People's Republic of China

Ex-Post Evaluation of Japanese ODA Loan Project
Beijing Environmental Improvement Project

External Evaluator: Noriyo Aoki, IC Net Limited

0. Summary

The objective of the project is to replace small size coal combustion boilers and cut down on emissions of various different pollutants by introducing co-generation facilities[1] that use natural gas in the Beijing Electronic Zone,[2] thereby contributing to reducing the air pollution.

The project is consistent with the priority areas in China's development plans related to its countermeasures against air pollution, as well as with Japan's ODA policy. The development needs is also high in China. Therefore the relevance of the project is high. The project has largely achieved major effect indicators like reducing air pollutants, and the beneficiary surveys performed through the evaluation study confirmed that the project contributed to reducing the air pollution in the electronic zone. Therefore the effectiveness of the project is high. The project's efficiency is fair because the project period took more time than planned but the project costs were lower than planned. The institutional aspects, technical aspects, financial aspects, and current status of operation and maintenance are satisfactory. Therefore, the sustainability of the project is high.

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

1. Project Description

Project Location

Gas turbine
(stored within a soundproof structure)

[1] Co-generation refers to highly energy efficient systems wherein gas turbines are used to simultaneously obtain two types of energy in the form of electricity and heat.

[2] Situated in the northeastern part of Beijing, the Beijing Electronic Zone was developed as a zone for promoting investment in priority sciences and technologies in order to gather high-tech industries. At the time of the ex-post evaluation its site area had grown to 12.78 million m^2. Also by the time of the ex-post evaluation approximately 200 electronics companies from China and 29 major foreign IT-related companies had made inroads there, including the Electron Science Institute and specialized educational institutions related to electronics.

1.1 Background

Although China has achieved rapid economic growth, it has also seen worsening environmental pollution since the 1980s as a result of industrialization and population increases. For this reason, the Chinese Government has been strengthening its environmental protection policies and has even achieved some measure of success with these, particularly in the latter half of the 1990s, but the pollution situation remains at serious levels. Regarding the air, sulfur dioxide (SO_2), total suspended particular (TSP),[3] and nitrogen oxide (NOx) are among the pollutants that have grown severe as a result of burning coal, which serves as the country's principal source of energy.

During the planning, the air pollution in Beijing exceeded Grade II of the National Ambient Air Quality Standards (NAAQS)[4] established by the Chinese Government. The targeted project region has been pressed to accommodate the fact that Beijing has mandated the abolishing of coal boilers within its urban areas.[5]

Table 1: Air Pollution Conditions in Beijing during the planning (Unit: mg/m^3)

Indicators	1997	1998	1999	2000	NAAQS Grade II
SO_2 emissions	0.099	0.152	0.140	N.A.	0.05
NOx emissions	0.040	0.120	0.080	0.071	0.06

Source: Appraisal document

Coal boilers used for heating emitted vast quantities of soot dust and other air pollutants, particularly in the vicinity around the electronic zone, and this has an impact on the lives of the nearby residents.

1.2 Project Outline

The project will replace small size coal combustion boilers and cut down on emissions of various different pollutants by introducing co-generation facilities that use natural gas in the Beijing Electronic Zone, thereby contributing to reducing the air pollution in the zone.

[3] Total suspended particular refers to particulate matter that is 100 microns in diameter or smaller, such as soot dust, that is suspended in the atmosphere. Whereas soot dust is emitted as a result of combustion, dust is generally given off from the crushing and sorting of objects.

[4] For SO_2 and NO_2 this is the same as the national ambient air quality standards enacted in 1996. The environmental standards that were revised in February 2012 raised the average value of 100 $\mu g/m^3$ for PM10 from the air quality standards from 1996 to 70 $\mu g/m^3$, while also newly establishing indicators for PM2.5.

[5] Notice on measures to curtail air pollution in Beijing (March 2001)

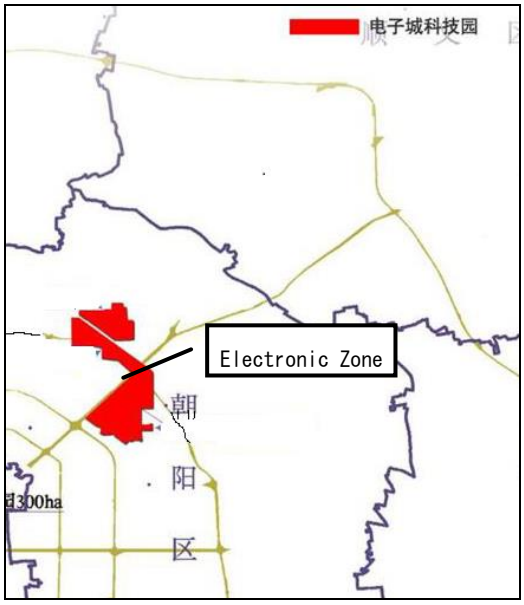


Figure 1: Project Site[6]

Loan Approved Amount/ Disbursed Amount	8,963 million yen / 8,961 million yen
Exchange of Notes Date / Loan Agreement Signing Date	March 29, 2002 / March 29, 2002
Terms and Conditions	• Interest Rate: 0.75% • Repayment Period: 40 years (Grace Period: 10 years) • Conditions for Procurement General untied (main body) Bilateral tied (consultant)
Borrower / Executing Agency(ies)	Government of the People's Republic of China / People's Government of Beijing Municipality
Final Disbursement Date	July 26, 2010
Main Contractor	China Electric Power Technology Import and Export Corporation (People's Republic of China) / Kawasaki Heavy Industries, Limited (Japan) JV
Main Consultant	Tokyo Electric Power Services Co., Ltd.
Feasibility Studies, etc.	F/S study, North China Power Engineering Co., Ltd., April 2001
Related Projects	None in particular.

[6] Chaoyang District in Beijing, where the electronic zone is located, houses numerous foreign diplomatic missions, foreign investment firms, Beijing Capital International Airport, and more.

2. Outline of the Evaluation Study

2.1 External Evaluator

Noriyo Aoki (IC Net Limited)

2.2 Duration of Evaluation Study

The studies have been carried out over the following durations for the ex-post evaluation.

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

None in particular

3. Results of the Evaluation (Overall Rating: A[7])

3.1 Relevance (Rating ③[8])

3.1.1 Relevance with the Development Plans of China

3.1.1.1 Development Plans at the Time of the Appraisal

In its Tenth Five-Year Plan (2001–2005) the Chinese Government set forth countermeasures against sources of air pollution and improving urban environments as its highest priority issues, and set out the objective of reducing the sum total of emissions of major pollutants by 10% relative to the year 2000. In its Tenth Five-Year Plan on Environmental Protection (2001–2005) it laid out a separate objective of cutting down on emissions, particularly of SO_2, by 20% as a specific numerical objective. In Beijing's Tenth Five-Year Plan (2001–2005), the government of Beijing set out its plan to modify its energy consumption structure and cut down on gas emissions by restricting the use of raw coal and expanding the use of natural gas. As far as specific measures go, it has promoted the issuance of an order to abolish coal boilers within the urban area as well as improvements to regional heat supply systems, including the adoption of natural gas co-generation projects.

3.1.1.2 Development Plan at the Time of the Ex-post Evaluation

At the time of the ex-post evaluation, in its Twelfth Five-Year Plan (2011–2015) the Chinese government indicated its plans to further strengthen its efforts to combat air pollution, and set out the objective of cutting net emissions of major pollutants by 8–10% relative to the year 2010. This is especially true for SO_2 and NOx, which it is aiming to reduce by 8% and 10%, respectively. In its Twelfth Five-Year Plan on Environmental Protection (2011–2015) it states that it will substantially reduce its emissions of major pollutants and continue to promote emissions reductions for pollutants in the electricity industry by the year 2015. In

[7] A: Highly satisfactory, B: Satisfactory, C: Partially satisfactory, D: Unsatisfactory

[8] ③: High, ②: Fair, ①: Low

Beijing's 12th Five-Year Plan (2011–2015) it set forth its goal to curb its emissions of pollutants down to the level of developed countries by adopting low NOx burner technology and exhaust gas denitration technology in power plant projects. It also states that it will achieve making the area inside Beijing's fifth ring roads[9] coal-free (transforming the region into one that does not use coal boilers) by the year 2015.

Based on the above, since the project aimed to improve air pollution, which was deemed a priority area within the development plans at the national and Beijing levels, it is highly relevant with the country's development plans both at the time of the appraisal and the time of the ex-post evaluation.

3.1.2 Relevance with the Development Needs of China

The electronic zone set up by the Beijing Municipality Government 40 years ago led to a surge of foreign companies entering the market amidst the country's economic development. However, improvements in the environmental infrastructure have lagged behind, and projects for supplying heat by using coal as their fuel have been carried out. Small coal boilers with poor combustion efficiency and with poor performing equipment for removing soot dust have been used in these facilities, which have brought about air pollution in the vicinity around the electronic zone. The early abolishing of the coal boilers within the urban area had to be done based on a notice from the Beijing Municipality Government.

This project is the first full-scale co-generation project by natural gas in Beijing. Its implementation was requested so that it could be positioned as a model project from the perspectives of cutting down on emissions of pollutants and conserving energy in order to disseminate similar types of projects in the future.

At the time of the ex-post evaluation, companies continued to make inroads into the electronic zone, which accounted for 23.9% of Chaoyang District's gross industrial production (2010), and it features many high tech industries. Owing to this, its gross industrial production has been increasing at 11.1% a year.[10] The rate of increase for the population in the electronic zone has remained high at 2.2%,[11] and, owing to the unparalleled convenience of the zone, it will continue to see real estate development and the entry of other companies on into the future. The expectation is that this will further increase the need for this project.[12]

The co-generation facilities that were introduced employ environmental protection technology. They were advanced with the dry gas turbine burners and other equipment, and were not yet in wide use in China back at the time. As a result, they met the demands for the NOx emissions standards for co-generation facilities in Beijing at the time of the ex-post evaluation. Beijing has decided to raise its NOx emissions standards for gas turbines no more

[9] These are ring roads that pass around the outer circumference around Beijing about 10 km from the city center. The electronic zone is located within the fifth ring roads.
[10] 2011 Chaoyang District Public Relations Statistics for the National Economy and Social Development
[11] 2011 Chaoyang District Public Relations Statistics for the National Economy and Social Development
[12] From the results of the hearings with the Electronic Zone's Jiuxianqiao Community Committee

than 15 ppm in 2014. They will be also compliant with the emissions standards required in 2014.

Since the project plan met the needs above, the need for the project's implementation was affirmed.

3.1.3 Relevance with Japan's ODA Policy

At the time of the appraisal, Japan International Cooperation Agency (JICA) defined environmental improvement projects as one of its three priority areas when it came to ODA loans to China in its Medium-Term Policy for Overseas Economic Cooperation Operations. In its country-specific policy for operations, it positioned environmental problems in China as global issues, and laid out its policy to give priority to supporting these through countermeasures against air pollution. The Japanese Government's Economic Cooperation Plan for China (2001) defined the assistance cooperation for dealing with global issues like environmental problems as the highest priority. All of these assistant policies addressed the strengthening support for environmental measures by introducing clean energy in projects for public utility, such as by switching over from coal to natural gas.

In light of the above, the implementation of this project is sufficiently consistent with China's development plans, the development needs and Japan's ODA policies, therefore its relevance is high.

3.2 Effectiveness[13] (Rating: ③)

3.2.1 Quantitative Effects

3.2.1.1 Operation Indicators

The objective of this project is to abolish small coal boilers and cut down on emissions of various different pollutants by introducing co-generation facilities that use natural gas. Therefore, the project's effectiveness was determined based on operation indicators in the form of the amount of electricity generated annually and the amount of heat supplied annually, as well as effect indicators in the form of the number of boilers abolished, the reduction in the amount of coal used, and the amount by which pollutants were reduced.

As is shown in Table 2, the amount of electricity generated annually by this project went according to plan. The actual amount of electricity generated is not determined by the demand for electricity, but rather the amount of electricity sold that was contracted with the electricity seller.

The target figure for the amount of heat supplied annually was set at a maximum capacity of 3.147 million GJ over the medium to long-term.[14] While the year by which this will be achieved has not been clearly defined, the actual figure for 2011 amounted to 39% of the

[13] The impact is also taken into consideration when determining the effectiveness for the rating.
[14] 2002 F/S document

planned maximum capacity. The Beijing Zhengdong Electronic Power Group Co., Ltd. anticipates that it will be 2020 or beyond (when demand will grow) before this capacity is met. Clear target figures were not established at the time of the planning for the actual heat supply results at this point in time. While a strict verification is difficult, the area to which heat is supplied has already reached approximately 60% of the planned figure, and this figure immediately after the project's implementation could be evaluated as showing favorable growth.

Aside from this, when it comes to heat supply, energy saving designs kept coming down in price, houses started using double windows, and heat insulating materials came to be used in walls and floors, all of which had an impact on demand during the course of the implementation period. A project to newly rebuilt housing complexes for workers at former state-owned factories, which had been planned since 2006, was delayed because of a steep increase in land prices. Therefore, provisions from this rebuilding project are slated to begin starting in 2015. As was mentioned in 3.1.2, a strong possibility of future expansion of heat supply is expected, since companies continue to make inroads into the electronic zone, which would bring stable growth of demand in the future.

Table 2: Operation Indicators for the Project

Name of indicator	Before the implementation of the project (produced by small boilers)	Target figures (after the implementation of the project) No specified FY	Actual figures (2010)	Actual figures (2011)
Amount of electricity generated annually	Not applicable	571 GWh	571 GWh	571 GWh
Amount of heat supplied annually	Consistent data could not be obtained	3,147,100 GJ Note 1)	790,000 GJ Note2)	1,230,000 GJ
Area to which heat is supplied annually	3 million m^2	5.15 million m^2 Note1)	1.88 million m^2 Note 2)	3.04 million m^2

Source: Answers to a questionnaire by Beijing Zhengdong Electronic Power Group Co., Ltd., 2002 F/S materials

Note 1) The maximum capacity after the implementation of the project was set as the target figure at the time of the appraisal, and this maximum figure made possible the area to which heat was supplied of 5.15 million m^2. The amount of heat supplied per 1 m^2 of area was calculated to be 3.147 million GJ/5.15 million m^2 = 0.61 GJ/m^2.

Note 2) As energy conservation has advanced the amount of heat supplied per 1 m^2 of area in 2010 came to 790,000 GJ/1.88 million m^2 = 0.42 GJ/m^2, while in 2011 it came to 1.23 million GJ/3.04 million m^2 = 0.40 GJ/m^2. The amount of heat supplied per unit of area reveals that energy saving effects have been making forward progress.

3.2.1.2 Effect Indicators

Before the start of the project there were a total of 128 small coal boilers in use in the electronic zone. However, as the abolishing of these inefficient small coal boilers through the project progressed, 119 boilers beyond the target of 102 boilers were abolished. Six coal boilers at the housing complexes for workers at former state-owned factories that were scheduled to be newly rebuilt as well as three such boilers from projects like an old hospital that could not be rebuilt were in use in the target year of the first year after operation began (2011), and were still being used at the time of the ex-post evaluation (May 2013). With the progress of abolishment of the above-mentioned boilers, as can be seen below, the amount of coal used was decreased by 356,000 tons a year, while the amount by which pollutants were reduced. Actual results exceeded the target figures for these indicators.

Table 3: Effect Indicators for the Project

Name of indicator	Amount of pollutants emitted / amount of coal used			Amount by which pollutants were reduced		
	Standard value (1) (2000)	Target figures (2) (1st year after the start of operation)	Actual figures (3) (2011)	Target reduction amount (2011) (1)-(2)=(4)	Actual reduction amount (2011) (1)-(3)=(5)	Plan vs. target (4)/(5)
No. of small coal boilers	128	26	9	Decrease of 102	Decrease of 119	117%
Amount of coal used annually[Note)]	400,000 tons/year	100,000 tons/year	44,000 tons/year	300,000 tons/year	356,000 tons/year	118%
Amount of soot dust emitted annually[Note)]	2,200 tons/year	526 tons/year	57 tons/year	1,674 tons/year	2,143 tons/year	128%
Amount of SO_2 emitted annually Note)	2,160 tons/year	439 tons/year	121 tons/year	1,724 tons/year	2,039 tons/year	118%
Amount of NOx emitted annually Note)	1,614 tons/year	600 tons/year	152 tons/year	1,014 tons/year	1,462 tons/year	144%

Source: Answers to a questionnaire by Beijing Zhengdong Electronic Power Group Co., Ltd.

Note) The amount by which pollutants were reduced and the amount of coal used submitted by Beijing Zhengdong Electronic Power Group Co., Ltd. were calculated from the number of boilers that were abolished, and were not figures that were obtained by monitoring or the like.

Note) For this table, the reduction amount was obtained from the reduction in the amount of coal used. However, aside from this, 75 tons of NOx are emitted from the co-generation facilities annually.

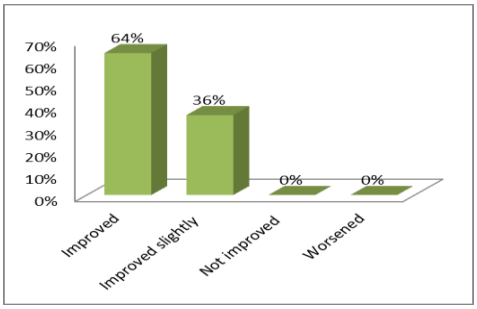
3.2.2 Qualitative Effects

3.2.2.1 Air Pollution Reduction Results for the Electronic Zone

During interviews with the faculty at an elementary school within the electronic zone, they responded to the effect that abolishing the small boilers and switching over to heat exchange stations had reduced soot dust within the elementary school and on the outskirts and had cleaned up the air. In addition, previously trucks hauling coal came and went out from a coal repository during the winter, but now this repository has been removed and it has been turned into a safe playground for children. This is but one of the improvement effects on the living environment that have been acknowledged.

Figure 2 : An abolished small coal boiler

Figure 3 : Interview survey with the faculty at a school in the electronic zone



Source: Results of the beneficiary surveys
Figure 4: People who responded that, "The air pollution in the area around the electronic zone, especially the area around the coal boilers, has improved."

Beneficiary surveys were carried out in order to determine the results from the project.[15]

With regard to the specific effects from the reduction of air pollution from the coal boilers in the electronic zone, 44% of the respondents replied that the pain in their eyes, throats, and so forth had abated, 52% answered that this had somewhat abated, 4% answered that it had not abated, and 0% answered that it had gotten worse. The responses as to the reasons why this had not abated were because the air pollution from vehicles and other sources of pollution in the region had not been improved.

As for the fact that people could not hang their laundry outside because of the soot dust from the boiler combustion in the winter, 36% said that this had improved, 54% said it had somewhat improved, 3% said it had not improved, and 0% said that it had gotten worse. Regarding the fact that windows could not be opened because of the soot dust from the boiler combustion in the winter, 46% said that this had improved, 44% said it had somewhat improved, 8% said it had not improved, and 2% said they did not know. From the beneficiary surveys it was confirmed that emissions of soot dust from coal boilers in *the electronic zone had been reduced through this project,* thereby bringing about improvements in the living environment.

Figure 5: Visit by officials from a design institute with an interest in the co-generation project
(Photo provided by Beijing Zhengdong Electronic Power Group Co., Ltd.)

3.2.2.2 Contribution to Setting in Place Infrastructure with Low Environmental Load

In its capacity as a natural gas co-generation model project, the project employed advanced emission reduction technologies and energy efficiency technologies. Many design institutes and construction contractors are considering adopting similar projects in the future, and have visited Beijing Zhengdong Electronic Power Group Co., Ltd. from this project. By the year 2014, four co-generation centers will be constructed within the city through the backing of the Beijing Municipality Government. Thus this project's applicability as a model for similar projects was confirmed.

[15] For the beneficiary survey 50 local residents were selected, and the sampling focused on people who had lived in the region of the area around the electronic zone and where the coal boilers had been operating from prior to the project (carried out at the end of February 2013).

3.3 Impact

3.3.1 Impact Status

3.3.1.1 Status of Air Pollution in Beijing

The amount of air pollutants in Beijing has continued to decline year by year, and in 2004 the reduction in the amount of SO_2 achieved Grade II of the NAAQS, while emissions of NOx achieved this in 2006. Conversely, major improvements have not been observed when it comes to the overall state of air pollution. This is because factors that increase pollutants have risen rapidly, such as the increase in the population as a result of economic and urban development and the rapid surge in automobile ownership. The population rose from 13.64 million[16] in 2000 to 20.19 million in 2011, while car ownership went from 3.5 million vehicles[17] in 2008 to 5.2 million vehicles in 2012. While there have been results in reducing air pollution, such conditions that occur simultaneously serve to counterbalance the results of the countermeasures.

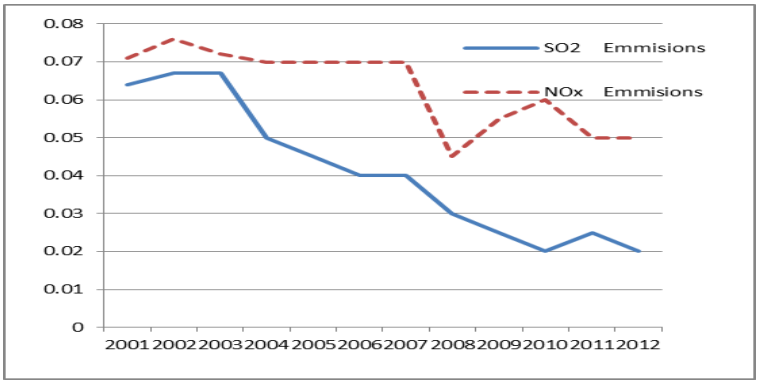


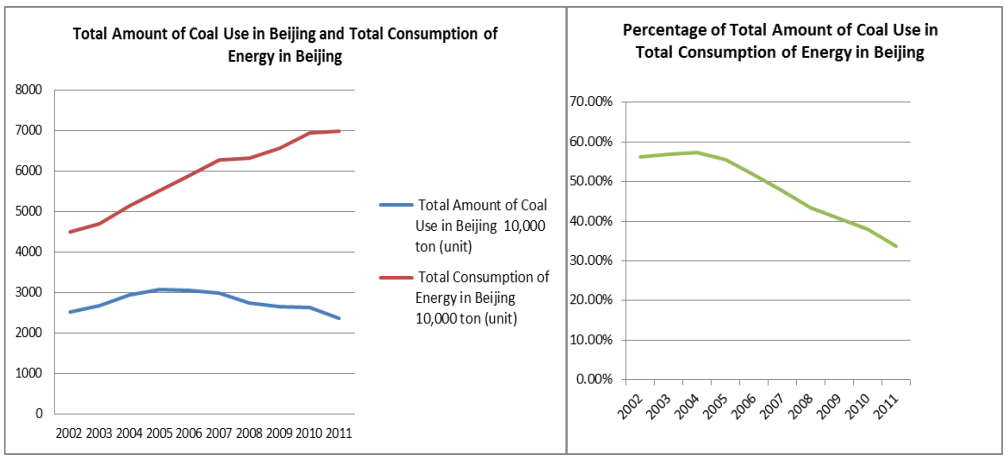
Figure 6: Status of Air Pollution in Beijing

Table 4: National Standards for Measures against Air Pollution in Beijing

	Standard At the time of the appraisal	Standard At the time of the ex-post evaluation	Actual Value at the ex-post evaluation time
Name of standard	Grade II of NAAQS	Grade II of NAAQS	Year of 2012
SO_2 emissions	0.05	0.05	0.02
NOx emissions	0.06	0.06	0.05

Source: Beijing Municipal Environmental Protection Bureau

[16] Beijing Municipal Bureau of Statistics
[17] Survey by the China Association of Automobile Manufacturers, the definition was number of vehicles registered.



Source: Beijing Statistical Yearbook, data from the Beijing Municipal Environmental Protection Bureau

Figure 7: Amount of Coal Used and Total Energy Consumption in Beijing

The proportion of net energy consumption in Beijing accounted for by the amount of coal used is shrinking. When the change in the amount of coal consumed in Beijing and the electronic zone is compared, the amount of coal used in the electronic zone that accounts for the amount used in Beijing in total fell from 1.6% in 2000 to 0.19% in 2011. The growth in the overall amount of coal consumed in Beijing had been holding steady since the latter half of the 2000s, but has started to fall, during which the share of the amount of coal used by the electronic zone has been declining. It was confirmed that the reduction in the amount of coal used in this zone advanced at a pace that surpassed that of the city as a whole. While the proportion of coal used in the electronic zone is a small part of the overall amount, it has been acknowledged that it contributes to some extent as part of the air pollution measures in Beijing. Moreover, it was confirmed from things like the opinions of the residents of the electronic zone that this project has led to effects such as improving the living environment within the zone. Therefore the project's effects have been acknowledged. In light of the above, the project can be evaluated as having largely achieved its objective of decreasing air pollution.

3.3.1.2 Internal Rate of Return

The financial internal rate of return (FIRR) for the project was recalculated on the basis of information submitted by Beijing Zhengdong Electronic Power Group Co., Ltd. based on the following prerequisites that were adopted during the planning. The result was 6.8%.

Pre-conditions	Planned (2001)	Actual (2011)
Project life: 25 years Profit: Revenue from sales such as the revenue from heat supply fees and revenue from electricity sales Costs: Fixed asset investment, operating funds, business costs (natural gas, water supply fees, etc.), sales tax, added value tax, financial costs	FIRR: 7.4%	FIRR: 6.8%

Source: Data from the time of the appraisal, data from the calculations at the time of the ex-post evaluation

3.3.2 Other Impacts

3.3.2.1 Response to Environmental Monitoring

The table below shows the actual responses to the Environmental Impact Assessment (EIA) from the time of the planning.

Table 5: Responses to the EIA

Issues at the time of the planning	Actual responses
1) Measures to reduce noise and protect against dust during the construction work	• To counter dust contamination, countermeasures such as covering things with dust sheets and sprinkling water around were taken during the construction work, and construction was suspended on days when the wind was strong. • In response to sound, break times and times when people were asleep at night were avoided as time periods for construction work.
2) Abolishing the existing coal boilers	• After the boilers were removed those that could be recycled were reused, and the waste was disposed of by being buried in designated disposal sites.
3) Adoption of low NOx burners	• Low NOx burners were installed on both gas burning boilers and exhaust heat recovery boilers.
4) Reuse of water and compliance with emissions standards	• All of the circulating water was used for the coolant. Hydrochloric acid and chemical soda are used in the treatment process for the effluent, which is neutralized in order to comply with emissions standards.
5) Countermeasures against noise during operation	• Intake silencers were installed on the ventilation openings of the gas compressors and noise barriers were attached to the coolers. For the sounds of the units, interior acoustic absorption materials were affixed and soundproofing measures were taken out of consideration for the surrounding areas.

After the completion of the project, the Beijing Municipal Environmental Protection Bureau carried out monitoring on exhaust emissions, effluent, noise, and other items. Since the results of this monitoring showed that the national standards for noise had been exceeded, the Beijing Municipality Government demanded that Beijing Zhengdong Electronic Power

Group Co., Ltd., which was the executing company, take corrective measures for this. Following this, the group installed intake silencers on the ventilation openings of the gas compressors and attached noise barriers to the coolers. For the sounds of the units, interior acoustic absorption materials were affixed and soundproofing measures were taken out of consideration for the surrounding areas. As a result, this met the Government's standards in relation to the noise at the time of the ex-post evaluation.

3.3.2.2 Land Acquisition and Resettlement

Land acquisition for the project was completed at the time of the planning, but it became necessary to change the electricity transmission route at the time of the feasibility study (F/S). Thus land for constructing transmission towers (33 towers × 20 m^2) for the new route became necessary. For the land acquisition, it was deemed necessary to acquire the rights to use agricultural land and warehouse sites. The time when the negotiations were held corresponded with a period of rapidly rising land prices in Beijing, and the coordination over this took some time. Finally, consensus was reached through talks with officials from Beijing Zhengdong Electronic Power Group Co., Ltd. There were no disputes regarding land acquisition, and no resettlement of residents took place.[18]

In light of the above, the operation effect indicators were mostly achieved according to plan. Since air pollutants were reduced as a result of the decrease in the number of small coal boilers in the electronic zone, the project was acknowledged as having an impact on improving the living environment as a result of this. Thus the effects by the implementation of the project were observed as taking place as planned, therefore the project's effectiveness and impact are high.

3.4 Efficiency (Rating: ②)

3.4.1 Project Outputs

The outputs (planned and actual) provided by the ODA loan and the outputs (planned and actual) set in place and provided by the Chinese side for this project are shown in Table 6.

Table 6: Outputs (Planned and Actual)

Item	Planned	Actual
	(a) Gas combined cycle[19] • Gas turbines: Power output of 40 MW × 2 sets • Exhaust heat recovery boilers: 100 tons of steam per hour × 2 sets	No change

[18] Information from Beijing Zhengdong Electronic Power Group Co., Ltd.

[19] Gas combined cycle refers to electricity generating facilities wherein natural gas is burned to turn a gas turbine engine, and then next the heat from the exhaust gas from this is collected and used to turn a steam turbine. By using both of these in conjunction with one another, namely, in a combined manner, high power generating efficiency can be achieved.

Item	Planned	Actual
	• Steam turbines: Power output of 49 MW × 1 set	
	(b) Gas burning boilers: Heat output of 58 MW × 4 sets	No change
	(c) Gas pipeline (for drawing gas in from the main pipeline): Approximately 9 km	No change
	(d) Heat supply pipes (hot water pipes, steam pipes), heat exchange station: (Performed in local currency) Hot water pipes: 10 km Steam pipes: 5 km	No change

Source: Responses to a questionnaire by Beijing Zhengdong Electronic Power Group Co., Ltd.

3.4.2 Project Inputs

3.4.2.1 Project Cost

The total project costs for the project came to 11.69 billion yen, of which foreign currency accounted for 8.961 billion yen and local currency accounted for 2.729 billion yen. Of this, disbursements of ODA loans accounted for the full amount of the foreign currency portion at 8.961 billion yen. The total project costs from the time of the planning was 11.535 billion yen, and the actual total project costs were disbursed largely as planned at 101% of the plan.

While it had no affect on the outputs either way, the local currency project costs were slightly higher than the planned figure for these. The reason is outlays on things like the interest payments caused by the lengthening of the project, the steep rise in personnel expenses, and the maintenance and management fees for non-operated facilities while the construction work was being prolonged.

3.4.2.2 Project Period

The project period[20] for the project was planned to last from March 2002 to December 2007 (66 months, or five years and six months), but it actually lasted from March 2002 to April 2009 (85 months, or seven years and one month). A comparison of the planned and actual periods reveals that the overall project period was 128% of the planned one. The reason for the delays is that it took time for the land acquisition procedures for the construction work to connect to the outside lines.

[20] Completion is defined as the time when the trial run begins (materials from the time of the appraisal, information from Beijing Zhengdong Electronic Power Group Co., Ltd.).

Table 7: Comparison of the Planned and Actual Project Periods

	Period (planned)	Period (actual)
Bidding preparations	24 months	14 months
Design	12 months	10 months
Equipment procurement	36 months	26 months
Public works	33 months	46 months
Equipment installation	27 months	28 months
Trial run / hand over	12 months	4 months
Consulting services	60 months	76 months

Source: Beijing Zhengdong Electronic Power Group Co., Ltd.

The consulting and service portion took longer than had been planned because of the impact from the time needed for the land acquisition for the construction work to connect to the outside electrical system. While the overall project period increased, the bidding, procurement, and trial run were concluded in a shorter time period than had been planned. Although this was the first co-generation project for Beijing Zhengdong Electronic Power Group Co., Ltd., the people in charge of overseeing the project had a strong sense of responsibility towards it and worked on it efficiently. As such, they would move ahead with preparations for the bidding and procurement even if they had to work all night or on their days off. The trial run succeeded the first time around, which made it possible to begin operating.

In light of the above, the project costs for the project were largely lower than planned while the project period required longer than planned, therefore the project's efficiency is fair.

3.5 Sustainability (Rating: ③)

3.5.1 Institutional Aspects of Operation and Maintenance

3.5.1.1 Executing and Supervisory Agencies

There were no organizational changes relative to the time of the planning. While the executing agency is the Beijing Municipality Government, the project implementing agency for the project is Beijing Zhengdong Electronic Power Group Co., Ltd. Similar to the way it was at the time of the planning, Beijing Electronics Holding Co., Ltd., which is a holding company of the Municipality of Beijing, is a government-run company that provided 100% of the financing, and the Beijing Municipality Government has no plan to privatize it in the future. The Municipality of Beijing performed environmental assessments, financial audits, and more in its capacity as the supervisory agency.

3.5.1.2 Operation and Maintenance Agency

Beijing Zhengdong Electronic Power Group Co., Ltd. was the operation and maintenance agency. The company's operation and maintenance structure for this project consisted of four teams in charge of onsite management on a rotating basis under one onsite foreman, one assistant onsite foreman in charge of the Operational Management Division, one assistant onsite foreman in charge of the Inspection and Repair Division, and one assistant onsite foreman in charge of the Technology Division. The number of personnel required for operational management was appropriately allocated. These managers had a strong awareness of property management regarding the facilities, and this awareness fed into a continuous urge to improve the technology and thoroughly undertake operation and maintenance procedures.

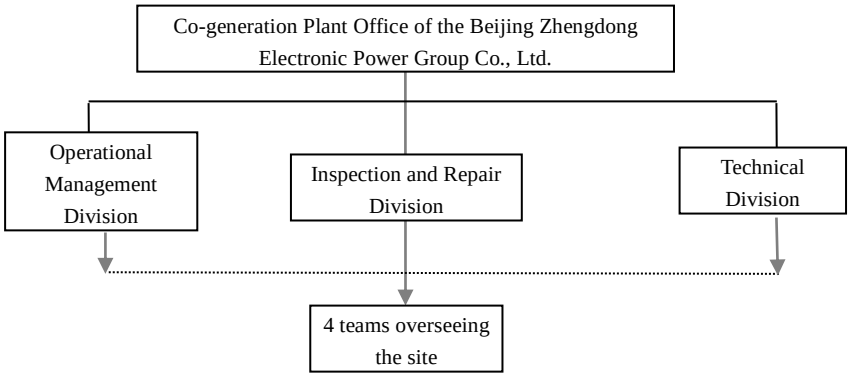


Figure 8: Organizational chart of Beijing Zhengdong Electronic Power Group Co., Ltd.

Operation and maintenance was carried out by on-site teams that consisted of four teams by narrowing it down to the minimum number of core personnel needed for management and administration while also ensuring that operational roadblocks did not arise. Since the bare minimum personnel required were allocated and arranged, the operational efficiency of the project can be assessed as being high.

When it comes to its organizational management from prior to the project's implementation, the company had an outstanding structure and carried out efficient initiatives for organizational management, and this management was utilized continuously in the project as well.

Table 8: Actual Hiring Results for the Project

	Target (at the start of operations)	Actual (2012)
Technicians[21]	35	40
Other employees	51	46
Total	86	86

Source: Beijing Zhengdong Electronic Power Group Co., Ltd.

With regard to personnel changes and turnover, there were no changes with the major managers or personnel regarding this project since the time of the planning. In the event that co-generation projects are newly started by harnessing the experience from this project, then there is the possibility that related personnel will be transferred among the group companies. The turnover rate is similar to that for other state-run companies in China, as there are some people who gain a certain level of experience before quitting their job. According to the company, as a result of the slowing down of economic development in China in recent years the people are strongly oriented towards stability and since the pay scales at state-run companies have been upwards they tend to have lower turnover rates.

3.5.2 Technical Aspects of Operation and Maintenance

Combined cycle facilities have a high level of automation and there are many imported facilities. Thus graduates of university technical courses were hired for many of the positions for employees related to operation and maintenance. They are working to adequately learn the instructions from the facility suppliers, as well as from the Chinese consulting company at the time of F/S and Japanese consulting company. All of the personnel have received technical instructions on operation and maintenance and onsite tests are periodically carried out, but only those who have acquired qualifications undertake operation and maintenance. From the interview surveys with the onsite technicians it was found that their technical level is adequate and they are highly motivated to learn skills.

Annual training plans are prepared in order to maintain and improve the employees' technical levels. Intensive study sessions are held every week for each team regarding maintenance, and on-the-job training and tests, training in accident countermeasures, and training in specialized technical fields are also provided. Not only are people who fail to pass the tests not allowed to perform the work, but they are also subject to punitive measures like having their bonuses reduced. Mechanisms for sharing and transferring skills within the organization are being set up.

[21] The reason that the number of technicians increased compared to the initial plan is because the facilities that were installed were automated facilities with the latest technology, which necessitated the hiring of technicians who had graduated from a university course or higher and who had been educated in advanced technology.

Figure 9 : Automatic control room (decentralized control system[22])

Figure 10 : A scene from internal training

Regarding operating examinations and maintenance inspections, their own guidelines were formulated based on the instructions of the government and the facility manufacturers related to domestic power station management, and specific facility inspection regulations were established for the machinery, electricity, and meters. The on-duty managers in charge of operations make the rounds to perform inspections based on the regulations on a rotating system between three teams every day, and specific inspection records are made during their rounds. Moreover, temperature, vibration, and flammable leak detection equipment is used to periodically perform failure diagnoses on the facilities.

A certain quantity of expendable spare parts that are replaced periodically and spare parts that are replaced on an irregular basis have been set aside in reserve in storage. Only the facility manufacturer for the gas turbines undertakes procurement management for spare parts.

Emergency training for handling accidents and training on accident prevention is held as a form of training for preventing and responding to emergency situations. Training is carried out once a year prior to the start of winter pertaining to emergency measures for when the water level in the boilers falls, dealing with blackouts, and handling flammable gas.

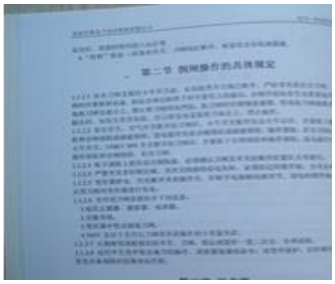


Figure 11 : Management manual

Figure 12 : Inspection records

Figure 13 : Inspecting a coolant circulation pump

[22] A decentralized control system does not have one single primary control unit that acts as the brain, but rather there are control units in each of the devices that comprise the system. The control units are connected via a network over which they communicate and monitor one another.

The interviews with management-level employees showed that there is a strong awareness of property management for the facilities, and that detailed attention to human resources and management regarding maintenance is paid and utilized onsite. Moreover, efforts are continuously made to gather information to improve operation and maintenance.

3.5.3 Financial Aspects of Operation and Maintenance

Since the company's stock is not listed, it does not release financial statements. The major sources of revenue of the executing agency are revenue from heat supply fees and revenue from electricity sales. As is indicated in Table 9, according to financial data from the operation and maintenance agency, the co-generation project is profitable.

Table 9: Financial Information Related to Income and Expenditures (Unit: Yuan)

Items	Detailed items	1st year of operations (2009)	2nd year of operations (2010)	3rd year of operations (2011)	4th year of operations (2012)
Costs	Fixed asset investments	NA	NA	NA	NA
	Operation and maintenance fees	1,184,185.65	4,191,921.19	8,314,849.22	8,868,941.43
	Business costs	192,883,880.02	266,862,244.74	306,069,615.28	315,680,947.81
	Financial costs	5,481,500.00	5,675,300.00	5,675,300.00	5,628,762.67
	Added value tax	8,778,888.61	15,090,484.38	11,557,778.91	15,377,164.60
	Other costs	5,738,602.64	6,277,878.60	7,489,779.91	7,772,552.89
	Total	**214,067,056.92**	**298,097,828.91**	**339,107,323.32**	**353,328,369.40**
Income	Revenue from electricity sales	198,896,860.83	295,081,254.40	296,566,300.80	315,213,030.00
	Revenue from supplying heat	16,180,600.00	23,366,160.00	30,190,403.00	49,770,000.00
	Government subsidies	27,222,357.00	14,178,626.58	52,878,556.58	31,145,400.00
	Other revenue	NA	NA	NA	NA
	Total	**242,299,817.83**	**332,626,040.98**	**379,635,260.38**	**396,128,430.00**

Source: Data from Beijing Zhengdong Electronic Power Group Co., Ltd.

Note 1) Business costs include the purchase cost for natural gas, the cost of using water, and so forth. Financial costs include loan repayments.

Note 2) Personnel expenses are included under other costs.

Note 3) Subsidies vary from fiscal year to fiscal year because of budget planning for sectors emphasized by the Beijing Municipality Government.

The electricity sales price only rose within the range of 1.1-times that from the time of the planning because of the rise in the price of natural gas, whereas the purchase price for natural gas climbed steeply by 1.6-times. The Beijing Price Bureau sets all of the fees. In order to promote the replacement of coal through the expansion of natural gas, the Beijing Municipality Government sets new prices for electricity sales and offers the appropriate subsidies when the cost of using natural gas is higher than that of coal. Through this the Beijing Municipality Government provides financial support to companies that use natural gas.[23] For this reason no serious problems have arisen with the financial conditions on the part of the executing agency itself at this point in time, but a close watch must be kept on the future trends in the fee settings and the implementation status for subsidy policies.

Table 10 shows the trends in the operation and maintenance fees for the project over the past four years. Operation and maintenance on the gas turbines accounts for 95% of the overall operation and maintenance fees; this is entrusted to a manufacturer from the United States. The gas turbines that were adopted employ the state-of-the-art technology; according to the executing company, it concluded a contract based on the determination that it would be necessary to outsource the operation and maintenance of the turbines to companies that were reliable suppliers with numerous licenses approved by supervisory divisions in the government. The technicians who were hired perform operation and maintenance on the other facilities aside from the gas turbines. Other items in the operation and maintenance fees include the chemicals for treating the wastewater (hydrochloric acid, chemical soda).

Table 10: Operation and Maintenance Fees (Actual)

(Unit: Yuan)

	Operation and maintenance fees
2009[24]	1,184,185.65
2010	4,191,921.19
2011	8,314,849.22
2012	8,868,941.43

Source: Data from Beijing Zhengdong Electronic Power Group Co., Ltd.

Trends for future heat supply and co-generation projects include the advancement of policies for energy conservation and the like, but a certain degree of growth in demand is expected. In particular, the project to newly rebuild housing complexes for workers at former state-owned factories in the surrounding region that was supposed to have gotten underway in

[23] Results of interviews with Beijing Zhengdong Electronic Power Group Co., Ltd.
[24] The trial run concluded in April 2009. Since the official operation will begin partway through the year, the operation and maintenance fees are minimal.

2006 is gradually making progress, and additional demand is expected from 600,000 m^2 of area to which heat is to be supplied. In light of these trends, it is estimated that stable demand will be ensured for the future.

3.5.4 Current Status of Operation and Maintenance

When the state of the equipment and facilities was confirmed visually during the on-site inspection, it was found that things like vibration and noise were being kept down to a minimum. The performance indicators for the various facilities used for operation and maintenance while the factory is operating are consistent with the industrial standards and environmental conservation standards of the national government or those of the Municipality of Beijing. Operation and maintenance inspections and analyses are being carried out appropriately, and the records for these were confirmed. The operation and maintenance status for the facilities and machinery is satisfactory. Beijing Zhengdong Electronic Power Group Co., Ltd. established inspection items and their frequency in its general principles for facility inspections. There are annual inspection and maintenance plans, as well as monthly inspection and maintenance plans made by Beijing Zhengdong Electronic Power Group Co., Ltd. Only for the gas turbines, their operation and maintenance plans are made by the manufacturer. At present there are no plans for future upgrading or repairing the facilities.

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

4. Conclusion, Lessons Learned and Recommendations

4.1 Conclusion

The objective of the project is to replace small size coal combustion boilers and cut down on emissions of various different pollutants by introducing co-generation facilities that use natural gas in the Beijing Electronic Zone, thereby contributing to reducing the air pollution.

The project is consistent with the priority areas in China's development plans related to its countermeasures against air pollution, as well as with Japan's ODA policy. The development needs is also high in China. Therefore the relevance of the project is high. The project has largely achieved major effect indicators like reducing air pollutants, and the beneficiary surveys performed through the evaluation study confirmed that the project contributed to reducing the air pollution in the electronic zone. Therefore the effectiveness of the project is high. The project's efficiency is fair because the project period took more time than planned but the project costs were lower than planned. The institutional aspects, technical aspects, financial aspects, and current status of operation and maintenance are satisfactory. Therefore the sustainability of the project is high.

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

4.2 Recommendations

4.2.1 Recommendations to the Executing Agency

None in particular

4.2.2 Recommendations to the Operation and Maintenance Agency

None in particular

4.2.3 Recommendations to JICA

None in particular

4.3 Lessons Learned

The project was the first co-generation project for Beijing Zhengdong Electronic Power Group Co., Ltd., which served as both the project implementing agency and the operation and maintenance agency. The company's enthusiasm when it comes to organizational operation seems to be one of the factors leading to the project's success. The company learned operation and maintenance methods for the project from design institutes, manufacturers, and consulting companies in the interest of further ensuring the sustainability of the project. Moreover, all of the employees have received technical instruction in operation and maintenance and intensive study sessions are held for each of the teams, while on-the-job training and tests (those that fail have their bonuses reduced), training in accident countermeasures, and training in specialized technical fields are also provided.

It is not easy to measure enthusiasm in relation to management and operation. However, during the planning, it is important to examine the status of operation and management, and concretely confirm the policies and activities for effectively carrying out operation & maintenance such implementing situation of training, testing etc., plans afterwards, and so forth.

End

Comparison of the Original and Actual Scope of the Project

Item	Planned	Actual
1) Project Outputs	(a) Gas combined cycle • Gas turbines: Power output of 40MW × 2 sets • Exhaust heat recovery boilers: 100 tons of steam per hour × 2 sets • Steam turbines: Power output of 49 MW × 1 set (b) Gas burning boilers: Heat output of 58 MW × 4 sets (c) Gas pipeline (for drawing gas in from the main pipeline): Approximately 9 km (d) Heat supply pipes (hot water pipes, steam pipes), heat exchange station: (Performed in local currency) Hot water pipes: 10 km Steam pipes: 5 km	As planned
2) Project Period	March 2002 – December 2007 (66 months)	March 2002 – April 2009 (85 months)
3) Project Cost Amount paid in Foreign currency	8,963 million yen	8,961 million yen
Amount paid in Local currency	2,572 million yen (171 million Yuan)	2,729 million yen (190 million Yuan)
Total	11,535 million yen	11,690 million yen
Japanese ODA loan portion	8,963 million yen	8,961 million yen
Exchange rate	15 yen = 1 Yuan (As of September 2001)	14.3 yen = 1 Yuan (Average between March 2002 and April 2009)