People's Republic of China

Ex-Post Evaluation of Japanese ODA Loan
Shenyang Environment Improvement Project: Phase 1 and 2

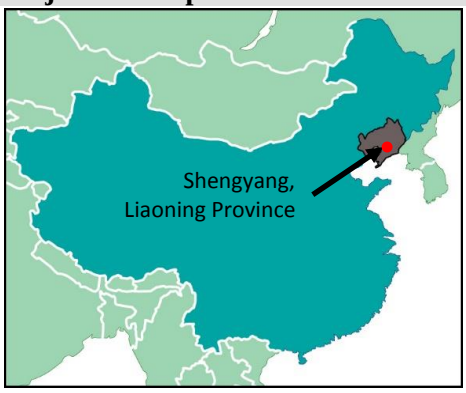
External Evaluator: Kenji Momota, IC Net Limited

0. Summary

This project was implemented with the aim of improving the worsening air quality in the city of Shenyang. The subprojects finally selected were consistent with the needs and therefore were appropriate; however, in the process of project formulation, there were repeated cancellations and replacement of subprojects. These caused delays of the project implementation period, so it can be said that there was some room for improvement in the subproject planning and selection processes. The reduction in air pollutants by the project was prominent, and all of the expected results were achieved. Neighborhood residents commented that they noticed the improvement in air quality, and actual improvements were recognized in the concentration of air pollutants within the city of Shenyang. Hence, it can be concluded that the project made contributions to the improvement of air quality in the city. The equipment installed during the project is still being used effectively, and there appear to be no problems in terms of institutional, technical, and financial sustainability.

In light of the above, the project is evaluated to be highly satisfactory.

1. Project Description



Project Location

Heat supply/electricity-generating turbine installed

1.1 Background

Since 1978, when China first embarked on its path of “reform and openness,” the country has continued to achieve steady economic development. At the same time, however, China has been highly dependent on coal as a source of energy, and air pollution caused by the burning of coal has become an increasingly serious issue. Shenyang, which is the provincial capital of Liaoning Province, located in Northeast China, was no exception. As Shenyang continued to develop as one of the major industrial cities in Northeast China, the city grew to encompass the historically

industrial areas, and thus began to have a negative impact on the surrounding urban environments. In addition, despite increase in the consumption of coal used for heaters in individual households during the winter period, the small-scale boilers used as heaters operated with poor combustion efficiency, and the measures taken to reduce air pollutants were inadequate. As a result, air pollution became an increasingly serious problem in the city of Shenyang. For example, the average maximum value of sulfur dioxide (SO_2)[1] for winter days came to reach 2.7 times that of the national standards.

1.2 Project Outline

The objective of this project was to either convert factories that are the source of air pollution to low-emission factories or relocate them outside of the city, and to put into place central heat supply projects, thereby improving the level of air pollution in the city of Shenyang.

This project consisted of multiple subprojects, including those upgrading factories that had been the sources of air pollution in Shenyang. The project was implemented in two phases: Phase 1 and 2 which commenced in 1996 and in 2001 respectively. During the implementation process, there were replacement and changes of the subprojects, resulting in a significant change on the final structure of the project. The list below shows the changes of the structure of the project as well as the names of the subprojects that appear in the report.

Table 1: Outline of the Project

Phase 1		
Original project plan	**Actual project makeup**	**Subproject outline**
1-1. Improvements to Copper Refining Processes at a Smelting Plant	**Cancelled**	The objective of this subproject was to build and relocate new facilities for copper refining processes and sulfuric acid manufacturing facilities of Shenyang Smelting Plant within the existing factory grounds, thereby reducing SO_2 emissions.
1-2. Shenyang Heat Supply	As planned	The objective of this subproject was to perform construction to expand the scope of existing thermoelectric power plants with the aim to supply heat to factories, thereby reducing the use of small-scale boilers at individual factories.

[1] Sulfur dioxide (SO_2) is a sulfur oxide emitted through the burning of coal and in automobile exhaust, among other sources. Exposure to sulfur dioxide has been associated to respiratory diseases.

Phase 2

Original project plan	Actual project makeup	Project outline
2-1. Environmental Treatment at an Alloy Company	As planned	The objective of this subproject was to relocate the Shenyang Alloy Material Corporation plant outside the city and at the same time effect a transition to cleaner production.
2-2. Taiyuan Jie Central Heat Supply	As planned	The objective of this subproject was to eliminate inefficient small and medium-scale coal-fired boilers and construct a heat supply plant with large-scale boilers equipped with emission controls.
No initial plan	**Added** Construction to Expand the Taiyuan Jie Central Heat Supply	The objective of this subproject was to perform construction to expand the heat supply plants for the 2-2. Taiyuan Jie Central Heat Supply subproject listed above to meet rising heat supply demands.
2-3. Jinshan Thermoelectric Expansion	**Cancelled**	The objective of this subproject was to construct a heat supply plant with large-scale boilers equipped with emission controls, thereby expanding the area covered by the central heat supply.
2-4. No initial plan	**Added** (Shenyang) Yuhong District Xin Cheng Central Heat Supply	The objective of this subproject was to utilize the treated water from the Fairy River Wastewater Treatment Plant in Yuhong District Xin Cheng and to construct a central heat supply facility and pipe grid to supply heat within the city of Shenyang.

Figure 1: Taiyuan Jie Central Heat Supply Boiler

Figure 2: Yuhong District Xin Cheng Heat Supply Subproject Pipe Grid

Loan Approved Amount/ Disbursed Amount	Total for Phases 1 & 2: 11,196 million yen/7,781 million yen Phase I: 5,000 million yen/1,637 million yen Phase II: 6,196 million yen/6,142 million yen
Exchange of Notes Date/Loan Agreement Signing Date	Phase 1: December 1996/December 1996 Phase 2: March 2001/March 2001
Terms and Conditions	Interest Rate: 2.1% Repayment Period: 30 years (Grace Period: 10 years) General Untied
Borrower/Executing Agency	Phase 1: Government of the People's Republic of China/People's Government of Shenyang Phase 2: Government of the People's Republic of China/People's Government of Shenyang
Final Disbursement Date	Phase 1: January 2004 Phase 2: January 2012
Main Contractor (Over 1 billion yen)	None
Main Consultant (Over 100 million yen)	None
Feasibility Studies, etc.	None
Related Projects (if any)	None

2. Outline of the Evaluation Study

2.1 External Evaluator

Kenji Momota, IC Net Limited

2.2 Duration of the Evaluation Study

For the purpose of this ex-post evaluation, the evaluation study was carried out as follows:

Duration of the Study: August 2012 - October 2013

Duration of the Field Study: April 7–18, 2013 and August 19–23, 2013

2.3 Constraints during the Evaluation Study (if any)

None

3. Results of the Evaluation (Overall Rating: A[2])

3.1 Relevance (Rating: ③[3])

3.1.1 Relevance to the Development Plan of China

1) Development plans of China at the time the Project was being planned

In China, as a consequence of rapid economic growth and industrialization, the problem of air pollution has worsened. To address this problem, in its Ninth Five-Year Plan (1996–2000), the Chinese government set target regulations on total emissions that sought to bring the total amount of emissions of major pollutants down to 1995 levels by the year 2000. As a means to curb air pollution, Shenyang, which was designated by the Chinese government as a "sulfur dioxide pollution control zone," pursued policies designed to upgrade processes at factories, centralize heat supply endeavors, and to take other steps to remedy air pollution.

2) Development plans of China at the time of the ex-post evaluation

In the Eleventh and Twelfth Five-Year Plans (the latter of which covers 2011–2015), which began after the implementation of this Project, the Chinese government has continued to strive for a reduction in the total amount of emissions of major pollutants, and has set concrete targets such as an 17% reduction in CO_2 emissions per unit GDP. In this series of policies, the government has named Liaoning a province with a particularly high priority on the environment. With the slogan "Industrial processes [conducive to] clear skies, blue waters, and green hills," the province has been promoting improvement of air and water pollution and fostering ecosystems. The city of Shenyang has been developing as the capital of Liaoning Province, as exemplified by the presence of economic development zones within the city. Given this continuing urban development, the city has been designated as an area where environmental protection measures are of a particularly high priority. During its Twelfth Five-Year Plan for Environmental Protection of the city of Shenyang, the policy which materialize the objective above, the municipal government of Shenyang has committed to reduction targets of 10.7% and 13.7% for SO_2, NOx[4] respectively compared with 2010 levels, and has adopted such steps as the mandatory installation of desulfurizing units on new coal-fired boilers and numerical targets for total NOx removal efficiency for coal-burning facilities and equipment. In addition, there continue to be stated goals for improved coverage in heat supply and better supply efficiency through the expansion of central heat supply systems.

3.1.2 Relevance to the Development Needs of China

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[2] A: Highly satisfactory; B: Satisfactory; C: Partially satisfactory; D: Unsatisfactory

[3] ③ High; ② Fair; ① Low

[4] Nitrogen oxides (NOx) are sources of air pollution, and as with SO_2, exposure to nitrogen oxides has been associated with respiratory diseases.

1) Development needs of China at the time the Project was being planned

Shenyang has prospered as the chief industrial city in Northeast China. With the progress of urbanization, Shenyang expanded to include traditionally industrial areas within its enlarged city center, and as a consequence had a negative impact on the air quality of surrounding areas. In addition, the city saw an increase in the consumption of coal used for heaters to heat individual households in the winter. The use of small-scale and inefficient boilers had progressively detrimental effects on air quality.

2) Development needs of China at the time of the ex-post evaluation

Shenyang has continued on a path of economic development since the commencement of this project. The expansion of urbanization, the increased number of automobiles, and other factors have contributed to an increase in sources of air pollution. Though the Shenyang Environmental Protection Bureau says that it is pushing for the diversification of energy sources, the main source of energy for the heat that supplies heaters in Shenyang is still coal. Given that the sources of pollution continue to rise, in the interests of curbing air pollution, the demand for efficient supplies of heat remains high.

3) Changes made to subprojects and their relevance

During both Phase 1 and Phase 2 of this project, some of the subprojects initially planned were cancelled and replaced with other subprojects. The background of the cancellations and replacements of the respective subprojects are as follows.

Phase 1 — 1-1. Improvements to Copper Refining Processes at a Smelting Plant: Cancelled

This subproject was cancelled because The Shenyang Smelting Plant, the implementing organization of this subproject went bankrupt before its commencement. The Shenyang municipal government requested that the balance of the loan associated with the cancellation to be reallocated for another subproject, but JICA did not consent. Thus Phase 1 of the project ended in the implementation of just one subproject.

The cancelled subproject 1-1.improvement of smelting plant involved an old-style plant that was installed before World War II. This plant had been recognized as a major source of pollution, therefore the needs to cope with this plant was high at that time. However, the plant was closed by the Chinese government policy to apply more stringent environmental standards. Fortunately enough, because of delays in project relending agreements and such during this period, there were physical delays in the progress of this subproject, so it was possible to cancel it and substitute it with another subproject before it commenced.

Phase 2— 2-3. Jinshan Thermoelectric Expansion: Cancelled

In the area initially expected for the heat supply (Sujiatun New District), the construction of automotive plants and wholesale markets -- which were supposed to be the chief consumers

-- was halted and led to the cancellation of the subproject. Because of this cancellation, 4,068 million in yen loans went unused. According to the Shenyang Environmental Protection Bureau, these funds were planned to be reallocated to the following three subprojects:

1-2. Shenyang Heat Supply (Phase IV Project/2,038 million yen)

2-1. Environmental Treatment at an Alloy Company (290 million yen)

2-2. Taiyuan Jie Central Heat Supply (1,770 million yen)

Of these subprojects, the 1-2. Shenyang Heat Supply (Phase IV Project) subproject was not implemented, and the remaining two were implemented first. This was a consequence of the government policy that forbid the construction of small-scale (5 MW or less) power generators, as well as the policy change of the company associated with the change of shareholder composition, caused by the sales of government-owned stock to private investment companies. As a replacement of 1-2.Shenyang Heat Supply subproject (Phase IV Project), further studies were conducted, which finally led to the addition of the 2-4. Yuhong District Central Heat Supply subproject in 2008.

As was symbolized by two-time extension of loan disbursement period, these cancellations of and repeated changes to subprojects had a significant impact on the efficiency of the project. This gave an undesirable impact on the implementation of the project overall. It can be concluded that there was room for improvement in the subproject selection process so that these negative impacts could have been minimized. In general, when considering the relevance of a project, the consistency with the project and its needs are of the utmost concern. This fact applies to this project as well. Furthermore, it would have been better if studies into the sustainability of this Project had been conducted in a more rigorous manner than with ordinary projects, i.e., that studies had taken into account trends such as the speed at which the Chinese government at the time was reforming its environmental policy and the degree to which it was tightening restrictions. Nevertheless, given the policy environment at the time, it would have been extremely difficult to predict accurately these changes. When one considers the inevitability of canceling certain subprojects, the compatibility and high level of need for environmental improvement projects as a whole, and the great need for the replacement subprojects, these changes above in no way diminish the relevance of this Project.

3.1.3 Relevance to Japan's ODA Policy

The environment was one of the three priority areas for ODA loans to China under the overseas economic cooperation policies at the time. Even under the country-specific policy for operations, China's environmental problem was considered a global problem. The policy, therefore, was to give priority assistance by means of air pollution controls and other steps.

Given the above, this project has been highly relevant with China's development plan,

development needs, as well as Japan's ODA policy, therefore its relevance is high.

3.2 Effectiveness[5] (Rating: [3])

3.2.1 Quantitative Effects (Operation and Effect Indicators)

The target of this Project is to reduce the air pollutants (SO_2/TSP) in the city of Shenyang. However, since the concentration of air pollutants is largely influenced by its external environment, the initial and primary objective of this project is to **reduce emissions of air pollutants by target plants, factories, and facilities**. The long-term objectives shall be analyzed in terms of impact level indicators measuring changes in the concentration of overall air pollutants in Shenyang.

To begin with, an analysis of the operational status of subprojects is shown below.

(1) Heat Supply Subprojects

The primary indicators to assess the operational status of the heat supply subprojects were: the amount of heat supplied, the coverage of the supply (in terms of area), and the number of households supplied with heat. For subprojects 1-2 and 2-2, operation indicators set at the time of project appraisal were not available. For this reason, based on interviews with the implementing agency, the evaluator assessed whether the current operational status is kept at appropriate levels compared to the capacity of the plants and equipment.

1) Subproject 1-2. Shenyang Heat Supply

Table 2: Operational Status of the Shenyang Heat Supply Subproject

	2011	2012
Households supplied with heat	For factories For residents: 30,000 households	For factories For residents: 30,000 households
Amount of heat supplied (Gcal/h)	n/a	80.37
Amount of heat supplied (Gcal/yr.)	n/a	704,053
Area supplied (ha)	280	280

Source: Shenyang Thermal Power Plant questionnaire responses

The main consumer in this subproject had been large-scale consumers such as the nearby pharmaceutical factories. However, upon the relocation of one of the factories originally expected as major consumer, the implementing agency started the supply to households (over an area equivalent to around 2,000,000 m^2). Although the major consumer changes from original plan, both the amount supplied and area of coverage have remained stable, therefore

[5] "Impact" is also factored into the "effectiveness" rating.

the operational status can be deemed good.

2) Subproject 2-2. Taiyuan Jie Central Heat Supply

Table 3: Operational Status of the Taiyuan Jie Central Heat Supply Subproject

	2011	2012
Households supplied with heat	61,857	65,875
Amount of heat supplied (Gcal/h)	360.2	361.2
Amount of heat supplied (Gcal/yr.)	843,969	843,969
Area supplied (ha)	666.35	693

Source: Shenyang Third Heating Co., Ltd.

As for the amount of heat supplied, with the ongoing development of housing, there is expected to be a further increase of 1,000,000 m^2 in coverage over the next two years. The implementing agency commented that the current surplus in supply capacity is enough to fulfill those needs for the foreseeable future. The actual operating rate as a factor of the current capacity of the plant and equipment is about 65%, which is an appropriate load level. Both the number of households supplied and area of coverage are steadily increasing, and the operational status can be deemed good.

3) Subproject 2-4. Yuhong District Xin Cheng Central Heat Supply

Table 4: Operational Status of the Yuhong District Xin Cheng Central Heat Supply Subproject

	2011	2012
Households supplied with heat	31,000	36,000
Amount of heat supplied (Gcal/h)	75.22	109.02
Amount of heat supplied (Gcal/yr.)	274,426	397,700
Area supplied (10,000 m^2)	287	410

Source: Guohui Supply Energy Co. Ltd.

The current area of coverage achieves approximately 80% of its target 5,100,000 m^2, which is deemed satisfactory. One of the reasons the target was not fully achieved is, the Yuhong District Xin Cheng, the area covered by the subproject, is an emerging development zone, and the pace of housing development has slowed from its initial expectations. However, the implementing agency commented that they can achieve its target for sure, with the progress of housing development. The completion of this subproject was the last among those in this Project, and only a few years have passed since the completion of the project. For this reason, it is considered that it is likely that the final supply levels will be achieved.

(2) Factory Environmental Treatment Subproject

Since this subproject was designed to improve overall production line, it was difficult to set indicators that would directly demonstrate the subproject's operational status. That being said, the performance of the factory in terms of output has increased compared to before the subproject was implemented, so it is reasonable to conclude that the operational status itself is stable. The factory's main products are nickel allow rods, wire rods, etc. The annual production has increased from 300 tons before the subproject to the current figure of 540 tons, suggesting that the subproject has gone smoothly.

Figure 3: An Exterior View of the Shenyang Alloy Material Co., Ltd. Plant

Figure 4: The Alloy Production Process

As the above data has shown, all of the implemented subprojects continue to operate smoothly to date and can therefore be deemed to be fulfilling the functions of the initial plans. Next section assesses how these subprojects contributed to the original objective of the project, namely the reduction in air pollutants.

(3) Reduction in Air Pollutants

1) Heat Supply Subprojects

Here we shall examine the degree of reduction in air pollutants the three heat supply subprojects (1-2. Shenyang Heat Supply, 2-2. Taiyuan Jie Central Heat Supply, and 2-4. Yuhong District Xin Cheng Central Heat Supply) had. The objective of the central heat supply subprojects was to eliminate the use of the inefficient, small-scale boilers that had conventionally been used, and replace them with more efficient, centralized boilers, thereby supplying a greater amount of heat with a smaller amount of coal. The effects of these subprojects were examined based on the notion that if there is a reduction in the amount of coal used, there should be a corresponding reduction in the amount of air pollutants emitted in supplying that heat.[6]

[6] The amount of coal consumption necessary to supply the current heat supply coverage area using small-scale boilers of the type used before the Project implementation was calculated, as was the consumption amount necessary to supply the same using the current supply systems. The difference between the two was considered to be the amount of coal saved. Next, the amount of pollutants emitted per unit volume of consumed coal was calculated, and

Table 5: Reduction in Air Pollutants as a Result of This Project

	Before Project implementation	Present	Reduction	Percentage reduced
Total for Three Subprojects				
Coal consumption (t/yr.)	622,350	336,798	285,552	53%
SO_2 emissions (t/yr.)	8,464	4,580	3,884	53%
NOx emissions (t/yr.)	1,805	977	828	53%
1-2. Shenyang Heat Supply				
Coal consumption (t/yr.)	126,000	55,440	70,560	56%
SO_2 emissions (t/yr.)	1,713.6	759.98	959.6	56%
NOx emissions (t/yr.)	365.4	160.7	204.6	56%
2-2. Taiyuan Jie Central Heat Supply				
Coal consumption (t/yr.)	311,850	173,250	138,600	44%
SO_2 emissions (t/yr.)	4,241.1	2,356.2	1,884.9	44%
NOx emissions (t/yr.)	904.3	502.4	401.9	44%
2-4. Yuhong District Xin Cheng Central Heat Supply				
Coal consumption (t/yr.)	184,500	63,960	120,540	65%
SO_2 emissions (t/yr.)	2,509.2	1,470.2	1,038.9	65%
NOx emissions (t/yr.)	535	313.5	221.5	65%

Source: Compiled by the evaluator based on data provided by the Shenyang Environmental Protection Bureau.
The postulates for the calculations were as follows.

1. The raw coal emission factors in the heat supply subprojects are SO_2=13.6kg/t and NOx=2.9kg/t (supplied by the Shenyang Environmental Protection Bureau).
2. The coal combustion efficiency per square meter achieved through the conversion from small-scale boilers to a centralized heat supply improved from 45 kg to roughly 20 to 25 kg (based on data supplied by the Shenyang Environmental Protection Bureau as well as the implementing agency).

The table above suggests that the volume of pollutants emitted annually has decreased to a level that is 53% of what it would have been had the project not been implemented. In other words, pollutants decreased by about half. Of particular note is the 2-4. Yuhong District Xin Cheng Central Heat Supply subproject, which enable a more efficient heat supply through the use of the high-temperature treated water from a wastewater treatment plant, resulting in a more than 60% reduction in coal consumption per square meter, from 45 kg (estimated) before the Project to 15.6 kg after implementation. Although these preliminary calculations are just estimates, given the stable operations of the present subprojects, it can be concluded that this Project more or less brought about all of the reductions in pollutants that could have been

the reduction volume was yielded based on those figures. That being said, because the calculations were based on estimated values, there is the possibility that the figures would fluctuate depending on the actual conditions under which heat is supplied. Additionally, if we consider the fact that the use of low-sulfur coal and the like has spread since the Project was implemented, it is possible that the actual amount of emissions may have been reduced even further.

achieved within the project parameters.

2) Factory Environmental Treatment Subproject (Subproject 2-1. Environmental Treatment at an Alloy Company)

In this Project, because of the nature of the subprojects designed to partially modify factory production processes, it was not possible to collect or verify quantitative data the reduction in pollutants. As an alternative, evaluations were performed using qualitative analyses based on interviews with the implementing agency. The following effects of this Project were confirmed upon discussions with the implementing agency.

- By relocating the factory from the central part of the city of Shenyang to an area outside of the city, the impact on surrounding residents in terms of air quality and noise was successfully reduced.
- Because of changes made to production processes, air pollution, noise pollution, and the amount of wastewater discharge were all reduced. For example, noise pollution was reduced by replacing forging methods with bloom rolling methods, conventional fuel oil heaters were replaced with electric heaters, bag dust removal equipment was installed, and to curb water pollution wastewater treatment processes were adopted, among other positive achievements.

According to the implementing agency, all of the facilities and equipment are operating smoothly. As the scale of production at the factory has grown to levels exceeding those before the project was implemented, it is reasonable to conclude that the amount of pollutants would have been greater without these facilities and equipments. In light of the above, it is reasonable to assume that the amount of these pollutants have been reduced to some extent.

3.2.2 Qualitative Effects

One of the anticipated effects of this project is the improvement of living conditions among residents through improvement in air quality. On this point there is a high correlation with the overall air quality in Shenyang, the impact on which is described in some detail below.

3.3 Impact

3.3.1 Intended Impacts

The major impacts anticipated in this Project consisted of "improvements in the concentration of air pollutants within the city of Shenyang achieved through pollution reduction efforts " and "associated improvements in living conditions among residents". To verify these impacts, concentrations of air pollutants in Shenyang were confirmed over time, and residents were asked via beneficiary surveys how they felt the air quality in the city

Shenyang had changed.

(1) Changes over time in the concentration of air pollutants in Shenyang

The following table shows changes in the concentration of air pollutants in Shenyang from the time the Project was planned to the present as well as comparisons with national standards.

Table 6: Changes over Time in the Concentration of Air Pollutants in Shenyang

Indicators	Before Project implementation		During implementation		Time of the ex-post evaluation		National standards (mg/Nm^3)		Comparison with 1996 levels
	1996	1999	Planned values (2005)	2005	2011	2012	Standard values	Achievement	
SO_2	0.18	0.072	0.056	0.118	0.041	0.042	<0.06	Achieved	23%
NOx	0.075	0.065	0.065	0.054	0.031	0.03	<0.05	Achieved	17%
TSP/PM_{10}	0.422	0.304	0.275	0.037	0.082	0.074	<0.10	Achieved	44%

Source: 2000–2012 Liaoning Province newsletter on the state of the environment.
*As of 2002, TSP measurements were replaced with PM_{10} measurements, so in the table above, the actual values for 2005 onward reflect PM_{10} values. The current national standards for PM_{10} are 0.1 mg/Nm^3.

As shown in the table above, compared to the emission levels at time the Project was implemented, all of the main pollutants have dropped below 50%. Even when we look at the planned figures for Phase 2 of the project, all of the targets had already been achieved by the 2011–2012 period, when the project was nearly complete. National standards (Grade II) were met, even when one takes into account the changes in measurement methods from the time of the project plan (from TSP to PM_{10}). As a result, it can be concluded that the sustained environmental improvement efforts by the provincial government throughout the 2000s which, encompass this project have yielded consistent results. According to the Shenyang Environmental Protection Bureau, because sources of pollution continue to rise with continued urbanization and economic development, concentrations of air pollutants have remained more or less at the same levels for the past several years. For this reason, the government has continued in its efforts, for example the mandatory installation of desulfurizing units on existing small-scale coal-fired boilers of 35 ton or lighter, the mandatory installation of desulfurizing units on new coal-fired boilers, etc. Since 2007, of the 240 small-scale 35 ton boilers within the city, 140 have been upgraded. In addition to these improvements, the Environmental Protection Bureau has indicated that it is further willing to disperse pollution sources, agglomerate businesses within individual industries, go forward with energy diversification plans through the promotion of natural gas use, and take other steps to improve the overall air quality in the city.

Figure 5: The Air around the Shenyang Thermal Power Plant

Figure 6: The Air around Taiyuan Jie

(2) Impressions by residents about the air quality

What follow below is a summary of the results of a beneficiary survey of residents.

Outline of survey

1) Sample size: 50
2) Target area: Ordinary residents of the Tiexi District, Shenyang.
3) Contents of survey: To assess air pollution and associated diseases before the Project was implemented (1990's) as well as subsequent changes afterwards.

Results of survey

- Improvement in the air quality: 82% of respondents said that air quality had improved compared with the 1990s. 76% observed decrease in smog.
- Occurrence of respiratory and similar diseases: 64% of respondents said that incidents of eye pain and respiratory complaints had declined among the respondents themselves or the people around them.
- State of heat supply: Around 90% of respondents said that they were satisfied with the current services (heating functions, etc.).

Remarks

- Because of the limited sample sizes, the results of such a beneficiary survey should be considered useful only as information for reference. Nevertheless, for a phenomenon such as air quality that is so visual and so subject to other sensory impressions, the fact that so many beneficiaries recognize improvements, as noted above, can be afforded some relevance as information demonstrating improvement to the air quality.
- Furthermore, given the high level of satisfaction with the quality of services of the heat supply subproject, it would be reasonable to consider that there are no problems with the Project implementing agency's ability to provide services. This observation also holds true in the analysis of sustainability presented below.

As we have seen above, environmental statistics, data from user interviews, etc. have demonstrated that the air quality improvement initiatives in Shenyang, including those covered by this Project, have had a positive impact.

3.3.2 Other Impacts

(1) Impacts on the natural environment

Under the JICA Guidelines for Environmental and Social Considerations[7], this project is categorized as an ODA loan project whose potential adverse impacts on the environment and society are not significant (Category B). An environmental impact assessment report had already been drafted at the time this project was planned and received final approval from all of the arms of the ministries to approve it.

With regard to the problem of noise associated with the heat supply plants and equipment -a problem that had already been addressed during the planning stage of the project- measures were taken such as the relocation of facilities to suburban areas and installation of insulation system. According to the interview to the officer of implementing agency, major problem related to noise were almost solved by these measures.

(2) Land acquisition and resettlement

The main scope of present Project was improvements to urban heat supply works and the relocation of factories to sites outside of the city. The area of land acquired was 17 hectares, and the number of resettled persons was about 20. For both acquisition and resettlement, discussions were nearly complete at the time of the planning of Project, and no problems have arisen. The issue of land acquisition and resettlement arose when the 2-1. Environmental Treatment at an Alloy Company subproject was relocated to a site within a new development zone owned by the Shenyang municipal government. Compensation and other such procedures were being handled within the framework of the establishment of this development zone, before this subproject commenced.

In light of the above, the intended effects of this project came to be more or less as planned. Hence, both the effectiveness and impact of this project are high.

7 "JICA Guidelines for Environmental and Social Considerations" (established April 2002).

3.4 Efficiency (Rating: ②)

3.4.1 Project Outputs

The outputs actually installed are shown in the table below. There were no substantial changes except minor changes on the specification and composition of equipment as specified below.

Table 7: Main Planned and Actual Outputs of the Subprojects

Planned outputs	Actual outputs
1-1 Improvements to Copper Refining Processes at a Smelting Plant	
Omitted here because the subproject was cancelled.	
1-2 (Shenyang) Heat Supply	
1) Circulating fluidized bed boilers: two 220 t/h units 2) Turbine: one 50 MW unit 3) Generator: one 60 MW unit 4) Other related equipment	Implemented as planned
2-1 Environmental Treatment at an Alloy Company	
Introduced into the following production line with the relocation of the plant: 1) Smelting: 4 vacuum induction furnaces 2) Pressure rolling: continuous rolling press 3) Heat treatment: 4 bright annealing furnaces	Partial modifications made 1) Smelting: 6 vacuum induction furnaces (2 additional units) 2) Pressure rolling: continuous rolling press (as planned) 3) Heat treatment: 6 bright annealing furnaces (2 additional units)
2-2 Taiyuan Jie Central Heat Supply	
1) Chain-grate stoker-fired boilers: three 58 MWh units and one 36 MW unit 2) Heat supply piping: roughly 30 km * Construction for expanded portion 1) 70 MW boilers: 3 units 2) Heat supply pipework 3) Heat exchange station	Implemented as planned
2-3 Jinshan Thermoelectric Expansion	
Omitted here because the subproject was cancelled.	
2-4 (Shenyang) Yuhong District Xin Cheng Central Heat Supply	
1. Central heat supply facility Hot water boiler: one 70 MW unit Steam boilers: one 75t/h unit and three 130/h units Water-source heat pumps: four 4 MW units and eight 9 MW units 2. Heat supply pipe grid: roughly 120 km 3. Heat exchange stations: 20 units	Partial modifications made 1. Central heat supply facility Hot water boiler: one 70 MW unit Steam boilers: one 75t/h unit and one 64 MW hot water boiler Water-source heat pumps: one 8.4 MW unit, three 17 MW units, and one 22.8 MW unit 2. Heat supply pipe grid: roughly 150 km 3. Heat exchange stations: 33 units

Concerning the modifications above, there were applications for additional facilities and equipment submitted and implemented during the cancellations and Project reformatting noted in the section on relevance. For the 2-4. (Shenyang) Yuhong District Xin Cheng Central Heat Supply subproject, there were modifications to the makeup of the boilers, and to the

specifications of the water-source heat pumps, etc. All of these modifications were made in the context of rethinking more effective mechanisms by which heat might be supplied more efficiently.

3.4.2 Project Inputs

3.4.2.1 Project Cost

Because there were numerous subproject cancellations, modifications, and additions in the main project, it is difficult to make a direct comparison of the project costs anticipated at the time of the initial planning and the actual project costs. The comparison made here is between the planned and actual project costs of the final project structure, which excludes canceled subprojects and was finalized after the Phase II subproject replacements had been completed (2008). The planned total project cost was 25,177 million yen, while the actual cost was 22,419 million yen (89%), lower than planned. Some of the reasons that the actual costs were lower were that technological improvements made it possible to substitute some of the heat supply equipment slated to be imported with domestically produced equipment, and that competitive bidding curb costs as a result. Despite the major delay of overall project period, it did not increase the project cost, as there were no significant delays of the procurement and construction schedule which directly leads to the increase of project cost.

3.4.2.2 Project Period

The actual project periods were as follows. In both phases the project period were longer than planned.

Table8: Comparison of project period

Phase 1 of the Project Planned: October 1996 to December 2000 (51 months)	Actual: October 1996 to January 2003 (76 months, a 149% extension relative to the plan)
Phase 2 of the Project Planned: March 2001 to June 2004 (40 months)	Actual: March 2001 to December 2012 (142 months, a 355% extension relative to the plan)

The initial plan was for the 51 months from October 1996 to December 2000, but the actual Project period lasted significantly longer, covering a 76-months from October 1996 to January 2003 (149% of the planned period) and 142-months from March 2001 to December 2012 (355% of the planned period) respectively .

The loan disbursement period for both Phases 1 and 2 were extended. Major delays occurred particularly in Phase 2 because of the reselection of subprojects as noted in section above on Project relevance. Other reasons for delays are listed below.

Table 9: Factors affected to the delay of project period

	Duration delayed	Reasons
Phase 1 of the project	16 months	Delays in procedures in the period before construction could commence: Upon a request by a domestically-funded lending bank, a local corporate entity responsible for the implementation of the Project was established. The steps needed to establish this company and the related agreements for re-lending were the cause of this delay.
	20 months	Delays in procedures for procurement: This was because price negotiations with a turbine supplier took longer than initially planned.
Phase 2 of the project	16 months	Delay in procedures from the signing of an L/A to its effectuation: This was because it took time to re-appropriate the domestic portion of the funds supplied by the lending bank and to finalize the related agreements for re-lending regarding the 1-2. Shenyang Heat Supply subproject.
	6 months	Delays in procurement procedures associated with the SARS epidemic of the first half of 2003
	27 months	Changes to agreements due to the rising prices of raw materials
	9 months	Delays associated with construction on high-voltage transmission lines at the relocation site for the 2-1. (alloy company) subproject
	18 months	Delays associated with necessary repairs at the relocation site building caused by the roof collapsing during the heavy snowfalls in March 2006

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

Initially, there were plans to calculate the financial internal rates of return (FIRR) for the heat supply subprojects, but because the details of the maintenance and operations costs—which would be requisite for FIRR calculations—could not be obtained, the calculations have been omitted from this evaluation report.

In light of the above, although the project cost was within the plan, the project period was exceeded, therefore efficiency of the project is fair.

3.5 Sustainability (Rating: ③)

This Project is made up of several subprojects, and to assess the sustainability of these subprojects, a comprehensive analysis was performed that covered all of the agencies involved with these subprojects, specifically as they relate to the individual operations of the subprojects, as well as the Shenyang municipal government, which is responsible for overseeing these subprojects. It should be noted that the sustainability of the Project is ultimately assessed by way of the implemented subprojects.

3.5.1 Institutional Aspects of Operation and Maintenance

(1) Executing agency of the project

The agency responsible for overall management of the subprojects was the project office

set up inside the Shenyang Environmental Protection Bureau called the "Green Public Office." The people who were involved in the planning and implementation of this Project are still involved in the supervision of the subprojects. The Environmental Protection Bureau is the governmental agency in charge of environmental monitoring, and it does have a certain degree of authority over the companies, factories, and plants it monitors with regard to environmental concerns. Accordingly, even though this Project is over, as a monitoring agency the Bureau is still in a position to exert influence over these entities. During the field study, it was relatively easy to obtain the cooperation of the personnel involved with the subprojects. It can be concluded that there are no problems with the authority or institutions of the city government.

(2)Subprojects

Organizational and other changes did occur as follows in relation to the subprojects.

Table 10: Current institutional status of implementing agencies

Subproject	Time of plan	Present (2013)
1-2 (Shenyang) Heat Supply	Entity name: Shenyang Thermal Power Plant A state-owned corporation under the jurisdiction of the People's Government of Shenyang	**Changed since time of plan: privatized** The current operating entity is Dongdian Shenyang Thermal Power Company, which was established in 1998 and controlled by a private-sector company owned by multiple investment companies. There are currently 248 employees. Of those employees, those involved with the operations of heat supply-related plants and equipment are as follows: 22 employees in technical divisions, and six employees in planning divisions.
2-1 Environmental Treatment at an Alloy Company	Entity name: Shenyang Alloy Co., Ltd. A corporation with more than 50% of shares owned by the government, hence a *de facto* state-owned corporation	**Changed since time of plan: privatized** The company was renamed as Shenyang Alloy Material Co., Ltd.. As for the capital investment structure, the company was state-owned at the time of Project implementation, but ownership subsequently changed hands to an investment group called Xinjiang D'Long Co. Ltd, and is currently a private-sector corporation controlled by companies led by Liaoning Equipment Group Co., Ltd. There are currently 240 employees.
2-2 Taiyuan Jie Central Heat Supply	Entity name: Shenyang Third Heating Co., Ltd. (a corporation funded wholly by the government)	**Changed since time of plan: privatized** The company was reorganized in 2003, and renamed the Shenyang Third Thermal Heating Co.., Ltd. and privatized. At present it is owned by private-sector investment companies led by the Hong Kong-based Linz Global (HK) Limited. Employees involved with the operations of heat supply-related plants and equipment are as follows: 12 employees in technical divisions, and six employees in planning and administrative divisions.
2-4 Yuhong District Xin Cheng Central Heat Supply	Entity name: Shenyang Guohui Supply Energy Co. Ltd. (a corporation funded wholly by the private sector)	**No change since time of plan** The current plant and equipment operations staff consists of 93 employees assigned to production equipment, and total 109 assigned to pipelines and heat supply stations.

Source: Compiled by the study team based on questionnaire responses.

Institutional framework such as organizational setup, personnel assignment are basically kept at appropriate level, and no major problems were observed. Points of potential concern that deserve particular attention in the overall Project are as follows.

2-1 Environmental Treatment at an Alloy Company

The changes in the makeup of investors did have influence on delays in the commencement of the Project, as noted above on the section on efficiency. There have been no major changes since the establishment of the management systems by the current major shareholders. In fact, a certain stability has been established. Because the plants and

equipment introduced as a consequence of the project involved entire production lines, the details of how many and which personnel are assigned to what duties are unclear. There is no shortage of operational personnel at present. However, because of the overall improvement in working conditions across China, it is becoming more difficult to hire new graduates.

2-2 Taiyuan Jie Central Heat Supply

For the purposes of operations, there is no problem with the current size of the staff. Additionally, staff members have been assigned appropriately. In addition, they have been successfully promoting streamlining staff assignment by taking measures such as installation of unmanned computer controlled equipment, improving the efficiency of heat distribution pumps.

3.5.2 Technical Aspects of Operation and Maintenance

Upon visiting the various facilities in the field studies, the study team was able to check the status of the technologies and other factors relevant to the actual operations. The statuses of each project are shown below. No major problems were found.

Table 11: Technical aspect of operation and maintenance (subproject-wise)

Subproject	Outline
1-2 (Shenyang) Heat Supply	**No problems** Technology-wise, the current supply facilities are not that advanced, which means that it has been possible to operate the facilities in a stable manner with no apparent problems.
2-1 Environmental Treatment at an Alloy Company	**No problems** Technology-wise, the current supply facilities are not that advanced, which means that it has been possible to operate the facilities in a stable manner with no apparent problems.
2-2 Taiyuan Jie Central Heat Supply	**No problems** There are technical qualifications and training programs in place regarding the operations of the plants and equipment, and there have been no major problems. Furthermore, power consumption is being curbed with the implementation of unmanned computer controlled equipment and more efficient heat distribution pumps, which is evidence of the success of these cost-cutting measures. These are just some examples of higher technological standards facilitating efficiency initiatives.
2-4 Yuhong District Xin Cheng Central Heat Supply	**No problems** There are technical qualifications and training programs in place regarding the operations of the plants and equipment, and there have been no major problems. This company originally handled the development of new and energy saving devices. The personnel involved with technological development are of a rank above the technological and development staff of other companies. The company is currently designated by the government as a high-tech national firm, which amply demonstrates that it has the technical capabilities necessary to operate the Project.

Source: Compiled by the study team based on questionnaire responses.

Major trends are as follows:

1) Most of the plants, equipment, and technology implemented as part of this Project were already things that were established. They were not particularly advanced technologies.
2) From interviews with personnel upon visiting the facilities and reviewing the responses from questionnaires, it was clear that the qualifications systems for operational staff and technical seminars had been properly instituted. As a result, it was found that there were no problems present in terms of the operational capabilities for the duties necessary. The overall technological capabilities were thus judged to present no problems.
3) The technologies and production processes introduced as part of subprojects 2-2 and 2-4 have contributed to lower production costs and improved financial statuses. There seems to be room to implement similar initiatives in other heat supply projects.

3.5.3 Financial Aspects of Operation and Maintenance

According to the FY2012 Profit and Loss statement, the revenues and expenditures for the subprojects were as follows.

Table 12: Subproject Revenues and Expenditure (2012)

(Unit: 1,000 yuan)

	Operating revenues	Operating expenditures	Operating profits	Net profits
1-2 Heat Supply	225,199	229,702	-4,503	-1,760
2-1 Environmental Treatment at an Alloy Company	161,496	176,960	-15,464	2,363
2-2 Taiyuan Jie Central Heat Supply	255,694	267,182	-11,487	-6,032
2-4 Yuhong District (Shenyang) Central Heat Supply	110,978	84,823	26,173	23,287

Source: Supplied by the subproject implementing agency

Among the heat supply subprojects, subprojects 1-2 and 2-2, which employ conventional heat supply methods, have either gone into the red in terms of operating profits or seen negative profits because of the rise in the price of coal.[8] Subproject 2-4, which seeks to supply heat using highly-efficient treated wastewater, has achieved a high level of profitability among the subprojects within this Project. In the 2-2 Taiyuan Jie Central Heat Supply subproject, progress has been made in making manufacturing processes more efficient, as shown in the section on technical aspects above, and this has contributed to cost cuts.

[8] Although the net profit of 2-2 Taiyuan Jie Central Heat Supply in FY2011 marked slight red of 0.138 million Yuan, the account was barely break-even. Major factor of red was presumably the increase of operating expense such as the cost of raw materials, which rose 10% from previous year. In FY2010, when the operating expense increased similarly, the local government subsidized of approximately 2.185 million Yuan. Likewise, the local government subsidizes the executing agency when it is deemed necessary.

Going forward, there are plans to implement equipment using residual heat from steam turbines. The following is a table of key performance indicators based on balance sheets.

Table 13: Subproject Management Indicators

Subproject name	Indicator	2010	2011	2012
1-2 Heat Supply	Capital-to-asset ratio	33%	28%	35%
	Debt ratio	308%	357%	283%
2-1 Environmental Treatment at an Alloy Company	Capital-to-asset ratio	n.a	n.a	n.a
	Debt ratio	n.a	n.a	n.a
2-2 Taiyuan Jie Central Heat Supply	Capital-to-asset ratio	6.64%	6.90%	7.27%
	Debt ratio	1507%	1448%	1375%
2-4 Yuhong District Xin Cheng Central Heat Supply	Capital-to-asset ratio	20.7%	13.2%	9.6%
	Debt ratio	483%	758%	1045%

Source: Supplied by the subproject implementing agency

In terms of capital-to-asset ratio and their debt-ration, which reflect the financial health of the subprojects, there are variations depending on the particular subproject. For example, the debt-to-asset ratio of the 2-2 Taiyuan Jie Central Heat Supply subproject is high, but in recent years it has gradually fallen. With the 2-4 Yuhong District Xin Cheng Central Heat Supply subproject, there has been an increase in equipment investment to expand the heat supply coverage area, and as a result the debt-to-asset ratio has risen. However, the profitability of this project is high, and with expansions in areas of supply coverage going forward, the economic situation is expected to stabilize. With regard to other subprojects, in the past several years there have been no extreme fluctuations of the kind that would ensue major operational changes.

3.5.4 Current Status of Operation and Maintenance

In all subprojects, although we need to take the fact into account that their period of operation are just few years after their full operation, there found no substantial problem on the operation and maintenance of their facilities. We confirmed, based on the record of maintenance examined during field survey, that there has been no major failures. Given the stability of institutional, technological, or financial issues examined so far, it is reasonable to conclude that an adequate and proper operation and maintenance system is in place.

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

4. Conclusion, Lessons Learned and Recommendations

4.1 Conclusion

This project was implemented with the aim of improving the worsening air quality in the city of Shenyang. The subprojects finally selected were consistent with the needs and therefore were appropriate; however, in the process of project formulation, there were repeated cancellations and replacement of subprojects. These caused delays of the project implementation period, so it can be said that there was some room for improvement in the subproject planning and selection processes. The reduction in air pollutants by the project was prominent, and all of the expected results were achieved. Neighborhood residents commented that they noticed the improvement in air quality, and actual improvements were recognized in the concentration of air pollutants within the city of Shenyang. Hence, it can be concluded that the project made contributions to the improvement of air quality in the city. The equipment installed during the project is still being used effectively, and there appear to be no problems in terms of institutional, technical, and financial sustainability.

In light of the above, the project is evaluated to be highly satisfactory.

4.2 Recommendations

4.2.1 Recommendations to the Executing Agencies

None

4.2.2 Recommendations to JICA

None

4.3 Lessons Learned

It is fair to conclude that this Project as overall had a high effect, but as a result of multiple subproject cancellations, reselections, etc., there were major delays reflected in the Project period. In the Phase 1 part of the Project in particular, changes in policies at the central government led to bankruptcies of implementing institutions, and in turn led to the cancellation of certain subprojects. They ultimately did not lead to major losses since it happened before investment. But had the timing been different, there could have very well been a situation in which subprojects were cancelled after having invested considerable amounts in them. During the selection process, it was true to observe the need for subprojects to be able to adapt and there were little foreseeability of policy changes at the time. However, during subproject selection process, major subprojects account for around half of the total budget need to be carefully examined, taking the factors such as sustainability over the long term as well as relevance into account. In China, where the effects of national policy are particularly powerful, it is necessary not only to study the implementation capabilities of individual agencies, but also to consider the subproject selection process with a view to the risk including change in related policies. Especially, detailed assessment should be conducted when selecting the implementing agency

from private sector, which by its nature include relatively higher risk of bankruptcy. In such cases, it was necessary to perform detailed analyses that examined not just the particular needs of subproject, but the sustainability including examinations of the degree of involvement of a government in such implementing agencies over the medium- and long-term.

Comparison of the Original and Actual Scope of the Project

	Original plan	Actual outcome
1.Project Outputs 1-2 (Shenyang) Heat Supply	Circulating fluidized bed boilers: two 220 units Turbine: 1 unit Generator: 1 unit Other related equipment:	As planned As planned
2-1 Alloy Company	Smelting: 4 vacuum induction furnaces Continuous rolling press Furnaces: four heat treatment units	Smelting: 6 vacuum induction furnaces (2 additional units) Pressure rolling: continuous rolling press (as planned) Heat treatment: 6 furnaces (2 additional units)
2-2 Taiyuan Jie Central Heat Supply	Chain-grate stoker-fired boilers: three 58 MWh units and one 36 MW unit Heat supply piping: roughly 30 km * Construction for expanded portion 70 MW boilers: 3 units Heat supply pipework Heat exchange station	As planned
2-4 Yuhong District Xin Cheng Central Heat Supply	Central heat supply facility Hot water boiler: one 70 MW unit Steam boilers: one 75t/h unit and three 130 MW hot water units Water-source heat pumps: four 4 MW unit and eight 9 MW units Heat supply pipe grid: roughly 120 km Heat exchange stations: 20 units	Central heat supply facility Hot water boiler: one 70 MW unit Steam boilers: one 75t/h unit and one 64 MW hot water boiler Water-source heat pumps: one 8.4 MW unit, three 17 MW units, and one 22.8 MW unit Heat supply pipe grid: roughly 150 km Heat exchange stations: 33 units
2.Project period	Phase 1: October 1996 to December 2000 (51 months) Phase 2: March 2001 to June 2004 (40 months)	Phase 1: October 1996 to January 2003 (76 months) Phase 2: March 2001 to December 2012 (142 months)
3.Project costs Amount paid in Foreign currency Amount paid in Local currency Total Japanese ODA loan	 11,196 million yen 13,981 million yen (989 million yuan) 25,177 million yen 11,196 million yen	 7,781 million yen 14,638 million yen (989 million yuan) 22419 million yen 7,781 million yen

portion Exchange rate	1 yuan=15.05 yen (Phase 1) 1 yuan=13.00 yen (Phase 2)	1 yuan=14.26 yen (Phase 1 1996 - 2004 average) 1 yuan=13.91 yen (Phase 2 2001-2013 average)