People's Republic of China

Ex-Post Evaluation of Japanese ODA Loan

"Anshan Environmental Improvement Project"

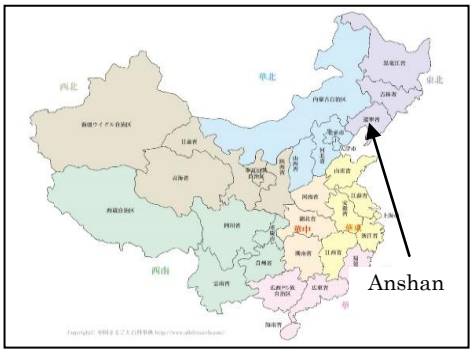
External Evaluator: Hiroshi Ishizato, IC Net Limited

0. Summary

This project aims to strengthen the measures taken by the municipal government of Anshan to improve air environment, water quality environment and living environment. Its relevance is high because the implementation of the sub-projects, though selected after a process of adjustment, has been relevant to the development policies and development needs of China and Japan's aid policy. The effectiveness and impact of the project is also high as the effect of pollutant reduction in terms of air and water and the effect of improvement in water supply resulting from the implementation of this project are remarkable, with the expected effects of sub-projects achieved in their respective years of target, the project's contribution to the improvement of air and water quality as well as living environment verified, and the recovery of groundwater having long been decreasing regarded as a positive impact of the project. With respect to efficiency, while the input of project cost was commensurate with the output achieved after the change of scope, the project period was substantially longer than planned even after subtracting the part of project period extension resulted from the necessity for the "Wastewater Treatment Project" to respond to the expanding need for the service. Therefore, the efficiency of this project is fair. The sustainability of the project is generally high considering the fact that the operation and maintenance (O&M) system is confirmed to be wholesome and stable, the efforts made by the implementing entities to maintain their technological level is being institutionalized, most of the adopted equipment are effectively utilized currently, and regarding the financial aspect, although at the moment the implementation entity of the Water Supply System Improvement Sub-project is facing the problem of deficit operation attributed to the cheap water rate, the problem is expected to be solved with the introduction of a new rate system in the near future.

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

1. Project Description



Project Location

Photo1: A Purification Plant Built with This Project

1.1 Background

Anshan, as one of the 113 National Prioritized Environment Protection Cities designated in the "National Environment Protection 10.5 Plan[1]", was required to take comprehensive air pollution countermeasures including acid rain control, with the implementation of measures to address especially the air pollution worsening due to the existence of plenty of small-size heat supply boilers fuelled by high-sulfur coal and the increase of automobile traffic volume becoming an urgent issue. Meanwhile, as described in the section of "Relevance", the city's water supply per capita in 2000 was below the average level of urban areas all over the country, and many households in the urban area had to live with a water supply under time restriction and the drinking of low-quality groundwater, which called for improvement of daily life water supply in terms of quantity and quality. In addition, while the Liao River flowing across Anshan was designated as one of the Prioritized Watersheds for Water Pollution Countermeasures Enforcement in the "National Environment Protection 9.5 Plan (1996-2000)" and the subsequent "National Environment Protection 10.5 Plan (2001-2005)", the exceptionally low sewage treatment ratio in the city's urban area was contributing to the water contamination of the Liao River Watershed. Therefore, it also became an imperative task to take countermeasures against water pollution.

In order to address the above-mentioned issues, the municipal government of Anshan made the decision in the document of "The 10th Five-Year Plan for Economic and Social Development in Anshan" to further strengthen its measures to improve air environment, water quality environment and living environment by upgrading the environmental infrastructure including heat supply, public transportation, water supply and sewage system.

1.2 Project Outline

The objective of this project is to strengthen the measures taken by the municipal government of Anshan to improve air environment, water quality environment and living environment by upgrading the environmental infrastructure including heat supply, public transportation, water supply and sewage system, thereby contributing to the speed-up of Anshan's sustainable development.

The project was initially assumed to be composed of four sub-projects in Anshan, i.e. the "Central Heating System Improvement Sub-project", "Urban Railway System Improvement Sub-project", "Water Supply System Improvement Sub-project", and "Wastewater Treatment Sub-project". However, with the occurrence of adjustment like cancel or replacement of part of the contents in some of the sub-projects during the process of implementation, the previously assumed composition of the project changed significantly. The change of project composition after the commencement of the project and the names of the sub-projects are reflected in the table below.

[1] "10.5 Plan" is the abbreviation for "10th Five-year Plan", referring to the five-year plan covering the period of 2001-2005. In China, there is the five-year plan covering the nation-wide overall economy and society as well as the five-year plan concerning a specific field for the whole country or the overall economy and society of a specific province or city as referred to hereinafter. Regarding the name of these documents, the abbreviation like "10.5 Plan" is also used officially.

Table 1: Project Outline

Name of Sub-projects	Status	Outline
1. Central Heating System Improvement Sub-project	Significant change of scope and shutdown of part of the adopted equipment	According to the initial plan, a bio-briquette[2] factory was to be built to provide cleaner fuel to substitute ordinary coal for boilers of central heating, and a new type of boilers with high combustion efficiency was to be adopted to replace the existing small-size boilers below 10 ton and to start heat supply to the newly established economic development zone. But in actuality, while the work of bio-briquette factory construction was cancelled, additional indoor and outdoor ducts and heat exchange stations were installed. Besides, some of the 40t boilers adopted in this sub-project were shut down after nine years of operation following the introduction of boilers of larger size in response to the growing needs.
2. Urban Railway System Improvement Sub-project	Cancelled	The sub-project was totally cancelled although it had been scheduled to demolish the existing facilities of the antiquated urban railway (surface railway) and to lay new tracks for the expansion of transportation capacity so as to reduce the number of buses in service.
3. Water Supply System Improvement Sub-project	No change of scope	In this sub-project, the river called Xi River, which is 15km to the east of the existing water source of Anshan, was used as the new water source from which a headrace tunnel leading to the Tanghe Dam was laid and a water purification system was built.
4. Wastewater Treatment Sub-project	Expansion of scope	In this sub-project, the Phase 2 facility of Western No.2 Wastewater Treatment Plant was constructed next to the site of Phase 1 facility which had been operated since March 2002. Following the change of Masterplan for Sewage Treatment of Anshan in December 2009, the wastewater discharged from the newly established Dadaowan Development Zone (DZ) was decided to be treated by the Western No,2 Wastewater Treatment Plant built with this project. Accordingly, the cost for laying the wastewater collecting conduit pipe connecting the Dadaowan DZ and the wastewater treatment plant was newly added to the scope of the Japanese ODA Loan.

[2] Bio-briquette refers to the fuel made from the blended raw materials containing 15-20% vegetative wastes (biomass) such as sawdust, rice straw, crumbled corn core, etc. , which are mixed with some hydrated lime for desulfurization and then molded with high pressure.

<table>
<tr><td>Loan Approved Amount/
Disbursed Amount</td><td colspan="3">14,525million yen / 14,524million yen</td></tr>
<tr><td>Exchange of Notes Date/
Loan Agreement Signing Date</td><td colspan="3">March 29, 2002 / March 29, 2002</td></tr>
<tr><td rowspan="6">Terms and Conditions</td><td rowspan="3">Sub-projects Other Than the Water Supply System Improvement Sub-project</td><td>Interest Rate</td><td>0.75%</td></tr>
<tr><td>Repayment Period (Grace Period)</td><td>40 years (10 years)</td></tr>
<tr><td>Conditions for Procurement:</td><td>Bilateral untied</td></tr>
<tr><td rowspan="3">Water Supply System Improvement Sub-project</td><td>Interest Rate</td><td>1.7%</td></tr>
<tr><td>Repayment Period (Grace Period)</td><td>30 years (10 years)</td></tr>
<tr><td>Conditions for Procurement:</td><td>General untied</td></tr>
<tr><td>Borrower /
Executing Agency</td><td colspan="3">Government of People’s Republic of China / Anshan Municipal Government</td></tr>
<tr><td>Final Disbursement Date</td><td colspan="3">April 25, 2012</td></tr>
<tr><td>Main Contractor
(Over 1 billion yen)</td><td colspan="3">1. Liaoning MEC Group Co., Ltd. (China): Procurement of boiler house, heat exchange stations and boiler heat conduits for the “Central Heating System Improvement Sub-project”.
2. China Railway Materials Import & Export Co., Ltd (China): Procurement of vehicle and heat conduits for the “Central Heating System Improvement Sub-project” and cement and steel stock for the “Wastewater Treatment Sub-project”.
3. Joint Venture of Nishihara Environment Technology Inc. (Japan)/ Hubei Rich States Industry Investment Co., Ltd (China): Procurement of equipment and building materials for the “Wastewater Treatment Sub-project”.</td></tr>
<tr><td>Main Consultant
(Over 100 million yen)</td><td colspan="3">None</td></tr>
</table>

Feasibility Studies, etc.	1. "Feasibility Study Report of Central Heating System Improvement Project", Anshan Coking and Refractory Engineering Consulting Cooperation & Anshan Heating Design and Research Institute, May, 2001. 2. "Feasibility Study Report of Urban Railway System Improvement Project", Beijing Urban Construction Designing Institute, May, 2001. 3. "Feasibility Study Report of Water Supply System Improvement Project", China Northeast Municipal Engineering Design Institute, May, 2001. 4. "Feasibility Study Report of Wastewater Treatment Plant Construction Project", Anshan Coking and Refractory Engineering Consulting Cooperation, March, 2001.
Related Projects	1. Japanese ODA Loan project "Anshan Water Supply System Improvement Project" as a sub-project of "Water Supply System Improvement Project in Three Cities (Tianjin, Hefei, Anshan)", 1990. 2. World Bank financed projects: 1) "Anshan Western No.1 Wastewater Treatment Plant Construction Project" as a sub-project of "Liaoning Environmental Improvement Project", 1995. 2) "Anshan Urban Traffic Reconstruction Project" as a sub-project of "Liaoning Urban Traffic Improvement Project", 1999. 3. "EU-China Liaoning Combined Environment Project" started from October 1999, consisting of seven sub-projects, out of which three had project sites in Anshan： 1) Clean Production Sub-project 2) Air Quality Management Sub-project 3) Capacity Building Sub-project

2. Outline of the Evaluation Study

2.1 External Evaluator

Hiroshi Ishizato, IC Net Limited

2.2 Duration of Evaluation Study

Duration of the Study: August, 2014 –November, 2015

Duration of the Field Study: November 2, 2014 – November 15, 2014

March 23, 2015－March 28, 2015

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

3.1 Relevance (Rating: ③[4])

3.1.1 Relevance to the Development Plan of China

(1) Development plan at the time of the appraisal

In the document entitled "The Tenth Five-Year Plan for National Economic and Socia Development (2001-2005)" (10.5 Plan) publicized in March, 2001, with respect to the concept of China's national economic and social development during the period from 2001 to 2005, the Chinese government came out with the following six top priority issues: a) economic growth, b) structural readjustment, c) reform and opening to the outside world, d) development of science and technology, e) improvement of people's living standards, and f) promotion of development balanced between economic and social aspects. It can be said that the aim of this project was consistent with the above-mentioned e) and f).

Meanwhile, the targets of total quantity control concerning emission of air and water pollutants and the targets of emission reduction in sulfur dioxide (SO_2), smoke dust and industrial powder dust, chemical oxygen demand (COD), and ammonia nitrogen, etc. were set up in the "National Environment Protection 10.5 Plan (2001-2005)" announced the same year. As the environmental improving effect expected with this project concerns reduction of the three pollutants of SO_2, smoke dust and COD included in the above-mentioned, it is evident that the project was planned in a manner consistent with China's national goals.

(2) Development Policy at the Time of the Ex-post Evaluation

In "The Eleventh Five-Year Plan for National Economic and Social Development (2006-2010)" (11.5 Plan) publicized in 2006 after the commencement of this project and the following "The Twelfth Five-Year Plan for National Economic and Social Development (2011-2015)" (12.5 Plan), while the issues of structural readjustment, reform and opening to the outside world, development of science and technology and improvement of people's living standards continued to be positioned as the top priorities, the issue of economic growth was excluded, and that of resource and environment protection was newly added to this category. This apparently shows that the demand for environmental improvement, which has been the aim of this project, is on the increase.

Moreover, although only two kinds of indicators, i.e. COD and SO_2 were specified as the objectives for the setting of target for pollutant emission reduction in the "National Environment Protection 11.5 Plan (2006-2010)", the indicators of ammonia nitrogen and nitrogen oxide (NOx) were added to them in the following "National Environment Protection 12.5 Plan (2011-2015)", evidencing the intensification of environmental protection measures. As all these have been set as the effect indicators of this project, it is clear that the project is highly consistent with China's national plans.

As explained above, the position of environmental protection issue in China's development

[3] A: Highly satisfactory, B: Satisfactory, C: Partially satisfactory, D: Unsatisfactory
[4] ③: High, ② Fair, ① Low

policies at the time of the ex-post evaluation is becoming more important as compared with that at the time of the appraisal, and the strictness of environmental regulation is also increasing. Therefore, it can be said that the consistency of this project with China's development policies is high even at the time of the ex-post evaluation.

3.1.2 Relevance to the Development Needs of China

(1) Relevance to the Development Needs at the Time of the Appraisal

Since the 1990s, the city of Anshan had been suffering from the worsening of air pollution accompanied by the rapid industrialization with the plant equipment getting antiquated, the heat supply by many small-size boilers fuelled by high-sulfur coal, and the increasing volume of automobile traffic, which called for immediate action to improve air quality. In this regard, Anshan was designated as one of the 113 National Prioritized Environment Protection Cities and was required to take comprehensive air pollution countermeasures including acid rain control in the afore-mentioned "National Environment Protection 10.5 Plan (2001-2005)".

In 2000, per capita water supply in Anshan was 171 L/day, falling below the average level of 220 L/day for all the urban areas of the whole country[5]. Besides, residents in 70% of the urban area of Anshan had to live with a water supply under time restriction, which posed a threat to their daily life. Furthermore, in view of the fact that the 250,000 residents in Lishan Ward had to put up with the drinking of groundwater with high manganese and excess iron, the shift of water source from underground to surface was believed to be indispensable.

At the same time, while the Liao River flowing across Anshan was designated as one of the Prioritized Watersheds for Water Pollution Countermeasures Enforcement in the "National Environment Protection 9.5 Plan (1996-2000)" and the subsequent "National Environment Protection 10.5 Plan (2001-2005)", the sewage treatment ratio in the city's urban area was not more than 6.1% and the untreated sewage was discharged into the river, resulting in the water quality of the city's river deteriorating to the extent even worse than the Class V level (the worst level) by the National Water Environment Standard[6] and becoming one of the causes of water contamination in the Liao River Watershed. Accordingly, it became an urgent task to take measures for water quality improvement.

In response to the above-mentioned development needs of Anshan, four components aimed to strengthen the measures taken by the municipal government to improve air environment, water quality environment and living environment through upgrading the environmental infrastructure in heat supply, public transportation, water and sewerage were selected as the sub-projects of this project. Therefore, it can be said that the project is relevant to the development needs at the time of the appraisal.

(2) Rationale for the Selection of the Sub-projects at the Time of the Appraisal

[5] "Per capita water supply" here refers to the average value of "daily life water in a broad sense" which includes not only the water used by households, but also the water used in commercial facilities like public bathhouse and restaurant, etc..

[6] According to the national standard "Surface Water Environment Quality Standard" (GB3838-2002) issued by China State Environment Protection Agency and State Administration of Quality Supervision, Inspection and Quarantine, the quality of surface water is classified into five classes from I to V, with Class V ranked as the worst.

The rationale for the selection of the sub-projects at the time of the appraisal is explained in the following Table 2.

Table 2: Reasons for the Selection of Respective Sub-projects at the Time of the Appraisal

Sub-projects	Major Items	Reasons for the Selection
Central Heating System Improvement	Construction of a bio-briquette factory	It was intended to provide the then prevailing below-10 t boilers with cleaner fuels so as to reduce the emission of SO_2.
	Introduction of 40 t boilers	The technical specification was decided taking into account its two advantages, i.e. the heat efficiency as high as over 80%, and the technological stability higher than the then large-size boilers of 80 t and above.
Urban Railway System Improvement	Extension of existing rail track and installation of additional equipment	The option of railway was regarded as better than that of energy-saving and environment-friendly bus in terms of transport efficiency and environmental protection effect.
Water Supply System Improvement	Construction of a purification plant with a capacity of 150,000 t/day	It was intended to provide the 250,000 residents in Lishan Ward with safer surface water in light of the fact that they had long been drinking the groundwater of bad quality.
	Laying of a headrace tunnel leading from Xihe River to Tanghe Dam	It was regarded as a necessary measure to maintain an adequate water volume in Tanghe Dam, the only large-scale source of surface water in Anshan. Besides, as the drawing of water from Xihe River was to be limited to the high-water season of a year, it was assumed that there would not be any impact on the water supply in the downstream area of Xihe River.
Wastewater Treatment	Construction of a wastewater treatment plant with a capacity of 200,000 t/day	It was decided considering the fact that while the future demand for wastewater treatment capacity in the area (Dadaowan) would be 300,000 t/day, there had already existed a wastewater treatment plant with a capacity of 100,000 t/day.

Source: Interview with respective implementing entities

(3) Reasons for the Change of Scope after the Start of Project Implementation

Among the four sub-projects, the two with cancel or significant change of scope occurring are "Central Heating System Improvement Sub-project" and "Urban Railway System Improvement Sub-project". Regarding the former, the previously scheduled construction of bio-briquette factory was cancelled before the start of equipment procurement and civil engineering work, and part of the adopted 40 t boilers were shut down after a period of operation. As for the latter, the sub-project was totally cancelled before the start of equipment procurement and construction work. The reasons for all these changes of scope are summarized in Table 3 below.

Table 3: Reasons for the Respective Changes of Project Scope

	Change of Scope	Reasons for the Change of Scope
Central Heating System Improvement	Construction of the bio-briquette factory was cancelled before the start of the work.	・The tendency for boilers to shift from dispersed and small-sized type to central and large-sized type became apparent all over China after the start of project implementation. ・The cost of procuring crop straws as the raw material of bio-briquette was soaring owing to the shrinking of rural area around Anshan with the advancement of urbanization, resulting in the fear of loss-making of the sub-project.
	Out of 11 40 t boilers, 6 were shut down after 9 years of operation.	・The heat supply area in "Gaoxin District" (with 6 boilers of 40 t installed), one of the two target districts of this sub-project, was assumed to be two million $m^{2,}$ in floor space at the time of the appraisal, but since it has now expanded into 9.2 million m^2, adoption of boilers of larger size becomes necessary. With the boilers sizing 80-140 t having been introduced successively since 2012, the scale of heat supply system is growing larger.
Urban Railway System Improvement	The sub-project was totally cancelled before the start of the work.	・As a part of the state-owned enterprise reform, many of the employees of Angang (Anshan Iron & Steel Company), who had been assumed to be the beneficiaries of the commuting facilitating effect expected by this sub-project, were laid off, relocated or re-employed. In addition, as a result of the massive redeployment of manufacturing companies from the urban area to the suburb, the commuting routes were changing drastically and the initially designed railway line had become irrelevant. ・While the prerequisites for the development of urban railway stipulated by the Chinese State Council in 2003 were an annual municipal fundamental revenue of 6,000 million yuan and above and an urban population of over 1.5 million, the respective figures of Anshan at that time were 3,500 million yuan and 1.45 million people, both failing to fulfil the requirements.

Source: Interview with respective implementing entities and information materials provided by JICA

The factors behind the above-mentioned various reasons for the changes of scope are considered to be the stricter regulations for energy-saving and environmental protection[7], the change of central government's policies[8], the change of external conditions resulted from the economic growth and the advancement of urbanization in China.

For example, although the bio-briquette factory was initially intended to provide the below-10 t small-size boilers with cleaner fuels, the possibility for these boilers to be shut down in the medium and long terms was actually very high as they failed to meet the heat efficiency target of 75-80% set in the "China Energy-saving Technology Policy Outline" published in 1996. In spite of this, it was known during the field study that the bio-briquette factory had been selected as a part of the sub-project based on the following two considerations: 1) the heat efficiency of 75-80% had no

[7] In addition to the target of heat efficiency set in the "China Energy-saving Technology Policy Outline", the aim to transform the existing diversified and small-sized heating boilers into the central heating type and raise the penetration rate of central heating in the urban area from 27% up to 40% was put forward in the "Medium- and Long-Term Plan for Conserving Energy Resources" issued in 2004 by the National Development and Reform Commission (NDRC). Besides, the coal boilers below 10 t were entirely rejected by the "Standards for Emission of Air pollutants from Boilers" issued by the Ministry of Environment Protection in 2014.

[8] The policies concerning the reform and restructuring of state-owned enterprises enforced by the then National Economy and Trade Commission as well as the document of "Circular Notice Regarding the Issue of Strengthening the Regulation of Urban Rapid Rail Transit System Construction" became the basis for the major restructuring occurring in Angang and cancelling of the railway sub-project.

coercive force, and 2) it was an urgent task to provide the small-size boilers existing in abundance at that time[9]with cleaner fuels.

As such, the above-mentioned changes of scope are regarded as acceptable in that they were unavoidable responses to the change of Chinese government's policies or change of needs. Additionally, as referred to hereinafter, the cancelation of part of the project as well as the shutdown of part of the adopted equipment after a period of operation did not significantly influence the efficiency and effectiveness of this project.

(4) Relevance to the Development Needs at the Time of Ex-post Evaluation

Although the atmospheric concentration of SO_2 in Anshan has met the Class 2 requirement (0.06mg/Nm^3) of the relevant national standard since 2008, as Anshan was continuously designated as one of the National Prioritized Environment Protection Cities in the "National Environment Protection 11.5 Plan (2006-2010)" and the subsequent "National Environment Protection 12.5 Plan (2011-2015)", improvement of air environment remains highly necessary. With respect to water environment, "Complete Development of Urban Water Supply and Drainage System" was determined to be one of the prioritized issues in "The 12th Five-Year Plan for Economic and Social Development in Anshan", and it remains an important task for Anshan municipal government to ensure 24-hour water supply and a high Pass Rate for Comprehensive Water Quality Standard. Furthermore, in the "National Environment Protection 12.5 Plan (2011-2015)", Liao River remains one of the Prioritized Watersheds for Water Pollution Countermeasures Enforcement, and wastewater treatment is expected to continue playing the role of an indispensable solution for water pollution problem. Therefore, the aim of this project to improve air environment, water quality environment and living environment (water supply) is consistent with the development needs even at the time of ex-post evaluation.

3.1.3 Relevance to Japan's ODA Policy

In view of the discussions about a review on Japan's ODA assistance to China, the Japanese government issued a document titled "Program of Economic Cooperation with China" in October 2001, whereby the policy of "prioritizing the fields centering on protection of environment and ecosystem undergoing serious contamination and destruction, livelihood improvement and social development in inland areas, human resource development, institutional development, technology transfer, etc." was put forward. Therefore, it is obvious that the aim of this project has been consistent with Japan's assistance policy for China

This project has been highly relevant to the country's development plan and development needs, as well as Japan's ODA policy. Therefore its relevance is high.

[9] Although the heat efficiency of the below 10 t boilers was around 60%, which failed to meet the target of 75-80% set in the "China Energy-saving Technology Policy Outline", as this target was not compelling, it had become the reason for the abundant existence of small-size boilers at that time.

3.2 Efficiency (Rating: ②)

3.2.1 Project Outputs

The planned and actual outputs of this project and the reasons for their discrepancies are summarized in Table 4 below.

Among the four sub-projects, the "Urban Railway System Improvement Sub-project" was cancelled, and two of the other three sub-projects underwent significant changes of scope. Therefore, it is hard to make a simple comparison between the final outputs and the initial plan. Nevertheless, the final outputs were mostly achieved according to the adjusted plan without notable deviation. Besides, as explained in the section of "Relevance", the changes of scope were necessary responses to the stricter regulations for energy-saving and environmental protection, the change of central government's policies, and the change of external conditions resulted from the economic growth and the advancement of urbanization. Moreover, as these changes were decided before the implementation of equipment procurement and construction work, they did not significantly influence the efficiency of this project. In addition, as described hereinafter, the extension of project period was virtually due to other reasons. Accordingly, the changes of scope are regarded as appropriate. Meanwhile, as formal agreements were reached between the Chinese government and JICA on major changes of scope, it can be said that the procedures of changes were also appropriate.

Regarding the "Central Heating System Improvement Sub-project", due to the reasons described in the section of "Relevance", bio-briquette factory construction was cancelled and the number of boilers installed was reduced to 11 from the originally planned 22 in accordance with the actual size of heat supply area (3.6 million m^2 in total for two districts). In addition, as mentioned above, some of the boilers were shut down and replaced by boilers of larger size after nine years of operation. Nevertheless, considering that the cost of the six boilers shut down accounts for only 1.3% of the total investment of the sub-project and 2.3%[10] of the portion of ODA loan used in the sub-project, this change is virtually insignificant as far as project cost is concerned. At the same time, the length of indoor and outdoor ducts and the number of heat exchange stations were increased from the original plan in consideration of the rising demand in the future as well as the rationality of completing altogether the necessary infrastructure installation work before the beginning of the aboveground construction work.

As for the others, the "Water Supply System Improvement Sub-project" and the "Wastewater Treatment Sub-project" were implemented as planned. But, regarding the latter, the wastewater collecting conduit pipe network and related equipment were added to the scope of the sub-project in response to the increased demand resulted from the establishment of the new Economic Zone.

[10] As the unit price of a 40 t boiler was 24 million yen, the total cost of 6 boilers amounted to 144 million yen, accounting for 1.3% of the actual total cost of the sub-project (11.102 billion yen) or 2.3% of the portion of ODA loan (6.182 billion yen).

Table 4: Outputs of the Project (Plan and Actual Results)

Sub-project	Plan	Actual Results and Reasons for Discrepancy
1.Central Heating System Improvement	● Bio-briquette factory: 60,000 t/year ● Boiler for heat supply: 20 (40 t) ● Indoor & outdoor conduit pipe: about 160 km ● Heat exchange station: 14	● Bio-briquette factory: cancelled (Refer Table 2 for the reasons) ● Boiler for heat supply: 11 (40 t) (Considering that 11 boilers were enough for the actual heat supply floor space) ● Indoor & outdoor conduit pipe: about 447 km ● Heat exchange station: 43 (The length of indoor and outdoor conduit pipe and number of heat exchange station were increased so as to get prepared for the rising demand in the future.)
2.Urban Railway System Improvement	● Extension of current rail: main line about 13 km, others (by-line etc.) about 6 km ● Tunnel: 1 (about 1 km) ● Elevated rail section: 2 (about 0.5 km in total) ● New passenger station: 17 (underground: 2, elevated: 4, aboveground: 11) ● Rail yard: new construction: 1, expansion: 1 ● Substation: 6, communication & signal, rail car: 44	Cancelled (Refer Table 2 for the reasons)
3.Water Supply System Improvement	● Water-conducting facilities: headrace tunnel 15.3 km ● Water purification facilities: Water purification plant 150,000 m^3/day Segmented formation pond 2 Sedimentation pond 2 Rapid filtration pond 10 Water purification pond 1 Water pump 3 Sludge disposal plant 1 ● Water delivery and distribution facilities: Distributing reservoir 1 Pump station 1 Water distributing pipe 24.3 km	Implementation as planned
4.Wastewater Treatment	● Wastewater treatment plant 200,000 m^3/day Pump station: 1 (200,000 m^3/day) Primary sedimentation pond: 4 Reaction pond: 1 Secondary sedimentation pond: 4 Sludge treatment facilities (Conveyor type condensation dehydrator: 4)	● Wastewater treatment plant 200,000 m^3/day Pump station: 1 (200,000 m^3/day) Primary sedimentation pond: 4 Reaction pond: 1 Secondary sedimentation pond: 4 Sludge treatment facilities (Conveyor type condensation dehydrator: 4) ● Wastewater collecting conduit pipe: 60.7 km Wastewater pump: 3 Adjustment pond: 2 (The installation of wastewater collecting conduit pipe etc. was added to meet the increased need resulted from the revision of Anshan Wastewater Treatment Plant Master Plan in 2009 following the formulation of Dadaowan EZ Construction Plan in 2006.)

Source: Interview with respective implementing entities and information materials provided by JICA

3.2.2 Project Inputs

3.2.2.1 Project Cost

The total project cost of this project was initially planned to be 39,339 million yen, including a foreign currency portion of 14,525 million yen and a domestic currency portion of 1,654 million RMB, with the whole of foreign currency portion raised by Japanese ODA loan.

The actual total project cost was 25,228 million yen, the foreign currency portion was 14,525 million yen and the local currency portion was 778 million RMB, with the whole of foreign currency portion raised by Japanese ODA loan. With the drastic decrease of local currency portion from the planned amount, the actual total project cost was 35.9% lower than planned. However, since the reduction of project cost was originally due to the reduction of outputs resulted from the change of project scope, it is inappropriate to make a simple comparison. Accordingly, here the actual total project cost is compared with the estimated amount of cost after the change of scope, and the result is indicated in Table 5, which shows that the actual total project cost including the local currency portion and the foreign currency portion was lower than the estimated amount of cost after the change of scope. Therefore, it can be said that the input of project cost was commensurate with the output.

Table 5: Comparison between the Estimated Project Cost after the Change of Scope and the Actual Project Cost （Unit: Million yen）

Sub-project	Total Project Cost in Original Plan		Total Project Cost after the Change of Scope			
	Scope	Amount	Scope	Estimated Amount	Actual Amount	Difference
Central Heating System Improvement	Bio-briquette factory(Equipment, material. reserve)	1,462	Bio-briquette factory (Cancel)	0	0	0
	Boiler 20 (Equipment, reserve)	541	Boiler 11 (Equipment, reserve)	297	N.A.	N.A.
	Heat exchange station 14 (Equipment, reserve)	395	Heat exchange station 14(Equipment, reserve)	1,214	N.A.	N.A.
	Indoor & outdoor conduit pipe 160 km(Equipment, reserve)	2,130	Indoor & outdoor conduit pipe 447km(Equipment, reserve)	5,949	N.A.	N.A.
	Others (civil engineering、installation, reserve etc.)	8,899	Others (civil engineering、installation, reserve etc.)	4,921	4,921	0
	Subtotal of the Sub-projects	13,427	Subtotal of the Sub-projects	12,381	11,102	-1,279
Urban Railway System Improvement	Extension of rail line etc. (Including reserve fund)	13,241	Cancelled	0	0	0
Water Supply System Improvement	Water-conducting, water purification, water delivery & distribution facilities (Including reserve fund)	6,363	Implementation as planned	6,363	5,440	-923
Wastewater Treatment	Wastewater treatment plant (Including related equipment and reserve fund)	6,309	Wastewater treatment plant (Including related equipment and reserve fund)	6,309	N.A.	N.A.
			Wastewater collecting conduit pipe network 60.7 km Wastewater pump 3 Adjustment pond 2	2,102	2,102	0
	Subtotal of the Sub-projects	6,309	Subtotal of the Sub-projects	8,411	8,685	274
Total of the Project		39,340	Total of the Project	27,188	25,298	-1,928

Source: Interview with respective implementing entities and information materials provided by JICA

Note: The values in the column of "Estimated Amount" were calculated based on an existing unit price or a unit price estimated from the total amount and total quantity (number of unit, length, etc.) available from the column of "Total Project Cost in Original Plan", with the exception that the estimated amount of "Others" in the sub-project of "Central Heating System Improvement" was an actual value provided by the implementing agency, and the estimated amount of cost for the additional equipment like wastewater collecting conduit pipe network in the sub-project of "Wastewater Treatment" was the value available from JICA's document regarding approval of the second-time extension of loan period.

3.2.2.2 Project Period

Whereas the project period scheduled at the time of the appraisal was from February 2002 to October 2006, the actual project period was from February 2002 to April 2012 (123 months in total and 215.8% of planned), significantly longer than planned.

Table 6: Project Period (Plan and Actual Results)

Sub-project	Plan	Actual Results	Result/Plan
1. Central Heating System Improvement	February 2002- October 2006 (4 years and 9 months/ 57 months)	February 2002- October 2004 (2 years and 10 months/ 34 months)	59.6 %
2.Urban Railway System Improvement	March 2002- March 2006 (4 years and 1 month/ 49 months)	Cancelled	—
3.Water Supply System Improvement	March 2002- September 2005 (3 years and 7 months/ 43 months)	August 2002- January 2010 (7 years and 6 months/ 90 months)	209.3 %
4.Wastewater Treatment	February 2003- December 2005 (2 years and 11 months/ 35 months)	January 2004- April 2012 (8 years and 4 months/ 100 months)	285.7 %
Total	February 2002- October 2006 (4 years and 9 months/ 57 months)	February 2002- April 2012 (10 years and 3 months/ 123 months)	215.8 %

Source: Interview with respective implementing entities and information materials provided by JICA

The loan period of this project was extended twice. The first-time extension was due to: a) belated approval of the feasibility study reports (hereinafter referred to as "F/S reports")[11], b) outbreak of "Severe Acute Respiratory Syndrome" (SARS) [12], c) application procedures relevant to "The Law of Land Administration of the People's Republic of China"[13], d) negotiations and formalities regarding land acquisition for the laying of headrace tunnel, and e) influence of snow disaster, etc., while the second-time extension arose from the necessity of installing additional facilities for the "Wastewater Treatment Sub-project". The specific reasons that resulted in the extension of loan period are to be analysed by sub-project as follows.

In this project, extension of project period actually occurred only in two sub-projects, i.e. "Water Supply System Improvement Sub-project" and "Wastewater Treatment Sub-project". In the case of the former, the detailed design originally scheduled to start from February had actually not begun until August 2003 because of the belated approval of the F/S Report, and then the outbreak of SARS gave rise to the delay in the completion of detailed design and equipment procurement tendering for up to 11 months and 3 months respectively. Besides, owing to the influence of snow disaster in March 2005 and the negotiations and formalities regarding land acquisition for the laying of headrace tunnel (referring to the later described "Resettlement and Land Acquisition" for further details), the period of civil engineering work was seven months longer than planned. In the case of latter, the start of detailed design was delayed for up to one year and the period of the work itself was eight months longer than

[11] The F/S Reports were submitted to NDRC via the implementing agency, Anshan Municipal Development and Reform Commission and Liaoning Provincial Development and Reform Commission, upon which, NDRC designated a special agency to evaluate the F/S Reports and made the decision of approval based on the results of evaluation.

[12] According to various news reports, the first infected person of SARS was confirmed in Guangdong Province of China in November 2002, and the infection became pervasive throughout 25 provinces/municipalities/autonomous regions of the country within 6 months after that. By the date of August 15, 2003, the number of SARS patients and the dead respectively reached 5,327 and 349 nationwide. Although the detection of infected persons peaked in May 2003, as quasi-infected persons were newly detected in Beijing in April 2004, the impact of SARS virtually lasted more than 1 year. Besides, some regions including Beijing and Guangdong were designated as "Plague Outbreak Areas" by WHO for a certain period. During the outbreak of SARS, in an atmosphere of high tension and caution throughout the country where the infected and quasi-infected persons were segregated in hospitals and those places (residential estate, large building, factory, agency, facility) with infected persons detected were temporally closed or blocked up, business activities in the areas with infected persons detected were forced to stop.

[13] With the enforcement of this new law in August 2004, application for the authority's review and approval regarding the legality of land use and a series of formalities including investigation, review and approval became necessary.

the originally scheduled 4 months as a result of the belated approval of the F/S Report and the outbreak of SARS. In addition, the application procedures relevant to the law of land administration and the influence of snow disaster caused the delay in the completion of tendering work for up to 3 years and 2 months (38 months), which in turn resulted in the prolonged implementation of civil engineering and installation work of the wastewater treatment plant with a period of 4 years and 2 months (50 months) longer than planned. In view of the delay in various stages of implementation of respective sub-projects attributed to various causes, JICA decided to extend the deadline of the loan period from the planned October 25, 2008 to October 25, 2010 upon consultation with the Chinese government.

The implementation of the above-mentioned two sub-projects was completed before the deadline of the first-time extension approved for the loan period. However, considering the necessity to expand the scope of the "Wastewater Treatment Sub-project" in response to the additional need as described in 3.2.1, JICA decided to authorize the second-time extension for the loan period with the deadline prolonged till April 25, 2012 after a second consultation with the Chinese government.

With regard to the above-mentioned extension of loan period twice, based on the principle of "taking no account of external factors during the evaluation of efficiency", whereas the first-time extension should be regarded as a basis for judgment in the evaluation of efficiency, it would be proper not to count the second-time extension as such a basis since it was a result of the scope expansion in the "Wastewater Treatment Sub-project", which should not be regarded as simply an outcome of external factors but rather a necessary measure to respond to the additional need and to effectively utilize the capacity of existing facilities. However, during the evaluation of project period, even after taking into account the above-mentioned and excluding the approved period of second-time extension (October 25, 2010- April 25, 2012) from the scope of evaluation, the actual project period of this project could still be counted as 8 years and 9 months (105 months), starting from February 2002 and ending in October 2010, which was 84% longer than planned (57 months).

3.2.3 Results of Calculations of Internal Rates of Return (Reference only)

The results of calculations of Internal Rates of Return (IRR) at the time of the ex-post evaluation were as follows:

As far as the "Central Heating System Improvement Sub-project" is concerned, owing to the earlier-than-expected shutdown of part of the adopted 40 t boilers, it was not possible to calculate its IRR based on the project scope of the original plan. Accordingly, a recalculation of FIRR was made by including the boilers sizing 80-140 t adopted to replace the shut-down 40 t boilers in the project scope with an eye to verifying the efficiency of the sub-project. By doing so, the result of FIRR was worked out as -14.35%, which arose from the problem that, while the investment cost increased with the additional equipment, the revenue from the heat supply charge remained unchanged.

With regard to the "Water Supply System Improvement Sub-project", FIRR was -2.65% as a result of the inappropriately low existing water rate. In the case of the "Wastewater Treatment Sub-project",

owing to the fact that the gap between the existing wastewater treatment charge and the operation and maintenance (O&M) cost was even larger, the calculation of FIRR was not possible.

As described above, the results of IRR for respective sub-projects were all negative values. These results need to be considered in the evaluation of effectiveness or sustainability where they could be used as an auxiliary factor for the rating of the respective items.

To sum it up, although the scope of this project underwent significant changes, these changes were appropriate in that they were necessary response to the changes of needs, and the input of project cost was commensurate with the outputs after the changes of scope. Meanwhile, the extension of project period was over 50% longer than planned even after excluding the part of extension regarded as reasonable. Therefore, efficiency of the project is fair.

3.3 Effectiveness[14] (Rating: ③)

3.3.1 Quantitative Effects (Operation and Effect Indicators)

As explained in the previous analysis regarding relevance, out of the four sub-projects of this project, three are now in operation with the cancellation of "Urban Railway System Improvement Sub-project" as an exception. The operational status of equipment adopted in respective sub-projects up to now since the beginning of the project was illustrated in Table 7.

Table 7: Operational Status of Equipment Adopted in Respective Sub-projects

Sub-project	Major Equipment	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Central Heating System Improvement	40 t boilers	■	■	■	■	■	■	■	■	■	△
	Indoor and outdoor conduit pipe	■	■	■	■	■	■	■	■	■	■
	Heat exchange station	■	■	■	■	■	■	■	■	■	■
Water Supply System Improvement	Purification plant						■	■	■	■	■
	Headrace tunnel						■	■	■	■	■
Wastewater Treatment	Wastewater treatment plant						△	△	■	■	■
	Wastewater collecting conduit pipe network								■	■	■

Note: ■ Fully operated、△ Partially operated

Detailed analysis of operation and effect indicators by sub-project is conducted as follows.

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

(1) Central Heating System Improve Sub-project

The 11 boilers of 40 t adopted in this sub-project were installed in boiler houses of two districts called "Gaoxin District" and "Yingchengzi District", with six in the former and five in the latter. The implementing entity of the sub-project, Anshan Heating Corporation, now operating 13 boiler houses, was in charge of heat supply to a floor space[15] of 21 million m^2 in total as of 2013. Out of this, 3.6 million m^2 including the above-mentioned two districts were covered by the service of the boilers adopted in this sub-project, which accounted for one sixth of the company's total heat supply floor space. Meanwhile, as the total heat supply floor space covered by all the 35 heat supply companies in Anshan now reached 63 million m^2, Anshan Heating Corporation roughly accounts for one third of the total, while this sub-project accounts for only 5.7%.

The operation and effect indicators of the sub-project are reflected in the Table 8. The operation indicators like Coal Consumption for Heating Boilers, Number of Boilers in Operation and Total Floor Space of Heat Supply show that the eleven 40 t boilers adopted in this sub-project were in full operation during the nine years from 2005 to 2013, and the target values set for 2007, which had been expected to be one year after completion, at the time of the appraisal were all achieved in the year of 2005[16]. Meanwhile, due to the reasons explained in "Relevance", among the eleven 40 t boilers, only the five installed in "Yingchengzi District" are continuing to operate after 2014. However, as this district is an old urban area with a constant resident population and a stable heat supply floor space, it has been confirmed that the possibility for these boilers to be replaced by boilers of larger size is very low.

Table 8: Operation and Effect Indicators of the Central Heating System Improvement Sub-project (in "Gaoxin District" and "Yingchengzi District")

Indicator	Baseline	Target	Actual Values					
	2000	2007	2005	2010	2011	2012	2013	2014
	Year of Appraisal	1 Year after Completion	1 Year after Completion	6 Years after Completion	7 Years after Completion	8 Years after Completion	9 Years after Completion	10 Years after Completion
Coal Consumption for Heating Boilers (Kt/year)	160	115	115	115	115	115	115	51
Number of 40t Boilers in Operation	0	11	11	11	11	11	11	5
Total Floor Space of Heat Supply (thou.m^2)	0	3,600	3,600	3,600	3,600	3,600	3,600	1,600
Heat Supplied Family (thou. families)	0	36	36	36	36	36	36	16
Annual Heat Supply (Gcal/year)	0	126	126	126	126	126	126	56
SO_2 Emission (t/year)	3,955	887	543	380	362	450	466	N.A

Source: Anshan Heating Corporation and Anshan Environmental Protection Bureau

Note: 1. The boilers for heat supply in Anshan operate from Nov. 1 to Mar, 31 every year.

Note: 2. The heat supply area of this project includes 2 million m^2 in "Gaoxin District" and 1.6 million m^2 in "Yingchengzi District".

[15] In China, the scale of heat supply is indicated in the total floor space of the heat supplied families.

[16] The sub-project was completed two years earlier than planned.

In 2005, practically one year after the completion of the sub-project, the value of SO_2 Emission[17] appeared lower than target and had been kept at the level lower than target till 2014 when some of the boilers were shutdown. Although six out of the 11 boilers adopted in this sub-project were shut down earlier than scheduled, the overall effectiveness of this sub-project was high in that the emergence of expected effect of the sub-project during the in-service period was verified, the remaining five adopted boilers and the facilities of indoor and outdoor heat conduits and heat exchange stations which made up most of the investment cost of the sub-project have been continuing to operate, and by utilizing these facilities, the boilers of larger size introduced by the implementing entity at its own expense have been in service with higher efficiency. Therefore, it can be said that, in spite of the shutdown of part of the equipment, the initially expected effect of this sub-project has been well-maintained. At the same time, in view of the afore-mentioned result of IRR analysis which stood at a negative value owing to the additional cost of investment, it can hardly be said that the investment efficiency has been high. However, taking into account the fact that the expected effect did appear during the period of operation, and the part of the replaced output virtually accounted for a small proportion of the project cost, it is proper to say that the effect of the sub-project has emerged to some extent.

Photo 2: A 40 t Boiler Installed in a Boiler House in "Gaoxin District"

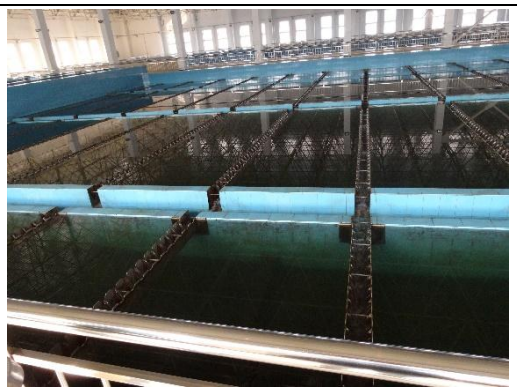


Photo 3: The 150,000 m^3/day Purification Plant Constructed in the Sub-project

(2) Water Supply System Improvement Sub-Project

The 150,000 m^3/day water purification plant planned for the sub-project is located next to the Phase 1 water purification plant constructed in the Japanese ODA loan project, "Water Supply System Improvement Project in Three Cities (Tianjin, Hefei, Anshan)" implemented in 1990. As indicated in Table 9, it can be said that the expected effect of the sub-project has already arisen.

It deserves high evaluation that, as one of the major purposes of this sub-project, the aim to lift the time restriction in water supply was realized. In the whole city of Anshan including the target area of the sub-project (Lishan Ward and part of Tiexi Ward), 24-hour water supply has been achieved since

[17] The data of this indicator were acquired from the observation point of the Environmental Protection Bureau established near the boiler house in "Gaoxin District" where six out of the eleven 40 t boilers of this sub-project were installed. As there were other boiler houses in the surrounding area, these data did not solely reflect the effect of all the equipment of this sub-project. However, they would allow for an estimation of their relevance with the sub-project to some extent.

2010, the year of completion of the sub-project. Also, the target values of effect indicators such as Non-Revenue Water Ratio (NRWR)[18], Water Supply per Person, Pass Rate for Comprehensive Water Quality Standard and Coverage of Water Supply System were all achieved in the year of completion of the sub-project.

Table 9: Operation and Effect Indicators of the Water Supply System Improvement Sub-project (Anshan)

Indicator	Baseline	Target	Actual				
	2000	2005	2010	2011	2012	2013	2014
	Year of Appraisal	Year of Completion	Year of Completion	1 Year after Completion	2 Years after Completion	3 Years after Completion	4 Years after Completion
Water Supplied Population in Anshan（thou.persons）	1,310.0	1,440.0	1,452.1	1,456.1	1,444.3	1,449.2	1,553.2
Water Supplied Family in Anshan (thou. families)	485.0	520.0	524.1	533.8	524.0	524.0	582.4
Hour of Water Supply in Anshan（hour/day）	12	24	24	24	24	24	24
NRWR in Anshan（%）	41	39	38	37	35	33	30
Water Supply per Person in Anshan（L/day）	85	110	115	115	115	115	120
Pass Rate for Comprehensive Water Quality Standard（%）	99.4	99.5	99.7	99.7	99.9	99.9	99.9
Coverage of Water Supply System（%）	90	95	100	100	100	100	100

Source: Anshan Water Corporation

Note: 1. “Water Supply per Person” refers to the daily life water used by households only instead of the daily life water in a broad sense including that of the bathhouses, restaurants, etc.
Note: 2. “Pass Rate for Comprehensive Water Quality Standard” is an indicator stipulated in the National Standard, “Drinking Water Sanitary Standard” (GB-5749), which is a weighted average of Number of Common Bacterial, Coli Group, Residual Chlorine, Degree of Pollution, Chromaticity, Smell & Taste, COD and other 35 items (altogether 42 items).

Photo 4: A Primary Sedimentation Pond in Dadaowan Wastewater Treatment Plant[19]

Photo 5: The Wastewater Pumps Additionally Adopted in the Sub-project

[18] China’s Industry Standard for NRWR is 18% (“Urban Water Supply Pipe Network Leakage Control and Evaluation Criteria” (Cjj92-2002), but according to the explanation by the implementing entity, in the frigid Northeastern China where all the water supply pipes have to be laid underground instead of above ground, as it is hard to conduct normal checkup and maintenance, NRWR is significantly higher than that of other areas. In view of the fact that the average level of NRWR in urban area here is 35%, the target set for this sub-project was an annual reduction rate of 1.2% beginning from the year of 2000. As a result, the actual level of NRWR of the sub-project has been reduced to 30.2% by now.

[19] It was called “Western No. 2 Wastewater Treatment Plant” at the time of the appraisal, but it was changed to “Dadaowan Wastewater Treatment Plant” in 2008.

(3) Wastewater Treatment Sub-project

With respect to this sub-project, the target values set for the year of completion were all achieved in the year of 2012, including the operation indicators of Volume of Treated Wastewater, Wastewater Treatment Area and Capacity Utilization Ratio as well as the effect indicators of Sewage System Penetration Rate, Discharge Amount and Concentration of COD, BOD and SS.

Table 10: Operation and Effect Indicators of the Wastewater Treatment Sub-project (Anshan Dadaowan Wastewater Treatment Plant)

Indicator	Baseline	Target	Actual				
	2000	2005	2010	2011	2012	2013	2014
	Year of Appraisal	Year of Completion			Year of Completion	1 Year after Completion	2 Years after Completion
Volume of Treated Wastewater (thou. m^3/day)	20	200	140	160	175	183	182
Area of Wastewater Treatment (km^2)		48	48	48	48	48	48
Capacity Utilization Ratio (%)		100	70	80	100	100	100
Sewage System Penetration Rate (%)		100	90	95	100	100	100
COD Discharge Amount (t/year)	31,390	8,760			4,407	4,809	2,431
COD Concentration (mg/L)	430	100			69	72	36.6
BOD Discharge Amount (t/year)	11,680	2,190			639	735	392
BOD Concentration (mg/L)	160	30			10	11	5.9
SS Discharge Amount (t/year)	22,484	2,190			958	868	438
SS Concentration (mg/L)	308	30			15	13	6.6

Source: Anshan Dadaowan Wastewater Treatment Plant

Note: 1. The data of discharge amount concentration of pollutants in 2014 were measured data up to October, with the data of concentration measured in the outlet of the wastewater treatment plant.

2. The data of "Sewage System Penetration Rate" were that of Anshan as a whole

3.3.2 Qualitative Effects

The qualitative effects of the project assumed at the time of the appraisal were the antipollution measure facilitating effect, living environment improving effect and global warming countermeasure facilitating effect. As the three effects are relevant to the issue of impact, they are to be dealt with in the following section.

3.4 Impacts

3.4.1 Intended Impacts

(1) Antipollution Measure Facilitating Effect

The antipollution measure facilitating effect assumed at the time of the appraisal included the effect of desulfurization by changing the fuel for central heating boilers and the effect of improving the polluted river water quality in Anshan. However, as far as the former is concerned, with the cancel of bio-briquette factory construction and the subsequent shutdown of the small-size boilers below 10 t, the way of achieving the desulfurization effect has become one of improving combustion efficiency to reduce SO_2 emission through adopting boilers of larger size instead of changing the boilers' fuel. The two effects are to be analysed in the following paragraphs.

1) Effect of SO_2 Emission Reduction through Improvement of Combustion Efficiency

As seen in Table 8, while the annual coal consumption for heating boilers in "Gaoxin District" and "Yingchengzi District" (where the boilers adopted in this project were installed) in 2000 was 160,000 t, this figure reduced to 115,000 t during the period from 2005 to 2013 with the adoption of the 11 boilers of 40 t, a 39% reduction from the baseline value. Based on this, the annual amount of SO_2 emission reduction during this period can be estimated at 450 t[20]. Moreover, as the 6 boilers installed in "Gaoxin District" under this project has been replaced by boilers of larger size with better performance since 2014, the actual values of annual reduction in coal consumption and SO_2 emission relevant to the same area of heat supply should be larger than the above-mentioned.

According to the year-wise data of atmospheric SO_2 concentration in Anshan as indicated in Table 11, the value of atmospheric SO_2 concentration peaked in 2005, the year of completion of the "Central Heating System Improvement Sub-project"[21], and exhibited a declining trend after that. Besides, the result of the Beneficiary Survey[22] shows that, with regard to the air quality of Anshan, those answering "slightly improved as compared with 5 years ago" stood at 53%, while those answering "significantly improved as compared with 14 years ago" and those of "slightly improved" amounted to 62%. Meanwhile, 95% of those answering "improved as compared with 14 years ago" cited "adoption of large-size boilers and shutdown of outdated small-size boilers" as the reason for the improvement of air quality. Accordingly, although it can hardly be said that the implementation of the sub-project itself has given rise to the significant improvement of the overall air environment of Anshan in light of the fact that the heat supply floor space covered by the sub-project accounts for not more than 5.7% of the total heat supply floor space of the whole city, it is appropriate to say that the sub-project has contributed to the city's air quality improvement to a certain extent.

Table 11: Change of Atmospheric SO_2 Concentration in Anshan

Indicator	2000 Baseline	2001	2003	2005	2007	2008	2009	2010	2011	2012	2013
Atmospheric SO_2 Concentration in Anshan (mg/Nm^3)	0.071	0.07	0.078	0.078	0.069	0.058	0.054	0.045	0.057	0.048	0.048

Source: Anshan Environmental Protection Bureau

[20] Calculating formula: $SO_2=2Cx$ (C=amount of combusted coal, x=content rate of sulfur, 2 refers to the phenomenon where the sulfur content grows to double in mass via chemical reaction during the process of coal combustion. In addition, the sulfur content of coal used in China differs from place to place, and the coal used in Anshan is said to be basically a kind of low-sulfur coal mined within Liaoning Province with a content rate of 0.5% on average.)

Annual amount of SO_2 emission reduction= 2×45,000t×0.005＝450t

[21] The test run of the sub-project was completed in November 2004.

[22] The survey was held in November 8, 2014 in the 219 Park at the center of Anshan with the visitors as respondents. The number of sample selected at random and number of effective response were both 34. The survey was conducted by the investigators who queried based on the questionnaire and filled in the answers on it.

2) Effect of Improving the Polluted River Water in Anshan through Construction of the Wastewater Treatment Plant

As seen in Table 10, the amount and concentration of the three kinds of pollutants discharged from the Dadaowan Wastewater Treatment Plant in 2012, the year of completion of the "Wastewater Treatment Sub-project", all achieved their targets set for the year of completion. Although the values of concentration that year all satisfied the Class 2 level of the National Standard, a new treatment technology was introduced in 2013, whereby the values of concentration were further improved to reach the Class 1A level[23].

Table 12: Change of Major Indicators of River Water Quality in Anshan

Indicator	National Standard	2000	2001	2003	2005	2007	2008	2009	2010	2011	2012	2013
COD Concentration (mg/L)	30.0	30.4	31.0	38.0	27.7	35.7	29.4	24.2	16.9	16.8	14.3	13.1
BOD Concentration (mg/L)	6.0	6.4	6.5	6.7	6.6	6.3	6.0	3.5	3.5	5.1	4.2	3.5

Source: Anshan Environmental Protection Bureau

Note: 1.The actual data were acquired via samples collection from the observation point in the Taizi River where all the rivers of Anshan converge.

2. The values of National Standard are of Class IV level stipulated in "Environmental Quality Standard for Surface Water" (GB3838-2002).

Meanwhile, as indicated in Table 12, a declining trend in the concentration values of COD and BOD began from 2008, but especially the value of COD registered a significant year-on-year decrease in 2010 when the facilities of the sub-project started operating with a capacity utilization rate of 70%, and it declined further in 2013, the year after the completion of the sub-project. Taking account of the proportion of the sub-project (36%) to the total capacity of wastewater treatment in Anshan (560,000 m^3), it can be said that its contribution to the improvement of river water quality has been significant.

[23] According to the existing National Standard, "Discharge Standard of Pollutants for Municipal Wastewater Treatment Plant" (GB-18918-2002), the values of Class 1A and Class 2 for the concentration of the above-mentioned three kinds of discharged pollutants are as follows. Class 1A: COD 50mg/L, BOD 10mg/L, SS 10mg/L, Class 2: COD 100mg/L, BOD 30mg/L, SS 30mg/L.

Photo 6: Yunliang River near Dadaowan Wastewater Treatment Plant

Photo 7: Residents Enjoying Fishing along the Yunliang River (Part of the Respondents to the Beneficiary Survey)

At the same time, the result of Beneficiary Survey[24] also bears out the contribution of the sub-project to the improvement of river water quality in Anshan. In this survey, with regard to the river water quality in Anshan, those answering "significantly improved as compared with 5 years ago" and "slightly improved" added up to 89%, while those answering "significantly improved as compared with 14 years ago" and those of "slightly improved" amounted to 91%. Meanwhile, 72% of those answering "improved as compared with 14 years ago" cited "construction of Dadaowan Wastewater Treatment Plant" as the reason for the improvement of river water quality.

Additionally, according to the respondents to the survey, as a river running through the nearby area of Dadaowan Wastewater Treatment Plant, Yunliang River used to be seriously polluted due to the direct discharge of untreated industrial effluent as well as domestic wastewater into the river. However, with the wastewater treatment plant coming into being, the river water quality has been improved, the habitat of fish has recovered, and the scene of anglers enjoying fishing has come back since 2014. All these points to the fact, the progress of water environment improvement has also brought about favourable change of living environment to the residents.

(2) Living Environment Improving Effect

As currently the four water purification plants[25] add up to a total capacity of 580,000 m^3/day and thus the "Water Supply System Improvement Sub-project" accounts for 26% of the total, it can be said that a considerable contribution has been made by this sub-project to the improvement of living environment reflected by the realization of 24-hour water supply and amelioration in drinking water quality in Anshan. Especially, what deserves high commendation is that the 250,000 people living in Lishan Ward have been able to drink the safer surface water from Tanghe Dam thanks to the

[24] The survey was held in November 9, 2014 along the Yunliang River near Dadaowan Wastewater Treatment Plant with mainly the anglers as respondents. The number of sample selected at random and number of effective response were both 35. The survey was conducted by the investigators who queried based on the questionnaire and filled in the answers on it.

[25] The purification plant operated by Angang itself is excluded here.

implementation of the sub-project, who used to live with the drinking of groundwater with high manganese and excess iron.

Furthermore, the result of Beneficiary Survey[26] held with the residents of Lishan Ward as respondents confirms that, the effect of the sub-project in "reducing the cases in interruption of water supply" and "decreasing the content of manganese and iron in drinking water" as compared with the situation before the implementation of the sub-project has been recognized by many of the residents. In this survey, with regard to the situation of water supply in Lishan Ward, those answering "significantly improved as compared with 5 years ago" and "slightly improved" added up to 95%, while those answering "significantly improved as compared with 14 years ago" and those of "slightly improved" amounted to the same proportion. Meanwhile, among those answering "improved as compared with 14 years ago", 76% and 47% of the answerers respectively cited "reduction of the cases in interruption of water supply" and "decrease of the content of manganese and iron in drinking water" to substantiate the answer.

(3) Global Warming Countermeasure Facilitating Effect

As illustrated by the afore-mentioned Table 9, the implementation of "Central Heating System Improvement Sub-project" resulted in the reduction of annual coal fuel consumption from 160,000 t in 2000 to 115,000 t after 2005. Based on this, by converting the amount of coal combustion into that of CO_2 emission, it can be estimated that the annual reduction of CO_2 emission since the completion of the sub-project has been 83,252 t as compared with the figure at the time of the appraisal[27]. Furthermore, as the 6 boilers installed in "Gaoxin District" under this project has been replaced by boilers of larger size with better performance since 2014, the actual values of annual reduction in coal consumption and CO_2 emission relevant to the same area of heat supply should be larger than the above-mentioned.

3.4.2 Other Impacts

(1) Impacts on the Natural Environment

1) Contribution to the Recovery of Groundwater Resource with the "Water Supply System Improvement Sub-project"

The implementation of the "Water Supply System Improvement Sub-project" has brought forth the positive impact unintended at the time of the appraisal with its contribution to the recovery of groundwater resource in Anshan.

A study[28] shows that, over the past several decades in Anshan, groundwater had been excessively

[26] The survey was held in November 8-9, 2014 with the visitors of Mengtai Park in Lishan Ward as respondents. The number of sample selected at random and number of effective response were both 36. The survey was conducted by the investigators who queried based on the questionnaire and filled in the answers on it.

[27] The way of calculation: 1) The conversion factor to convert CO_2 into coal combustion amount: CF=A×B×C=1.850037
(A=standard coal/raw coal=0.7143, B=carbon/standard coal=0.7, C=CO_2/carbon=3.7)
2) Annual CO_2 emission reduction with the sub-project after 2005:
Annual CO_2 emission reduction=(160,000t-115,000t)×1.850037= 45,000t×1.850037=83,252t

[28] Tong Lian-jun (Researcher, Institute of Northeast Geography and Agricultural Ecology, Chinese Academy of Science)

taken due to the lack of water resource, which resulted in the declining of groundwater level to the depth of 24.25 m from the ground surface as of 1986, with the deepest level even reaching 30 m in some places. Moreover, according to the result of another study[29], the level of groundwater in Shoushan as part of the water resource in Anshan had declined at a speed of 0.3 m per annum by the year 1999, which gave rise to the fear of aggravation of water quality, degradation of soil and ground subsidence resulted from excessive groundwater intake. In light of this, together with the formulation and enforcement of "Water-saving Regulation" and "Water Resource Protection Regulation", the municipal government has taken steps to convert the water resource from groundwater to surface water as an important countermeasure, including the work of "Transmitting Water from Xihe River to Tanghe Dam"[30] which was virtually a part of the sub-project. As a result, surface water has now mostly replaced groundwater which was the major source of raw water in Anshan at the time of the appraisal, and the used amount of water taken from the remaining groundwater resource has greatly decreased. Consequently in recent years, the level of groundwater has been observed rising 5.8 m in accumulated total, with the increase in the year of 2014 reaching 1.8 m, which has been highly publicized in the recent mass media[31].

2) The Problems of Offensive Odor and Noise during the Operation of Facilities

At the time of the appraisal, it was assumed that negative effects would arise during the construction work of the "Urban Railway System Improvement Sub-project" and problems of offensive odor, sludge and noise accompanied by the operation of the "Wastewater Treatment Sub-project" would occur. In this regard, countermeasures were proposed at the time of the ex-ante evaluation, and the status of implementation regarding these countermeasures was verified as described below.

With the cancellation of the "Urban Railway System Improvement Sub-project", the concern about negative effects arising from its construction work has been out of the question. As for the concern over the problems of offensive odor and sludge, the concern has been skirted with the installation of deodorization equipment at the spot of offensive odor emission source to significantly ease the stink, and the introduction of a facility at a cost of 14.8 million yuan to handle sludge treatment. With regard to the concern over noise, in the first place, the fact that there have been no resident at all living within a two km radius suggests that even if a noise was generated by the facility, it would not constitute a problem. The residents living around the wastewater treatment plant also confirmed that they were not feeling disturbed by the operation of the wastewater treatment plant when responding to the

"Sustainable Development and Rejuvenation of the Old Industrial Base in Northeast under the Framework of Environmental Economy" (2005)

[29] Geng Xiao-mei (Liaoning Province Environmental Engineering Evaluation and Review Center) "Study on the Issue of Groundwater Environment and the Trend of Development in Liaoning Province" (*Liaoning Urban and Rural Environmental Science and Technology*, No.3, 2007)

[30] The "Laohushan Water Purification Plant" constructed in 2013 was also intended to be a part of this countermeasure by drawing surface water from the Dahuofang Dam in Fushun City.

[31] One of the reports was posted in the 1st page of "Anshan Daily" on March 24, 2015, entitled "A Desirable Situation of Recovery in the Altitude of Groundwater in the Prioritized Regions of Anshan"

Beneficiary Survey. Accordingly, it can be said that the problems of offensive odor and noise have actually not occurred.

As for the other two sub-projects, it was confirmed during the field study that no complaint about offensive odor and/or noise had been received.

3) Measures against Possible Environmental Impacts during the Period of Construction Work

The possible environmental impacts during the construction period of the three sub-projects assumed and the counter-measures taken by the implementing entities are summarized as follows.

Among the major concerns over the environmental impacts arising during the construction period, three were common to all the sub-projects, i.e. the concerns about air pollution caused by dust stirred up during the process of transporting the earth and sand and building materials, noise generated by the operating machines at the construction sites, and wastes discharged from the construction sites. As the measures against dust, high fences were installed to enclose the construction sites and the vehicles transporting construction materials were closely covered with plastic sheets. With regard to the concern about noise, on the one hand low-noise construction machines were adopted preferentially, and on the other, muffling devices were mounted especially to the heavy excavation machines with high noise. As for the wastes discharged from the construction sites, distinction was made between construction wastes like sludge and gravels and kitchen garbage, with the former disposed of by landfill and the latter conveyed to the special waste treatment plant for disposal.

In the case of "Water Supply System Improvement Sub-project", in addition to the above-mentioned, there was also the concern about pollution of river due to the construction of headrace tunnel. Against this concern, measures like implementing the work of river-crossing pipeline laying only in the dry season and constructing a cofferdam before implementing the work, etc. were adopted.

It can be said that various concern were prevented owing to the above- measures.

(2) Land Acquisition and Resettlement

With respect to the issue of land acquisition in this project, the following points were verified.

Among the three sub-projects, land acquisition was actually needed in the "Wastewater Treatment Sub-project" and "Water Supply System Improvement Sub-project".

The area of land acquired for the "Wastewater Treatment Sub-project" was 10.8 ha (=108, 000 m^2), and the unit price of the land acquired was 151 yuan/m^2 decided by the Anshan Land and Resources Bureau according to the relevant national law. As resettlement did not happen, the acquisition of land was carried out without trouble.

In the case of the "Water Supply System Improvement Sub-project", according to the implementing entity, the total area of land acquired was 13.2 ha (=132,000 m^2) due to the necessity to build a 15.3 km long headrace tunnel across the three cities of Benxi, Liaoyang and Anshan, resettlement was not required and the price for land acquisition was decided based on the national

standard, the same as that of the "Wastewater Treatment Sub-project". As the negotiations regarding land acquisition required cooperation from the relevant government agencies of three cities, six wards and over 10 townships, it took virtually more than two years to complete the work of acquisition for all the needed land. Specifically, as far as land acquisition within the city of Anshan is concerned, the implementing entity was required to apply to all the relevant agencies of the municipal government (Land and Resources Bureau, Planning Bureau, Urban Construction Commission and Public Security Bureau) for their approval and support to the implementation of land acquisition. Upon receiving the application, the relevant agencies gave notice to their respective subordinate agencies of the wards and townships where land acquisition was to be conducted. Following this, the implementing entity started to hold briefing sessions, pay visits to and conduct negotiations with relevant farm families respectively accompanied by the government officials of the relevant wards and townships. Regarding the land acquisition in Liaoyang and Benxi, the application procedures became far more complicated due to the necessity to submit applications or give notice not only to the relevant government agencies of Anshan, but also to the relevant government agencies of the two cities, and the relevant wards and townships before the implementing entity was allowed to start negotiations with the relevant farm families. Nevertheless, owing to the appropriate steps taken during this process, the negotiations for land acquisition were completed without significant trouble.

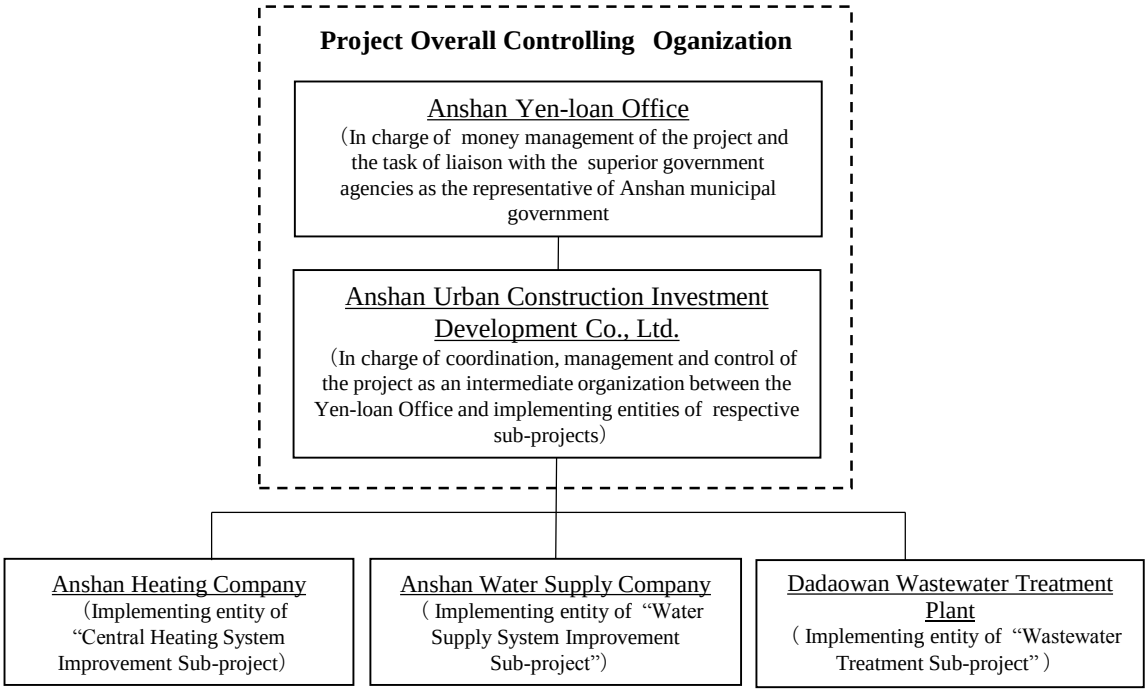
As described above, the project has largely exerted its effect as planned. The shutdown of part of the equipment earlier than expected has not significantly generated unfavourable effect on the project, and while no negative impact has arisen, some unintended positive impact has appeared. Therefore, effectiveness and impact of the project are high.

3.5 Sustainability (Rating: ③)

As the project was composed of multiple sub-projects, evaluation of its sustainability has been conducted in a comprehensive manner with the implementing entities of respective sub-projects (except the one already cancelled) and the municipal government of Anshan presiding over the whole project as the targets of evaluation.

3.5.1 Institutional Aspects of Operation and Maintenance

The organizational structure of this project in terms of Operation and Maintenance (O&M) is illustrated by the Figure below:



Source: Interview with Anshan Yen-loan Office

Figure 1: The Project's Organizational Structure in Terms of O&M

(1) The Project's Overall Controlling Organization

The project's overall controlling organization consists of two agencies, i.e. Anshan Yen-loan Office and Anshan Urban Construction Investment Development Co., Ltd, with their division of roles clearly defined. The former has been functioning as the representative of the Anshan municipal government by taking charge of money management of the whole project (Yen-loan and funding from the domestic financial institutions) and liaison with the superior government agencies (the government of Liaoning Province and the central government), while the latter, as an intermediate organization between Yen-loan Office and the implementing entities of respective sub-projects, has been in charge of coordination, management and control of the project.

Anshan Yen-loan Office was set up inside Anshan Financial Bureau, with its Director and Deputy Director assumed respectively by a Deputy Chief of the Financial Bureau and the Director of the Debt and Finance Division under the Financial Bureau. Meanwhile, Anshan Urban Construction Investment Development Co., Ltd was set up as a state-owned company wholly owned by Anshan Municipal government, with its Vice President taking charge of the operation and management of this project. Over the project period, concerned personnel of the two agencies met at least once a week to share information, and this kind of meeting has been continued since the completion of this project though on an irregular base. On the occurrence of a critical issue, the Director or Deputy Director of Yen-loan Office should take the responsibility to report it to NDRC and the Ministry of Finance and to receive their instructions.

It can be said that the project has been operated and managed without significant trouble under this

kind of overall controlling organization system.

(2) Implementing Entities of the Sub-projects

An overview of O&M organizational structure in respective sub-project implementing entities is given in Table 13 as below. Among these implementing entities, Anshan Heating Corporation has designated its subsidiary to take charge of the O&M work of "Central Heating System Improvement Sub-project", while in the case of "Water Supply System Improvement Sub-project", this work has been assigned to a branch company of Anshan Water Supply Corporation. The following points are the features of O&M organizational structure common to all implementing entities of the project:

1) A state-owned company practically 100% owned by the Anshan municipal government without any schedule of privatization currently.
2) Basically stable personnel positioning since the start of the facilities' operation.
3) Regularly held meetings on issues of production and safety and emphasis on safety education.
4) Record of equipment inspection and retention of records being institutionalized.

Accordingly, the O&M organizational structure also appears to be stable and sound at the level of sub-project.

Table 13: O&M Organizational Structure of Sub-projects

Sub-project	Implementing Entities	O&M Organizational Structure
Central Heating System Improvement	Anshan Heating Corporation (Subsidiary "Urban Heating Company")	・A state-owned company 100% owned by Anshan municipal government without any schedule of privatization currently. ・O&M of this sub-project taken care of by an organization of the whole company instead of a separate organization set up solely for this sub-project as equipment of this sub-project has functioned as part of the overall facilities of the company. ・Meetings on production and safety held weekly to discuss and solve problems of this kind, with the safety education conducted irregularly. ・Record of equipment and retention of records being institutionalized.
Water Supply System Improvement	Anshan Water Corporation (Branch "Water Supply Company"	・A state-owned company 100% owned by Anshan municipal government without any schedule of privatization currently. ・The number of employees of the branch company "Water Supply Company" fixed at 380 since 2010 when the equipment of the sub-project started operation. ・O&M of this sub-project taken care of by an organization of the whole company instead of a separate organization set up solely for this sub-project as equipment of this sub-project has functioned as part of the overall facilities of the company. ・Meetings on production and safety held weekly to discuss and solve problems of this kind, with the safety education conducted irregularly. ・Record of equipment and retention of records being institutionalized.
Wastewater Treatment	Anshan Dadaowan Wastewater Treatment Plant	・A state-owned company 100% owned by Anshan municipal government without any schedule of privatization currently. ・O&M organization set up for the purpose of this sub-project with the equipment of this sub-project installed as an independent facility. ・The number of employees fixed at 85 since 2010 when the equipment of the sub-project started operation. ・Meetings on production and safety held weekly to discuss and solve problems of this kind, with the safety education conducted irregularly. ・Record of equipment and retention of records being institutionalized.

Source: Interview with respective implementing entities

3.5.2 Technical Aspects of Operation and Maintenance

(1) Technological Level of Employees of the Implementing Entities

The implementing entities of sub-projects all possess a proper number of technicians required for their respective works.

As far as "Urban Heating Company", the actual implementing entity of the "Central Heating System Improvement Sub-project" is concerned, the total number of 143 staff members includes two senior engineers, 10 engineers, and 86 skilled workers. In the case of "Water Supply Company", the actual implementing entity of the "Water Supply System Improvement Sub-project", among the 380 staff members in total, there are three (3) senior engineers, 12 engineers, 10 skilled workers and other 45 staff members with an education background of junior college or university or above. With regard to the implementing entity of the "Wastewater Treatment Sub-project", "Dadaowan Wastewater Treatment", the total number of 85 staff members consists of one senior engineer, 10 engineers, 12 associate engineers and 62 skilled workers, which means that every one of the staff members has obtained some kind of technological qualification.

It is worth notice that while the equipment adopted in the respective sub-projects are practically not that sophisticated technologically, each of the implementing entities is equipped with a technical staff required for the O&M work. Additionally, in light of the fact that, as already verified in the section of "Effectiveness", all the three sub-projects have been operating stably so far, it can be said that no significant problem has been detected in the technical aspects of O&M.

(2) Institution Aimed to Maintain and Improve the Technological Level of Employees

All the implementing entities have established their respective training systems to maintain and improve the technological level of employees, which include in-house training and outside training. Both "Urban Heating Company" and "Dadaowan Wastewater Treatment Plant" dispatch managers and technicians to attend training courses on practical operation in the plant of the equipment manufacturer. In the case of "Water Supply Company", training courses are conducted by the company itself separately to cater to the respective needs of managers, technicians and frontline workers. Moreover, in the case of "Dadaowan Wastewater Treatment Plant", in addition to the continuation of training courses on practical operation, outside training in a design institute intended for theoretical study is also under contemplation, which reveals the company's proactive stance toward establishing a sound training system.

(3) Manuals Available for O&M

All the implementing entities have the manuals for the O&M of their respective sub-projects, which are being used practically. The manuals for the O&M of equipment are provided by respective manufacturers.

As described above, it can be said that there is no problem in the technical aspects of O&M for the project.

3.5.3 Financial Aspects of Operation and Maintenance

(1) Financial Resource Necessary for O&M

According to the results of IRR calculation in the section of "Efficiency", the IRR values of respective sub-projects turn out to be negative numbers, which points to the fact that each of the sub-projects is hardly profitable by itself. Therefore, with the view to evaluating the sustainability of O&M in the financial aspects, it is necessary to make a comprehensive analysis of the implementing entities' capacity for project implementation in terms of financial resource as to whether there is any plan to improve the profitability of individual sub-projects and whether a package of comprehensive financial measures are in place.

First of all, the current state of financial resource and the future prospect of improvement for respective sub-projects are summarized in Table 14 below.

With regard to the "Central Heating System Improvement Sub-project", although the IRR value yielded taking into account the investment cost is low, since it is possible to cover the cost of ordinary O&M by the revenue from the heating project, there is not too much concern over the financial resource for ordinary O&M of the project. As for the issues of recoupment of the initial investment and financial schedule, relevant analysis will be given in later sections.

In the case of the "Water Supply System Improvement Sub-project", although the current water rate is a kind of flat-rate system and has been kept at a low level, the situation is expected to improve against the background of a new trend of policy started by the central government and followed by the local government. To be more specific, in the document "Guidance on Accelerating the Establishment of Graduated Water Rate System for Urban Household Water" announced by the NDRC and the Ministry of Housing, Urban and Rural Development (MOHURD) in December 2013, it was set up as a target to "put the Graduated Water Rate System into operation for household water in all the cities with subordinate municipalities by the end of 2015 in principle" and to "practice this system actively in those townships (including administrative districts of the same class) with conditions permitted". In addition, it was also specified as a principle of the Graduated Water Rate System that "the water rate should be adjusted to the level which will be able to reflect the overall cost of water supply". Upon this, the Housing Construction Commission of Anshan is now in the process of deliberation on a working plan to be put forward by the end of 2015. Therefore, it is expected that the revenue from water rate in the future will be able to cover the O&M cost when looking at O&M only, regardless of the IRR value which takes account of the initial investment cost also.

As for the "Wastewater Treatment Sub-project", since the O&M cost is entirely funded by the municipal government, there is nothing to be worried about regarding the issue of O&M.

Table 14: Financial Resource Necessary for O&M of Respective Sub-projects

Sub-project	Financial Resource Necessary for O&M
Central Heating System Improvement	・The average annual O&M unit cost has been 27 yuan/m^2 since 2010, while the fee for heating has been 28 yuan/m^2. ・The fee structure is proper that the operation of the sub-project is expected to be sustainable even without financial support from the government.
Water Supply System Improvement	・The O&M cost is paid by water rate (household water at 1.9 yuan/m^3, and non-household water at 3.6 yuan/m^3). ・The current water rate is too low, but it is expected to be adjusted to the proper level.
Wastewater Treatment	・The annual O&M cost has been 1,627 yuan on average, but the revenue from wastewater teatment has been totally paid to the Anshan municipal government while the O&M cost has been covered by the disbursement from the government's budget in return. Therefore, the sub-project (as well as the whole company) is not financialy independent.

Source: Interview with respective implementing entities

(2) The Income and Expenditure and Financial Indicators of Implementing Entities

Based on the income statements acquired from the implementing entities of respective sub-projects through the field study, the status of revenue and expenditure of the implementing entities are summed up in Table 15 below.

The implementing entity of "Central Heating System Improvement Sub-project" is Urban Heating Company, the subsidiary of Anshan Heating Corporation. The balance of business income and expenditure of the company moved from deficit in 2012 to successive two years of surplus in 2013 and 2014. The business operation is expected to continue in a stable manner in years to come under the the appropriate rate system[32].

In the case of the "Water Supply System Improvement Sub-project", the income statement was provided by Anshan Water Supply Corporation[33]. Due to the low level of current water rate as mentioned before, the balance of business income and expenditure was in deficit over the three years from 2011 to 2013. However, this situation is expected to be improved steadily in the years to follow with the introduction of the Graduated Water Rate System. The above-mentioned deficit in the balance of business income and expenditure suggests a tendency of decreasing with the amount falling from 24.63 million yuan in 2011 to 17.79 million yuan in 2013. This improvement is mainly attributed to the increase in revenue by reducing NRWR (refer to Table 9) through measures to step up management by way of segmenting water supply region, strengthening staff management and concretizing the division of role and responsibility. Furthermore, the implementing entity is aiming at attaining the final goal of NRWR at 25%. With this background, the scheduled introduction of the new water rate system is believed to further contribute to the elimination of deficit[34].

[32] According to the implementing entity, the policy of Anshan municipal government on heating service is to ensure the sustainability of public utility by setting the fee for heating in a way that allow for a small margin of profit over the O&M cost.

[33] Though the branch company, "Water Supply Company" is the actual implementing entity of the sub-project, since it is not financially independent, the income statement is not available from it.

[34] According to the trial calculation done by Anshan Water Supply Corporation, the prerequisite for the company to turn a good profit under the current condition of NRWR level (30%) is to raise the water rates of both household water and non-household water by one yuan from the current 1.9 yuan/m^3 and 3.6 yuan/m^3 to 2.9 yuan/m^3 and 4.6 yuan/m^3 respectively. But, in the case that NRWR declines to 25%, it would become profitable even if the raise in the above-mentioned two kinds of water rates is not more than 0.5 yuan.

As for the implementing entity of the "Wastewater Treatment Sub-project", Dadaowan Wastewater Treatment Plant, on the one hand the government's subsidy accounts for more than 99% of its revenue, and on the other, all the fees for wastewater treatment has been paid to the government and has not been counted as the revenue of the wastewater treatment plant. As the only one among the implementing entities of this project that receives subsidy from the municipal government, it can be said that its financial sustainability is ensured by the government's support.

Table 15: The Status of Revenue and Expenditure of the Implementing Entities of Respective Sub-projects (Unit: 10 thousand yuan)

Sub-project (Implementing Entity)	Item	2011	2012	2013
Central Heating System Improvement (Urban Heating Company)	Cost of O&M and Others	27,735	34,452	36,686
	Income from the Fee for Heating	27,636	34,888	37,016
	Balance of Revenue and Expenditure	-99	436	330
Water Supply System Improvement (Anshan Water Supply Corporation)	Cost of O&M and Others	27,156	27,910	29,116
	Income from the Water Rate and Others	24,693	25,675	27,337
	Balance of Revenue and Expenditure	-2,463	-2,235	-1,779
Wastewater Treatment (Dadaowan Wastewater Treatment Plant)	Cost of O&M and Others	1,648	2,427	2,516
	Income from Financial Subsidy and Others	1,918	2,099	2,609
	Financial Subsidy Included in the Above	1,911	2,096	2,586
	Balance of Revenue and Expenditure	270	-328	93

Source: Income statements from Urban Heating Company, Anshan Water Supply Corporation and Dadaowan Wastewater Treatment Plant

Note: The data of Urban Heating Company are of the years from 2012 to 2014.

In addition, based on the balance sheets acquired from the implementing entities of the "Central Heating System Improvement Sub-project" and "Water Supply System Improvement Sub-project", their major financial indicators are summarized as follows:

Both of the implementing entities have increased equipment investment in recent years in response to the increasing demand accompanying the advance of urbanization, which has resulted in the tendency of increase in debt ratio of both companies. Nevertheless, as this kind of increase has been in a gradual manner that capital ratio of both companies has been kept at the level of around 30%, it can be said that the financial soundness has been ensured properly.

Moreover, as aforementioned, since both the sub-projects are expected to be operated under appropriate rate systems, it is conceivable that the financial sustainability will be maintained without problem.

Table 16: Major Financial Indicators of Implementing Entities of Respective Sub-projects

Sub-project	Implementing Entity	Major Financial Indicators	2011	2012	2013
Central Heating System Improvement	Urban Heating Company	Capital Ratio	34%	32%	32%
		Debt Ratio	198%	213%	215%
Water Supply System Improvement	Water Supply Company	Capital Ratio	40%	33%	28%
		Debt Ratio	150%	204%	261%

Source: Balance Sheets acquired from Urban Heating Company and Anshan Water Supply Corporation
Note: The data of Urban Heating Company are of the years from 2012 to 2014

(3) Analysis of the Financial Sustainability Taking Account of IRR Results

Although the IRR results of respective sub-projects all turn out to be negative values, this fact does not necessarily deny the financial sustainability of the project. To be more specific, as all the sub-projects are public utilities of Anshan, their initial investment costs were paid by expenditure from the municipal government's budget, and loan repayment will also be the obligation of the municipal government[35]. Besides, it is confirmed that the financial status of Anshan municipal government poses no problem[36]. For this reason, the financial sustainability in the future can be verified by focusing the analysis on the balance of annual O&M cost and utility bill revenue. As previously described, with regard to the "Central Heating System Improvement Sub-project", the utility bill revenue either confined to the sub-project itself or including the overall heat supply business of the implementing entity has been sufficient to cover the O&M cost. As for the "Water Supply System Improvement Sub-project", the balance of revenue and expenditure in terms of either the sub-project itself or the overall business activities of the implementing entity is expected to improve in the years to follow. In the case of the "Wastewater Treatment Sub-project", there is nothing to be worried about since the O&M cost is entirely paid by the municipal government.

3.5.4 Current Status of O&M

The current status of O&M for respective sub-projects is generally desirable as described below based on the result of field study.

(1) Central Heating System Improvement Sub-project

Although six out of the 11 40 t boilers adopted in this sub-project are now being used only as a kind of provisional substitute for larger boilers at the time of equipment inspection, all of them are in a condition available for operation as observed during the field study. As for the other five boilers in normal operation, it is confirmed that they are unlikely to be replaced by boilers of larger size since the

[35] Interview with the Director of Debt and Finance Division under Anshan Finance Bureau.

[36] According to the "Report on the Status of Annual Budget Use of Anshan Municipal Government" (2010-2014) published by the Secretariat of Anshan Municipal Government, although the annual government expenditure increased 12.7% year-on-year on average during this period as compared to the 7.6% increase of revenue, and the amount of deficit balance reached 8.9 billion and 8.31 billion respectively in 2013 and 2014, since Anshan, as an old heavy industrial production zone in Northeastern China, has been designated as a prioritized city to receive subsidy from the central government and Liaoning provincial government and the amount of subsidy received each year so far has always exceeded the amount of deficit balance, the balance of each year's revenue and expenditure taking into account the subsidy has become surplus.

heat-supplied district "Yingchengzi" is an old urban area with a stable population and hence there is no need for introduction of larger boilers. Meanwhile, the indoor and outdoor conduit pipes and heat exchange stations are connected to the larger boilers introduced after the completion of this sub-project, and are functioning normally.

According to the person in charge of the implementing entity (Vice President of Urban Heating Company), ordinary equipment checkout is conducted once every shift, or three times every day, while the "Annual Safety Inspection of Special Equipment" required by the General Administration of Quality Supervision, Inspection and Quarantine of P. R. C. (AQSIQ) is carried out once every year by the National Boiler Inspection Institute. Meanwhile, the maintenance works are implemented in three different scales with different frequency. The large-scale repair is conducted once every three years to mainly replace the heatproof plate of boilers on a mandatory basis, the medium-scale conducted once in a year for component replacement on a voluntary basis, and the small-scale conducted irregularly for the repair or replacement of components when needed. As a result, no trouble or accident[37] relevant to the operation of equipment has occurred so far.

(2) Water Supply System Improvement Sub-project

It has been confirmed through the field study that the water purification facilities and the water conveyance and distribution facilities are in normal operation as designed. Also, the state that the raw water transmitted from the water source normally flows into the purification facilities has been confirmed through interview with the person in charge of the implementing entity as well as visual observation.

According to the person in charge of the implementing entity (Manager of Water Supply Company), equipment inspection is required to be carried out before each important public holiday in addition to the ordinary equipment checkout conducted on a daily basis. At the same time, apart from equipment inspection and checkout, safety examination is conducted on a monthly basis and is reinforced by the campaign named "Month of Safety Activities" executed in June every year as stipulated in the "Law of Safe Production". Based on the results of these equipment inspection and safety examinations, equipment maintenance works of different scales are carried out, with the small-scale repairs conducted regularly every half year, and the medium-scale and large-scale on an irregular basis. With these efforts, no trouble or accident relevant to the operation of equipment has occurred so far.

(3) Wastewater Treatment Sub-project

The on-site visual observation confirmed that the wastewater treatment plant, pump station, sedimentation ponds, reaction pond, sludge treatment facilities, wastewater pumps constructed or installed with this sub-project were all in normal operation.

According to the person in charge of O&M work, equipment inspection has been conducted on a

[37] "Accident" here is defined as serious damage of equipment or heavy injury or even death of employee resulted from the trouble related to the operation of equipment.

quarterly basis to make sure of the extent of wear and tear on the plant facilities, operating hours of equipment, consumption of lubricant, etc. Besides, as in the case of the "Water Supply System Improvement Sub-project", the monthly safety examination and "Month of Safety Activities" campaign in June every year have been enforced rigorously. With regard to the maintenance of equipment, small-scale repairs are conducted regularly based on the results of quarterly inspections while the medium-scale and large-scale repairs are on an irregular basis. Similarly, major troubles or accidents have not happened so far owing to the above measures.

To sum it up, no major problems have been observed in the institutional, technical and financial aspects of the operation and maintenance system. Therefore sustainability of the project effects is high.

4. Conclusion, Lessons Learned and Recommendations

4.1 Conclusion

This project aims to strengthen the measures taken by the municipal government of Anshan to improve air environment, water quality environment and living environment. Its relevance is high because the implementation of the sub-projects, though selected after a process of adjustment, hasbeen relevant to the development policies and development needs of China and Japan's aid policy. The effectiveness and impact of the project is also high as the effect of pollutant reduction in terms of air and water and the effect of improvement in water supply resulting from the implementation of this project are remarkable, with the expected effects of sub-projects achieved in their respective years of target, the project's contribution to the improvement of air and water quality as well as living environment verified, and the recovery of groundwater having long been decreasing regarded as a positive impact of the project. With respect to efficiency, while the input of project cost was commensurate with the output achieved after the change of scope, the project period was substantially longer than planned even after subtracting the part of project period extension resulted from the necessity for the "Wastewater Treatment Project" to respond to the expanding need for the service. Therefore, the efficiency of this project is fair. The sustainability of the project is generally high considering the fact that the operation and maintenance (O&M) system is confirmed to be wholesome and stable, the efforts made by the implementing entities to maintain their technological level is being institutionalized, most of the adopted equipment are effectively utilized currently, and regarding the financial aspect, although at the moment the implementation entity of the Water Supply System Improvement Sub-project is facing the problem of deficit operation attributed to the cheap water rate, the problem is expected to be solved with the introduction of a new rate system in the near future.

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

Necessity to Draw Up a Checklist Specifying the Risk Factors at the Time of Deciding the Contents of Cooperation

The cancellation of bio-briquette factory construction work and the early shutdown of 40 t boilers adopted in the "Central Heating System Improvement Sub-project" and the total cancellation of the "Urban Railway System Improvement Sub-project" can be attributed to the change of needs perceived at the stage of project formulation due to the drastic change of external environment, and thus it could be regarded as unavoidable. However, one thing here needs to be borne in mind as a lesson to learn. In the case of an emerging country like China, the request to JICA for an ODA loan is submitted normally at a stage of relatively high economic growth, with which it is most likely that many of the external conditions will change drastically in terms of renewal of industrial technology and equipment, readjustment of environmental and energy saving policies, relocation of industrial facilities, urban redevelopment and so on. In this regard, it is necessary for JICA to foresee these changes of external conditions as much as possible at the time of deciding the contents of cooperation. To take the "Central Heating System Improvement Sub-project" as an example, the work of bio-briquette factory construction was selected initially with an eye to supplying cleaner fuels to the small-size coal boilers existing in great abundance at that time in response to the urgent need to curb the deterioration of air environment. However, as it has become evident nowadays, such a decision then contained two potential risks: the market risk where the supply of raw materials of bio-briquette, i.e. the straws of crops like wheat and corn would dwindle away and become insufficient as a result of the advancement of urbanization, and the policy risk arising from the government's push for the replacement of small-size boilers with low combustion efficiency by large-size boilers. Although these risks might not rise to the surface at that time, they ought to have been assumed at the very beginning especially in the case of an emerging country featuring a rapid growth and a drastic change. Therefore, it is necessary to draw up a checklist based on specific assumption of the market risk and policy risk at the stage of project formulation and review. Moreover, it is also recommendable that the risks likely to arise from these changes of external conditions be closely monitored even after the start of the project apart from the stage of project review, and the possible negative effect of these changes on the efficiency and effectiveness be avoided as much as possible by taking timely and appropriate measures whenever a risk is detected.

END.

Comparison of the Original and Actual Scope of the Project

Item	Plan	Actual
1.Project Outputs Central Heating System Improvement	Bio-briquette factory: 600,000 t/year Boiler for heat supply: 20(40 t) Indoor & outdoor conduit pipe: about 160 km Heat exchange station: 14	Bio-briquette factory: cancel Boiler for heat supply: 11 (40 t) Indoor & outdoor conduit pipe: about 447 km Heat exchange station: 43
Urban Railway System Improvement	Extension of current rail: about 19 km Tunnel: 1(about 1km) New passenger station: 17 Rail yard: new construction 1, expansion 1 Substation: 6 Communication & signal: (not specified) Rail car: 44	Cancelled
Water Supply System Improvement	Water-conducting facilities: headrace tunnel 15.3 km Water purification facilities: Water purification plant 150,000 m^3/day Segmented formation pond 2 Sedimentation pond 2 Rapid filtration pond 10 Water purification pond 1 Water pump 3 Sludge disposal plant 1 Water delivery and distribution facilities: Distributing reservoir 1 Pump station 1 Water distributing pipe 24.3 km	Water-conducting facilities: headrace tunnel 15.3 km Water purification facilities: Water purification plant 150,000 m^3/day Segmented formation pond 2 Sedimentation pond 2 Rapid filtration pond 10 Water purification pond 1 Water pump 3 Sludge disposal plant 1 Water delivery and distribution facilities: Distributing reservoir 1 Pump station 1 Water distributing pipe 24.3 km
Wastewater Treatment	Wastewater treatment plant 200,000 m^3/day Pump station 1(200,000 m^3/day) Primary sedimentation pond 4 Reaction pond 1 Secondary sedimentation pond 4 Sludge treatment facilities(Conveyor type condensation dehydrator 4)	Wastewater treatment plant 200,000 m^3/day Pump station 1(200,000 m^3/day) Primary sedimentation pond 4 Reaction pond 1 Secondary sedimentation pond 4 Sludge treatment facilities (Conveyor type condensation dehydrator 4) Wastewater collecting conduit pipe 60.7 km Wastewater pump 3 Adjustment pond 2
2.Project Period	February 2002 – October 2006 (57 months)	February 2002 – April 2012 (123 months)
3.Project Cost Amount paid in Foreign currency Amount paid in Local currency Total Japanese ODA loan portion Exchange rate	 14,525 million yen 24,814 million yen (1,654 million yuan) 39,339 million yen 14,525 million yen 1 yuan = 15 yen (As of September 2009)	 14,525 million yen 10,773million yen (778 million yuan) 25,298 million yen 14,525 million yen 1 yuan = 13.75 yen (Average between 2002 and 2012) Source: State Administration of Foreign Exchange