People's Republic of China

Ex-Post Evaluation of Japanese ODA Loan Project

"Taiyuan Environmental Improvement Project"

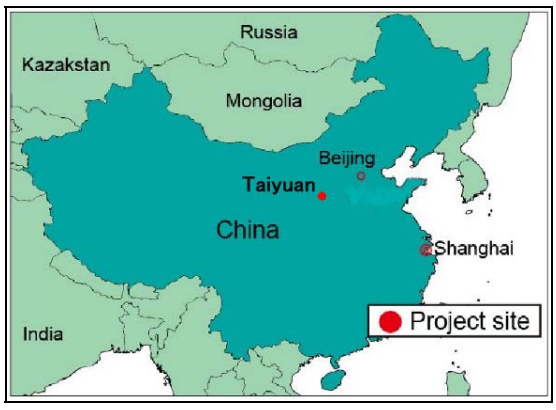
External Evaluator: Yasuhiro Kawabata, Sanshu Engineering Consultant

0. Summary

The objective of the project was to improve the environmental condition including air, water, and industrial solid waste pollution by introducing the cleaner production technology, installing emission treatment facilities and ensuring efficient use of waste energy at Taiyuan Iron and Steel Company (TISCO), thereby contributing to the improving the living environment of the people in Taiyuan. The project has been highly relevant to the development plans and needs of China and Shanxi Province, as well as Japan's ODA policies, and therefore its relevance is high. Regarding the improvement of environmental condition including air and water pollution, which is the project's objective, the project has largely achieved its objectives, therefore its effectiveness is high. Although the project cost was within the plan, the project period exceeded the plan. Therefore, efficiency of the project is fair. Since no major problems have been observed in the operation and maintenance system (organizational setup, technical capacity and financial status), sustainability of the project is considered high.

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

1. Project Description



Project Location

Blast Furnace Gas Combined Cycle Power Plant (Control Center)

1.1 Background

At the appraisal time (2001), the air pollution caused by SO_2, which evolved from coal burning (main energy resource), the total suspended particles (TSP), and NOx exhausted from motor vehicles was in the critical condition in China. The treated ratio of the sewage water in urban regions was low as 34.3% and the water pollution was also in the serious condition. In addition, as the economy had developed, the volume of industrial waste had been increasing, and thus occupation of huge land and adverse impacts to the river and ground water had been concerned issues.

Shanxi Province, where the project is located, is abundant with coal as it is called “Coal Province”, and it thrives with heavy industries using coal. Taiyuan, which is the capital city of Shanxi, has been developing as a heavy industry city. However, since renovation of facilities at each enterprise had been delayed, the air pollution level had been worsened. In 1998, Taiyuan was recognized as one of the worst 10 polluted cities in the world by World Health Organization (WHO). Moreover, even in China it was ranked as the worst among 91 cities in terms of the overall rating based on the national environmental standards in 1999, and the implementation of urgent countermeasures to improve air pollution had been anticipated. Regarding the water pollution, among 22 monitoring stations along Fen River, flowing through Taiyuan City, the water quality as a source for drinking water cleared the national standards only at one station. Thus, the domestic sewage issue was also needed to be urgently resolved.

The amount of industrial solid waste produced was huge, and the total amount produced in the province ranked in second in China in 2000. Most of solid waste have been buried or recycled. However, some of waste was illegally disposed without proper treatment, and environmental pollution has been concerned. At the appraisal time, the recycling ratio had been slightly decreasing, and thus, plans to properly treat the increasing industrial solid waste were anticipated.

1.2 Project Outline

The objective of the project isto improve the environmental condition including air, water, and industrial solid waste pollution by introducing the cleaner production technology, installing emission treatment facilities and ensuring efficient use of waste energy at Taiyuan Iron and Steel Company (TISCO), thereby contributing to the improving the living environment of the people in Taiyuan. The location of the project site is shown in Figure 1.

Figure 1 Location of Project Site

Loan Approved Amount/ Disbursed Amount	14,144 million yen / 13,995 million yen
Exchange of Notes Date/ Loan Agreement Signing Date	March 2002 / March 2002
Terms and Conditions	Interest Rate: 0.75% Repayment Period: 40 years (Grace Period: 10 years) Conditions for Procurement: General untied (Works) and Bilateral tied (Consultants)
Borrower / Executing Agency (ies)	Government of People's Republic of China/ Shanxi Provincial Government
Final Disbursement Date	October 2009
Main Contractor (Over 1 billion yen)	Sinosteel Equipment & Engineering Company (China) /Marubeni/Nippon Steel, Acre Coking & Refractory Engineering Consulting Corporation (China) /Steel Plantec /Shinko Corp., Hangzhou Steam Turbine Co., Ltd. (China) /Marubeni/Mitsubishi Heavy Industries, China CMIIC Engineering Corp.(China), China National Heavy Machinery Corp.(China)
Main Consultant (Over 100 million yen)	-
Feasibility Studies, etc.	F/S by Taiyuan Iron and Steel Company Design Institute (2001)
Related Projects (if any)	None

2. Outline of the Evaluation Study

2.1 External Evaluator

Yasuhiro Kawabata, Sanshu Engineering Consultant

2.2 Duration of Evaluation Study

Duration of the Study: July 2011 – September 2012

Duration of the Field Study: October 9 - October 22, 2011 and February 14 - February 24, 2012

2.3 Constraints during the Evaluation Study (if any)

None

3. Results of the Evaluation (Overall Rating: A[1])

3.1 Relevance (Rating: ③[2])

3.1.1 Relevance with the Development Plan of China

The 9th Five-Year Environmental Protection Plan (1996-2000) stated that China would make efforts to reduce the total emission amount of major pollutants such as SO_2, dust (soot and industrial dust), and COD up to the level in 1995 (23.7 million tons of SO_2, 17.44 million tons of dust and 22.33 million tons of COD) by 2000 and thus would develop the urban environmental fundamentals such as control of industrial pollution, sewage system and gas pipelines in the urban area. Under the 10th Five-Year Plan (2001-2005), China aimed to reduce the total emission amount of major pollutants by 10% against the amount in 2000 in order to further improve the environmental condition. In line with the central government plans, in the Metallurgic Industry 10th Five-Year Plan, the implementation of Cleaner Production (CP) at 14 model industries including TISCO was planned. In addition, under the Taiyuan 10th Five-Year Plan, the following programs for environmental improvement were planned: i) reduction of air pollution caused by coal burning; ii) enforcement of shutdown of sources for industrial pollution; iii) protection of sources for drinking water; iv) improvement of water quality of Fen River in Taiyuan; and v) enforcement of control of industrial waste pollution.

The main targets of the current China's 12th Five-Year Environmental Protection Plan (2011-2015) are to reduce the emitted amount of main pollutants, and thus to improve the environment to the level clearly visible. In order to achieve the target, China aimed to reduce the emitted amount of COD and SO_2 by 8% against the amount in 2010 respectively, and those of NH_3-N and NO_X by 10%, respectively. The following specific strategies to achieve the target have been established: i) the total emission amount shall be further reduced; ii) environmental protection measures are strengthened; iii) the environmental risk shall be lowered; and iv) the fundamental public service to address the environmental issues shall be improved. The Taiyuan's 11th Five-Year Plan (2006-2010) aims to transform the economic development policy and thus to construct the environmentally friendly urban city by protecting natural resources. In line with the city's plan, under the Taiyuan 11th Five-Year Environmental Protection Plan (2006-2010), the following targets are established: i) control of worsening of the environmental pollution; ii) promotion of effective use of resources; iii) reduction of the total emission amount of pollutants; and iv)

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

[2] ③: High, ② Fair, ① Low

improvement of the ecological and environmental condition.

3.1.2 Relevance with the Development Needs of China

At the appraisal time, Shanxi Province was an important base for industries of energy, heavy metal and science/technology sectors in China and one of major cities for industries of coal mining, metallurgy, mechanical, chemistry, and electricity sectors. However, since aged facilities had been used in the factories, the environmental pollution was worsened in Shanxi Province. Particularly, the condition in Taiyuan, which is the capital of the province, was worst in the Province. If TISCO[3] which was the biggest pollution producer in Shanxi, should have continued increase of production of steel without any effective measures to reduce pollution, it was obvious that the environment in the province would have been further worsened. Thus, improvement of air quality, treatment of domestic waste water, and proper treatment of industrial waste materials were considered to be the issues to be urgently resolved.

Taiyuan's 11th Five-Year Plan (2006-2010) states that the "Blue Sky Action Plan" shall be implemented in order to improve the air pollution. It requires enterprises producing heavy pollution to move to other locations or stop their operation or improve their production facilities. The large enterprises, which cannot be easily relocated, would be requested to improve control of emission of pollutants. Regarding the water quality control, the following strategies were established: i) protection of sources for drinking water shall be tightened; ii) recycling rate of sewage water shall be increased; and iii) discharge of industrial and domestic waste water to rivers shall be prohibited. Moreover, the recycling rate of industrial solid waste shall be also increased and eventually the recycling rate needs to be upgraded to 95% by 2010.

3.1.3 Relevance with Japan's ODA Policy

Under the Economic Cooperation Plan for China (2001), which is equivalent to the Country Assistant Strategy, the following policy was established: Priority shall be given to the following theme or sector: conservation of the environment and ecology, where pollution and destruction are in the critical condition, poverty alleviation and social development in inland regions, human resource development, institutional reform, and technology transfer. Furthermore, the aid assistance to address the global issues such as environmental problems was classified as the top priority issue among the priority agenda.

Accordingly, the project has been highly relevant with the Chinese and Shanxi's

[3] TISCO is a large scale state-owned enterprise with 72,000 employees, and a largest stainless steel sheet and magnetic steel maker.

development plan and needs, as well as Japan's ODA policies, therefore its relevance is high.

3.2 Effectiveness[4] (Rating: ③)

3.2.1 Quantitative Effects (Operation and Effect Indicators)

(1) Amount of Pollutants emitted by Taiyuan Iron and Steel Company (TISCO)

The amount of pollutants emitted by TISCO after completion of the project is shown in Table 1.

Table 1 Amount of Pollutants emitted by TISCO

Indicators	unit	2000 Base year	2007	2008	2009	2010
SO_2 (sulphur dioxide)	ton/year	3,048	2,500 (250)	303	245	240
Dust	ton/year	1,124	650 (166)	161	160	156
H_2S (hydrogen sulphide)	ton/year	23.3	23.3 (0)	23.3	0	0
HCN (hydrocyanic acid gas)	ton/year	10.4	10.4 (0)	10.4	0	0
Reduction of use of coal	1,000 ton /year	-	- (239.6) [5]	60.8	193.9	279.8
COD (chemical oxygen demand)	ton/year	4,525	200 (110)	75	0	0
Oil	ton/year	70	2.8 (3.7)	1.2	0	0
SS (suspended solids)	ton/year	2,309	50 (36.5)	0	0	0
BOD (biochemical oxygen demand)	ton/year	1,118	- (36.5)	13	0	0
NH_3N (ammonium nitrogen)	ton/year	406	20 (9.1)	4	0	0
Recycled amount of slug	1,000 ton/year	-	- (500) [6]	1,450	1,515	1,550

Source: Responses to Questionnaire

Note 1: Numbers in ( ) are projected figures (targets) at the planning stage

The emitted amount of SO_2 was slightly reduced from 2000 (base year) to 2007, and was substantially reduced upon completion of the project (2008). The emitted amount in 2010 was 240 tons/year (about 8% of the 2000's actual), which is less than the projected amount

[4] Sub-rating for Effectiveness is to be put with consideration of Impact.

[5] After the commencement of the project, specifications of some facilities were revised (refer to 3.4.1 Outputs). Although the planned reduction amount of coal use was also revised, it is not clear how each facility affected the reduction amount. Thus, the reduction amount projected at appraisal is used as the planned amount.

[6] After the commencement of the project, the specifications of the plant were reviewed and the treatment capacity for slug recycling was tripled. Thus, it is assumed that the planned recycled amount would be also increased by three times of the originally planned amount (500,000 tons), that is, 1.5 million tons.

(250 tons/year) at the project completion. The emitted amount of dust was also substantially reduced. The emitted amount in 2010 was 156 tons/year (about 14% of the 2000's actual), which is less than the projected amount (166 tons/year) at the project completion. Other pollutants such as hydrogen sulphide, hydrocyanic acid gas, COD, Oil, suspended solids, BOD, and ammonium nitrogen have not been emitted upon completion of the project.

The reduced amount of coal used right after completion of the project (2009)[7] was 190,000 tons. However, it exceeded the planned reduced amount (240,000 tons/year) in 2010 and has reached up to about 280,000 tons.

Before the project, the slug, which is scrap after steel melting, was neither crushed nor treated, and abandoned. By introducing the treatment facilities under the project, it became possible to reuse the slug as a construction material. In 2008, after the slug treatment facility was completed in December 2007 and the reuse of slug became possible, 1.45 million tons of slug, which is about the planned amount was recycled as construction materials. The recycled amount of slug was 1.55 million tons in 2010.

(2) Monitoring Indicators on Environment in Taiyuan

Improvement of environmental conditions in Taiyiuan after the completion of the Project is shown in Table 2.

Table 2 Improvement of Environmental Conditions in Taiyuan

Indicators	unit	2000 Base Year	2007	2008	2009	2010
SO_2 (sulphur dioxide)	ton/year	198,226	106,650 (67,000)	100,089	90,487	94,233
	mg/N m^3	0.200	0.077 (0.06)	0.073	0.059	0.056
TSP/PM10 (particle matter)	mg/N m^3	0.401	0.124 (0.1)	0.094	0.091	0.089

Source: PCR , Responses to Questionnaire, Taiyuan Annual Statistics 2008-2011

Note 1: Numbers in ( ) are projected values at appraisal

Note 2: The monitoring indicator on air floating particle matter in Taiyuan was changed from TSP to PM10 since 2001

Note 3: The numbers show the total amount emitted in Taiyuan urban area.

Because of the additional efforts made to improve the environmental condition by major industries in Taiyuan, the SO_2 amount emitted in 2008 was reduced by 50% against the amount emitted before the project (2000) in ton unit, and by 63% in mg/Nm^3 unit. The emitted amount in 2010 was reduced by 52% (in ton unit) against the amount emitted in the base year. Even though the Taiyuan's GDP as of 2010 was increased by 17% against the

[7] The originally planned completion date at appraisal was December 2006. However, it was extended to December 2008. Details are discussed under 3.4.2.2 Project Period.

2008 GDP, and the amount of industrial products has increased, the amount of SO_2 emitted is constant. The SO_2 amount emitted by TISCO was about 1.54% of the amount emitted in Taiyuan in 2000 (base year). However, the share of TISCO was reduced as low as about 0.25% in 2010. Because of the efforts made by Taiyuan Municipal Office to reduce the air pollution, the level of TSP/PM10 (particle matter) in 2010 has been lowered to the 78% of that observed before the project (2000).

3.2.2 Qualitative Effects

(1) Environmental Improvement (Air and Water Pollution)

In this ex-post evaluation work, beneficiary surveys through interviews were conducted in the project affected area. The total number of respondents was 100. The classification of respondents by sex was 50% female and 50% male. Main results of the beneficiary surveys are as follows. Regarding the improvement of air quality, almost all the respondents admit that the air quality has been improved after the project (December 2008). With respect to the level of improvement, 44% of respondents cognize that it is substantial and 55% do that it is fairly. Regarding the water quality of Fen River, all the respondents admit that it was improved after the project. With respect to the level of improvement, 49% of respondents cognize that it is substantial and remaining 51% think that it is fair.

3.3 Impact

3.3.1 Intended Impacts

(1) Improvement of urban and living environment

As mentioned previously, TISCO was one of main sources generating air pollution in Taiyuan. Thus, it was expected that the implementation of the project with the objective to improve environmental condition of TISCO plants would greatly contribute to the improvement of environmental condition in Taiyuan. Changes of environmental condition made before and after the project in Taiyuan are shown in Table 3.

Table 3 Changes of Environment before and after the Project in Taiyuan

Indicator	2007	2008	2009	2010
Amount of Industrial Water discharged (million tons/ year)	31.04	26.25	24.83	25.57
Amount of Industrial Dust emitted (1,000 tons/year)	35.97	32.35	30.46	27.85
Amount of Industrial Solid Waste produced (million tons/ year)	26.39	25.32	24.10	25.54
Amount of Industrial Solid Waste disposed (million tons/ year)	0.45	0.19	0.09	0.08
GDP and Growth Rate of Taiyuan (100 million yuan)	1,291	1,526 (18.2%)	1,545 (1.2%)	1,778 (15.0%)

Source: Taiyuan Annual Statistics 2008-2011

GDP in 2009 was almost the same as the previous year due to the economic crisis after the Lehman Shock, and all other indicators were also slightly lowered. However, if values of indicators before the project (2007) are compared with those in 2010, values of each indicators were lowered (substantially lowered particularly with the amount of dust emitted) even though GDP was increase by 38%. It is clear that the efforts to improve the environmental condition by Taiyuan Municipal Office are successful.

The perception by citizens on improvement of living environment through the beneficiary surveys are shown in Table 4 and 5.

Table 4　Perception by Citizens on Improvement of Living Environment (Air)

Effects by improvement of Air (multiple choice)	%
Lowering of dirtiness of clothes by dust	91
Less coughing and eye's pain	91
Possible to dry clothes outside	98
No use of mask and sun glass to prevent dust	74

Table 5　Perception by Citizens on Improvement of Living Environment (Water)

Improvement of water quality (Fen River)（multiple choice）	%
Turbidity improved	100
Less smell than before	98
Fishing possible	98
Possible to use as irrigation water	97
Landscaping along the river improved	100

The improvement of living environment (air and water quality) in Taiyuan was not achieved only by this project. However, it was proven through the results of the beneficiary surveys that the improvement of environment of TISCO, which was the most polluted industry in Taiyuan, contributes to the improvement of living environment. To the question on the contribution of the project to improvement of environment, 36% of respondents cognize that the living environment (air and water quality) was substantially improved upon completion of the project and 64% cognize that it was fairly improved.

As an overall assessment to the project, 15% of respondents answer that they are totally satisfied and 85% answer that they are fairly satisfied. From these results, it was confirmed that citizens admit the contribution of the project to the improvement of urban/living environment.

3.3.2 Other Impacts

Impacts on the natural environment:

The construction waste materials disposed from the project were hauled to the special treatment depot in the TISCO's compound and treated properly. Currently, the environmental protection bureau (staffed with 50 employees) of TISCO (now Shanxi TISCO Stainless Steel Company) has been automatically monitoring the air quality at 87 ejecting points and water quality at 4 discharging points in the TISCO compound, and it is reported that the ejected air and discharge water meet the standards required for each item. The monitoring results are reported to the Environmental Protection Bureau of Taiyuan Municipal Office, and no particular problem has been identified.

Land Acquisition and Resettlement:

Since the project scope is improvement or reconstruction of the facilities and equipment within the existing TISCO compound, no additional land acquisition occurred. According to the executing agency, since two families of company employees lived in the area where the sewage plant was to be constructed, it took longer time to negotiate the compensation for relocation with the house owners. Construction commenced after the complete agreement had been made.

This project has largely achieved its objectives, therefore its effectiveness and impact is high.

3.4 Efficiency (Rating: ②)

3.4.1 Project Outputs

The original and actual output of the project is shown in Table 6.

(1) Construction and Installation of Facilities to reduce Pollution at Taiyuan Iron and Steel Company

Table 6 Output (original and actual)

Item	Original	Actual
1. Coke Dry Quencher (CDQ) Plant	Installation of CDQ facilities (treatment capacity of 110 tons/hour) to No. 5 and 6 coke ovens	Installation of CDQ facility (treatment capacity of 150 tons/hour) to No. 7 coke oven
2. Desulphurization and HCN Removal Plant	Installation of desulphurization facility (treatment capacity of 63,000 m^3/hour) Vacuum Carbonate/Claus	Treatment capacity increased to 130,000 m^3 /hour and treatment process was changed to MEA removal method
3. Blast Furnace Gas Combined Cycle Power Plant (CCPP)	Installation of Combined Cycle Power Plant (output power 81.4 MW)	Output power was lowered to 51.6 MW
4. Top Gas Recovery Turbine (TRT) Plant	Installation of a turbine plant to No.3 blast furnace (Output power 6 MW)	Output power was increased to 12 MW
5. Electric Arc Furnace (EAF)	Construction of Arc Furnace with dust collectors (capacity 90 tons) Disposal of 6 old small furnace	as planned
6. Steel Dregs Treatment Plant	Installation of steel dregs treatment plant, capacity: 380,000 tons/year for ordinary steel and 120,000 tons/year for stainless steel	Installation of steel dregs treatment plant, capacity:920,000 tons/year for ordinary steel and 760,000 tons/year for stainless steel
7. Sewage Treatment Plant	Construction of a sewage plant to be used for domestic water discharged from residential area (treatment capacity: 50,000 m^3 /day)	as planned

Source: PCR, Response to Questionnaire
CDQ : Coke Dry Quenching

All the facilities to reduce pollution under the project were constructed and installed. However, changes of specifications were made on some facilities. Major changes of output are as follow:

1) Coke Dry Quencher (CDQ): Originally, CDQs were planned to be installed to No. 5 and 6 plants. However, since both plants were abandoned (decision made in September 2005), the CDQ was installed to newly constructed No.7 plant. The treatment capacity was increased from the original 110 tons/hour to 150 tons/hour. Another new No.8 plant was constructed with their own fund.
2) Since the originally planned treatment method was not appropriate to handle the treatment capacity of No. 7 and 8 plants, the desulphurization treatment capacity was increased to 130,000 m^3 /hour and the treatment process was changed as well.
3) The originally planned ready-made power plant with the output power of 81.4 MW was not available in the market, the output power was changed to 51.6MW.
4) Since the furnace capacity was increased from 1,200 m^3 to 1,800 m^3, the specification of the turbine plant was upgraded and the generating power was also increased to 12 MW.

5) Since the steel production amount was increased and thus the slug amount was also increased, increase of the slug treatment capacity was needed. The annual slug treatment capacity was increased to 920,000 tons for normal steel and 760,000 tons for stainless steel.

After the loan was signed in 2003, the need for increase of production capacity based on the future demand projection was reviewed. As a result, it was judged that the increase of production capacity was needed and design changes were partly made. Changes made are essential for an enterprise to promptly cope with the technical innovation, and they are considered appropriate.

(2) Consulting Services

The originally planned consulting services included the consulting assignment with a total input man/month of 30 M/M on the following facilities: Coke Dry Quencher (CDQ) Plant (5M/M), Desulphurization and HCN Removal Plant (6M/M), Top Gas Recovery Turbine (TRT) Plant (10M/M), and Electric Arc Furnace (EAF) (9M/M). The consulting services included assistance in bidding activities, review of detailed designs, construction supervision, and safeguards (review of impacts on environmental improvement). However, since no qualified consultant submitted an Expression of Interest to the assignment on Desulphurization and HCN Removal Plant (6M/M), this assignment was cancelled. The actual input by consultants was 24 M/M.

Electric Arc Furnace (EAF)

Desulphurization and HCN Removal Plant

3.4.2 Project Inputs

3.4.2.1 Project Cost

The estimated project cost at appraisal was 23.403 billion yen, of which the Japanese ODA loan with a total amount of 14.144 billion yen was to be used to only the foreign currency portion and the rest was to be funded by TISCO. Since the specifications of some

plans were revised during the project implementation, the planned project cost was revised to be 26.072 billion yen. The actual project cost was 25.734 billion yen, of which the Japanese ODA loan used was 13.995 billion yen and the rest was funded by TISCO. The actual cost is equivalent to 98.7% of the planned cost based on the revised specification, and thus it was lower than planned.

Table 7 Comparison of Project Cost (Planned and Actual)

Item	Planned					Actual				
	Foreign	Local		Total		Foreign	Local		Total	
	million yen	million yuan	million yen	million yuan	million yen	million yen	million yuan	million yen	million yuan	million yen
Coke Dry Quencher (CDQ) Plant	1,722	41	618	156 (373)	2,340 (5,140)	1,945	243.78	3,604	375.39	5,549
Desulphurization and HCN Removal Plant	495	46	696	79 (194)	1,191 (2,673)	1,749	47.5	702	165.81	2,451
Blast Furnace Gas Combined Cycle Power Plant (CCPP)	5,897	76	1,145	469	7,042	4,971	105.4	1,558	441.69	6,529
Top Gas Recovery Turbine (TRT) Plant	635	13	201	56	836	285	7.96	118	27.26	403
Electric Arc Furnace (EAF)	3,171	183	2,746	394	5,917	3,623	243	3,592	488.09	7,215
Steel dregs treatment plant	524	22	326	57	850	955	97.9	1,447	162.49	2,402
Sewage Treatment Plant	437	28	413	57	850	385	48.6	718	74.62	1,103
Taxes & Management	0	174	2,608	174	2,608	14	-	-	0.95	14
Consulting services	104	0	0	7	104	68	-	-	4.60	68
Price escalation	492	5	78	38	570	-	-	-	-	-
Contingency	667	29	428	73	1,095	-	-	-	-	-
Total	14,144	617	9,259	1,560 (1,892)	23,403 (26,072)	13,995	794.14	11,739	1740.90	25,734

Source: Appraisal documents, PCR, Responses to Questionnaire

Note 1: Exchange rate at appraisal: 1 yuan = 15 yen, Exchange rate at post evaluation 1 yuan = 14.782 yen (average during the period between July 2004 and March 2009)

Note 2: Taxes, management costs and contingencies spent are included in the cost of each component at post evaluation.

Note 3: Since changes of specifications on the Coke Dry Quencher Plant and Desulphurization and HCN Removal Plant were approved though the formal procedures, the revised planned costs were estimated as shown in parentheses. The exchange rate used at reestimation (September 2005) is 1 yuan = 13.78 yen.

Main reasons for the increased/lowered project cost against the original plan are as follows.

1) Since the treatment capacity of dry quencher plant of CDQ facility was increased from the original 110 tons/hour to 150 tons/hour, the specifications of heat boilers and generators were also upgraded, resulting in increase of construction cost. However, the actual cost spent was almost equivalent to the revised planned cost.
2) The desulphurization treatment capacity was increased to 130,000 m^3/hour and the treatment process was also changed. However, the actual cost spent was lower than the revised planned cost.
3) Since the Blast Furnace Gas Combined Cycle Power Plant (CCPP) was constructed with lower output power, construction cost was reduced.
4) When the cost estimation was made on the Top Gas Recovery Turbine (TRT) Plant at the planning stage, the equipment to be installed was assumed to be imported. However, since the awarded contractor actually installed the domestic product, the cost was reduced.
5) Regarding the Electric Arc Furnace (EAF), the latest model of imported equipment was procured and the furnace facility, which was originally covered by roof only, was included in the building resulting in cost increase.
6) With respect to the Steel Dregs Treatment Plant, the cost was increased because of delay of the implementation schedule and upgrading of the treatment capacity.
7) Regarding the sewage treatment plant, since the material costs including steel and cement was increased, the civil work and installation costs, which were locally funded, were increased.

3.4.2.2 Project Period

The project period was longer than planned. The project period planed at appraisal was from March 2002 (signing of the Loan Agreement) to December 2006 (completion of civil work) with a total period of 58 months. The actual project period was from March 2002 (signing of the Loan Agreement) to December 2008 (completion of civil work) with a total period of 82 months, equivalent to 141% of the planned period.

Main reasons for delay of the project period are as follows:

1) Since the person in charge of the execution agency was unfamiliar with the JICA's procurement procedure and process and it took longer time to secure the internal clearance, the implementation of some sub-projects was delayed by about 2 years against the original plan.

2) Regarding the Coke Dry Quencher (CDQ) Plant, the change of project scope, redesigns and revision of designs have occurred (destruction of No. 5 and 6 furnaces, and new construction of No.7 and 8 furnaces).
3) Although the Desulphurization and HCN Removal Plant was once bid through the International Competitive Bidding (ICB) procedure as one package, the bid was not realized. Consequently, this package was divided into three packages (2 direct contracts and one ICB contract), and the rebid took longer time resulting in delay of the construction period.
4) Regarding the Blast Furnace Gas Combined Cycle Power Plant (CCPP), it took longer time to review the technical specification to make balance between the amount of gas turbine and the capacity of a gas emission furnace.
5) Although the Steel Dregs treatment plant was once bid through the ICB procedure as three packages, the bid was not realized. Thus, two packages were rebid through the ICB procedure and one package was changed to the direct contract. The rebid took longer time resulting in delay of the construction period.
6) Regarding the Sewage Treatment Plant, since two families lived in the area where the plant was to be constructed, it took longer time to negotiate with the house owners. Construction commenced after the complete agreement had been made, resulting in delay of construction period.

Steel dregs treatment plant

Sewage Treatment Plant

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

Financial Internal Rate of Return

By using the same conditions and assumptions applied to calculate FIRRs at appraisal, the FIRRs at post evaluation was calculated by the executing agency as shown in Table 8. The construction cost of some sub-projects substantially increased because of upgrading of the specification, while the benefits also increased. Consequently, FIRRs of each sub-project were calculated to be slightly higher than those calculated at the planning stage.

Table 8 FIRR (at appraisal and at post evaluation)

Facility	Benefits	Cost	FIRR (%)	
			at appraisal	at post evaluation
Coke Dry Quencher Plant	Collected steam and others	Construction, and Operation/ Maintenance costs	8.0	8.1
Desulphurization and HCN Removal Plant	Coke gas	- do -	7.8	7.9
Blast Furnace Gas Combined Cycle Power Plant	Electricity	- do -	10.8	11.5
Top Gas Recovery Turbine Plant	Electricity	- do -	7.3	7.7
Electric Arc Furnace (EAF)	Reduction of production costs	- do -	8.3	9.6
Steel dregs treatment plant	Recycled slugs as construction materials	- do -	7.7	8.9
Sewage Treatment Plant	Reuse the recycled water	- do -	4.4	6.2

Note: Project life 20 years

Although the project cost was within the plan, the project period exceeded the plan. Therefore, efficiency of the project is fair.

3.5 Sustainability (Rating: ③)

3.5.1 Structural Aspects of Operation and Maintenance

Shanxi TISCO Stainless Steel Company (owned by TISCO by 64.24%), which is a subsidiary company of Taiyuan Iron and Steel Company (TISCO), is currently responsible for operation and maintenance of the facilities constructed under the project. Shanxi TISCO Stainless Steel Company was established in 1998 and listed in the Shenzhen Stock Market. In June 2006, it purchased the main assets (steel production division and related equipment/facilities) of the parent company and became the largest steel production company in China. The company has 21 divisions and offices under the management of President and General Manager with a total number of 21,000 employees. The number of staff in charge of operation and maintenance of each facility and plant is shown in Table 9. Sufficient number of staff is assigned to operation and maintenance work, and thus, no problem is observed in its institutional setup.

Table 9 Numbers of Staff in charge of Operation and Maintenance of Each Facility and Plant

unit: persons

Facility	Number of staff
Coke Dry Quencher Plant	33
Desulphurization and HCN Removal Plant	15
Blast Furnace Gas Combined Cycle Power Plant	22
Top Gas Recovery Turbine Plant	12
Electric Arc Furnace (Special Steel Plant)	52
Steel dregs treatment plant	20
Sewage Treatment Plant/Energy Source/ Power Plant deepening process	12
Total	166

Source: Response to Questionnaire

3.5.2 Technical Aspects of Operation and Maintenance

The technical level of staff, who are responsible for operation and maintenance of each facility and plant is shown in Table 10.

Table 10 Technical Level of Workers who are Responsible for Operation and Maintenance of each Facility and Plant

Facility	Technical level
Coke Dry Quencher Plant	Workers are graduated from college, junior college, high school and vocational school. Their technical level is junior engineer's level and they have more than three-year working experience in the equipment maintenance and repairs.
Desulphurization and HCN Removal Plant	Workers are graduated from high school and vocational school. Their technical level is engineer's level and they have more than ten-year working experience in the equipment maintenance and repairs.
Blast Furnace Gas Combined Cycle Power Plant	Among 22 workers, five are graduated from college and three from technical junior college. Their technical level is junior or middle engineer's level. A few workers have more than ten-year working experience in the fields of electric, gas, boiler and steam turbine, and the rest are fresh workers graduated from school.
Top Gas Recovery Turbine Plant	Among 12 workers, one is graduated from college and 8 from technical junior college. Their technical level is engineer's level. All have more than ten-year working experience in the operation of electric equipment.
Electric Arc Furnace	Among 52 workers, one is graduated from graduate school, 2 from college and the remaining 49 are from high school. Their technical level is junior or middle engineer's level. All have more than eight-year working experience in the operation of furnace.
Steel dregs treatment plant	Among 20 workers, one is graduated from college, one from technical junior college and the remaining 18 are from high school. Their technical level is junior or middle engineer's level.
Sewage Treatment Plant	Among 12 workers, two are graduated from college, 6 from technical junior college and the remaining 4 are from high school. All have been engaged in the sewage treatment work since joined the company.

Source: Response to Questionnaire

Employees have taken training modules (lasting for 2 days through 40 days) in each field offered by the TISCO Training Center and external institutes in 2010. The number of training modules offered was 16, and the number of trainees was between 1 and 22 depending on the subject.

From the interview with employees during the inspection of TISCO plants, it was confirmed that the technical level of employees are solid, and that the manuals and guidelines on each facility including the following are well prepared.

- TISCO CDQ Equipment Maintenance and Management Regulations (TISCO Coke Furnace, 2008)
- Desulphurization Treatment Manual, Acid Production Operating Manual
- Gas Turbine Operating Manual
- Gas and its Related Knowledge (TISCO Training Center)
- Electric Steel Production Process Manual (TISCO)
- Steel Slug Treatment Process and Operating Manual
- Local Sewage Treatment Equipment Maintenance and Management Regulations and Technical Operating Regulations (TISCO Water Supply Station, 2007)

3.5.3 Financial Aspects of Operation and Maintenance

The revenue and expenditure status of Shanxi TISCO Stainless Steel Company for the past three years is shown in Table 11.

Table 11 Revenue and Expenditure Status of Shanxi TISCO Stainless Steel Company for the past Three Years

unit: 000 yuan

Item	2008	2009	2010
Main business revenue	71,330,765	57,970,542	75,339,849
Operating costs	62,902,972	51,487,557	67,833,736
Taxes and miscellaneous expenses	262,251	77,921	75,165
Sales expenses	1,110,801	988,198	1,187,469
Management costs	2,382,757	2,618,062	2,861,214
Financing costs	1,732,634	960,622	1,129,194
Depreciation	1,138,248	598,935	825,938
Investment effectiveness ratio	-5,276	42,594	1,193,662
Operating profit	1,795,824	1,281,840	2,620,795
Non business revenue	94,969	88,159	44,556
Non business expenses	89,190	52,512	37,509
Profit before tax	1,801,604	1,317,487	2,627,842
Corporate taxes	-149,858	42,184	73,033
Net Profit	1,951,462	1,275,303	2,554,809

Source: Response to Questionnaire

In 2009, the sales revenue decreased due to the economic crisis after the Lehman Shock. However, in 2010, the revenue went up more than that in 2008 and the company has remained in surplus for the past three years.

The budgets allocated to operation and maintenance of each plant and expenditures actually spent are shown in Table 12.

Table 12 Budgets allocated to Operation and Maintenance of each Plant and Expenditures actually Spent

unit: million yuan

Facility	Budget (year)	Expenditure		
		2008	2009	2010
Coke Dry Quencher Plant	13	21	11.1	12
Desulphurization and HCN Removal Plant	3.5	0.8	1.2	3.35
Blast Furnace Gas Combined Cycle Power Plant	14	-	-	13.5
Top Gas Recovery Turbine Plant	7.5	7.1	7.45	7.51
Electric Arc Furnace	13.20	11.37	12	12.31
Steel dregs treatment plant	7.0	6.3	6.5	6.7
Sewage Treatment Plant	0.53	0.40	0.16	0.40

Note: Operation and maintenance costs for the equipment and facilities constructed and installed under the project.

Budgets for operation and maintenance have been allocated to each facility every year, and the required maintenance costs have spent depending on needs.

The company has remained in surplus for the past three years. The budget needed for operation and maintenance of the equipment and facilities procured under the project is secured, and thus, no major financial issue is observed.

3.5.4 Current Status of Operation and Maintenance

The current status of operation and maintenance of the facilities installed/constructed under the project is as follows:

Coke Dry Quencher Plant: The periodic maintenance of the plant has been undertaken every 1.5 – 2 months, and the major overhaul inspection every 1.5 years. The plant has been operating properly and the operational efficiency is high.

Desulphurization and HCN Removal Plant: The overhaul inspection has been implemented every year. The plant has been operating properly and the desulphurizing efficiency is high. All the required technical parameters meet the planned targets.

Blast Furnace Gas Combined Cycle Power Plant: The required overhaul has been

implemented every 12,000 operational hours or every 1.5 years. The plant has been operating as planned and the high quality material supply has been required.

Top Gas Recovery Turbine Plant: The overhaul has been undertaken every 2 years. The plant has been operating properly. Since there are some minor problems on scaling of blades, some chemical agent needs to be added depending on the gas condition.

Electric Arc Furnace: The regular inspection, which needs 6 - 8 hours, has been implemented three times a month. Moreover, the medium-level comprehensive inspection, which needs two days, has been implemented twice a year. The furnace with dust collectors has been operating properly.

Steel dregs treatment plant: The spot check has been implemented every two hours every day, and the specific professional spot check once a week. The plant has been operating properly.

Sewage Treatment Plant**:** The spot check has been implemented every two hours every day, and the specific professional spot check once a week. When any irregularities were found, repairs are made immediately. The plant has been operating properly. The quality of the treated water is satisfactory and recycled for reuse.

The operation and maintenance has been regularly implemented per management plans. No major issues on the quality and physical durability on the facility and equipment installed/constructed were found.

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

The objective of the project was to improve the environmental condition including air, water, and industrial solid waste pollution by introducing the cleaner production technology, installing emission treatment facilities and ensuring efficient use of waste energy at Taiyuan Iron and Steel Company (TISCO), thereby contributing to the improving the living environment of the people in Taiyuan. The project has been highly relevant to the development plans and needs of China and Shanxi Province, as well as Japan's ODA policies, and therefore its relevance is high. Regarding the improvement of environmental condition including air and water pollution,

which is the project's objective, the project has largely achieved its objectives, therefore its effectiveness is high. Although the project cost was within the plan, the project period exceeded the plan. Therefore, efficiency of the project is fair. Moreover, since no major problems have been observed in the operation and maintenance system (organizational setup, technical capacity and financial status), sustainability of the project is considered 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

4.2.2 Recommendations to JICA

None

4.3 Lessons Learned

Since the executing agency was unfamiliar with the clearance process among the domestic relevant agencies and the JICA's procurement process and procedures regarding the implementation of the Japanese ODA loan project, the implementation was delayed at the early stage of the project implementation. Thus, it is suggested that during discussions with the executing agency at appraisal, detailed review and discussions should be held on the implementation schedule and technical specifications of the equipment to be procured.

Comparison of the Original and Actual Scope of the Project

Item	Original	Actual
1. Project Outputs		
Coke Dry Quencher (CDQ) Plant	Installation of CDQ facilities (treatment capacity of 110 tons/hour) to No. 5 and 6 coke ovens	Installation of CDQ facility (treatment capacity of 150 tons/hour) to No. 7 coke oven
Desulphurization/HCN Removal Plant	Installation of desulphurization facility (treatment capacity of 63,000 m^3/hour) Vacuum Carbonate/Claus	Treatment capacity increased to 130,000 m^3 /hour and treatment process was changed to MEA removal method
Blast Furnace Gas Combined Cycle Power Plant (CCPP)	Installation of Combined Cycle Power Plant (output power 81.4 MW)	Output power was lowered to 51.6 MW
Top Gas Recovery Turbine (TRT) Plant	Installation of a turbine plant to No.3 blast furnace (Output power 6 MW)	Output power was increased to 12 MW
Electric Arc Furnace (EAF)	Construction of Arc Furnace with dust collectors (capacity 90 tons) Disposal of 6 old small furnace	as planned
Steel dregs treatment plant	Installation of steel dregs treatment plant, capacity: 380,000 tons/year for ordinary steel and 120,000 tons/year for stainless steel	Installation of steel dregs treatment plant, capacity: 920,000 tons/year for ordinary steel and 760,000 tons/year for stainless steel
Sewage Treatment Plant	Construction of a sewage plant to be used for domestic water discharged from residential area (treatment capacity: 50,000 m^3/day)	as planned
2. Project Period	March 2002– December 2006 (58 months)	March 2002– December 2008 (82 months)
3. Project Cost		
Amount paid in Foreign currency	14,144 million yen	13,995 million yen
Amount paid in Local currency	9,259 million yen 617 million yuan	11,739 million yen 794.14 million yuan
Total	23,403 million yen	25,734 million yen
Revised project cost	26,072 million yen	-
Japanese ODA loan portion	14,144 million yen	11,739 million yen
Exchange rate	1 yuan = 15 yen (As of September 2001)	1 yuan = 14.782 yen (Average between July, 2004 and March, 2009)