | 34,000 tons/year | 103% |
| <Type 3> | | | | |
| Guizhou Crystal Organic Chemical Plant Mercury Pollution Treatment Project ¹⁸ | | | | |
| SO ₂ emissions | Not applicable | 3,600 tons/year | 0 tons/year | 0% |
| Soot/powder dust emissions | Not applicable | 5,300 tons/year | 0 tons/year | 0% |
| Lindong Clean Coal Project | | | | |
| SO ₂ emissions | Not applicable | 26,500 tons/year | 0 tons/year | 0% |
| Soot/powder dust emissions | Not applicable | 14,700 tons/year | 0 tons/year | 0% |

Sources: Questionnaire answers; Sino-Japan Friendship Environment Model City (Guiyang) Project Report, 2006; results of interview surveys.

As shown above, Both Type-1 and -2 subprojects can be highly evaluated, because their effects have emerged mostly as planned at this point of time. In contrast, because of political and environmental changes described so far, the status of emergence of effects of each subproject until the ex-post evaluation is as follows:

¹⁷ Although the Steel Plant operated until 2010, it is evaluated by the values in 2005. It has partially operated because of the Government's production control in the central part of the City.

¹⁸ Although the main objective was to remove mercury owing to a change in the process of manufacturing acetic acid, an effect of reducing air pollution, however small, was expected because the factory includes facilities for converting coal fuel into coke gas.

Table 5: Time Series Flow of Operational Situation

| | | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 |
|--------|---|--------------|-------------------|------|------|--|------|------|-------------------------|------|
| Type 1 | Guiyang Gas-Transportation and Distribution Extension Project | operated | mostly as planned | | | | | | | |
| | Guiyang Steel Plant Air Pollution Treatment Project | operated | mostly as planned | | | operated lower than planned due to policy measures | | | | |
| | Guiyang Monitoring Project | operated | mostly as planned | | | | | | | |
| Type 2 | Guizhou Cement Plant Dust Comprehensive Control Project | operated | mostly as planned | | | | | | suspension of operation | |
| | Guiyang Power Plant Air Pollution Treatment Project | operated | mostly as planned | | | | | | suspension of operation | |
| Type 3 | Guizhou Crystal Organic Chemical Plant Mercury Pollution Treatment Project | not operated | | | | | | | | |
| | Lindong Clean Coal Project | not operated | | | | | | | | |
| | | | | | | | | | | |
| | operated and gained effects mostly as planned | | | | | | | | | |
| | due to the change of external factors, gained about half of effects that were planned | | | | | | | | | |

Details of each type so far are as follows:

Type 1: operation has continued since completion

1) Guiyang Gas-Transportation and Distribution Extension Project

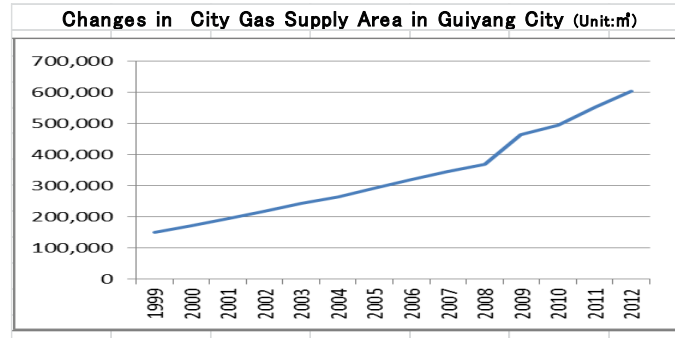
As shown in Table 6, the objective of Guiyang Gas-Transportation and Distribution Extension Project was achieved during the target year in terms of numbers of households and users. As shown in Figure 3, an area of city gas supply has been increasing smoothly. According to a result of interviews with people involved in the executing agency, the status of operation has continued to be good until the ex-post evaluation. The achievement has exceeded the effects of reducing air pollutants that was described in Table 4.

Table 6: Target Effects of Guiyang Gas-Transportation and Distribution Extension Project

| Indicator | Target (2005) | Result (2005) | At the time of ex-post evaluation (2012) |
|--------------------------------|-----------------|-----------------|--|
| No. of gas supply households * | 287,100 | 292,400 | 603,700 |
| No. of gas users | 100.51 | 102.35 | 211.29 |
| SO ₂ emissions | 265.5 tons/year | 31.41 tons/year | 62.02 tons/year |
| Soot/powder dust emissions | 770.5 tons/year | 6.91 tons/year | 13.82 tons/year |

Source: Guiyang City Gas Company's answer to questionnaire

Figure 3 shows an increase in the gas supply area until the ex-post evaluation. The supply area reached about 600,000 m³ in 2012, doubling from 2005. The reason could be considered because an urban development of Guiyang City has advanced and gas demand has expanded as its population and economic scale increased.



Source: Guiyang City Gas Company's answer to questionnaire

Figure 3: Year-by-Year Changes in City Gas Supply Area of Guiyang City

If heat was supplied to the supply area at the time of the ex-post evaluation by using old-fashioned equipment before beginning of the subproject, a large quantity of pollutants would be emitted. Guiyang Gas-Transportation and Distribution Extension Project can be evaluated as having an effect larger than originally expected.

2) Guiyang Steel Plant Air Pollution Treatment Project

Although Guiyang Steel Plant had a negative effect of emitting powder and soot dust as a source of pollution, powder and soot dust were reduced more than the target value in the target year (2005). Although the project achieved an effect larger than the target effect for four years, given that air pollution in Guiyang City was considerably serious at that time, and taking into consideration the impact of the project on the improvement, the effect can be highly evaluated. Guiyang Steel Plant which has run a partial operation for a while owing to the government production control, at the time of field survey of ex-post evaluation, just started to move to another site and a part of production line has just resumed its operation.

Table 7: Target Effect of Guiyang Steel Plant Air Pollution Treatment Project

| Indicator | Standard (1999) | Result (2005) | Current status of operation |
|--|-----------------|---------------|---------------------------------|
| Operation rate | 89.6% | 96.3% | Suspended because of relocation |
| Volume of coal used for 1 ton of steel | 506 kg | 367 kg | Suspended because of relocation |

Source: Answer for project completion report; the steel plant's answer to questionnaire; result of field interview.



(Source) Sino-Japan Friendship Environment Model City (Guiyang) Project Report, 2006.

Figure 3: Air pollution around Guiyang Steel Plant (before the subproject)

Figure 4: Surroundings of Guiyang Steel Plant (after the subproject)

It was confirmed from the related personnel of the steel plant that relocation and resuming operation have been planned, and the equipment introduced in the project is likely to be used. Therefore, the subproject is expected to have effects of reducing air pollutants after the reopening.

3) Guiyang Monitoring Project

Guiyang Monitoring Project made it possible to enhance both quality and quantity of monitoring capabilities. In addition, it had following secondary effects: appropriate measures based on provision of correct information; contribution to decision making; and promotion of supply of information to residents.

Here are concrete achievements: it became possible to monitor main pollutants at any time, and the laboratory chemical analysis based on hand-operated sampling was replaced with an automatic and efficient system for monitoring air quality. Main items covered by the monitoring are SO₂, TSP/PM₁₀, NO/NO₂, CO, and O₃. These achievements enabled the following:

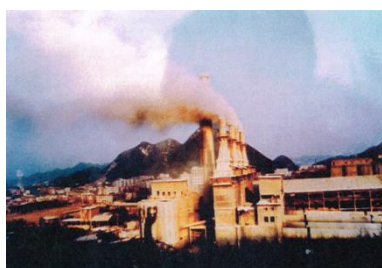
- 24-hour online monitoring remote-controlled from an environmental control center
- Environmental factor monitoring concentration analysis
- Data on time-zone distribution and daily changing pattern of emission from sources of pollution
- Pollution analysis that reflects weather parameters

There are other secondary effects. As the Air Quality Monitoring Observatory began to measure pollution data, air pollution indexes and air pollution forecast began to be announced through mass media, such as radio and television in 2008. Also, because the Air Pollution Publicity Department carried out PR activities, people's awareness of air pollution increased.

As described above, Type-1 subprojects have shown almost the same effect as planned or a larger effect than planned, excluding Guiyang Steel Plant. Therefore, the effectiveness is high.

Type 2: suspended after operation for 5 to 6 years following completion

As shown in Table 5, Guizhou Cement Plant Dust Comprehensive Control Project and Guiyang Power Plant Air Pollution Treatment Project each have larger effects than planned. In a case of Guiyang Power Plant in particular, because new power generating equipment and a device for removing sulfur from emitted smoke were installed, the power plant makes the greatest contribution to the reduction of pollutants.



(Source) Sino-Japan Friendship Environment Model City (Guiyang) Project Report, 2006
The related personnel of Cement Factory provided.

Figure 5: Air pollution by Guizhou Cement Plant
(before the subproject)

Figure 6: New power generation equipment of Guizhou Cement Plant
(after the subproject)

In 2005, the ratio of pollutants reduced by the subprojects in operation to the total volume of pollutant emissions in Guiyang City was as shown in the table below. The subprojects contributed to a reduction of SO₂ by about one-third of the total volume in Guiyang City and a reduction of soot and powder dust by 63% of the total emissions at the time of planning. These data show that the project played a great role in 2005.

Table 8: Total Volume of Air Pollutant Reduction in Guiyang City and the Volume of Reduction by the Project

| Item | Total emissions in Guiyang City (1999) | Volume of reduction by this project (2005) | The project's degree of contribution |
|------------------|--|--|--------------------------------------|
| SO ₂ | 428,000 tons | 132,000 tons | 31% reduction |
| Soot/powder dust | 92,000 tons | 57,600 tons | 63% reduction |

As is clear from the above, although the project had a considerable effect just after completion, the duration of these subprojects was as short as about five to six years. Given the period and the scale of funds invested in this project, it cannot be said that the emergence of effects for several years represents sufficient outputs. However, it seems that urgent need for measures against sources of pollution was high when the project began and the effects of the project had reasonable significance just after the beginning. Based on comprehensive evaluation of these results, Type-2 subprojects are rated as fairly effective.

Type 3: discontinued or production suspended just after the beginning of operation

Guizhou Crystal Organic Chemical Plant Mercury Pollution Treatment Project and Lindong Clean Coal Factory have not achieved any effect. The chemical plant failed to reduce water pollutants such as mercury because its acetic acid plant did not operate.¹⁹ The acetic acid production line by use of the traditional mercury method was suspended during implementation of the project, and no mercury was emitted at the time of the ex-post evaluation. No effect has been achieved by Type 3.

Therefore, the effectiveness of each type can be evaluated as follows:

Table 9: Evaluation of Effectiveness of Each Type

| Type | Effect |
|--|--|
| Type 1: in operation | The same effects as planned or a larger effect than planned emerged. |
| Type 2: operated for 5 to 6 years after completion | Although the effects on improvement of environment was high at that time, because the operation lasted for only a few years, the effects remains fair, taking the size of investment into account. |
| Type 3: discontinued or not operated | The subprojects did not achieve any effect and are evaluated as having no effectiveness because they were discontinued or never operated. |

The effectiveness of the project as a whole between the beginning and the ex-post evaluation is evaluated as follows:

- 1) Although the effectiveness was high for several years after project completion, it was halved at the time of the ex-post evaluation. As the number of subprojects in operation at the time of the ex-post evaluation was three, which is less than half of seven, the total number of the subprojects under the project, the effect expected for the future will also be less than half. Therefore, the effects at the time of the ex-post evaluation seem low.
- 2) In contrast, the effects of reducing air pollutants were high during several years after the project completion. The effectiveness can be rated as high because it emerged before the Government of China began to carry out pollution control by full-scaled measures, although the emergence period of the effects was short.

Based on comprehensive judgment on these circumstances, the effectiveness of the project is rated as fair.

3.2.2 Qualitative Effects

The qualitative effects will be summarized in the section concerning impact because they are closely connected with the emergence of impact.

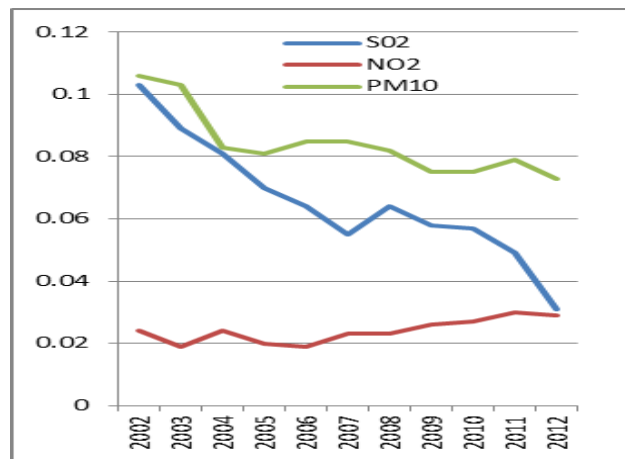
¹⁹ At the time of waste water treatment, reduction of COD (Chemical Oxygen Demand) was expected.

3.3 Impact

3.3.1 Emergence of Impacts

1) Changes in air pollution in Guiyang City

According to year-by-year data on air pollutant concentration provided by Guiyang City Air Quality Monitoring Observatory, as shown in Figure 4, SO₂ has been decreasing year by year. TSP, which began to be measured by PM₁₀ in 2002, has been on a slight downward trend. NO₂ has been on an upward trend. It seems that the effect of a decreasing volume of coal burnt has been offset by the effect of an increasing number of cars and other transportation means.



Source: Data provided by Guiyang City Monitoring Observatory.

Figure 7: Year-by-Year Data on Air Pollutant Concentration in Guiyang City

2) Improvement of urban environment

According to the results of a beneficiary survey,²⁰ the effects of air pollution measures and an improvement of living environment were confirmed around Guiyang Steel Plant. According to multiple answers, 86% of the respondents answered “Became able to open windows,” followed by 68% answering “Became able to dry clothes outdoors,” 30% answering “Became able to ease pain in the eyes or throat,” and 24% answering “Frequency of wearing a mask or sunglasses decreased.” No respondent answered “Don’t know.”

Table 10 shows the result of a survey on diseases related to air pollution in Guiyang City before the project. Table 11 shows the result of a beneficiary survey, whose number of samples was smaller than in a prior survey. Although air pollution occurred widely in Guiyang City in a basin at the time of the ex-post evaluation, it can be judged that the project eased health damage to residents caused by air pollution.

²⁰ The survey covered residents who live around the Steel Plant. Of those who had lived since before the subproject in areas suffering air pollution from the Steel Plant, 50 residents were selected randomly.

Table 10: Hospitalization with Respiratory Disease

(unit: per person per year)

| | Urban areas Nanming / Yunyan districts | Suburb Zhuchangzhen |
|--------------------------------|---|------------------------|
| No. of days of hospitalization | 0.2021 | 0.0213 |
| No. of times of consultation | 0.4690 | 0.0445 |

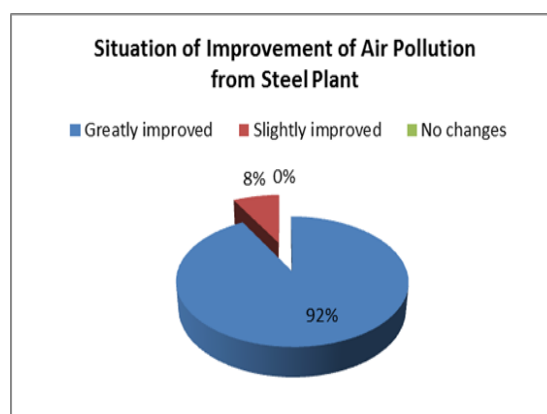
Source: JICA internal documents.

Note: The number of samples is 1,021. The size of the survey is different from that of the beneficiary survey.

Table 11: Effect of Improvement of Steel Plant Air Pollution
(multiple answers permitted)

| | % |
|--|----|
| Respiratory diseases and problems were eased (such as a decrease in the frequency of cough) | 34 |

Source: Result of beneficiary survey

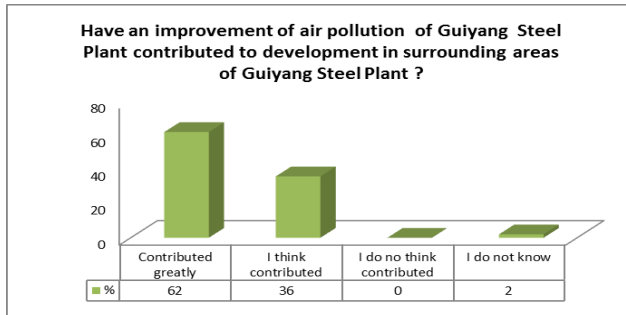


Source: Result of beneficiary survey.

Figure 8: Improvement of Air Pollution from Guiyang Steel Plant

3) Impact on development in surrounding areas

Housing land development was promoted in neighboring areas after the problem of soot and powder dust in Guiyang City was solved because of Guiyang Steel Plant Air Pollution Treatment Project, Guizhou Cement Plant Dust Comprehensive Control Project, and Power Plant Air Pollution Treatment Project. According to the executing agencies, because these factories are next to the Nanming River area at the city center, development of parks and green spaces has advanced in the area, starting formation of recreation places for residents.



Source: Result of beneficiary survey.

Figure 9: Impact of Reduction of Air Pollution from the Steel Plant on Development of Surrounding Areas



Figure 10: Vicinity of Nanming River²¹ at the time of the ex-post evaluation

According to personnel involved in Guiyang Steel Plant, an improvement of air pollution in the City resulted in reduction of erosion due to acid rain²² at Jiaxiu Tower and Guanyin'an, which are important historic structures in Guiyang City. It seems to have gained a certain protection effect against the erosion.

4) Impact on household environment

Before the project, households which were unable to access to city gas had used charcoal and briquettes. The number of carbon monoxide poisoning accidents decreased and rooms became clean without soot or ashes because the project promoted a spread of city gas. According to the result of Guiyang City Gas Company's survey, PM10 is 130.0 ($\mu\text{g}/\text{m}^3$) in households using coal, such as charcoal or briquettes, while it is 68.2 ($\mu\text{g}/\text{m}^3$) in households using city gas, which indicates that the project also contributes to improvement of household environment.

5) Improvement of working environment

The working environment of Guiyang Steel Plant and Guizhou Cement Plant improved because of the decrease in soot and powder dust.²³

3.3.2 Other Impacts

3.3.2.1 Impacts on natural environment

Although there was no negative impact, positive impact on natural environment was recognized, such as a decrease in soot and powder dust and a change in street tree leaves from grey to green.²⁴

It was impossible to check whether measures for reducing environmental burdens were taken

²¹ Because Guiyang Steel Plant and Guizhou Cement Plant are located around Nanming River, the river received the greatest influence from the air pollution control measures before the project.

²² Questionnaire answers from Guiyang Steel Plant. Because acid rain with pH of up to 5.6 was monitored at different places before 2010, there are no observation data that accurately show time-series changes (Guiyang City Monitoring Observatory).

²³ Answers to questionnaires sent to Guiyang Steel Plant and Guizhou Cement Plant.

²⁴ Results of an interview survey on people involved in Guizhou Cement Plant and Guiyang Steel Plant.

according to the results of environmental impact assessment (EIA) due to the absence of stakeholders.²⁵

3.3.2.2 Relocation of residents and acquisition of sites

A 3.7-km railway construction site was necessary for Lindong Clean Coal Project. The area, the acquisition price, and the acquisition method could not be confirmed, because of the absence of people involved. Acquisition of sites was unnecessary for the other subprojects. The results of interviews with people involved in the subprojects show that there was no relocation of residents.

With regard to evaluation of the effectiveness, the effects of the subprojects in operation and the subprojects that operated for a certain period reached the target values, and effects other than those shown by indicators and positive impacts were confirmed. Given that the effects were limited because some subprojects did not begin to operate or operated for a certain period, the effectiveness and impact of this project can be rated as fair.

3.4 Efficiency (Rating: ②)

3.4.1 Project Outputs

Table 12 summarizes plans and results of project outputs and their changes:

Table 12: Outputs (Plans and Results)

| | Plan | Result and reason for change |
|--|--|---|
| 1) Guiyang Gas-Transportation and Distribution Extension Project | <ul style="list-style-type: none"> • Construction of 1 city gas tank of 100,000 m³ and compressor facilities (foreign currency portion) • 1 city gas tank of 50,000 m³ (local currency portion) and compressor facilities • Distribution pipeline extension of about 172.1 km (foreign currency portion, 144.5 km; local currency portion, 27.6 km) | <ul style="list-style-type: none"> • Construction of 1 city gas tank of 100,000 m³ (foreign currency portion) and compressor facilities (local currency portion) • Construction of 1 city gas tank of 50,000 m³ (local currency portion) and compressor facilities (local currency portion) • Distribution pipeline extension of about 172.1 km (foreign currency portion, 144.5 km; local currency portion, 27.6 km) <p>There was no change in the scope.</p> |
| 2) Guiyang Steel Plant Air Pollution Treatment Project | <ul style="list-style-type: none"> • Installation of dust collection systems in 2 electric furnaces of 20 tons and 1 refining furnace • Construction of 7 gas generation furnaces • Gas conversion of 16 heating furnaces • Desulfurization of 2 existing 10-ton boilers | <ul style="list-style-type: none"> • Installation of dust collection systems in 1 refining furnace of 30 tons (foreign currency) • Construction of 7 gas generation furnaces (foreign currency) • Gas conversion of 16 heating furnaces (local currency) • Desulfurization of 2 existing 10-ton boilers (foreign currency) • Installation of pollution source monitoring equipment (foreign currency) |

²⁵ Because a lot of time has already passed, it was impossible to gain information from people involved in the construction.

| | Plan | Result and reason for change |
|---|---|---|
| | <ul style="list-style-type: none"> • Installation of pollution source monitoring equipment | No duct collection system was installed because 2 electric furnaces of 20 tons each have 3 soot dust emission places and it is impossible to collect dust. |
| 3) Guizhou Cement Plant Dust Comprehensive Control Project | <ul style="list-style-type: none"> • Installation of a set of $\phi 3.5 \times 54.0$ m wet grinder dry clinker kiln system • Dismantling of 4 old-fashioned $\phi 3 \times 88.68$ m wet rotary kiln production lines and 1 vertical electric dust collector of 30 m² • Installation of 1 horizontal electric dust collector of 120 m² • DXC (B) multi-cyclone dust collector (for outlet cooler) • Installation of MDC dry-proof dust collector (for coal crushing system) | <ul style="list-style-type: none"> • Installation of a set of $\phi 3.5 \times 54.0$ m wet grinder dry clinker kiln system • Dismantling of 4 old-fashioned $\phi 3 \times 88.68$ m wet rotary kiln production lines and 1 vertical electric dust collector of 30 m² • Installation of 1 horizontal electric dust collector of 120 m² • DXC (B) multi-cyclone dust collector (for outlet cooler) • Installation of MDC dry-proof dust collector <p>Changes were addition of drainage treatment systems and installation of dust collectors in the existing kilns. These were necessary for continuously using old facilities.</p> |
| 4) Guizhou Crystal Organic Chemical Plant Mercury Pollution Treatment Project | <ul style="list-style-type: none"> • Coal gasification system (80,000 tons/year) (local currency portion) • CO purification system (20,000 tons/year) (local currency portion) • Synthetic methanol system (30,000 tons/year) (local currency portion) • Construction of a carbonylation acetic acid plant (36,000 tons/year) • Construction of waste water treatment facilities (200 m³/h) • Remodeling of 5 existing boilers • Installation of pollution source monitoring equipment | <ul style="list-style-type: none"> • Coal gasification system (80,000 tons/year) (local currency portion) • CO purification system (20,000 tons/year) (local currency portion) • Synthetic methanol system (30,000 tons/year) (local currency portion) • Construction of a carbonylation acetic acid plant (36,000 tons/year) • Construction of waste water treatment facilities (200 m³/h) • Remodeling of 5 existing boilers (20 tons/h) • Installation of pollution source monitoring equipment <p>The following were added to the scope:</p> <ul style="list-style-type: none"> • Measures against soot dust, slag, and waste water from existing boilers (35 tons/h \times 4; 75 tons/h \times 1) • Technological remodeling of cement production processes (2,500 tons/d); introduction of the dry rotary kiln method; cement production organic waste water treatment facilities that reuse slag from acetylene production equipment, lime coal from boilers, etc. (4,800 m³/d) • Mercury pollution control measures (dismantling of the old acetic acid manufacturing factory, removal of mercury, 3.17-km drainage) <p>These items were added because it became necessary to take measures based on China's total volume control policy against three waste matters (waste water, waste objects, and air pollution) and Guiyang City's water quality control policy concerning drinking water sources.</p> |
| 5) Guiyang Power Plant Air Pollution | <ul style="list-style-type: none"> • Installment of smoke desulfurization equipment in | <ul style="list-style-type: none"> • Construction of 200-MW power generator • Installment of smoke desulfurization equipment |

| | Plan | Result and reason for change |
|-------------------------------|--|---|
| Treatment Project | newly constructed 200-MW power generator (disposal of old equipment) and existing 200-MW power generator | in newly constructed 200-MW power generator and existing 200-MW power generator |
| 6) Guiyang Monitoring Project | <ul style="list-style-type: none"> • General air quality automatic monitoring substations (13 monitoring places) • 1 main station • 1 telecommunications system quality assurance laboratory • 1 system support laboratory | <ul style="list-style-type: none"> • Establishment of general air quality automatic monitoring substations (8 monitoring places) • 1 main station • 1 telecommunications system quality assurance laboratory • 1 system support laboratory <p>The number of substations changed from 13 to 8 because Guiyang City is located in a basin. Priority is given to monitoring within the basin. Using local currency, substations will be established in development zones newly constructed from 2000 and suburban cities as soon as manpower is ready.</p> |
| 7) Lindong Clean Coal Project | <ul style="list-style-type: none"> • Construction of 2 clean coal production factories (capacity of 500,000 tons/year) | <ul style="list-style-type: none"> • Construction of 1 clean coal production factory (capacity of 500,000 tons/year) <p>The number of clean coal factories changed from 2 to 1 because the coal mine was closed pursuant to a provincial order for reasons of environmental consideration. Although materials and machines were procured, one of the two factories was not constructed.</p> |

Source: JICA internal documents; answers to questionnaires

As described in “3.1.2 Relevance to the Development Needs of China,” four of the above-described seven subprojects were suspended just after completion or after five to six years’ operation. Accordingly, given the status of use at this point in time, the outputs of the project have not reached the expected level in comparison with the invested money and time. However, two of the outputs out of operation functioned and played important roles in environmental pollution control measures for five to six years after completion of the subprojects. Therefore, it is necessary to take this into consideration when the project is evaluated comprehensively.

3.4.2 Project Inputs

3.4.2.1 Project Cost

The planned total project cost for the first and second phases is 28,639 million yen: 14,435 million yen in foreign currency and 1,028 million yuan in local currency. Of the project cost, the total amount of foreign currency portions, 14,435 million yen, is covered by Japanese ODA loans.²⁶

The actual total project cost is 27,757 million yen: 8,180 million yen in foreign currency and 1,391 million yuan in local currency. Of the project cost, the total amount of foreign currency

²⁶ The currency exchange rate was 15 yen per yuan in the first phase and 13 yen per yuan in the second phase.

portions, 8,180 million yen, is covered by Japanese ODA loans.²⁷ Guiyang Power Station was implemented only by the capital of the Government of China for the purpose of needs to promptly complete the subproject in accordance with the Policy to supply electricity to the Eastern Area of China.

The actual total project cost is 96% of the planned cost. The project cost is lower than planned because local currency was used for some items of the scope. Expenditures in local currency were able to be reduced because the procurement for the subprojects related to iron manufacturing and gas transportation was completed before a sharp rise in material prices.

3.4.2.2 Project Period²⁸

Although the duration of the project was planned to be 46 months between March 2000 and December 2003, it was actually 152 months between March 2000 and October 2012 (330% of the planned period).

Table 13: Project Period

| Subproject | Plan | Actual period and reason for delay |
|---|---|--|
| 1) Guiyang Gas-Transportation and Distribution Extension Project | Mar. 2000–Jun. 2003 (3 years 4 months: 40 months) | Mar. 2000–Dec. 2003 (3 years 10 months: 46 months) The period was prolonged a little because it became necessary to change the distribution pipeline route according to Guiyang City’s urban plan. |
| 2) Guiyang Steel Plant Air Pollution Treatment Project | Mar. 2000–Jun. 2001 (1 year 6 months: 16 months) | Mar. 2000–Aug. 2004 (4 years 6 months: 48 months) The start was delayed because it took a lot of time to obtain a construction permission related to design, and started in 2002. |
| 3) Guizhou Cement Plant Dust Comprehensive Control Project | Mar. 2000–Oct. 2001 (1 year 8 months: 20 months) | Mar. 2000–May 2004 (4 years 3 months: 51 months) It took a lot of time to add dust collectors. |
| 4) Guizhou Crystal Organic Chemical Plant Mercury Pollution Treatment Project | Mar. 2000–Jun. 2002 (2 years 4 months: 28 months) | Mar. 2000–Oct. 2012 (12 years 8 months: 152 months) ²⁹ As material and equipment prices rose sharply during the basic design of the project and contract negotiations, it became necessary for China to increase their funds and much time was required for procedures for reducing or changing some items of the scope. Because, after that, the drainage standards for the acetic acid plant became stricter as a result of changes in the national environmental standards, some changes should have been made in parts of the plant, which required changes in the design and implementation of procedures for obtaining permission. Thus the construction of the acetic acid plant itself started in 2007 and completed in June 2009, when preparations for a test run began. |

²⁷ The currency exchange rate in the first phase was 14.166 yen per yuan, the average rate between March 2000 and August 2004. In the second phase, it was 14.133 yen per yuan, the average rate between March 2001 and April 2005. The rate for the Organic Chemical Factory was 13.939 yen per yuan, the average rate between March 2001 and October 2012.

²⁸ The project was planned to start in the month when the loan agreement is concluded and, in principle, end when a trial run begins.

²⁹ Based on JICA’s internal decision.

| | | |
|--|--|--|
| | | Although a test run began in July 2009, it was suspended for various technological reasons. The contract was terminated mainly because reopening of the test run required a lot of money for repair and purchase of chemicals. While the subproject was delayed, technology related to acetic acid production rapidly progressed and it became possible to manufacture acetic acid more inexpensively and in a more environment-friendly way than in the subproject. |
| 5) Guiyang Power Plant Air Pollution Treatment Project | Mar. 2001–Dec. 2003 (2 years 10 months: 34 months) | Mar. 2001–Dec. 2004 (3 years 6 months: 46 months) Details are unclear because of the absence of any person involved. |
| 6) Guiyang Monitoring Project | Mar. 2001–Jun. 2002 (1 year 4 months: 16 months) | Mar. 2001–Apr. 2003 A test run began. Bidding began in 2002. (2 years 1 month: 25 months) As a result of change of the measurement method, it took time to select suppliers suitable for the new measurement method. |
| 7) Lindong Clean Coal Project | Mar. 2001–Sep. 2003 (2 years 7 months: 31 months) | Mar. 2001–Apr. 2005 (4 years 1 month: 49 months) When F/S was planned, coal was planned to be transported from the factory to the railway station by truck. Actually, it was difficult to transport coal of 500,000 tons/year by truck. It took time to add construction of a 3.7-km railway line. |

3.4.3 Results of Calculations of Internal Rates of Return (IRR) (referential value)

At the time of the appraisal, neither the financial internal rate of return (FIRR) nor the economic internal rate of return (EIRR) was calculated. FIRR and EIRR are not calculated at the time of the ex-post evaluation either because the conditions, such as cost, benefit, and project life are unclear.

With regard to the overall evaluation of efficiency, usually, based on the status of development of outputs, comparison is made between the planned cost and period and the results. In the case of the project especially, it is necessary to clarify how to evaluate the above-described discontinuation of outputs in the context of all the evaluation items.

1) Given that more than half of the outputs were discontinued, it cannot be said that the development of the outputs is effective compared with the inputs. Also, given that some project period became far longer than planned, efficiency is rated as low.

2) However, the discontinuation of each output was already evaluated in the section concerning effectiveness. Efficiency was evaluated based on the comparison between the project period and the cost and by reference to the status of development of the outputs.

3) Some of the discontinued outputs can be regarded as having been used because they had effect for five to six years after the completion and played great roles in the improvement of air pollution in Guiyang City. Therefore, the development of the outputs can be rated as mostly planned except the Organic Chemical Plant.

4) Based on the above three points, although the status of development of the outputs is not necessarily good, it is unnecessary to lower the rating of the project period and the cost. With regard to the rating of efficiency, it was judged proper to conduct the rating based on comparison between the planned project period and cost and the results.

In light of the above, because the project cost was lower than planned, while the project period greatly exceeded the plan, efficiency is fair.

3.5 Sustainability (Rating: ②)

As described above, four of the seven subprojects originally planned in the project are out of operation. As sustainability is evaluated mainly from that of emerged effects, the subprojects out of operation are evaluated on it in the section concerning effectiveness. Moreover, sustainability is analyzed and evaluated only concerning the subprojects in operation at the time of the ex-post evaluation.

3.5.1 Institutional Aspects of Operation and Maintenance

3.5.1.1 Executing agency

A supervision of the subprojects was transferred from Guiyang City's Environment Protection Bureau, which had been responsible for a project planning and implementation, to Foreign Investment Division of Guiyang Development and Reform Commission in 2009. The Environment Protection Bureau was reorganized into an organization under the Ecological Committee at the end of 2012.

3.5.1.2 Agencies for operation and maintenance

Table 14 shows the agencies for operation and maintenance. At the time of the planning and the ex-post evaluation, all the companies are wholly owned by the Province or the City. The Air Quality Monitoring Observatory is a government agency.

Table 14: Agencies for Operation and Maintenance

| | At the time of planning | At the time of ex-post evaluation |
|--|--|---|
| 1) Guiyang Gas-Transportation and Distribution Extension Project | Guiyang City Gas Transportation Company | Guiyang City Gas Company |
| 2) Guiyang Steel Plant Air Pollution Treatment Project | Guiyang First Steel Plant | Guiyang First Steel Plant of Shougang Group |
| 3) Guiyang Monitoring Project | Guiyang City Environment Protection Bureau | Guiyang City Ecological Committee's Environment Protection Bureau |

Source: Each subproject's Project Completion Report; answers to questionnaires; results of field surveys.

3.5.2 Technical Aspects of Operation and Maintenance

1) Personnel and technical level

With regard to the subprojects in operation, both structure of personnel and technical level have been maintained well for the purpose of operation and have no special problem. Details are as follows:

Guiyang City Gas Company has many qualified employees and is expected to keep maintenance sustainable. It has 12 pressure welders, five safety inspectors, and 10 emergency repair workers, all of whom are highly technical and have adequate qualifications and skills. Therefore, the company's technical level of operation and maintenance is high.

Guiyang Steel Plant has acquired ISO to improve operation and maintenance. It has 10 finishers, 15 electricians, and 15 block layers, all of whom have adequate qualifications and skills, and reaches a certain level of basic technique. It receives technical advice from the parent company, named Shougang Group. The Air Quality Monitoring Observatory has four engineers with adequate qualifications, skills, and experience. They are endeavoring to acquire skills to measure PM2.5, photochemical oxidant, aerosol, and others that have recently been added to the items to be measured.

2) Training system

Guiyang Gas-Transportation and Distribution Extension Project includes provision of training and education to engineers and supervisors before they occupy posts. They receive guidance from field experts and are required to pass examinations before working in the field. Guiyang Steel Plant provides in-house training to electricians and finishers. The Air Quality Monitoring Observatory holds training regularly and receives training from relevant equipment manufacturers.³⁰

3.5.3 Financial Aspects of Operation and Maintenance

Although financial statements for each project have not been published, the financial condition can be inferred from questionnaire answers and other information as follows:

The financial condition of Guiyang Gas-Transportation and Distribution Extension Project is good because the company has been in the black. It is planned that Guizhou Province's main source of gas will be partially replaced with natural gas. With diversification of structure of energy sources, Guiyang City Gas Company plans to promote use of coke gas in manufacturing sector.

Guiyang Steel Plant fell into the red, because, at the time of the field surveys, it did not have production capacity to keep up with demand due to the process of moving to another site and the production limit of government, although a steel market demand has been strong. It has not received permanent financial aid from the parent company, Shougang Group although it received a new investment capital for a new production line construction. After the field surveys, a production line

³⁰ Results of interviews with agencies.

was partially completed and just started to operate³¹. However, it is still uncertain whether the financial condition will constantly become sound.

According to personnel involved, because the Air Quality Monitoring Observatory is a government agency, it is guaranteed to receive appropriate budgets and has no financial problem. Budgets have been on an upward trend as a whole because the Government of China has recently strengthened air pollution control measures in Guiyang City.

Therefore, because the financial condition of Guiyang Steel Plant is partially uncertain, the current status of operation and maintenance costs is fair as a whole.

3.5.4 Current Status of Operation and Maintenance

1) A current status of operation and maintenance of Guiyang Gas-Transportation and Distribution Extension Project is favorable. An inspection of gas pipes and the attached facilities, maintenance of piping and attached equipment, emergency treatment of transportation through the gas pipes, and emergency repair have been appropriately managed through emergency repair workers' operations. Measures for removing rust from outer walls of the facilities and preventing erosion have been carried out thoroughly.

2) Guiyang Steel Plant was relocated to a suburb in accordance with the City's urban plan, which has been implemented from 2007, and suspended operation of dust collectors in 2009. However, it has been relocating gradually because of a problem of relocation cost. It has acquired a relocation site, has been constructing buildings, and plans to relocate dust collectors. A gas generation furnace is dismantled owing to its poor production capacity and its inclusion in Guiyang City's list of facilities to be disposed of. Regarding a heating furnace, only the forging equipment³² will be relocated. Desulfurizing devices attached to existing boilers will be disposed of, because coal is not used. A pollution source monitoring system will be replaced with a new one because it has defects in some sensors and was installed several years ago. Since operation and maintenance system has been established, maintenance personnel on duty are due to check equipment of each facility and to control system instructions. The computer monitor inspects a status of each control point (e.g., bag filter dust collectors, electric dust collector temperature, air blowers, scavenging equipment, and oil pressure) online. A status of operation is recorded for inspections to carry out the maintenance.

3) The monitoring equipment in Air Quality Monitoring Observatory was replaced with one including new measurement items in 2010 because a service life of the observatory was eight years. The main observatory, the telecommunications system quality assurance laboratory, and the system support laboratory have continued to be used after the ex-post evaluation. Inspections have been recorded according to a manual. A 24-hour rotating schedule has been applied to operation and maintenance of equipment. The purpose of this is to find any trouble in equipment and secure an

³¹ It is expected that a new operation of production line in Guiyang Steel Plant positively contribute to the financial situation.

³² Equipment for processing iron while forging it.

acquisition of data. The staff regularly maintains each station's equipment according to national rules on automatic monitoring of air quality to guarantee normal operation of each station and equipment. The observatory has passed quality control examinations conducted by the National Environment Monitoring Center every year. The observatory prepares a spare parts procurement plan every year and has a plan to install new equipment for measurement items added according to the Government of China's policy.



Figure 11: Guiyang City Taiciqiao Observatory



Figure 12: Air quality monitoring automatic control screen



Figure 13: Observation and maintenance management record

In light of the above, Guiyang Gas-Transportation and Distribution Extension Project and Air Quality Monitoring have no problem concerning sustainability of the effects of the project, and operation and maintenance system and technical capabilities have no problem. Taking into account the future financial uncertainty of Guiyang Steel Plant, which is in the process of relocation, sustainability of the project effect is fair.

4. Conclusion, Lessons Learned and Recommendations

4.1 Conclusion

The objective of the project was to reduce pollutants, thereby contributing to improvement of the environment in Guiyang City, an environment model city.

The project matches the priority sectors in China's development plan and Japan's aid policy, and development needs are high. Therefore, the relevance of the project is high as a whole. Although some subprojects greatly contributed to reduction of pollutants, the effects of reducing environmental pollutants is moderate because of such factors as the suspension of operations. The efficiency is fair because it is hard to say that the outputs of the project were good. Although the project cost was lower than planned, the project period was significantly longer than planned. With regard to the sustainability of the effects of the project, there is no problem concerning Guiyang Gas-Transportation and Distribution Extension Project and Guiyang Monitoring Project, excluding dismantled or discontinued subprojects, and no major problems have been observed in terms of institutional and technical aspects of the operation and maintenance. Taking into account the future financial uncertainty of Guiyang Steel Plant, which is in the process of relocation, sustainability of the project

effect is fair.

In light of the above, it is fair to say that this project is partially problematic.

4.2 Recommendations

4.2.1 Recommendation to the Executing Agency

None in particular

4.2.2 Recommendations to the Operation and Maintenance Agencies

None in particular

4.2.3 Recommendations to JICA

None in particular

4.3 Lessons Learned

- It is essential to introduce environmental technologies by foreseeing tightening of environmental measures and standards according to the development stages. In this project, there were cases where it became impossible to operate facilities because of the tightening of environmental standards and cases where the tightening influenced construction and installation processes. ODA loan projects in emerging countries require plans that keep up with tightening of environmental measures and standards according to their development stage and speed.
- In the project for a government-run company, it is necessary to examine whether the project can deal with management finance, management practices, and future changes in market conditions. After examining it strictly, it is necessary to select the target agency of the project. If the finance of the target agency greatly depends on national budgets, it is inevitable to improve management systems and management practices during implementation of the project. It is required to evaluate the project agency's eligibility as precondition, assuming that private-sector initiatives may be introduced or the project agency may be privatized. For example, the project agency's management culture should be evaluated at the stage of preliminary study.
- In this project, the prioritized polluting companies had existed, and some subprojects started as measures for such companies. If any prioritized polluting company exists, it is crucial to collect information on possibility of relocation to a suburban area beforehand and, and to flexibly reexamine the project plan when a necessity for relocation is predicted in an urban plan for the future.

Comparison of the Original and Actual Scope of the Project

| Item | Plan | Result |
|--|--|---|
| (1) Output | | |
| 1) Guiyang Gas-Transportation and Distribution Extension Project | <ul style="list-style-type: none"> • Construction of 1 city gas tank of 100,000 m² and compressor facilities (foreign currency portion) • 1 city gas tank of 50,000 m² (local currency portion) and compressor facilities • Distribution pipeline extension of about 172.1 km (foreign currency portion, 144.5 km; local currency portion, 27.6 km) | <ul style="list-style-type: none"> • Construction of 1 city gas tank of 100,000 m² (foreign currency portion) and compressor facilities (local currency portion) • Construction of 1 city gas tank of 50,000 m² (local currency portion) and compressor facilities (local currency portion) • Distribution pipeline extension of about 172.1 km (foreign currency portion, 144.5 km; local currency portion, 27.6 km) |
| 2) Guiyang Steel Plant Air Pollution Treatment Project | <ul style="list-style-type: none"> • Installation of dust collection systems in 2 electric furnaces of 20 tons and 1 refining furnace • Construction of 7 gas generation furnaces • Gas conversion of 16 heating furnaces • Desulfurization of 2 existing 10-ton boilers • Installation of pollution source monitoring equipment | <ul style="list-style-type: none"> • Installation of dust collection systems in 1 refining furnace of 30 tons (foreign currency) • Construction of 7 gas generation furnaces (foreign currency) • Gas conversion of 16 heating furnaces (local currency) • Desulfurization of 2 existing 10-ton boilers (foreign currency) • Installation of pollution source monitoring equipment (foreign currency) |
| 3) Guizhou Cement Plant Dust Comprehensive Control Project | <ul style="list-style-type: none"> • Installation of a set of $\phi 3.5 \times 54.0$ m wet grinder dry clinker kiln system • Dismantling of 4 old-fashioned $\phi 3 \times 88.68$ m wet rotary kiln production lines and 1 vertical electric dust collector of 30 m² • Installation of 1 horizontal electric dust collector of 120 m² • DXC (B) multi-cyclone dust collector • Installation of MDC dry-proof dust collector | <ul style="list-style-type: none"> • Installation of a set of $\phi 3.5 \times 54.0$ m wet grinder dry clinker kiln system • Dismantling of 4 old-fashioned $\phi 3 \times 88.68$ m wet rotary kiln production lines and 1 vertical electric dust collector of 30 m² • Installation of 1 horizontal electric dust collector of 120 m² • DXC (B) multi-cyclone dust collector • Installation of MDC dry-proof dust collector • Addition of drainage treatment systems • Installation of dust collectors in existing kilns |

| Item | Plan | Result |
|---|--|---|
| 4) Guizhou Crystal Organic Chemical Plant Mercury Pollution Treatment Project | <ul style="list-style-type: none"> • Coal gasification system (80,000 tons/year) (local currency portion) • CO purification system (20,000 tons/year) (local currency portion) • Synthetic methanol system (30,000 tons/year) (local currency portion) • Construction of a carbonylation acetic acid plant (36,000 tons/year) • Construction of waste water treatment facilities (200 m³/h) • Remodeling of 5 existing boilers • Installation of pollution source monitoring equipment | <ul style="list-style-type: none"> • Coal gasification system (80,000 tons/year) (local currency portion) • CO purification system (20,000 tons/year) (local currency portion) • Synthetic methanol system (30,000 tons/year) (local currency portion) • Construction of a carbonylation acetic acid plant (36,000 tons/year) • Construction of waste water treatment facilities (200 m³/h) • Remodeling of 5 existing boilers (20 tons/h) • Installation of pollution source monitoring equipment • Measures against soot dust, slag, and waste water from existing boilers (35 tons/h × 4; 75 tons/h × 1) • Technological remodeling of cement production processes (2,500 tons/d) • Cement production organic waste water treatment facilities (4,800 m³/d) • Mercury pollution control measures (dismantling of the old acetic acid manufacturing factory, removal of mercury, 3.17-km drainage) |
| 5) Guiyang Power Plant Air Pollution Treatment Project | <ul style="list-style-type: none"> • Installment of smoke desulfurization equipment in newly constructed 200-MW power generator (disposal of old equipment) and existing 200-MW power generator | <ul style="list-style-type: none"> • Construction of 200-MW power generator • Installment of smoke desulfurization equipment in newly constructed 200-MW power generator and existing 200-MW power generator |
| 6) Guiyang Monitoring Project | <ul style="list-style-type: none"> • General air quality automatic monitoring substations (13 monitoring places) • 1 main station • 1 telecommunications system quality assurance laboratory • 1 system support laboratory | <ul style="list-style-type: none"> • Establishment of general air quality automatic monitoring substations (8 monitoring places) • 1 main station • 1 telecommunications system quality assurance laboratory • 1 system support laboratory |

| Item | Plan | Result |
|-------------------------------|---|---|
| 7) Lindong Clean Coal Project | Construction of 2 clean coal production factories (capacity of 500,000 tons/year) | • Construction of 1 clean coal production factory (capacity of 500,000 tons/year) |
| (2) Period | Mar. 2000–Dec. 2003 (3 years 10 months) | Mar. 2000–Oct. 2012 (12 years 8 months) |
| (3) Project cost | | |
| Foreign currency | 14,435 million yen | 8,180 million yen |
| Local currency | 15,420 million yen (1,028 million yuan) | 19,696 million yen (1,391 million yuan) |
| Total | 28,639 million yen | 27,757 million yen |
| ODA loan portion | 14,435 million yen | 8,180 million yen |
| Exchange rate | <p>1st phase 15 yen per yuan (Mar. 2000)</p> <p>2nd phase 13 yen per yuan (Mar. 2001)</p> | <p>1st phase 14.16 yen per yuan (Average rate between Mar. 2000 and Aug. 2004)</p> <p>2nd phase The exchange rate was 14.133 yen per yuan, the average rate between Mar. 2001 and Apr. 2005. Only in the case of Organic Chemical Factory, the exchange rate was 13.939 yen per yuan, the average rate between Mar. 2001 and Oct. 2012.</p> |