People's Republic of China

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

External Evaluators: Yuko Kishino and Shima Hayase, IC Net Limited

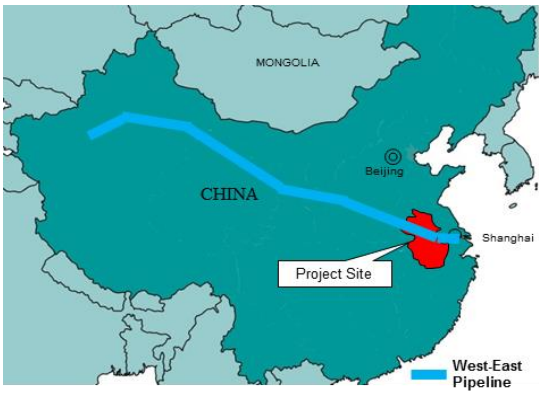
0. Summary

The Chinese government has set targets of raising the ratio of natural gas as clean primary energy consumption and reducing gross emissions of pollutants in order to improve atmospheric environment. In Anhui Province, at the time of project appraisal, coal accounted for over 80% of energy and pollutant emissions associated with the coal combustion caused serious problems of worsening air quality. This project aimed to develop natural gas supply infrastructure and reduce air contaminants in eight cities of Anhui Province in conjunction with the start of supply from the West-East Pipeline national project[1], so implementing the project has a high degree of relevance. Supply of and conversion to natural gas are proceeding smoothly and it can be recognized that the purpose of the project has been generally accomplished. The main pollutants found in the targeted cities, except for a small portion of them, meet the second grade National Air Quality Standard and the project is having a positive impact on atmospheric environment. The efficiency is considered to be fair because the project was delayed due to changes in city planning and the operating cost went slightly over the budget due to inflation. The natural gas suppliers of those cities have no particular problems regarding organizational, technical and financial aspects, and the operation supervision, environmental monitoring and safety management setups of the provincial and city governments are established, therefore, the sustainability is high.

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

[1] It is the national project to build a pipeline with total length of approximately 4,000 km, extract natural gas from the Tarim oilfield of Xinjiang Uygur Autonomous Region in western China and transport the gas through the pipeline to the big cities including Shanghai in the eastern coastal area; the first line over the entire route was completed in 2004.

1. Project Description



The West-East Pipeline and Anhui Province

SCADA System (Hefei City)

1.1 Background

In China environment pollution progressed since the 1980s due to industrialization and population growth, while it achieved a remarkably rapid economic growth. The Chinese government took firm steps, especially since the latter half of the 1990s, to protect the environment and achieved a certain degree of success. The contamination was, however, still serious when the project was conceived.

The air pollution at the time of project appraisal was indeed grave in terms of sulfur oxides (SOx) caused by the use of coal as well as nitrogen oxides (NOx) caused by dust and car exhaust among others. Harnessing the increasing emission of carbon dioxide (CO_2), a major cause of global warming, was an impending issue in the face of expanding economy.

Also in Anhui Province, the primary energy consumption increased dramatically with rapid economic growth; the growth rate from 1991 through 1999 reached 70%. Most of all, coal is widely used for industry, power generation and household uses including home heating, and the consumption continued to increase. In four out of the targeted eight cities, the concentration of total suspended particles (TSP) didn't meet the National Air Quality Standard Grade II level and there was a concern about the possibility that the quantity of SO_2 and NOx would not meet the standard if dependence on coal continued. Under such circumstance, the West-East Pipeline project and this project were planned as priority projects of the 10th Five-Year Plan.

1.2 Project Outline

The objective of this project is to develop natural gas supply infrastructure in eight cities (Chaohu, Chuzhou, Fuyang, Hefei, Huainan, Ma'anshan, Tongling and Wuhu)[2] of Anhui Province in order to facilitate energy conversion from coal and other fuels to natural gas, thereby

[2] Those eight cities were included in the loan agreement, but Chaohu City declined to utilize the ODA loans soon after the conclusion of the agreement in 2003 and it was cancelled. Therefore, this project was implemented by the seven cities of Chuzhou, Fuyang, Hefei, Huainan, Ma'anshan, Tongling and Wuhu.

contributing to the improvement of the atmospheric environment.

Loan Approved Amount / Disbursed Amount	18,558 million yen / 18,538 million yen
Exchange of Notes Date / Loan Agreement Signing Date	November 2002 / March 2003
Terms and Conditions	Interest Rate: 0.75% Repayment Period: 40 years (including Grace Period: 10 years) General untied
Borrower / Executing Agency	Government of People's Republic of China / The People's Government of Anhui Province
Final Disbursement Date	July 2010
Main Contractor (Over 1 billion yen)	Hubei International Trade Investment & Development Co., LTD. (China)
Main Consultant	None
Feasibility Studies, etc.	Feasibility study of each sub-project (January 2001)
Related Projects	None

This project is an ODA loan project planned to coincide with the construction of main pipeline for natural gas which covers the area extending from Xinjiang Uygur Autonomous Region in western China to Shanghai (the West-East national project). Its objective was to build the supply facilities in eight cities of Anhui Province located in the middle of the pipeline to Shanghai so as to achieve energy conversion from fossil fuels such as coal that cause air pollution to clean natural gas.

Construction of the main pipeline of the West-East project is performed by PetroChina Company Limited, which supplies natural gas from the gas field. As shown in Figure 1, the main pipeline has been laid down; on the sub-projects, Fuyang City, Huainan City, Hefei City and Chuzhou City are directly supplied with the gas from the main pipeline, and Ma'anshan City, Wuhu City and Tongling City are supplied from sub-pipelines connected to the main pipeline.

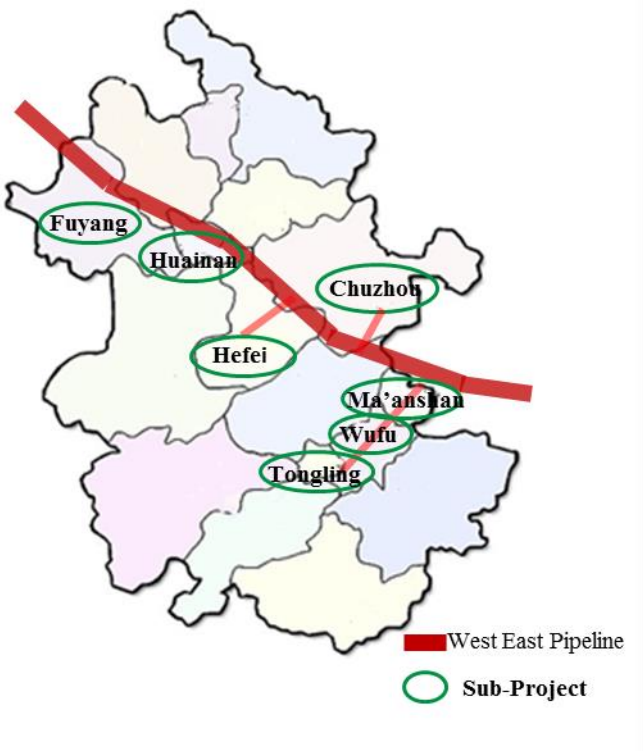


Figure 1: Location of the Main pipeline (the West-East Pipeline) and sub-projects

The scope of ODA Loan project consists of the natural gas supply systems of the companies that are the PIUs (Project Implementation Unit) of each of the cities, including the gate stations at the entry points from the main pipeline or sub-pipeline into the cities, pressure governors to enable supply to household, industrial and transportation users in the city, distribution lines, natural gas stations and gas holders for storage. Figure 2 shows the flow of natural gas supply and the scope of the ODA Loan project.

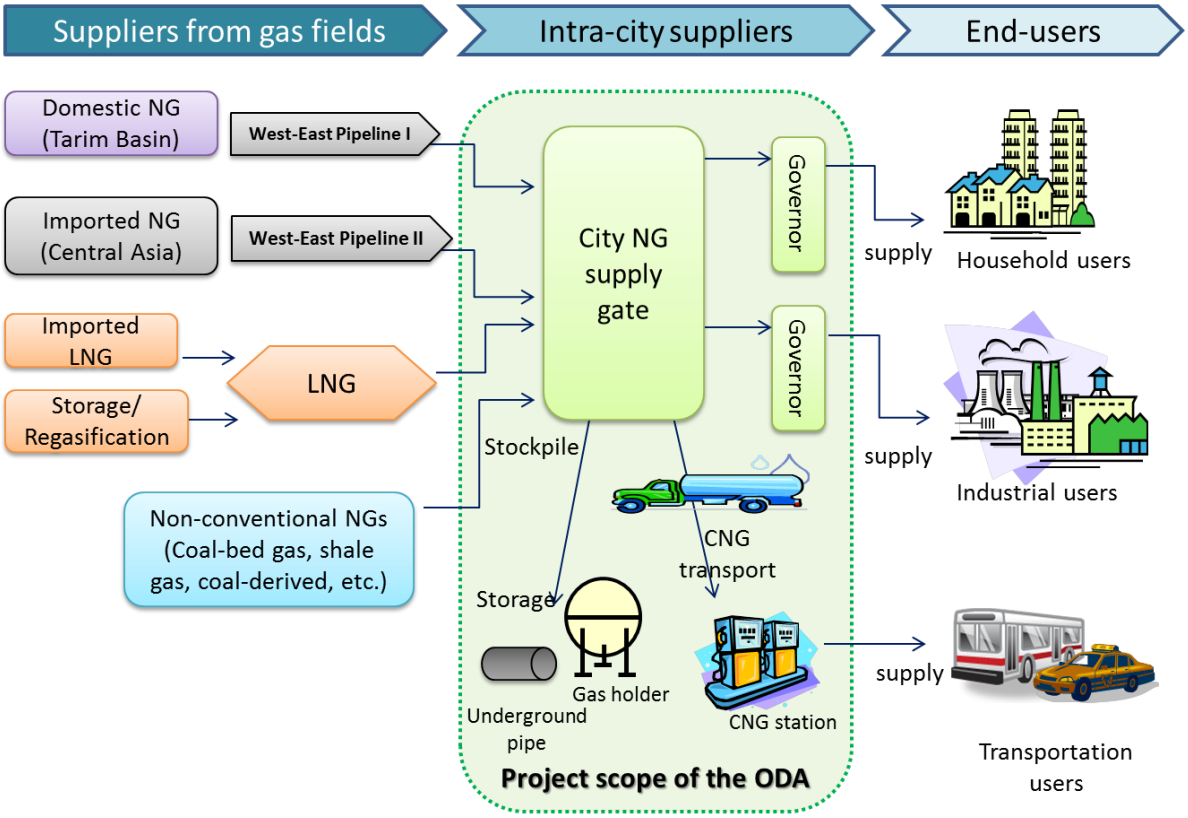


Figure 2: Supply flow of natural gas

2. Outline of the Evaluation Study

2.1 External Evaluator

Yuko Kishino and Shima Hayase (IC Net Limited)

2.2 Duration of Evaluation Study

The ex-post evaluation study was carried out during the following period:

Duration of the Study: August, 2012 – November, 2013

Duration of the Field Study: April 9 - April 18, 2013; August 1 - August 3, 2013

2.3 Constraints during the Evaluation Study

Nothing in particular

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 policy at the time of project appraisal

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

[4] ③: High, ②: Fair, ①: Low

In 1994 the Chinese Government issued the Agenda 21 which emphasized the importance of compatibility between economic growth and environmental protection. The 9th Five-Year Environment Protection Plan (1996 – 2000) that reflected Agenda 21 set out the goal of reducing the total emissions of SO_2, dust and other major pollutants to the 1995 levels by the year 2000, and measures were implemented accordingly to combat industrial pollution, widen the use of city gas and to otherwise improve the urban environment. In 1998 the SO_2 Control Area (mainly north of the Yangtze) and the Acid Rain Control Area (mainly south of the Yangtze), together known as the Two Areas, were designated to promote intensified efforts. Even though the initial goals of the Plan were achieved, air pollution was still a serious issue.

The National 10th Five-Year Plan for Environmental Protection (2001 – 2005) called for further improvement in environment by setting out a goal of 10% reduction in the total emissions of major pollutants from the levels of year 2000. With respect to air quality, the Plan set a goal of 20% reduction in SO_2 emissions in the SO_2 Control Area and in the Acid Rain Control Area.

In the 10th Five-Year Plan of Anhui, the PGAP (People's Government of Anhui Province) aimed at accelerating conversion from fossil fuels including coal to natural gas in order to optimize the energy structure and to raise energy efficiency. Additionally, they set the goal to keep the concentration of SO_2, nitrogen dioxide (NO_2) and TSP[5] below the levels of the National Air Quality Standard Grade II. To achieve the targets, they formulated the policies of switching to clean energy mentioned above, as well as introduction of cleaner production, use of clean coal and closure of crucial pollution sources. They also encouraged research on reduction of SO_2 emissions, and introduction and construction of industry-scale facilities especially for disposal of pollutants and recycling in major electricity enterprises.

(2) Development policy at the time of ex-post evaluation

The national economy social development 11th Five-Year Plan (2006–2010) set out the targets of lowering the country's unit energy consumption by around 20%, and reducing the total emissions of major pollutants by 10%. The Plan advocated the enhancement of recycling economy, ecosystem protection, environment protection and resources management. The 12th Five-Year Plan (2011‐2015) specified the targets of 17% reduction in carbon dioxide emission, 8% for SO_2 and 10% for NOx in an effort to improve air quality. The Plan calls for also a 16% reduction in unit energy consumption with a view to building an economically stable and safe and clean modern industrial energy system by adjustment and optimization of the country's energy structure. More specifically, the ratio of natural gas use in the primary energy was to be increased to 8.3% by 2015 from the 4% in 2010. The Plan states that major pipeline networks should be added and improved for the more stable natural gas supply and that the development

[5] For example, Hefei City, Huaibei City, Wuhu City, Ma'anshan City and Tongling City. The cities other than them were aiming at achieving the third grade standard.

and use of coal-bed methane, shale gas and other non-conventional natural gas sources should be promoted.

Air quality improvement is given a priority status also in national five-year plans for environment protection. The national environment conservation 11th Plan (2006-2010) identified comprehensive air quality improvement in 113 selected cities and urban clusters a priority task, and called for a 20% reduction in the unit energy consumption for GDP[6] and a 10% reduction in the emissions of major pollutants. The 12th Plan (2011-2015) urges continuous reduction in the total emissions of major air pollutants by setting out the targets of 10% reduction in China's total SO_2 emission from the 2010 level and also 10% reduction in the emission of ammoniac nitrogen in the industries and districts of prime importance. The PGAP, too, has set out the policy of continuing to expand the use of clean energy and promoting shift in energy structure so as to realize a low-carbon society.

The National Development and Reform Commission issued in August 2007 "Natural Gas Utilization Policy," by which the use of natural gas for household and commercial purposes was prioritized and the use for industrial and power generation purposes was restricted, as the gap in supply and demand had enlarged and the need for air quality improvement was eminent. The new policy announced in October 2012 as a revision of the above-mentioned policy provided that not only conventional type of natural gas but also shale gas, coal-bed gas, coal-derived synthetic natural gas (SNG) be covered by the policy with a view to encouraging use of these new energy sources. The new policy aimed to increase the use of natural gas by giving priority to natural gas-driven public transportation means (bus, taxi); logistics, vessels, freight trains and other transportation: centralized heating and air-conditioning; energy for the industrial sectors such as building materials, electricity, textile, petrochemicals, metallurgy and others.

This project represents an effort to improve the air quality thorough promotion of conversion to natural gas. It was highly relevant to the development policy, both at the time of project planning and of ex-post evaluation.

3.1.2 Relevance to the Development Needs of China

3.1.2.1 The need for conversion to natural gas

Anhui Province has marked real GDP growth rates in double digits since project appraisal (Table 1). As shown in Table 2, the primary energy consumption more than doubled in 2011 from 52.15 million tons in 2001. The consumptions by type in Table 3 shows that the percentage of coal increased from 84.3% in 2001 to 88.5% in 2011, while natural gas had a low percentage of 2.4% even at the time of the ex-post evaluation. With respect to the coal consumption by sector, household sector use decreased from 5.5% in

[6] Amount of energy required to raise one unit of GDP

2005 to 1.8% in 2011, but the industrial use increased from 82.8% to 86.7%. As seen above, the negative influence on atmospheric environment caused by especially coal combustion in the industrial sector is still the challenging problem and there are high policy needs for a conversion toward natural gas.

Table 1: Real GDP growth rate of Anhui and China (national average)

Year	2002	2004	2008	2010
Anhui	9.6%	13.3%	12.7%	14.6%
China	9.1%	10.1%	9.6%	10.4%

Source: China statistical yearbook; Anhui Province statistical yearbook.

Table 2: Primary energy consumption in Anhui (Unit: ten thousand ton/year)

2001	2005	2011	Growth rate (compared to 2001)
5,215	6,564	11,118	213%

Source: Documents at JICA appraisal for the planned value;
Actual values from Anhui Province's response to the questionnaire.

Table 3: Breakdown of the primary energy consumption in Anhui

Year	2001	2005	2011	2005/compared to 2011
Coal	**84.3%** Consumer N/A Industrial N/A	**88.3%** Consumer 5.5% Industrial 82.8%	**88.5%** Consumer 1.8% Industrial 86.7%	**Whole +0.2%** Consumer **-3.7%** Industrial **+3.9%**
Petroleum	15.6%	9.0%	6.2%	- 2.8%
Hydro	0.1%	0.7%	0.9%	+ 0.2%
Natural Gas	0%	0.2%	**2.4%**	**+2.2%**
Others	0%	0%	0.6%	+ 0.6%

Source: JICA's appraisal document for the data of 2001; Anhui Province statistical yearbook for others.

3.1.2.2 Relevance of the selection of sub-projects

The sub-projects were selected on the basis of geographic location to the route of the West-East Pipeline, preparations status for the implementation, capability of self-funding and repayment credibility. Through the symposium held by the Province, eight cities were finally selected out of 12 cities that had applied for sub-projects.

At appraisal, the percentage of secondary industries in Hefei City (43%), Ma'anshan

City (49%), Tongling City (51%) and Wuhu City (59%) were higher than the Anhui Province average (38%); substantial increase in demand for coal in the industrial sector was anticipated and the atmospheric pollution associated with that was a great concern.

The sub-projects were selected based on clear criteria and there was great need for both conversion to natural gas and improvement of air quality in the selected cities. Thus, it is deemed that the sub-projects selection had relevance.

Table 4: Change of the percentages of primary industries and secondary industries in Anhui and the target cities

	At appraisal (2002)		At ex-post evaluation (2011)		Growth rate of secondary industries
	Primary	Secondary	Primary	Secondary	
Anhui	22%	38%	13%	54%	+16%
Chuzhou	25%	39%	20%	52%	+13%
Fuyang	41%	25%	27%	35%	+10%
Hefei	8%	43%	6%	55%	+12%
Huainan	N/A	N/A	8%	65%	-
Ma'anshan	12%	49%	6%	68%	+19%
Tongling	6%	51%	2%	75%	+24%
Wuhu	8%	59%	7%	63%	+4%

Source: PGAP and responses to the questionnaire of each sub-project.
Note: For figures at appraisal, 2003's data in Chuzhou City and 2004's Wuhu City were used.

Table 5: Population and urban population at appraisal and at ex-post evaluation

(Unit: ten thousand)

	Population			Urban population		
	At appraisal (2002)	At ex-post evaluation (2011)	Growth rate	At appraisal (2002)	At ex-post evaluation (2011)	Growth rate
Anhui	6,369	6,876	104%	1,886	2,674	142%
Chuzhou	433	452	104%	97.6	100.2	103%
Fuyang	898	1,040	116%	123.3	170.7	138%
Hefei	448	711	159%	153.5	259.9	169%
Huainan	207	246	119%	108	144.2	134%
Ma'anshan	122	228	187%	54.2	81.5	150%
Tongling	70	74	106%	37.2	55.5	149%
Wuhu	225	385	171%	102	145	142%

Source: PGAP and responses to the questionnaire of sub-projects.
Note: At appraisal, data of Chuzhou City is of 2003, and Wuhu City 2004; at evaluation data of Huainan is of 2010.

Shortly after the conclusion of the loan agreement (L/A) in 2003, one of the eight cities,

Chaohu City, cancelled the sub-project implementation. The Executing Agency said in the interview that the gas corporation that was to be the Project Implementation Unit of Chaohu City chose to utilize private financing instead of the ODA loan. As a result of consultation with the Japan International Cooperation Agency (JICA), according to the Executing Agency, cancellation was decided. Since no substituting sub-project was found, the project continued with the seven cities.

L/A was not modified or the objectives of the project were not changed to reflect this change. Since there was no compelling need for substitution, the reduction of the targeting cities from eight to seven in itself does not entail any problem. However, as concrete numerical targeted values of natural gas transportation and pollutant reduction in this project were agreed at the time of appraisal between the two entities, changing these targeted values to reflect the change in the number of sub-projects would have been more appropriate from the perspective of project management. It should be noted that the projects of the seven cities are being carried out smoothly and their works are ongoing. Also in Chaohu City, which departed from the project, the conversion to natural gas is said to be proceeding smoothly.

3.1.3 Relevance to Japan's ODA Policy

At the time of project appraisal, environmental protection was an area of focus in the Country Assistance Program for China effective, the Medium-Term Strategy for Overseas Economic Cooperation Operations then in effect and the 2002 Country-Assistance Strategy. The Country-Assistance Strategy, in particular, pointed out that effective emissions reduction of causal substances of acid rain and global climate change was the task that needs to be addressed in the air environment arena. For that goal, decrease of coal dependency and conversion to natural gas and other clean energies were called for. The document stated that support would be extended to projects including pollutants reduction by installing flue-gas desulfurization and other equipment to existing plants, cleaner production systems for pollutants generation minimization and energy efficiency, clean coal technologies and renewable energy. The ODA loan assistance strategy listed conversion to natural gas as a priority project area, while the importance of "software" assistances such as capacity building in environment policy administration and knowhow transfer through closer cooperation with local governments was underlined.

The Economic Cooperation Plan for China issued in 2001, which corresponds to a Country Assistance Policy, cites air quality improvement as one of the environmental protection challenges in China that require long-term efforts. Environment protection is mentioned in the top priority assistance area of "Cooperation to address global issues."

In summary, this project has been highly relevant with the development policies of the

Chinese Government and the Anhui Provincial Government, with the development needs in the environment and energy sectors as well as Japan's ODA policy, therefore its relevance is high.

3.2 Effectiveness (Rating: ③[7])

Here the same indicators as were applied in the project appraisal, namely, natural gas delivery volume, household conversion ratio[8] and air pollutants (SO_2, NOx and TSP) reduction will be used to evaluate effectiveness. The appraisal set out target figures for these operation and effect indicators for Years 1, 2 and 7 following the project completion. Since no sub-projects have completed or even entered the 7th year from project completion as of this date, our ex-post project evaluation relied on a comparison of the targets and the actual in, counting from the year of project completion, the second year of the project in service. This translates into 2009 for Chuzhou, 2009 for Fuyang, 2010 for Hefei, 2008 for Huainan, 2009 for Ma'anshan, 2008 for Tongling and 2009 for Wuhu.

3.2.1 Quantitative Effects (Operation and Effect Indicators)

(1) Natural gas delivery volume

The total transportation amount of natural gas delivered in a day of the seven cities after two years of the project completion was 1,823,301m^3 compared to the target figure of 2,208,000m^3, resulting in 83% achievement ratio. Each sub-project's achievement was, 103% in Chuzhou City, 137% in Fuyang City, 135% in Hefei City, 22% in Huainan City, 105% in Ma'anshan City, 54% in Tongling City, and 81% in Wuhu City. Chuzhou City, Fuyang City, Hefei City, and Ma'anshan City achieved the targets and Wuhu City almost achieved the target. Tongling City and Huainan City could not achieve the targets and they greatly fell below the planned values.

[7] Sub-rating for Effectiveness is to be put with consideration of Impact
[8] Ratio of number of households using natural gas to number of total households

Table 6: Natural gas delivery (Unit: m^3/day)

Delivery	Target in Year 2	Actual in Year 2	Achievement Ratio
Total of 7 Cities	**2,208,000**	**1,823,301**	**83%**
Chuzhou City	258,000	222,810 (2009)	103%
Fuyang City	118,000	161,387 (2009)	137%
Hefei City	3940,000	531,801 (2010)	135%
Huainan City	440,000	98,989 (2008)	22%
Ma'anshan City	252,000	263,972 (2009)	105%
Tongling City	225,000	122,424 (2008)	54%
Wuhu City	521,000	421,918 (2009)	81%

Source: Target figures from JICA document at appraisal; actual data from responses of the cities to our questionnaire.

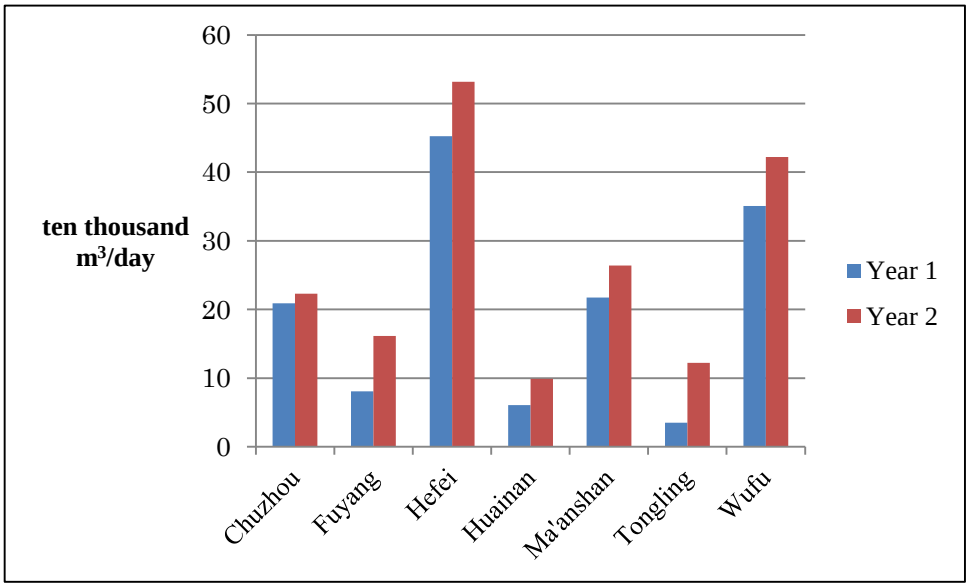


Figure 3: Progress of natural gas delivery by sub-project

The National Development and Reform Commission announced the "Natural Gas Use Policy" in 2007[9]. In this policy, supplying the household sector gained the highest priority in each city and supplying industrial sectors, which were anticipated to be main users of natural gas, was limited. The factors that made a difference in the degree of attainment

[9] In order to promote the rational development and use of natural gas as limited resources, the fields of natural gas use were classified in four categories of "City gas", "Industrial fuel", "Power generation" and "Chemical industry" and priorities were given to four phases of "Priority / Permission / Limit / Prohibition". Supplying city gas in household sector was regarded as Priority.

among the sub-projects are considered as follows:

- Whether the targeted values were set or not based on careful planning between the Petro China Company Limited as the supplier of the West-East Pipeline and the PIUs (the Project Implementation Units), e.g. exchanging letters of intent specifying the confirmation of conditions such as supply quantity of natural gas or pressure at a stage prior to the conclusion of the Loan Agreement; and
- Whether or not the advantages of conversion to natural gas (or support measures by the governments and preferential treatment for the price) were provided; whether or not any compulsory measures for the conversion to natural gas were taken. (For details, see "(3) Reductions of the main pollutants" below.)

In Chuzhou City, which achieved the target (103% compared to the planned value), letters of intent had been exchanged with large users of coal and with the transport sector at appraisal, and plans of the project were prepared based on accurate information of such switches to natural gas. In addition, the targeted values were set at reasonable levels.

In Fuyang City (137% compared to the planned value), it was planned that the conversion to natural gas in the industrial and commercial sectors would account for 77% of overall delivery quantity, but actually it was 2.4% in industrial sector and approximately 17% in commercial sector. It was mainly because a large energy user who had been anticipated to switch at the time appraisal went bankrupt and also the construction of some planned new factories has been stopped halfway at the time of ex-post evaluation. In addition, the plans included a company that was unlikely to switch because it had a coal mine among its group companies and was able to supply cheap coal. However, while industrial and commercial sectors remained restrained, the transport sector marked 60%, exceeding by far the predicted 2%. The household sector smoothly pushed up the growth rate almost at the same percentage as the planned value, so the targets were accomplished.

In Hefei City (135% compared to the planned value), the percentage of the industrial sector which had been predicted to be 80% or more in the plan remained at 37%. On the other hand, the conversion rate of household sector was estimated to be less than 10% as a whole, but affected by the "Natural Gas Use Policy", it actually exceeded the plan to reach 43% and contributed to accomplishment of the target.

In Ma'anshan City (105% compared to the planned value), the household sector pushed up the growth rate smoothly; and natural gas consumption in the transport sector, which had been predicted to be around 2% at appraisal, increased to 13% at the time of the ex-post evaluation, which contributed to the accomplishment.

In Wuhu City (81% compared to the planned value), letters of intent were exchanged with users of coal, heavy oil and light oil, and specific geographical areas where use of kerosene and light oil would be forcibly converted to natural gas were agreed. However,

conversion in the transport sector was actually less than the planned value, so the targeted value was not accomplished.

In the sub-projects of Huainan City and Tongling City, where the conversion rates were substantially less than the targets, the conversion in the industrial sector was sluggish compared to the prospect at appraisal. It is because the planning was not developed based on any letters of intent, resulting in a gap with accomplishments; and companies had to pay by themselves for the necessary modification of their facilities for conversion to natural gas use, so many factories kept a distance from the natural gas whose unit price per heat capacity is high. In Huainan City and Tongling City where there is a large-scale coal mine and coal is the local industry, it is easy to obtain coal and it can be thought that coal is supplied cheaper than the market price in case where coal mines are operated by their own group companies, which had an influence on the conversion accomplishment. The status of each sub-project is as follows. For the natural gas use by sector at appraisal and ex-post evaluation, see Table 7 and Table 8.

・ Huainan City (22% compared to planned value)

Affected by the Natural Gas Utilization Policy, the shift rate of industrial sector, which was anticipated to be 37% of the whole in the plan, resulted in mere 12%. This was because the power generation use, which had been predicted to be 20%, was not converted by the time of the ex-post evaluation and no natural gas was used.

・ Tongling City (54% compared to planned value)

The natural gas consumption in the industrial sector was predicted to account for 76% at the time of the plan, but the result was over 10 percentage points lower than the prediction. A major company was closed down for policy reasons, and there was no natural gas shift by large industrial users, which had an influence on the accomplishment.

Table 7: Percentages of each sector of the natural gas consumption predicted at appraisal (2002)

	Chuzhou	Fuyang	Hefei	Huainan	Ma'anshan	Tongling	Wuhu
Electricity				19.56%			
Household	15.3%	14.44%	9.9%	23.15%	22.0%	22.8%	25.3%
Industrial/Commercial	77.4%	70%	86.6%	37.38%	7.7%	76.4%	62.5%
Transportation	7.3%	1.95%	3.0%	19.91%	2.2%	0.8%	12.2%
Public facilities		12.0%					
Boiler		1.7%	0.5%		68.2%		
Others				25.8%	8.8%		

Source: Appraisal documents of JICA e; trial calculation of planning of the convert to natural gas trial balance (August, 2002).
Note: For the boilers of Ma'anshan City, trial calculation of the forced switch of boilers with capacities not exceeding 2 tons was used.

Table 8: Percentages of each sector of the sales volume of natural gas at ex-post evaluation (2012)

	Chuzhou	Fuyang	Hefei	Huainan	Ma'anshan	Tongling	Wuhu
Electricity							
Household	10.3%	16.9%	42.5%	29.0%	20.8%	13.2%	23.5%
Industrial	66.7%	2.4%	37.3%	12.3%	46.6%	65.4%	76.5% (Transportation is excluded)
Transportation	6.9%	59.7%	7.4%	20.0%	13.1%	15.3%	
Commercial	6.4%	17.3%	12.8%	12.9%	9.8%	6.1%	
Public facilities	3.9%	3.7%					
Boiler	5.8%						
Others				25.8%	9.7%		

Source: Response to the questionnaire.

The most recent year of 2012 corresponds to years 4 through 6 from the completion of the sub-projects. Comparing the delivery quantity of 2012 with targeted value of the seventh year, according to Table 9, some sub-projects have already reached the targeted value as in Chuzhou City and Wuhu City, and some sub-projects remain at the rate of 30% as in Huainan City. Most of sub-projects marked 50% or higher compared to the planned value of the seventh year. Furthermore, delivery quantity per day in the seventh year from completion was estimated by multiplying the actual values of 2012 by the yearly average growth rate from completion to 2012. As a result of that, the total quantity of natural gas transportation per day of seven cities in the seventh year from the completion was estimated to be 5,150,146 m^3 compared to the target of 4,422,000 m^3 representing 116% of the plan. By sub-project, the attainment rate is 383% in Chuzhou City, 90% in Fuyang City, 117% in Hefei City, 42% in Huainan City, 76% in Ma'anshan City, 74% in Tongling City and 159% in Wuhu City. Chuzhou, Hefei and Wuhu City have achieved the targets and Fuyang and Ma'anshan City are expected to almost achieve the targets. In comparison with the second year, Huainan City and Tongling City have improved the rate of accomplishment. If the delivery quantity increases at the same growth rate, Tongling City will accomplish the target in 2014 (eighth year) and Huainan City in 2018 (twelfth year) based on the calculation.

Table 9: Prediction about the quantity of natural gas transportation in the seventh year since the project completion (Unit: m^3/day)

Quantity of transportation	Targets in the 7th year	The most recent actuals (2012)	Compared to the targets in the 7th year	Plans in the 7th year	Compared to the plan
Total of 7 Cities	**4,422,000**	2,994,793	68%	**5,150,146**	**116%**
Chuzhou City	324,000	359,629 (the 5th year)	111%	1,240,351 (2014)	383%
Fuyang City	446,000	225,033 (the 5th year)	50%	402,322 (2014)	90%
Hefei City	1,020,000	731,349 (the 4th year)	72%	1,190,298 (2015)	117%
Huainan City	559,000	196,521 (the 6th year)	35%	233,986 (2013)	42%
Ma'anshan City	850,000	444,528 (the 5th year)	52%	642,073 (2014)	76%
Tongling City	594,000	333,624 (the 6th year)	56%	442,386 (2013)	74%
Wuhu City	629,000	704,110 (the 5th year)	112%	998,731 (2014)	159%

Note: The predicted values were calculated on the assumption that the quantity of transportation would increase at the same rate as the average of the yearly growth rate since the completion year to 2012.

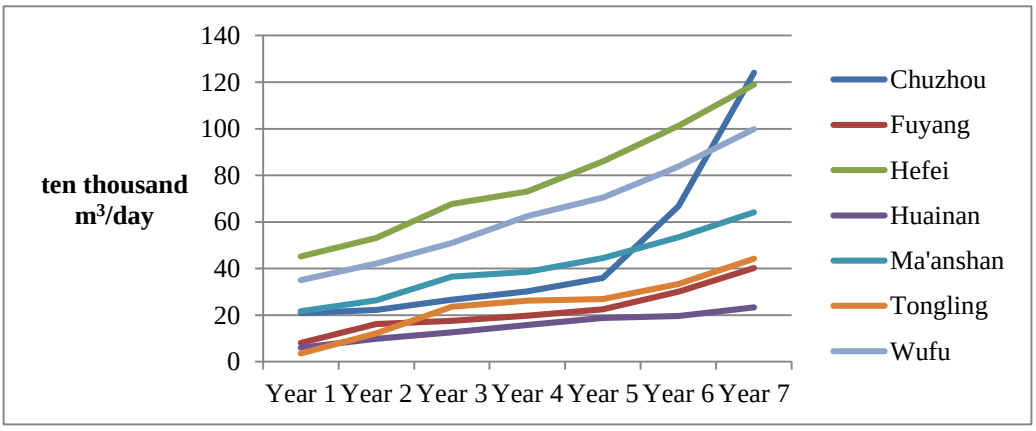


Figure 4: Prediction about the change of the quantity of natural gas delivery until the seventh year

BOX: Burden of the converting cost for the switch to natural gas

The high conversion cost is the factor that restrains medium and small-sized companies which hope to shift to natural gas. In case of switch from city gas, it is only necessary to retrofit with equipment including reinforcement of pipes for gas that have been already in use and exchange of meters. However, in case of switch from fossil fuel such as coal and heavy oil, it is necessary to lay out pipelines from pressure control facilities to companies and to perform large-scale upgrading in the internal facilities.

According to the questionnaire in this evaluation, the converting cost of seven large natural gas users ranged between 3 million yuan and 20 million yuan.

The graphite electrode manufacturer in Hefei City spent 3 million yuan on conversion and preparation of facilities. Annual fuel cost was reduced to 12.8 million yuan from 13 million yuan by the switch, and it was able to reduce the maintenance cost to 250,000 yuan from 300,000 yuan and thus with the additional sales growth, it could recover the conversion investment in five years. The company qualifies for the discount available to users of more than 3.6 million m^3 of natural gas annual usage. This company in Hefei City, however, is an ideal example. Financing such an investment is difficult for most medium and small-sized companies and they do not consume so much natural gas, so it takes many years to recover the facilities modification costs. For this reason, companies often hesitate about switching from the viewpoint of cost-effectiveness.

Like the Natural Gas Utilization Policy, which was announced in 2007 and revised in 2012, some policies undergo irregular revisions and the contents of the revision have a direct influence on this project. For example, if the restriction on the use of natural gas for thermal power generation is lifted, the demand from the power stations for natural gas will increase drastically and the delivery quantity will increase rapidly. With respect to the burden of the converting cost, if the government changes its policy and starts providing some subsidy, conversion to natural gas would be promoted further.

(2) Household conversion ratio

The conversion ratio indicating the ratio of households which has converted to natural gas was 69% in all seven cities and the accomplishment was 115% compared with the targeted value at the time of the appraisal, so it was higher than the 83% achievement rate in delivery volume. While the total supply availability of the natural gas was limited, the high attainment level reflected the high priority the sub-projects gave to the household in accordance with the principle of priority given to public welfare by the central government.

The household conversion ratio of natural gas in the sub-projects were 64% in Chuzhou City, 87% in Fuyang City, 92% in Hefei City, 27% in Huainan City, 90% in Ma'anshan City, 52% in Tongling City and 68% in Wuhu City; Chuzhou City, Fuyang City, Hefei City and Ma'anshan City achieved the targets, and Tongling City and Wuhu City almost achieved the targets. The accomplishment of Huainan City was less than 50%.

Table 10: Natural gas household conversion ratio

Conversion ratio	Targeted in Year 2	Actual in Year 2	Achievement Ratio	Recent actual data
7 Cities Average	**60%**	**69%**	**115%**	—
Chuzhou City	60%	64% (2009)	107%	74% (2012)
Fuyang City	24%	87% (2009)	372%	94% (2012)
Hefei City	70%	92% (2010)	131%	94% (2012)
Huainan City	61%	27% (2008)	44%	63% (2012)
Ma'anshan City	72%	90% (2009)	125%	92% (2010)
Tongling City	60%	52% (2008)	87%	75% (2012)
Wuhu City	74%	68% (2009)	92%	79% (2011)

Source: JICA appraisal document for the targeted values; response from each city to the questionnaire for the actual values.

The conversion rate is an indicator related only to household sector and it is not necessarily linked with quantity of natural gas delivery volume. Like Fuyang City and Huainan City, the reasons why delivery volume did not increase in spite of increase in conversion rate are considered as follows: 1) although natural gas came into service, other fuels continue to be used; 2) there is a gap between actual demand and the conversion rate, or a gap between registered population and the real residential population, so the rate of absentees is high and actual gas use does not increase even though the conversion rate has been increased. The details are described below:

1) Continuous use of other fuels

In city centers, conversion to natural gas in the household sector progressed rather easily,

because coke furnace gas and other city gas had been available before the implementation of this project. The mass of natural gas is not much different from that of such city gas and there was no change in lifestyle. However, the story is different in rural areas such as Fuyang City where city gas is supplied for the first time. Conversion to natural gas from charcoal and firewood represents a significant change in lifestyle, which has acted as hindrance to full-scale use of natural gas. In many such households, natural gas is used only for cooking.

2) Gap between population statistics and actual residence

As shown in Table 11, the ratio of population which is absent for more than half a year is 31.4% in the entire Anhui Province; especially the rate of absentees is high in Fuyang City (53%) and Huainan City (38%). Houses are purchased and natural gas is installed, but residents work away from home. So this is the environment where delivery volume as gas consumption does not increase even if the conversion rate increases. In the regions where many migrant farming workers and in rural areas, a strong tendency for this is observed. A similar problem occurs in the developing areas where there are many houses purchased for investment purposes. According to the Project Implementation Unit, this has an influence on the quantity of natural gas delivery.

Table 11: Absence rate in Anhui Province[10]

	2011
Anhui Province	31.4%
Chuzhou City	24.5%
Fuyang City	53.0%
Hefei City	22.9%
Huainan City	37.7%
Ma'anshan City	29.8%
Tongling City	19.9%
Wuhu City	32.1%

Source: Anhui statistical yearbook 2012.

(3) Major pollutants reduction

The third indicator for the evaluation of project effectiveness is reduction of major air pollutants (SO_2, NOx and TSP)[11]. The reduction volume is calculated by multiplying the quantity of the fossil fuel replaced by natural gas by the pollutants emissions per unit[12] and then subtracting the emissions by natural gas. The replaced fuels include: household use coal, industrial coal and commercial purpose coal. Some sub-projects include diesel fuel and

[10] Absence rate means the ratio of population compared to the register of population which is absent for more than half a year.

[11] The reduction in pollutants enabled by switching from fossil fuels such as coal to natural gas, which is clean energy with emission of few pollutants.

[12] The quantity of reduced pollutants is determined according to the feasibility study, but the calculating formula is different in each sub-project.

other fossil fuels, too.

As shown in Table 12; the achievement ratios of reductions of the main air contaminants (SO_2, NOx and TSP) of the seven cities as a whole were SO_2: 85%, NOx: 97% and TSP: 80%. In the sub-projects, Hefei City and Ma'anshan City exceeded the planned ratio, and Tongling City marked 80% of SO_2 level as the achievement. The achievement of Chuzhou City was approximately 70% and that of Huainan City remained at around 20%.

While the accomplishment of the natural gas delivery volume was 105% in Ma'anshan City, the accomplishments of reductions were 266% SO_2, 581% NOx, and 313% TSP. It is assumed all the coal boilers with high reduction effect were converted to natural gas in 2005. In Wuhu City, the attainment ratio of NOx reduction turned out to be 52%, significantly lower than those of the other pollutants. This is considered to be due to the hardly any progress made in the transportation sector for which 12% conversion ratio was estimated.

Table 12: Major pollutants reductions

Total of seven cities	Target (Year 2)	Actual (Year 2)	Achievement ratio
SO_2 emission reduction (ton/year)	17,719	14,975	**85%**
NOx emission reduction (ton/year)	10,635	10,319	**97%**
TSP emission reduction (ton/year)	30,583	27,372	**80%**

Chuzhou City	Target (in the 2nd year)	Actual (2009)	Achievement ratio	Recent Data (Actual in 2012)
SO_2 emission reduction (ton/year)	4,355	2,911	**67%**	3,127
NOx emission reduction (ton/year)	780	527	**68%**	1,596
TSP emission reduction (ton/year)	5,704	3,919	**69%**	6,639

Fuyang City	Target (in the 2nd year)	Actual (2009)	Achievement ratio	Recent Data (Actual*)
SO_2 emission reduction (ton/year)	1,205	825	**68%**	**N/A**
NOx emission reduction (ton/year)	615	190	**31%**	**N/A**
TSP emission reduction (ton/year)	2,554	947	**37%**	**N/A**

*: Same as 2009 data.

Hefei City	Target (in the 2nd year)	Actual (2010)	Achievement ratio	Recent Data (Actual in 2012)
SO_2 emission reduction (ton/year)	3,355	3,485	**104%**	5,016
NOx emission reduction (ton/year)	4,560	5,953	**131%**	8,568
TSP emission reduction (ton/year)	10,124	12,814	**127%**	18,445

Huainan City	Target (in the 2nd year)	Actual (2008)	Achievement ratio	Recent Data (Actual in 2012)
SO_2 emission reduction (ton/year)	3,758	711	**19%**	1,544
NOx emission reduction (ton/year)	1,902	336	**18%**	729
TSP emission reduction (ton/year)	7,907	1,920	**19%**	3,299

Ma'anshan City	Target (in the 2nd year)	Actual (2009)	Achievement ratio	Recent Data (Actual in 2010)
SO_2 emission reduction (ton/year)	1,219	3,240	**266%**	4,716
NOx emission reduction (ton/year)	154	894	**581%**	1,072
TSP emission reduction (ton/year)	489	1,530	**313%**	2,219

Tongling City	Target (in the 2nd year)	Actual (2008)	Achievement ratio	Recent Data (Actual in 2011)
SO_2 emission reduction (ton/year)	1,431	1087	**76%**	1,673
NOx emission reduction (ton/year)	728	903	**124%**	1,223
TSP emission reduction (ton/year)	3,029	2,876	**95%**	4,437

Wuhu City*	Target (in the 2nd year)	Actual (2009)	Achievement ratio	Recent Data (Actual in 2012)
SO_2 emission reduction (ton/year)	2,695	2,690	**100%**	3,189
NOx emission reduction (ton/year)	1,897	1,010	**53%**	1,220
TSP emission reduction (ton/year)	777	572	**74%**	669

Source: JICA appraisal documents for the targeted values; response to the questionnaire for the actual values.

It should be noted that the coal replaced by natural gas varies in kind, depending on the sub-project involved and on the sector (industrial, household, transportation) and therefore the pollutants reduction volumes differ for a same one ton of coal replaced. For this reason, it is more worthwhile to analyze the factors that influenced the reduction amounts of each sub-project than to simply compare their relative performances and discuss which sub-project fared better or the like.

1) Compulsory and preferential measures for conversion to natural gas

Reflecting the national and provincial policies for environmental improvement, the following compulsory and preferential measures for converting to natural gas were implemented in each sub-project location. That became the factor to reduce coal consumption and to promote the effectiveness of the project[13].

[13] The quantity of reduced coal is numerical value through the response to the questionnaire of each sub-project.

Table 13: Compulsory and Preferential Measures Implemented in Each Sub-project and Their Impacts

Reduction	Compulsory Measures	Preferential Measures
Chuzhou City 19,000 tons (2012) Switch to natural gas was 11,000 tons	• The Chuzhou government has placed regulations on the coal boilers with less than 2 tons in the center of the city since June 2007.	None.
Fuyang City 4,689 tons (2011) Switch to natural gas was 4,106 tons	• The notice of Fuyang City[14] in 2007 aimed at promotion of natural gas and required closure and shutdown of coal boilers in the city zone. • Since October, 2012, driving of vehicles that have not acquired Environmental protection examination pass mark has been regulated by the City Environmental Protection Agency and public safety department[15].	None.
Hefei City (2011) 6,888 tons Switch to natural gas N/A	• The City's Clean Air Ordinance and Centralized Heat Supply Management Regulations placed regulations on the coal boilers used for heating, power supply, and industrial production in the center of the city.	None.

[14] Notice of the further acceleration of natural gas use promotion by the People's Government of Fuyang City. (Fuyang Administrative Secretariat Branch (2007) No. 109).

[15] The laws having legal ground are the "Clean Air Act of the Government of the People's Republic of China" and the "Road Transportation Safety Act of the Government of the People's Republic of China".

Huainan City Reductions of coal use and Switch to natural gas N/A	・ The coal boilers used for the community bathhouse, heating, industrial manufacturing in the city center were driven out of service by Huainan City. ・ The notice of dust pollution management strengthening was announced and environmental management was enhanced[16].	None.
Ma'anshan City 51,000 tons (2012) switched to 100% natural gas	・ The city government placed regulations on the coal boilers in the center of the city in 2005, and maintenance and tune-ups were required by a set deadline. ・ Thermal power stations and steel industry not complying with the emission standards of the atmospheric pollutants were to be shut down.	None.
Tongling City Reductions of coal use and Switch to natural gas N/A	・ The Tongling City government placed regulations on coal boilers used for industry and daily life in the center of the city, and most of them were decommissioned. ・ 35 in 2007, 35 from 2008 to 2009, 54 in 2010, and 70 in 2012 (total 194) were retired.	・Subsidies are provided by the city government and the environmental protection encouragement fund to companies that remove, replace or retrofit boilers. In addition, pipe laying expenses are discounted when natural gas is switched to.

[16] "Notice of the reinforcement of the city smoke and dust contamination control of the People's Government of Huainan City", Huainan Administrative Secretariat Branch (2003) No. 22; "Working opinion about the additional reinforcement of the environmental supervision management of the People's Government of Huainan City", Huainan Administrative Secretariat Branch (2007) No. 86.

Wuhu City Industrial coal 25,000 tons (2011) Switch to natural gas N/A	• In 2010, the city government required that all the combustion facilities such as boilers, industrial reactors, and furnaces which burn high-level pollution fuel should be switched to clean energy by the end of July in the year[17]. • The coal boilers in the center of the city were retired. Remodeling to natural gas was not performed and all were removed.	None.

2) Natural gas conversion by large-scale plants and power stations

When factories using fossil fuel in large scale switch fuel to natural gas, contribution is made to improvement of the concentration of atmospheric pollutants. For example, a large user of natural gas, producing copper electrode in Tongling City, uses 23.3 million m^3 of natural gas per year, which equal to 2% of natural gas consumption in the entire Tongling City. The factory installed flue-gas desulfurization equipment as atmospheric environment measures till then. However, by having switched from coal, heavy oil, and liquefied petroleum gas to natural gas, the emissions of the pollutant decreased[18].

Figure 5: Coal boiler facilities
(in Chuzhou City)

Figure 6: Thermal power station
(in Huainan City)

In the hearing with the provincial government, thermal power stations were listed as the pollution source ahead of all others. Anhui is a production center of coal and most of the fuel used at thermal power stations is coal. Comparing 2011 with 2000, the annual electrical power output increased by a factor of 4.5 to 165.5 billion kilowatts from 36.46 billion

[17] "Notice of strengthening management of the high-level pollution fuel burning prohibition zone of the People's Government of Wuhu City", (2010) No. 20.
[18] According to the response to the questionnaire from large users of natural gas.

kilowatts (for details, refer to Table 18). On the other hand, installing of desulfurization equipment has been required in the "Standard Act of Air Pollutant Emission at Thermal Power Stations (GB13223-2003)" announced in 2003 and the revised Act (GB13223-2011) as part of environmental measures against the power stations. Any concrete data either on the pollutant emissions from the increased number of power stations or the emissions reduction effect of such environmental protection measures were not available. According to the Project Implementing agency, however, the negative impact of the pollutant emissions caused by increased thermal power generation is great as coal use in the large-scale plants as described in the Impact section. However, if the restrictions on the use of natural gas in thermal power stations pursuant to the "Natural Gas Use Policy (2007; revised in 2012)" are lifted, there is a possibility that switch to natural gas will proceed in the target cities.

3) Price differences between natural gas and other fuels[19] (cf. Attachment 3)

Comparing fuel prices in the industrial sector with corresponding values per heat capacity, coal gas is about half the price of natural gas. The price of coal varies according to quality and acquisition method, but it is much lower than the price of natural gas and one third or one-tenth that of natural gas. Especially, Anhui produces coal, so it appears that some large-scale coal users enjoy lower-than-market prices from a coal mining company of the same group of companies. Although soot will not be generated by converting to natural gas, a clean energy, and there is an advantage in terms of reducing the maintenance cost of machines, the gap of fuel cost as well as expenses for converting and introducing facilities and retrofitting have become a disincentive.

In the household sector, the people in the residential areas have no option to choose the type of utility gas supplied to their domiciles, but they are allowed to install and use other fuels such as LPG at their own discretion. However, with the LPG being approximately double in price of natural gas, it did not act as a hindrance factor for conversion to natural gas.

[19] The natural gas price varies according to conveying distance, but retail price standard is stipulated by the Price Bureau; the example of Chuzhou City is employed here for illustration.

Table 14: Comparison of city gas price per calorific value (Chuzhou City)

(Unit: Yuan/MKcal)

	Natural gas			Coal gas	LPG
	Household	Industrial	Transportation	Industrial	Household
2006	0.235	0.235	0.304	0.112	0.458
2008	0.235	0.283	0.342	0.143	0.437
2009	0.235	0.283	0.342	0.125	0.472
2010	0.235	0.338	0.426	0.147	0.552
2011	0.235	0.338	0.426	0.154	0.64

Source: Response from Chuzhou City to the questionnaire.
Note: Calorific values were calculated as 8,400kcal/m^3 for natural gas, 5,000kcal/kg for coal gas, and 11,000kcal/kg for LPG.

3.3 Impact

3.3.1 Intended Impacts

3.3.1.1 Improvement of air environment

This project aims to promote conversion to natural gas and thereby contribute to the improvement of air environment. Through implementation of this project, there were expectations of having pollutant (SO_2/ NO_2 / TSP/ PM10/CO) concentrations meet Grade II Air Quality Standards. At the time of ex-post evaluation, apart from the PM10 values of Hefei, all sub-project cities met Grade II Air Quality Standards. However, although concentrations for all pollutants in Chuzhou have been declining every year, there are a number of pollutants in other cities whose concentrations have increased since the time of appraisal (see Attachment 4).

When looking at the emissions volume of air pollutants in Anhui Province, although SO_2 peaked in 2006 and has been constantly decreasing, NOx decreased in 2009 but has continued to increase since then. TSP has continued a drastic decrease since 2005. As can be seen, although emissions volumes vary depending on the substance, the percentage of reduction of the emissions volume of air pollutants across the whole of Anhui Province as a result of this project was 3.72% for SO_2, 1.34% for NOx, and 7.19% for TSP as of 2011. Even when compared to policy objectives, these numbers are not quite small. It is certain that this project has contributed to the improvement of the air environment (see Attachment 5).

Table 15: Total Emissions of Major Air Pollutants in Anhui Province

(Unit: Tons/year)

	2003	2004	2005	2006	2007
SO_2	454,900	489,000	571,200	584,500	571,700
NOx	N/A	N/A	N/A	609,692	569,010
TSP	701,900	716,700	760,100	717,800	613,200
	2008	2009	2010	2011	2012
SO_2	555,700	538,424	532,576	529,474	519,600
NOx	547,500	538,971	636,425	959,113	921,300
TSP	613,300	564,766	519,109	452,224	N/A

Source: Questionnaire response from the People's Government of Anhui Province.

Factors that inhibit the improvement of the air environment include increase in population, increase in the amount of coal used due to economic growth, as well as an increase in the number of vehicles owned. When looking at the emissions volumes of SO_2, NOx, and TSP according to type of fuel, as can be seen from the table below, increased emissions of SO_2 and TSP are attributable to coal for industrial uses and the increase in NOx to gasoline (see the highlighted sections of the table). According to the executing agency, the sources of pollutants, in order of greatest impact, are the use of fossil fuels in thermal power plants, use of fossil fuels in large-scale factories, and exhaust fumes from cars. Although indicated in the Relevance section, the greatest factor is the increased volume of use of coal in thermal power plants and large-scale factories due to the increased demand for primary energy. Below are the states of each factor.

Table 16: Air Pollutant Emissions by Fuel Type

Emissions volume per ton of coal heat	SO_2 (kg/ton)	NOx (kg/ton)	TSP (kg/ton)
Commercial coal: 1 ton	7.10	1.45	0.70
Industrial coal: 1 ton	20.0	15.0	50.0
Gasoline: 0.48 tons	2.4	39.36	0.432
Fuel oil: 0.48 tons	4.8	8.16	0.456
Coal gas: 128 m^3	0.77	2.6	0
Natural gas: 537m^3	0.097	0.097	0

Source: JICA appraisal documents.
Note: These equivalent values for each material have been recalculated according to coal heat volume by the evaluator based on the Natural Gas Conversion Plan Provisional Calculation (August 2008) by JICA.

1) An increase in demand for primary energy and coal (volume of coal use)

Across the whole of Anhui Province, the demand for primary energy increased 213% in a 10-year period from 2001. As a result, the demand for coal also increased by 218% to satisfy the demand for primary energy. Although the household demand for coal has

decreased, dependence on coal remains high at around 80% because the demand for industrial coal, which accounts for the majority of the entire demand.

Between 2000 and 2011, electricity production in Anhui Province increased by 4.5 times. In the cities where sub-projects were implemented, apart from Fuyang which has no power plants, almost 100% of electricity production was dependent on coal-fired power plants. As a result, the volume of coal used in the thermal power plants in each city also increased in proportion, and it is considered that the volume of air pollutant emissions from the burning of coal has increased.

Table 17: Volume and Ratio of Coal Demand in Anhui Province

	Primary energy Total demand (10,000 tons)	Coal demand (10,000 tons)			Coal dependence rate (%)
		Total	Household	Industrial	
2001	5,216	4,504	N/A	N/A	86.18
2005	6,564	5,798	360	5,438	88.33
2006	6,999	6,169	306	5,863	88.15
2007	7,718	6,840	268	6,572	88.63
2008	8,924	8,019	236	7,784	89.86
2009	9,776	8,748	222	8,526	89.48
2010	10,373	9,229	284	8,945	88.97
2011	11,118	9,840	203	9,637	88.51

Source: 2001 data from responses from Anhui Province (June 2002), values from 2005 to 2011 based on questionnaire responses from Anhui Province.

Table 18: Electricity Production and Consumption Volumes

(Unit: 100 million kw /year)

	2000	2011	Percentage	2000/ 2011 comparison
Electricity production	364.63	1,655.07		454%
Of which thermal generation	360.05	1,624.0	98%	270%
Hydro, other	4.58	31.07	2%	678%
Electricity consumption	338.92	1,221.19		360%
Of which industrial	238.26	877.79	72%	368%
Household	53.03	191.55	16%	361%

Source: Anhui Province Statistical Yearbook 2012 Edition.

2) Number of automobiles owned

Exhaust fumes from vehicles in particular, are a factor behind the increase in NOx. As shown in Table 19, the number of vehicles owned in all cities in which sub-projects were implemented has increased drastically, as the result, affecting the air environment. In regards to the seven sub-project cities, number of vehicles has increased from 249,000 in 2002 to 1,502,000 in 2011. In every city, the transition from gasoline and diesel fuels to natural gas vehicles has advanced, in particular among public transportation such as buses and taxies. However the percentage of natural gas vehicles still remains in single digits and the contribution to the improvement of the air environment through conversion to natural

gas vehicles is still on the way.

Table 19: Number of Automobiles Owned in Each City (Unit: 10,000 vehicles)

	Chuzhou	Fuyang	Hefei	Huainan	Ma'anshan	Tongling	Wuhu	Seven cities	Anhui Province
2002	4.2	4.9	6.7	3.0	0.9	1.1	3.2	27.4	52.3
2011	15.7	33.5	55.0	10.3	10.6	5.0	20.1	150.2	330.2

Source: Anhui Province Statistical Yearbook 2003 Edition, 2012 Edition.

Table 20: Type of Fuel and Number of Automobiles Breakdown (Unit: Vehicles)

Chuzhou	Gasoline	Diesel	Natural gas	Hybrid	Electric vehicles	Total
2006 - No. of vehicles	54,580	26,739	150	0	0	81,469
Percentage	67.0%	32.8%	0.2%	—	0%	—
2012 - No. of vehicles	97,902	56,596	3,400	10	0	157,908
Percentage	62.00%	35.84%	2.15%	0.01%	0%	—

Source: Chuzhou City questionnaire response.

Ma'anshan	Gasoline	Diesel	Natural gas	Hybrid	Electric vehicles	Total
2006 - No. of vehicles	18192	5621	12	2	5	23,832
Percentage	76.33%	23.59%	0.05%	0.01%	0.02%	—
2012 - No. of vehicles	65242	13927	213	158	6	79,546
Percentage	82.01%	17.51%	0.27%	0.20%	0.01%	—

Source: Ma'anshan City questionnaire response.

Figure 7: Housing complexes that benefitted from the project (Tongling City)

Figure 8: Customer center that serves as a window for bill payments and customer supports (Huainan City)

3.3.1.2 Residents' awareness of air improvement

In order to confirm the qualitative effects of this project, a beneficiary survey based on a questionnaire was conducted in Tongling. Compared to other cities, Tongling had serious air

pollution issues before the implementation of this project. The 50 residents lived in housing complexes near large industrial users which had converted from coal to natural gas use in 2007, were selected as the survey's samples. The results of the survey were as follows.

(1) Status of natural gas utilisation

In areas where the survey was conducted, the conversion to natural gas took place between 2007 and 2008. More than approximately half of all households converted from coal gas. The conversion incurred cost on average of 1,172 yuan[20] per household in order to purchase cooking and hot-water supply equipment.

In regards to the reasons for converting to natural gas, 88% responded that "Natural gas is more convenient" because of its relatively stable supply compared to other sources of energy and because it can be used at any time. This was followed by "It is better for the health of my family" with 48% and "It is good for the air environment" with 42%, raising the advantage that it produces little air pollutants (Figure 9). After using natural gas, 90% of users responded that "Convenience has improved"(Figure 10) and 66% responded that the time that they use equipment such as cooking, hot water and heating equipment has decreased (Figure 11). Regarding cost, 82% responded that "Natural gas is cheaper" in terms of usage fees (Figure 12). In addition, after starting to use natural gas 86% responded that their health has improved (Figure 13) and 88% responded that the environment has improved (Figure 14).

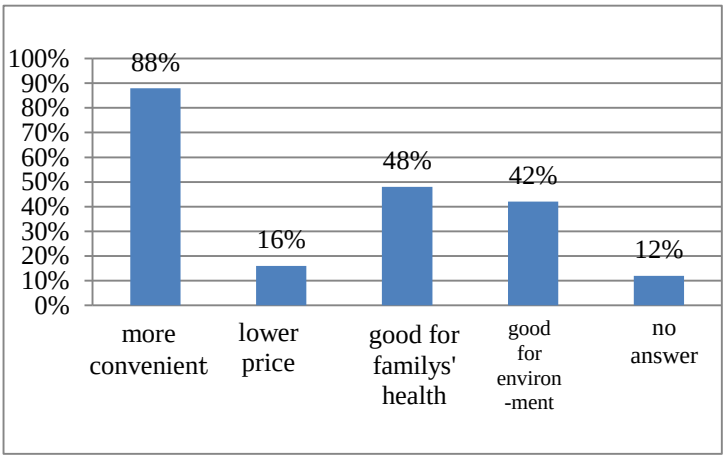


Figure 9: Reasons for converting to natural gas

[20] GDP per person in Tongling City 2007 was 38,454 yuan/year.

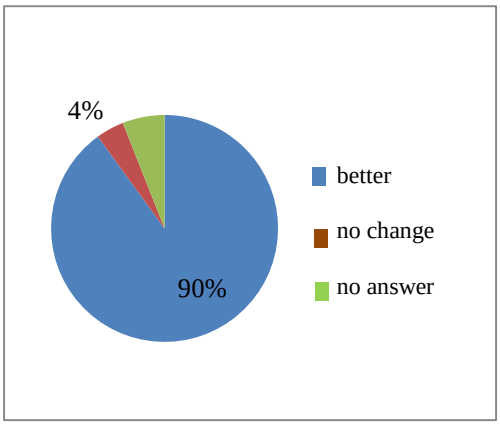


Figure 10: Changes in convenience after converting to converting to natural gas

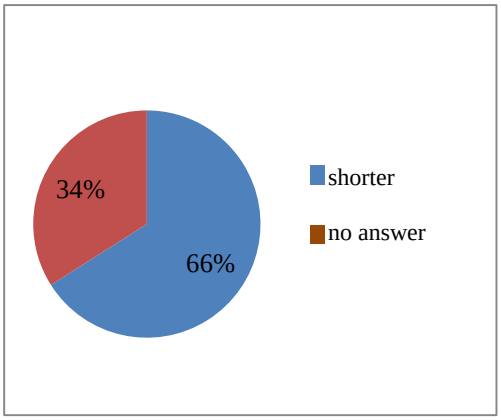


Figure 11: Time of use of cooking equipment after converting to natural gas

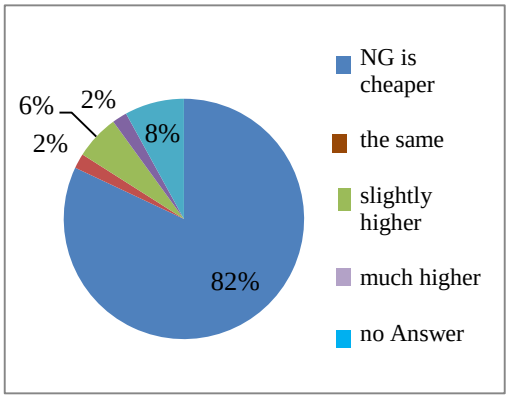


Figure 12: Changes in primary energy usage fees after converting to natural gas

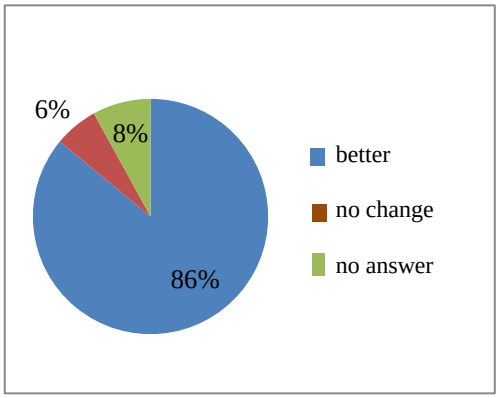


Figure 13: Changes in state of health after converting to natural gas

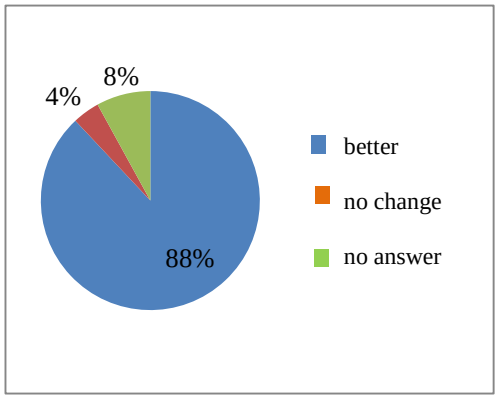


Figure 14: Changes in environment after converting to natural gas

(2) Awareness of air improvement

Comparing the air environment near residences to that of 10 years ago, 62% of respondents said that "The air environment has improved substantially" and 24% responded that it "Has improved somewhat." Reasons for the responses included "There is less of a pungent odor (from the sulfur content of coal) "and" The walls no longer change yellow in

color." (Figure 15)

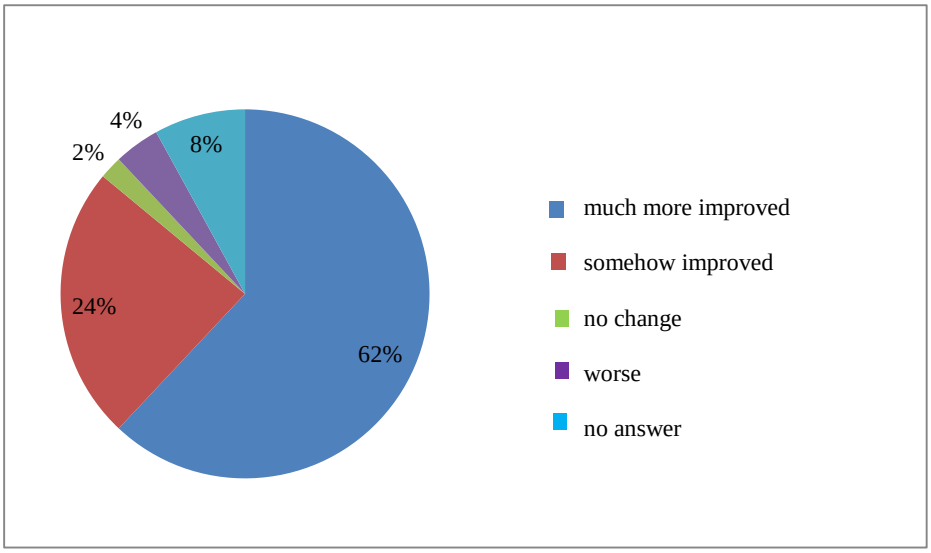


Figure 15: Comparison of air environment now to 10 years ago

(3) Changes in living environment

Compared to 10 years ago, in regards to access to fuel and convenience of equipment used after converting to natural gas, 72% responded that this was "Substantially more convenient" and 16% responded that this was "Somewhat more convenient." In particular, many responded that the reason for this was that after converting to natural gas, supply has become consistent even during the winter when, under fuel use peak; the supply of town gas used to be interrupted due to fuel shortage (Figure 16).

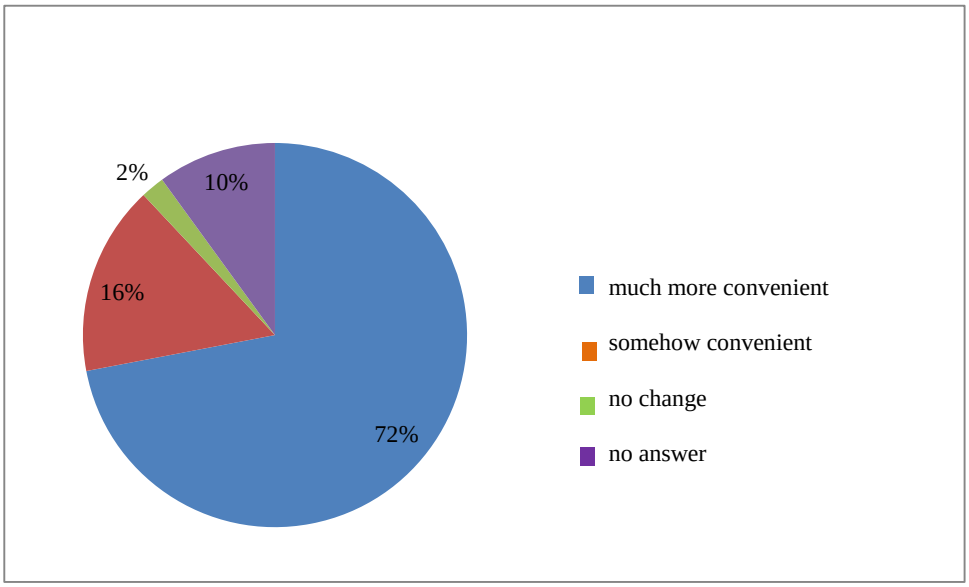


Figure 16: Comparison of living environment now to 10 years ago

Because of the small sample size for this survey, the results are not representative of the beneficiaries of this project. However, in areas where sub-projects were implemented, there is awareness that natural gas has contributed to improvement of the air environment as well as improvements to the living environment from the perspectives of convenience, health and environment. It is considered that this project has had a certain degree of impacts.

3.3.2 Other Impacts

3.3.2.1 Impact on industrial users

With the cooperation of seven major natural gas user companies of the targeted cities, a questionnaire survey was conducted to find out why they have converted to natural gas and how they are using it. Conversion to natural gas was from liquefied coal gas, fuel oil and coal. All companies responded that the effect on the environment was the reason for conversion, followed by 85% citing convenience. In regards to the questions about usage volume of natural gas and conversion costs, four companies provided responses, which ranged from 130,000 m^3 /year to 23.3 million m3 /year in usage volume and from 3 million yuan to 20 million yuan in conversion costs. Generalizations are not possible because of the small sample size and the varied scales and industry types of the companies. Looking at individual responses, three companies provided figures on fuel and maintenance costs. Two of the three companies suffered increased fuel cost of approximately 20% to 25% after converting to natural gas from liquefied petroleum gas or coal. On the other hand, the conversion allowed them to reduce their maintenance costs to 35% and to 15% respectively of the original costs. The remaining company responded that fuel costs decreased by 2% after converting from coke to natural gas, and that maintenance costs had decreased by 17% because emissions of soot had decreased due to the use of natural gas, resulting in less man power and frequency of cleaning and maintenance. At this company, it has taken five years to recover the 3 million yen it cost to convert to natural gas. In regards to improvement of the air environment, all six companies that responded stated that they have been able to reduce the emission of major air pollutants through the conversion to natural gas[21].

[21] This data cannot be said to be representative of industrial users for this project due to the small sample size and due to the fact that the respondents are large companies that use 70,000 to 150 million m^3/year of natural gas.

Figure 17: Coal-fired boiler before conversion (Ma'anshan City)

Figure 18: Natural gas furnace after conversion (Ma'anshan City)

3.3.2.2 Land acquisition and resettlement

Land acquisition for this project increased from the planned total of 26.5 hectares for all seven cities to 34.0 hectares (128% against the plan). Acquisition cost increased from the planned 11.96 million yuan to 35.23 million yuan (295% against the plan). There was no resettlement of residents resulting from this project.

Acquisition areas by Chuzhou, Fuyang and Ma'anshan cities were according to the plan while those by Huainan, Tongling and Wuhu cities were smaller than planned. In terms of cost, costs were lower than planned in Fuyang and Wuhu. Because the land to be acquired in Huainan and Tongling was farmland, costs for land acquisition increased due to additional payments for the compensation for crops. The reason for the area of land acquisition increasing in Hefei was due to changes in urban planning after the start of implementation of the project, resulting in the necessity to change the planned pipeline construction site. As the result, an area approximately eight times the size of the 1.4 hectares that was planned to be acquired for free was acquired for 11.93 million yuan.

In each of the sub-projects, the same acquisition procedure was taken. At first the Project Implementation Units applied to the city governments for their construction sites, then the city governments and PIU negotiated acquisition and compensation to the local governments who are owner of the land. With the city government taking part in the process, reviews and coordination proceeded smoothly, and there were no issues during negotiations with the counties, towns, or villages in Fuyang, Hefei, Huainan, and Tongling cities where farmland was acquired. The only exception was in Ma'anshan City where negotiations with the regional government took longer than expected, resulting delays in construction period.

Table 21: Land Acquisition in Each Sub-project

	At planning		At ex-post evaluation	
	Acquired area	Price (ten thousand yuan)	Acquired area	Price (ten thousand yuan)
Total of seven cities	26.5 hr	1,196.15	34.0 hr	3,522.8
Chuzhou	2.7 hr	6	2.7 hr	400
Fuyang	3.4 hr	2.6	3.4 hr	2.3
Hefei	1.4 hr	0	12.5 hr	1,192.57
Huainan	8.0 hr	8.55	6.0 hr	415.13
Ma'anshan	3.3 hr	750	3.3 hr	750
Tongling	3.0 hr	6	1.7 hr	365
Wuhu	4.7 hr	423	4.4 hr	397.8

Source: Questionnaire responses from each sub-project

3.3.2.3 Impacts on the natural environment

During the course of the project implementation, necessary measures based on the national regulations were taken to prevent water pollution and soil contamination such as the effect of heavy metals or so, to manage sludge waste, and to control noise and vibration, therefore no negative impact occurred.

In light of the above, this project has largely achieved its objectives, therefore its effectiveness is high.

3.4 Efficiency (Rating: ②)

3.4.1 Project Outputs

The plan and actuals for this project are as shown in the table below. Except for the fact the number of project cities decreased from eight to seven, the project was implemented largely as planned.

Table 22: Output List

	Plans	Actuals
Chaohu	Gate station: 1 location Gas holders: 2 units SCADA: 1 unit Gas pipes (medium pressure pipes: 82km) Natural gas stands: 3 locations	Cancelled
Chuzhou	Gate station: 1 location Gas holders: 2 units SCADA: 1 unit Gas pipes (high pressure pipes: 38km, medium pressure pipes: 260km) Natural gas stands: 3 locations	As planned
Fuyang	Gate station: 1 location Gas holders: 4 units SCADA: 1 unit Gas pipes (medium pressure pipes: 290km, low pressure pipes: 437km) Natural gas stands: 5 locations	As planned
Hefei	Gate station: 1 location Gas holders: 12 units SCADA: 1 unit Gas pipes: 456km (high pressure pipes: 20km, medium pressure pipes: 409km, low pressure pipes: 27km) Natural gas stands: 1 location	Mostly as planned Changes were: Gas holders: 9 units Gas pipes: 1,042km (high pressure pipes: 22km, medium pressure pipes: 570km, low pressure pipes: 450km)
Huainan	Gate station: 1 location Gas holders: 6 units SCADA: 1 unit Gas pipes: 204km (high pressure pipes: 56km, medium pressure pipes: 131km, low pressure pipes: 17km) Natural gas stands: 6 locations	Mostly as planned Changes were: Gas holders: 2 units Gas pipes: 614km (high pressure pipes: 38km, medium pressure pipes: 129km, low pressure pipes: 447km) Natural gas stands: 5 locations
Ma’anshan	Gate station: 1 location Gas holders: 5 units SCADA: 1 unit Gas pipes: 228km (high pressure pipes: 1km, medium pressure pipes: 227km) Natural gas stands: 1 location	Mostly as planned Changes were: Gas holders: 2 units SCADA: 1 unit Gas pipes: 10,856km (high pressure pipes: 10km, medium pressure pipes: 227km, low pressure pipes: 629km)
Tongling	Gate station: 1 location SCADA: 1 unit Gas pipes: 261km (medium pressure pipes: 74km, low pressure pipes: 187km) Natural gas stands: 1 location	As planned
Wuhu	Gate station: 1 location Gas holders: 6 units SCADA: 1 unit Gas pipes: 336km (medium pressure pipes: 132km, low pressure pipes: 204km) Natural gas stands: 2 locations	As planned

In Hefei, Huainan and Ma'anshan, where the number of gas holders was reduced and the total length of gas pipes was changed, construction of some spherical gas holders was cancelled and changed using underground pipelines for storage. This was made possible

through conduit reinforcement technology, which enabled the conduits to also act as storage through applying increased pressure. As a result, not only was land for the planned construction of gas holders no longer required, but also costs for construction of the gas holders and for maintenance were eliminated. In addition, in regards to the changing of the total length of gas pipes, although there were plans to receive sub-pipelines in Hefei from PetroChina Company Limited, the main pipeline was directly fed in by changing its location. In Huainan and Ma'anshan, there were adjustments in construction plans in accordance with urban planning, resulting in an extension in the total distance laid down.

Figure 19: Spherical natural gas holders (Hefei City)

Figure 20: CNG station (Chuzhou City)

3.4.2 Project Inputs

3.4.2.1 Project Cost

The total planned cost at the time of appraisal was 37,079 million yen (of which the ODA loan portion was 18,558 million yen). Of the eight target cities, Chaohu declined the use of ODA loans and so for the purpose of this sub-rating here, this was subtracted from the total planned project cost to a total of 35,090 million yen (of which the ODA loan portion was 17,293 million yen). The actual total project expense was 36,586 million yen (of which the ODA loan portion was 18,538 million yen), 104% mostly as planned. Cost for four of the seven cities were equal or lower than the plan, and for the other three cities were within 120%, resulting in no sub-projects exceeded significantly higher than the planned budget (see Attachment 1). In Fuyang, Huainan, and Wuhu, actual cost was higher than planned, but for each of the sub-project, the reason was the rise in domestic commodity prices.

3.4.2.2 Project Period

Compared to the planned period of March 2003 to December 2007 (58 months) for this project, the actual period was from March 2003 to September 2008 (67 months/116% against the plan), which is longer than planned. Results for each city were as follows:

Chuzhou (58 months/126% against the plan), Fuyang (58 months/126% against the plan), Hefei (67 months/116% against the plan), Huainan (46 months/100% to the plan), Ma'anshan (58 months/126% against the plan), Tongling (46 months/100% to the plan), and Wuhu (58 months/126% against the plan) (see Attachment 2). The reasons for delay in the four cities that exceeded 125% were as below.

In Chuzhou, some of the planned gas holders were constructed by procuring finances within China due to the rapid increase in price caused by inflation. Additionally, because the storage design was changed to partly include a method to store gas in the underground pipelines, procedures and coordination for these changes required some time.

In Fuyang, the sub-project was affected by the major changes in the road construction plans that came with the urban development plan at the end of 2005. Natural gas pipeline construction is managed together with road construction in urban planning. Construction for a natural gas pipeline had to be temporarily suspended until the latter half of 2007 to accommodate road construction timelines.

In Wuhu, the designs of the supply stations had to be modified to meet the new standards that came with a revision of the city's environmental standards. Modification in design to meet new standards required changes in the equipment procurement list, and also in adding project implementation unit's own funds. Therefore the process led delay in the construction of supply facilities in the city.

In Ma'anshan, contract negotiations and applications with the local government concerning gate station construction sites led delay.

3.4.3 Financial Internal Rate of Return (FIRR)

The financial internal rate of return (FIRR) at the time of appraisal was calculated on the assumption that the project life is 20 years, the benefit is fare earnings, and the expenditure is construction and maintenance expenses. The table below shows the result of recalculation done in the same way at the time of appraisal. At the time of ex-post evaluation, Hefei, Huainan and Ma'anshan had negative FIRR values. At Huainan, the reason for this was that although natural gas sales revenues were significantly lower than planned, maintenance costs exceeded plans. In the other two cities, costs associated with the natural gas sales accounting for a high proportion of expenses which lead to low revenues had affected the FIRR. The high tax rates also can be the cause of the low FIRR value in Ma'anshan.

Table 23: Financial Internal Rate of Return

	At appraisal	At ex-post evaluation
Chuzhou	6.3%	7.26%
Fuyang	3.5%	7.11%
Hefei	7.2%	Negative
Huainan	5.8%	Negative
Ma'anshan	3.8%	Negative
Tongling	4.9%	11.56%
Wuhu	7.7%	0.4%

Source: See JICA appraisal material for values at time of appraisal. Values at time of ex-post evaluation were recalculated by the evaluator based on questionnaire responses from the Project Implementation Unit.
Note: Actual and predicted values are those provided by the Project Implementation Unit.

In light of the above, both project cost and project period exceeded the plan, therefore efficiency of the project is fair.

3.5 Sustainability (Rating: ③)

3.5.1 Institutional Aspects of Operation and Maintenance

(1) Executing Agency

At the time of appraisal, a guided group for decision-making on vital matters and for monitoring was established within The People's Government of Anhui Province, and the Japanese Loan Office of Anhui Environmental Improvement Project was set as its secretariat in 2005 within the Banking Department of Finance Bureau of Anhui Province. The Office was responsible for supervising over the sub-project implementation including annual plan, construction progress management, inspections, and financial management. Following completion of the project, it continues to supervise sub-projects and manage ODA loan repayments.

(2) Project Implementation Units

Although the name of the Project Implementation Unit of the Ma'anshan sub-project was changed, there have been no changes in the implementing bodies themselves since the time of appraisal. Because all Project Implementation Units were the suppliers of city gas based on coal gas, coke furnace gas, and liquefied petroleum gas (LPG) before the project, they are able to provide natural gas by improving and replacing the same pipelines. Because the PIUs have experience in operating and maintaining gas-supply businesses, conversion to natural gas by users was conducted without any major problem and there have been no accidents at the gas supply facilities.

Table 24: Names of the Project Implementation Units

Implementation site	Name at the time of appraisal	Name at the time of ex-post evaluation	Organisation form
Chuzhou	Chuzhou Gas Company	No change	State owned enterprise with 100% investment by the city[22]
Fuyang	Fuyang Guozhen Energy Development Co., Ltd.	No change	Private enterprise
Hefei	Heifei Gas Group Co., Ltd.	No change	State owned enterprise with 100% investment by the city
Huainan	Huainan Gas General Company	No change	State owned enterprise with 100% investment by the city
Ma'anshan	Maanshan Gas General Company	Maanshan Ganghuo Gas Limited Company	State owned enterprise with 100% investment by the city
Tongling	Tongling Gas General Company	No change	State owned enterprise with 100% investment by the city
Wuhu	Wuhu Parent Gas Company	No change	State owned enterprise with 100% investment by the city

3.5.2 Technical Aspects of Operation and Maintenance

(1) Executing Agency

The city governments under the supervision of the provincial government conduct the inspections of construction and facilities as well as environmental management. There is cooperation between the province and the city governments, with agencies possessing specialized techniques taking the parts in operation and supervision, there are no foreseeable technical capability issues.

1) The Development and Reform Commission of each sub-project city government provided permits and supervision of construction by the Project Implementation Units. At

[22] State run enterprises whose ownership and management had been separate were changed to state owned enterprises. A stock system was implemented on the premise of public ownership to procure funds, and the objective is to establish an effective and modern corporate system that matches the market economy.

the time of the ex-post evaluation, financial conditions and asset auditing are conducted semi-annually by the commission.

2） In the environmental sector, on-site inspection has been conducted in every quarter, and air pollutants measured at monitoring stations set by the Environmental Protection Bureau of each city. The city government Environmental Protection Bureau is responsible in providing guidance if there is any violation.

3） Monitoring the safety management at the natural gas-related facilities is conducted by the safety authority of the city government through unannounced on-site inspection once every half a year or so. As the part of the entire facility inspection on pipelines and gas control meters, detailed guidance on meters and parts replacement is provided.

4） The fire department of each city supervises the fire-prevention equipment at natural gas-related facilities.

(2) Project Implementation Units

All the project implementation units satisfy the technological requirements for the following reasons:

1) The project implementation units have established technical standards for their operation, maintenance and management, and the technicians suitably trained for their assigned duties are in place. The technicians are required to meet the technical evaluation standards set up for operation, maintenance and management. Also the technical training programmes for improving their technical capabilities are established. The programmes are revised annually in line with the technological advancement.

2) All the project implementation units have formulated plans for facility management, maintenance and inspection based on the national safety regulations, and they are conducting the management on the basis of these plans. The personnel are trained in relations to relevant manuals, and copies of these manuals are distributed to each office.

3) On-site study in this evaluation has confirmed that the management, maintenance and inspection of the facilities are being conducted without any particular problems. The facilities are patrolled on an hourly basis, and the maintenance and inspection records are kept on an hourly and daily basis. If there is any abnormality in the facilities, its content and the countermeasures taken are recorded. Furthermore, the personnel are informed of the procedures to be followed in the event of any abnormalities.

4) Spare parts are stored in places to which the repair teams can immediately access, and are replaced as necessary.

3.5.3 Financial Aspects of Operation and Maintenance

Natural gas fees are collected through bank transfer from large-scale users such as industrial and commercial users. Small-scale commercial and household users make

payments of natural gas fees by using prepaid IC cards. The highly convenient collection system has been thus established and the collection rates for all sub-projects are close to 100%. Therefore, collection rates do not have a negative influence on financial aspects.

Retail prices for end users[23] have been set at a fixed price by the Price Bureau of the central government plus a profit for the supplying company. There are different prices set for each sector. Although user prices for the household sector are near or below initial cost, this is compensated for by revenues from high-profitability sectors such as transportation and industry, thus sustaining a balance for the business as a whole.

Although it was pointed out at the time of appraisal that profitability was low for six sub-projects except Fuyang, at the time of ex-post evaluation, all major financial indicators had improved for all sub-projects excluding Huainan, which did not provide data. Although there were sub-projects such as Ma'anshan where there were negative numbers as a natural gas supply project, the company as a whole has increased current accounts and operating margins and has stable management. As a result there are no problems regarding sustainability from the financial aspect (see Attachment 6). When comparing the equity ratio of the Project Implementation Units at the time of appraisal and at the time of ex-post evaluation, Ma'anshan and Tongling had increased from the time of appraisal, Fuyang had decreased 28%, Hefei had decreased 10%, and Wuhu had decreased roughly 16%[24]. This is due to increased investment in facilities and operations. There is a continued period of growth for expansion of natural gas-related facilities, current accounts for the companies are stable and there are no particular problems. The Project Implementation Unit in Fuyang is exceptionally good in financial management. The reasons behind this were efforts to not only increase delivery volume, but also to decrease the rate of loss during transport in the supply of natural gas. Normally, although there is a loss of around 8% on average when transporting natural gas, the Project Implementation Unit at Fuyang had reduced this to approximately 3%[25].

Because no financial indicators provided by Huainan, the evaluation employs the annual balance of payments for natural gas as the substitution. After posting losses in 2005, the first year of operations and 2006, Huainan had showed profits until 2010 when it again posted losses. The losses have increased every year since then (Table 25).

[23] Retail price for natural gas users is a combination of the city gate price for gas pumped from gas fields determined at the national level via main pipelines to the city gate station, and a city price determined at the provincial level.
National level: Delivery cost＋Pipeline transportation cost＝City gate price
Provincial level: City gate price＋Intra-city pipeline transportation cost (＋supply company profit)＝Retail price

[24] No data provided by Chuzhou and Huainan.

[25] Patrols by personnel at Fuyang were increased above the national standards. The SCADA system continuously monitors the pipelines for large-scale customers as well as pressure, enabling early detection and resolution of gas leaks and abnormalities in order to reduce losses from gas leaks and theft. Through these efforts, of the total loss rate, a 3% to 4% improvement has been achieved through theft prevention measures.

Table 25: Huainan Annual Balance of Payments

(Unit: 10,000 Chinese yuan)

	2005	2006	2007	2008	2009	2010	2011	2012
Administrative expenses	1,003	3,080	3,379	7,661	9,342	13,117	17,466	18,770
Revenue	822	2,938	3,536	7,816	9,654	12,416	15,790	17,100
Balance of payments	-481	-142	157.5	157.9	312	-700	-1,676	-1,670

Source: Huainan questionnaire response.

According to an interview with the Huainan Project Implementation Unit, for a few years since operation, coordination with a new real estate developer has not been well, and they did not enable to gain new household and industrial users in the areas, as the result, revenue did not grow as planned. Although coordination was later successful and the number of natural gas users increased, on the other hand, investment in construction increased due to rapid pipeline networks constructions in the city from 2010 onwards. Under such a situation, the PIU's balance turned into red again and it is in lead time to gain financial return from the investment.

In the case of a natural gas supply project posts losses, in general, corporate efforts are required. However, there are cases where the city government provides deficit compensation, as in the case of the Hefei Project Implementation Unit[26]. At the interviews with the Development and Reform Commissions of each city government, in the reason of that natural gas provision is a public utility, if it is determined that there is a high rate of necessity for compensation such as in cases endanger the supply by the Project Implementation Unit, there would be a possibility of compensation. Although there is slight concern regarding the finances of Huainan, the other six cities are in good financial condition, and it can be said that there are no significant problems regarding overall financial sustainability.

3.5.4 Current Status of Operation and Maintenance

The state of operation, maintenance and management was confirmed to be satisfactory in all sub-projects. The facilities have backup equipment for inspection and management. The maintenance and management plan for the facilities was formulated in accordance with the national guideline, and the facilities are being managed based on that plan. Also the management and inspection records and other manuals are kept in place. In particular, the gate station that brings in natural gas from the main pipeline to the city is a critical facility. As such, it is situated within premises surrounded by the fences and strict measures such as

[26] According to questionnaire responses and an interview with the Hefei Project Implementation Unit, there was compensation of 18 million yuan in 2004 and 2005 as well as 15 million in 2006 and 2007, for a total of 66 million yuan.

24 hours a day monitoring, control and checking of in-and-out of people and the fire and static electricity prevention measures are taken.

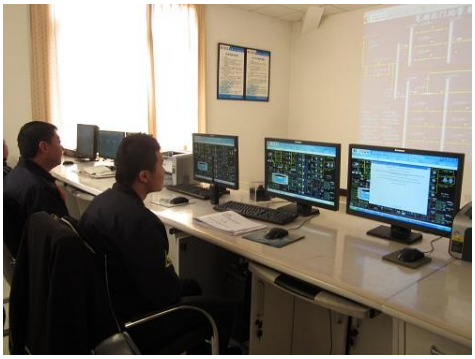


Figure 21: Security room inside the gate station (Wuhu City)

Figure 22: Fire prevention pond for emergency (Huainan City)

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

4. Conclusion, Lessons Learned and Recommendations

4.1 Conclusion

The Chinese government has set targets of raising the ratio of natural gas as clean primary energy consumption and reducing gross emissions of pollutants in order to improve atmospheric environment. In Anhui Province, at the time of project appraisal, coal accounted for over 80% of energy and pollutant emissions associated with the coal combustion caused serious problems of worsening air quality. This project aimed to develop natural gas supply infrastructure and reduce air contaminants in eight cities of Anhui Province in conjunction with the start of supply from the West-East Pipeline national project, so implementing the project has a high degree of relevance. Supply of and conversion to natural gas are proceeding smoothly and it can be recognized that the purpose of the project has been generally accomplished. The main pollutants found in the targeted cities, except for a small portion of them, meet the second grade National Air Quality Standard and the project is having a positive impact on atmospheric environment. The efficiency is considered to be fair because the project was delayed due to changes in city planning and the operating cost went slightly over the budget due to inflation. The natural gas suppliers of those cities have no particular problems regarding organizational, technical and financial aspects, and the operation supervision, environmental monitoring and safety management setups of the provincial and city governments are established, therefore, the sustainability is high.

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

4.2 Recommendations

4.2.1 Recommendations to the Executing Agency

Although use of natural gas in the household sector was promoted in all sub-project implementation cities through the "Natural Gas Utilization Policy" (2007), regarding the industrial and electrical sectors where there were restrictions, the Project Implementation Units had to hold back on conversion to natural gas by business operators who would otherwise have promoted to natural gas conversion. Since this time, this policy may have been revised and restrictions on the industrial and electrical sectors might have been eased, and there are chances that the demand for natural gas will be increased. In addition, in order to accommodate the shortage of natural gas in the winter, the Project Implementation Units are considering, or have already started purchases from other natural gas pipelines suppliers other than the West-East Pipeline. In addition to expanding natural gas supply sources, considerations are being made to expand the types of natural gases to include non-conventional natural gases such as coal gas, and coal-derived gases that are detoxified through new technologies. It is expected that the Executing Agency promote the increase in the number of natural gas supply sources to ensure stable supply, to clearly indicate the policy to use the limited availability of the domestic natural gas efficiently, and to facilitate such stable supply and efficient utilization.

4.2.2. Recommendations to JICA

None in particular

4.3 Lessons Learned

(1) In regards to air pollutants reduction, which was one of the project effect indicators, it was difficult to make an accurate qualitative analysis across all the sub-projects since their understandings on the indicators themselves and the calculation methods were not all the same. Definitions of “fossil fuels” as source of air pollution for instance, differed among the sub-projects whether or not to include diesel and other fuels, although domestic coal and industrial coal were the common baseline. Because the emissions volumes of major pollutants per unit of an economic activity adopted at the time of project appraisal would change over the course of 10 years, it is difficult to come up with an accurate value if one were to pursue scientific accuracy. In place of these reduction volumes, which require complicated calculations, it would have been better to apply an indicator: the volume of conversion to natural gas from fuels such as coal (household, industrial, commercial), gasoline, diesel, kerosene, town gas (coal gas) and liquefied petroleum gas (LPG). Recording these data would have been simpler and the trend is easier to observe. It is desirable to choose a project effect indicator consisting of data

which the Project Implementation Units routinely keep in record, and that preferably the first-source data.

(2) Domestic production volumes of natural gas in China was unable to meet the demand, so the "Natural Gas Utilization Policy" (2007) restricted the usage of natural gas by the industrial and electrical sector, resulting in the conversion to natural gas in these sectors for the sub-projects delayed beyond the plan. In projects such as this one where many external factors affect the results of the project, there is a need to ensure a stable supply of natural gas through expanding utilization of liquefied natural gas (LNG), and further, to take appropriate policy measures to promote the reduction of fossil fuels and conversion to natural gas by implementing strict and comprehensive controls over coal boilers in urban centers.

End of Document

Comparison of the Original and Actual Scope of the Project

Item	Original	Actual
1.Project Output Chaohu	Gate station: 1 location Gas holders: 2 units SCADA: 1 unit Gas pipes (medium pressure pipes: 82km) Natural gas stands: 3 locations	Cancelled
Chuzhou	Gate station: 1 location Gas holders: 2 units SCADA: 1 unit Gas pipes (high pressure pipes: 38km, medium pressure pipes: 260km) Natural gas stands: 3 locations	As planned
Fuyang	Gate station: 1 location Gas holders: 4 units SCADA: 1 unit Gas pipes (medium pressure pipes: 290km, low pressure pipes: 437km) Natural gas stands: 5 locations	As planned
Hefei	Gate station: 1 location Gas holders: 12 units SCADA: 1 unit Gas pipes: 456km (high pressure pipes: 20km, medium pressure pipes: 409km, low pressure pipes: 27km) Natural gas stands: 1 location	Mostly as planned Changes were: Gas holders: 9 units Gas pipes: 1,042km (high pressure pipes: 22km, medium pressure pipes: 570km, low pressure pipes: 450km)
Huainan	Gate station: 1 location Gas holders: 6 units SCADA: 1 unit Gas pipes: 204km (high pressure pipes: 56km, medium pressure pipes: 131km, low pressure pipes: 17km) Natural gas stands: 6 locations	Mostly as planned Changes were: Gas holders: 2 units Gas pipes: 614km (high pressure pipes: 38km, medium pressure pipes: 129km, low pressure pipes: 447km) Natural gas stands: 5 locations
Ma’anshan	Gate station: 1 location Gas holders: 5 units SCADA: 1 unit Gas pipes: 228km (high pressure pipes: 1km, medium pressure pipes: 227km) Natural gas stands: 1 location	Mostly as planned Changes were: Gas holders: 2 units SCADA: 1 unit Gas pipes: 10,856km (high pressure pipes: 10km, medium pressure pipes: 227km, low pressure pipes: 629km)

Tongling	Gate station: 1 location SCADA: 1 unit Gas pipes: 261km (medium pressure pipes: 74km, low pressure pipes: 187km) Natural gas stands: 1 location	As planned
Wuhu	Gate station: 1 location Gas holders: 6 units SCADA: 1 unit Gas pipes: 336km (medium pressure pipes: 132km, low pressure pipes: 204km) Natural gas stands: 2 locations	As planned
2. Project Period	March 2003 - December 2007 (58 months)	March 2003 - September 2008 (67 months)
3. Project Cost Amount paid in Foreign currency Amount paid in Local currency Total Japanese ODA loan portion Exchange rate	 18,558 million yen 18,511 million yen (1,234 million yuan) 37,079 million yen 18,558 million yen 1 yuan＝ 15 yen (As of March 2003)	 18,538 million yen 18,048 million yen (1,266.5 million yuan) 36,586 million yen 18,538 million yen 1 yuan＝14.2514 yen (March 2003 - September 2008 average) Source: PACIFIC Exchange rate service University of British Colombia

Attached Documents

Attachment 1 Project Costs

	Plan			Actual			
	Foreign funds (million yen)	Domestic funds (million yuan)	Total (million yen)	Foreign funds (million yen)	Domestic funds (million yuan)	Total (million yen)	Against plan
Chaohu	1,265	48.29	1,989	Cancelled			
Chuzhou	1,210	60.26	2,114	1,210	60.26	2,069	98%
Fuyang	1,815	108.01	3,435	2,192	130.3	4,049	118%
Hefei	4,841	370.41	10,397	4,874	371	10,162	98%
Huainan	2,190	139.98	4,290	2,378	161.88	4,685	109%
Ma'anshan	2,057	157.91	4,426	2,059	157.91	4,309	97%
Tongling	1,369	85.64	2,654	1,402	86.13	2,629	99%
Wuhu	3,811	264.21	7,774	4,424	298.99	8,685	112%
8 city total	18,558	1,234.71	37,079				98.7%
7city total	17,293	1,186.42	35,090	18,538.09	1266.47	36,587.06	104.3%

Source: PACIFIC Exchange rate service University of British Colombia
Note: Exchange rates At time of plan 1 yuan = 15 yen At time of evaluation 1 yuan = 14.2514 yen

Attachment 2 Project Period Plan/Actual Difference

(Unit: Months)

	Plan		Actual		Difference
Total	March 2003 - December 2007	58	March 2003 - September 2008	67	116%
Chuzhou	March 2003 - December 2006	46	March 2003 - December 2007	58	126%
Fuyang	March 2003 - December 2006	46	March 2003 - December 2007	58	126%
Hefei	March 2003 - December 2007	58	March 2003 - September 2008	67	116%
Huainan	March 2003 - December 2006	46	March 2003 - December 2006	46	100%
Ma'anshan	March 2003 - December 2006	46	March 2003 - December 2007	58	126%
Tongling	March 2003 - December 2006	46	March 2003 - December 2006	46	100%
Wuhu	March 2003 - December 2006	46	March 2003 - December 2007	58	126%

Note: The project period is defined as the period between the signing of the L/A until completion of acceptance inspections by the People's Government of Anhui Province. However, in the case of Hefei, because the time of completion of acceptance inspections is unknown, completion was deemed as the time of completion of test operations.

Attachment 3　Transitions in Fuel Prices and Comparison by Type

Comparison of town gas prices per calorific value (Chuzhou)

(Unit: yuan/MKcal)

	Natural gas			Coal gas	LPG
	Household	Industrial	Transportation	Industrial	Household
2006	0.235	.235	0.304	0.112	0.458
2008	0.235	0.283	0.342	0.143	0.437
2009	0.235	0.283	0.342	0.125	0.472
2010	0.235	0.338	0.426	0.147	0.552
2011	0.235	0.338	0.426	0.154	0.64

Source: Chuzhou questionnaire response

Note: *Calculated as: Natural gas calorific value: 400kcal/㎥, coal gas: 5,000kcal/kg, LPG: 11,000kcal/kg

Attachment 4　Impacts from the Project

Air environment standards (GB3095－Enacted in 1996)*

Average annual value (g/m^3)	Japanese environmental standards **	Grade I standard	Grade II standard	Grade III standard
SO_2 (Sulfur dioxide)	0.04	0.02	0.06	0.10
TSP (Total Suspended Particulates)	0.10	0.08	0.20	0.30
NO_2 (Nitrogen dioxide)	0.04－0.06	0.04	0.04	0.08
PM10 (Particulate Matter (PM-10)	0.04	0.04	0.10	0.15
CO (Carbon monoxide)	10	4.0	4.0	6.0

*: No changes in standard values in the Ambient Air Quality Standard (GB3095－2012). Year of objective completion is specified by the city.

**: Average daily value of hourly values.

Improvement of air pollutant concentrations from sub-projects

Values that exceed the target value are highlighted. Values that have increased from the previous year are indicated with an upward facing arrow.

(Unit: mg/m^3)

Chuzhou　Chuzhou Environmental Observatory Target value: No. 10 - No. 12　Grade II standards

Yearly average	10th target (2005)	11th target (2010)	2002	2007	2011
SO_2	0.06	0.06	0.031	0.027	0.015
TSP	0.2	0.2	0.15	0.11	0.07
NO_2	0.04	0.04	0.055	0.031	0.024
PM10	0.1	0.1	0.09	0.082	0.05
CO	4	4	N/A	N/A	N/A

Source: Questionnaire response.

Fuyang　Fuyang District Environmental Observatory Target value: No. 10 - No. 12 Grade II standards

Yearly average	10th target (2005)	11th target (2010)	2002	2007	2011
SO_2	0.06	0.06	0.011	0.022	0.022
TSP	0.2	0.2	N/A	N/A	N/A
NO_2	0.04	0.04	0.034	0.03	0.021
PM10	0.1	0.1	0.112	0.091	0.088
CO	4	4	N/A	N/A	N/A

Source: Questionnaire response.

Hefei Observatory average values

Target value: No. 10 Industrial district: Grade III, other areas: Grade II, No. 11 - No. 12 Grade II standards

Yearly average	10th target (2005)	11th target (2010)	2002	2007	2011
SO_2	0.10	0.06	0.02	0.023	0.024
TSP	0.30	0.2	0.112	0.124	0.124
NO_2	0.08	0.04	0.024	0.026	0.025
PM10	0.15	0.1	0.096	0.116	0.112
CO	6.00	4	N/A	N/A	N/A

Source: Questionnaire response.

Huainan target value: No. 10 Industrial district: Grade I, other areas: Grade III, No. 11: Grade III, No. 12 Grade II by 2015

Yearly average	10th target (2005)	11th target (2010)	2002	2007	2011
SO_2	0.10	0.06	0.018	0.035	0.031
TSP	0.30	0.2	0.226	N/A	N/A
NO_2	0.08	0.04	N/A	0.02	0.028
PM10	0.15	0.1	N/A	0.087	0.094
CO	6.00	4	N/A	N/A	N/A

Source: Anhui Province Statistical Yearbook. 2002 data are natural gas utilization regulations (Anhui Province Chemical Design Institute, January 2003).

Ma'anshan Observatory center point

Target value: No. 10 landscape district: Grade I, Matong Industrial Zone: Grade III, other areas: Grade II, No. 11

Yearly average	10th target (2005)	11th target (2010)	2002	2007	2011
SO_2	0.06	0.06	0.031	0.02	0.027
TSP	0.2	0.2	N/A	N/A	N/A
NO_2	0.04	0.04	0.02	0.023	0.032
PM10	0.1	0.1	0.111	0.092	0.092
CO	4	4	N/A	N/A	N/A

Source: Questionnaire response

Tongling Observatory average values (TSP measurements up to 2003. CO values are 2010 values)

Target value: Grade II

Yearly average	10th target (2005)	11th target (2010)	2002	2007	2011
SO_2	0.06	0.06	0.029	0.083	0.055
TSP	0.2	0.2	0.275	N/A	N/A
NO_2	0.04	0.04	0.034	0.032	0.022
PM10	0.1	0.1	N/A	0.088	0.079
CO	4	4	2.29	1.76	2.08

Source: Questionnaire response

Wuhu Target values: No. 10: Grade II, Industrial districts: Grade III, No. 11 - No. 12: Grade II

Yearly average	10th target (2005)	11th target (2010)	2002	2007	2011
SO_2	0.06	0.06	0.018	0.022	0.031
TSP	0.2	0.2	0.122	N/A	N/A
NO_2	0.04	0.04	N/A	0.023	0.03
PM10	0.1	0.1	N/A	0.072	0.084
CO	4	4	N/A	N/A	N/A

Source: Anhui Province Statistical Yearbook. 2002 data are natural gas utilization regulations (Anhui Province Chemical Design Institute, January 2003).

Attachment 5　Contribution to Air Environment Pollutant Reduction

Table: Reduction of air environment pollutants in seven sub-project cities

(Unit: Tons/year)

	2007	2008	2009	2010	2011	2012
SO_2	7,298	12,576	13,563	16,630	19,687	24,858
NOx	4,994	7,403	9,505	11,056	12,895	16,294
TSP	14,270	18,951	23,717	27,898	32,523	41,402

Table: Degree of contribution to Anhui Province emissions volume by sub-projects

	2004	2005	2006	2007	2008	2009	2010	2011	2012
SO_2	N/A	N/A	N/A	1.28%	2.26%	2.32%	3.12%	3.72%	4.78%
NOx	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.34%	1.77%
TSP	N/A	N/A	N/A	2.33%	3.11%	4.20%	5.37%	7.19%	N/A

Attachment 6　Main Financial Indicators

Chuzhou

	Data at appraisal	Data at ex-post evaluation	Difference
Return on total capital	N/A	N/A	N/A
Operating margin Pre-tax profit margin	△198% △100.1%	4.2% 4.2%	202.2% 104.3%
Current account rate	90%	148%	58%
Equity ratio	17.2%	N/A	N/A

Source: Date at appraisal from JICA appraisal document, “Project Implementation Unit (PIU) Financial Analysis Evaluation Reports”.

Fuyang

	Data at appraisal	Data at ex-post evaluation	Difference
Return on total capital	N/A	3.0%	N/A
Operating margin Pre-tax profit margin	8.1% 8.1%	6.1% 6.1%	△2.0% △2.0%
Current account rate	128.0%	125.5%	△2.5%
Equity ratio	50.7%	28.3%	△30.4%

Source: Date at appraisal from JICA appraisal document, “Project Implementation Unit (PIU) Financial Analysis Evaluation Reports”.

Hefei

	Data at appraisal	Data at ex-post evaluation	Difference
Return on total capital	N/A	0.9%	N/A
Operating margin Pre-tax profit margin	3.6% 0.4%	6.2% 3.7%	2.6% 3.3%
Current account rate	89.7%	127.6%	37%
Equity ratio	66.9%	10.6%	△56.3%

Source: Date at appraisal from JICA appraisal document, "Project Implementation Unit (PIU) Financial Analysis Evaluation Reports".

Huainan

	Data at appraisal	Data at ex-post evaluation	Difference
Return on total capital	N/A	N/A	N/A
Operating margin Pre-tax profit margin	△106.8% △117.3%	N/A N/A	N/A N/A
Current account rate	93.5%	N/A	N/A
Equity ratio	10.4%	N/A	N/A

Source: Date at appraisal from JICA appraisal document, "Project Implementation Unit (PIU) Financial Analysis Evaluation Reports".

Ma'anshan

	Data at appraisal	Data at ex-post evaluation	Difference
Return on total capital	N/A	29.4%	N/A
Operating margin Pre-tax profit margin	△106.8% △117.3%	26.9% 10.9%	133.7% 128.2%
Current account rate	93.5%	136.9%	43.4%
Equity ratio	10.4%	32.4%	22%

Source: Date at appraisal from JICA appraisal document, "Project Implementation Unit (PIU) Financial Analysis Evaluation Reports".

Tongling

	Data at appraisal	Data at ex-post evaluation	Difference
Return on total capital	N/A	14.9%	N/A
Operating margin Pre-tax profit margin	△6.6% △4.8%	13.4% 13.3%	20% 18.1%
Current account rate	101.9%	115%	13.1%
Equity ratio	45.4%	42.8%	△2.6%

Source: Date at appraisal from JICA appraisal document, "Project Implementation Unit (PIU) Financial Analysis Evaluation Reports".

Wuhu

	Data at appraisal	Data at ex-post evaluation	Difference
Return on total capital	N/A	6%	N/A
Operating margin Pre-tax profit margin	△81.9% △42.4%	8% N/A	89.9%
Current account rate	94.4%	115%	20.6%
Equity ratio	34.0%	16%	△18%

Source: Date at appraisal from JICA appraisal document, "Project Implementation Unit (PIU) Financial Analysis Evaluation Reports".

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