People's Republic of China

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

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

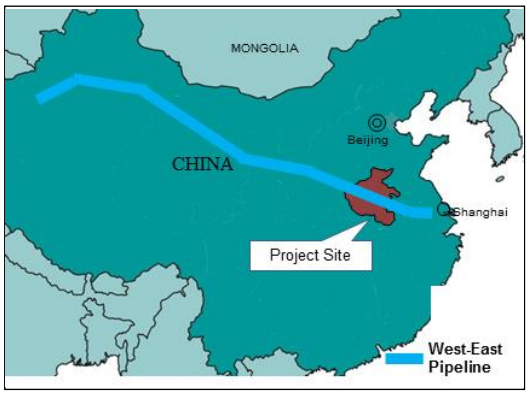
0. Summary

In order to improve the air environment, the Chinese Government has established a goal of increasing the use ratio of a clean energy source, i.e. natural gas, thereby reducing the total emissions of pollutants. At the time of appraisal, of the four candidate cities in Henan Province, three cities, Pingdingshan, Xinyang and Zhumadian, were more than 90 per cent dependent on fossil fuels such as coal for primary energy, and even Jiaozuo had a dependence ratio of almost 80 per cent. Amid such circumstances, the deterioration of the air environment was becoming a serious issue. This project was intended to improve the atmospheric environment by streamlining the natural gas supply facilities in each city in concert with the inauguration of the West-East Pipeline[1] national project. The relevance of this project, therefore, is high. Although the project was affected by the shortage of natural gas supply by the West-East Pipeline in its early stage, the problem is being gradually resolved thanks to the opening of the second pipeline and securing of other supply sources. With the constructed facilities, supply of and conversion to natural gas has been steadily progressing and though there has been no obvious improvement for the air environment, the project has promoted the reduction of air pollutants by converting fossil fuels to natural gas, thereby contributing to the improvement of the air environment. Thus the effectiveness and impact of the project is considered to be fair. In light of the fact that the project was delayed due to changes in city planning and other factors, and the fact that the project costs slightly exceeded the planned budget, the efficiency of the project is considered to be fair. No organisational, technological or financial problems have been observed with the natural gas supplier in each city. There are also systems in place for operational management, environmental monitoring and safety control, and thus the sustainability of the project is high.

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

[1] China's national project to construct a natural gas main pipeline stretching about 4,000 kilometers in total from Tarim Basin gas fields in Xinjiang Uyghur Autonomous Region in the western part of China to Shanghai and other major cities in the coastal area on the east. The entire line of Pipeline I was put into service in 2004.

1. Project Description



The West-East Pipeline and Henan Province

Gate station (in Zhumadian 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 which was the major primary energy source, 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.

The economic growth of Henan Province in 2000 was at 9.5%, which was higher than the national average. Accordingly, energy consumption was going up considerably. The province relied 86% of its energy demand on coal.[2] Air pollution from SOx, NOx and dust was aggravating because coal was used widely not only for industrial purposes but also for power generation and home heating. Fourteen of the 18 cities in the province (including the four cities covered by this project) failed to meet the national ambient air quality standard Grade II[3] in terms of total suspended particulates (TSP). It was concerned that continued reliance on coal would lead to non-conformance also in terms of SO_2 and NO_X.

[2] Data for year 2001

[3] National Ambient Air Quality Standard【GB3095－1996】provides the maximum yearly average concentrations of 0.06 g/m^3 for SO_2, 0.04 g/ m^3 for NO_2, 0.20 g/ m^3 for TSP, 0.10 g/ m^3 for PM10 and 4.0 g/ m^3 of CO as Grade II.

1.2 Project Outline

The objective of this project is to build natural gas supply facilities in four cities in Henan Province (Jiaozuo, Pingdingshan, Xinyang, Zhumadian) [4] so that coal and other fuels can be replaced by natural gas, thereby contributing to the improvement of air quality.

Loan Approved Amount / Disbursed Amount	19,295 million yen / 19,174 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 (inclusive of 10-year grace period) Conditions for Procurement: General untied
Borrower / Executing Agency	Government of People's Republic of China / Henan Provincial People's Government
Final Disbursement Date	July 2010
Main Contractor (Over 1 billion yen)	Shashi Steel Pipe Works of Jianghan Petroleum Administration (China), Beijing Xingqiao International Commercial Corporation (China), Beijing Meili Zhongsheng Environmental Engineering Co. LTD (China)
Main Consultant	None
Feasibility Studies, etc.	Feasibility study of each sub-project (June 2002)
Related Projects	● ODA projects aimed at improving air quality such as city gas installation, flue-gas desulfurization and other improvements of existing facilities, and conversion to natural gas and other wider use of clean energy ● 2001Taiyuan Environmental Improvement Project and Beijing Environmental Improvement Project ● The West-East Pipeline Project (2003 -) ● Air quality improvement cooperation by the Global Environment Centre Foundation and the City of Osaka (2004)

[4] The loan agreement included a fifth city, Luohe, which subsequently declined to use the ODA Loan and instead receive a private-sector financing because of the need to move the construction schedule forward in order to be in time for the opening of the West-East Pipeline. Consequently, the project was implemented in the four cities of Jiaozuo, Pingdingshan, Xinyang and Zhumadian.

This Japanese ODA Loan project was conceived in conjunction with the West-East Pipeline Project, China's national project to construct a natural gas main pipeline stretching from Xinjiang Uyghur Autonomous Region in the western part of China to Shanghai. Natural gas distribution system, it was planned, would be constructed in five cities in the Henan Province through which the pipeline would pass so that the use of coal and other fossil fuels, the source of the airborne pollutants, would be reduced by the introduction of environmentally clean natural gas.

The West-East Pipeline is constructed by PetroChina Company Limited, which supplies natural gas out of the gas field. As Figure1 illustrates, Jiazuo takes in natural gas from the main pipeline and the other four cities were to receive the supply through sub-pipelines that are connected to the main pipeline.

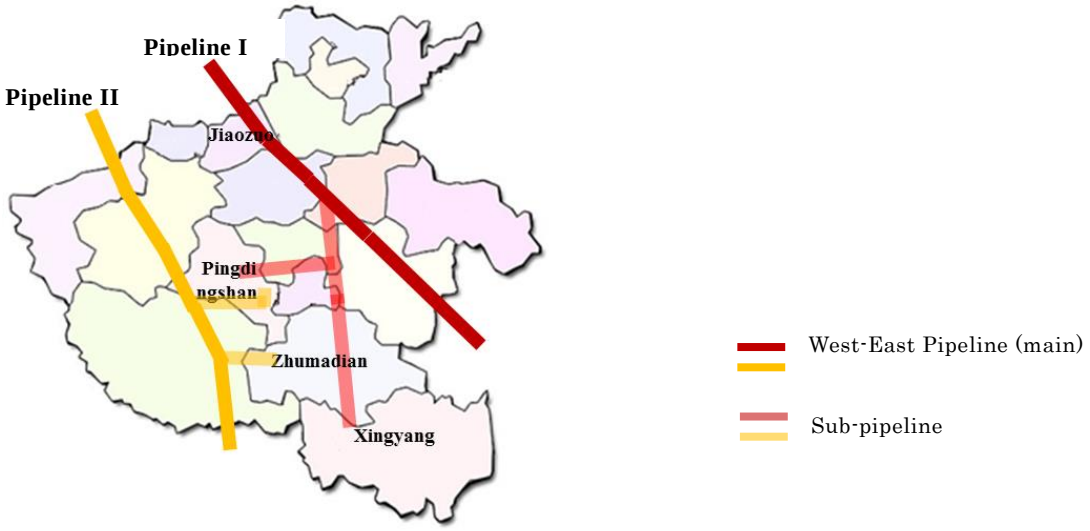


Figure 1: Natural gas pipelines (West-East Pipeline) and locations of sub-projects

The scope of Japanese 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 Japanese ODA Loan project.

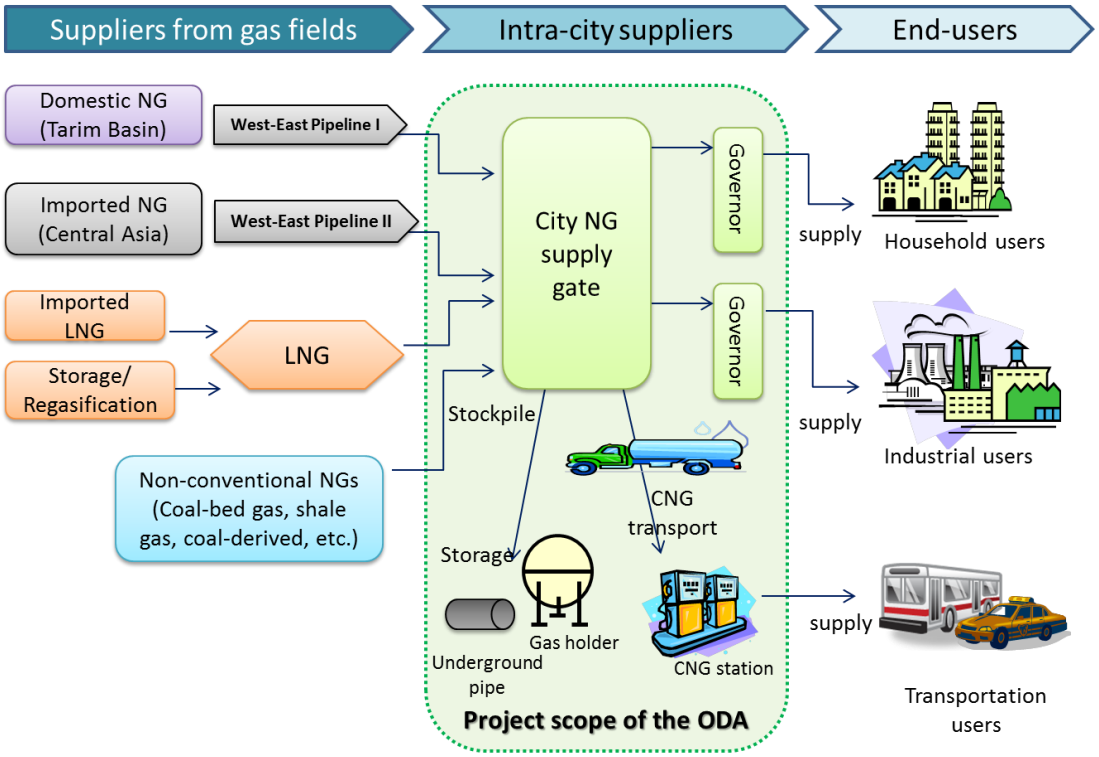


Figure 2: Supply flow of natural gas

Natural gas supply from the West-East Pipeline to Henan Province began in 2004 to the cities of Jiazuo and Zhumadian, in 2005 to Pingdingshan and in 2007 to Xinyang.

The West-East Pipeline initially transported only the gas from China's domestic gas fields. Increased demand throughout the country, however, led to the supplementary use of natural gas of foreign sources. Thus, West-East Pipeline II was constructed. Consequently, the original West-East Pipeline came to be called West-East Pipeline I. Among the cities covered by this project, Pingdingshan and Zhumadian started to receive additional supply from the Pipeline II in 2008.

2. Outline of the Evaluation Study

2.1 External Evaluators

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 Studies: April 21 - April 27, 2013 and July 29 - 30, 2013

2.3 Constraints during the Evaluation Study

Nothing in particular

3. Results of the Evaluation (Overall Rating: B[5])

3.1 Relevance (Rating: ③[6])

3.1.1 Relevance to the Development Plan of China

(1) Development policy at the time of project appraisal

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 called for further improvement in environment performance 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.

On the part of Henan Provincial Government, shift to clean energy, introduction of cleaner production, use of clean coal, closure of serious pollution sources, expansion of centralized heat supply systems and other measures were to be promoted in order to achieve the air quality improvement goals set by the Henan Province 10th Environment Protection Plan.

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

The 11th Five-Year Plan (2006-2010) set out the targets of lowering the country's energy intensity by around 20% and reducing the total emissions of major pollutants by 10%. The Plan advocated the development 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 energy intensity 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 and use of coal-bed methane, shale gas and other non-conventional natural gas sources should be promoted.

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

[6] ③: High, ②: Fair, ①: Low

Air quality improvement is given a priority status also in national five-year plans for environment protection. The 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[7] and a 10% reduction in the emissions of major pollutants. The 12th Plan (2011-2015) urges continued reduction in the total emissions of major air pollutants by setting out the targets of 10% reduction in China's total SO2 emission from the 2010 level and also 10% reduction in the emission of ammoniac nitrogen in the industries and districts of prime importance.

The National Development and Reform Commission issued in August 2007 a "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; fuel conversion in building materials, electricity, textile, petrochemicals, metallurgy and other industrial sectors.

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 evaluation.

3.1.2 Relevance to the Development Needs of China

3.1.2.1 The need for conversion to natural gas

Henan Province continued to achieve double-digit real GDP growth rates: 10.7% at the time of appraisal and 12.5% at evaluation. Accordingly, consumption of primary energy has risen rapidly (Table 1). The primary energy consumption at the time of project appraisal was 73 million tons and was projected to increase 135% by 2010. In fact, the consumption in 2010 reached 214.38 million tons or more than twice the amount in 2001 (Table 2). In terms of composition of the primary energy, the plan was to lower the dependency on coal from 85.9% to 73%. In reality, it is still over 80% (Table 3). Comparing the data for 2003 when the project was started with those for 2012, it can be seen that the dependency on coal did decline in the household sector but went up by 9% in the industrial sector. There is a continued strong need

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

for conversion to natural gas, not only to meet the increasing primary energy demand but also to reduce emission of airborne pollutants emanating from industrial coal.

Table 1: Real GDP growth rates of Henan Province and China (national average)

	2000	2003	2007	2010
Henan	9.5%	10.7%	14.6%	12.5%
China	8.6%	10.0%	14.2%	10.4%

Source: China Statistical Yearbook, Henan Province Statistical Yearbook.

Table 2: Energy consumption in Henan Province

(Unit: x 10^4 tons/year)

	2001	2003	2010	change
Plan	7,300	-	9,880	135%
Actual	7,300	10,595	21,438	294%

Source: Planned values by JICA, Actual values from Henan Province's response to questionnaire.
Note: unit expressed as quantity of standard coal.

Table 3: Composition of primary energy consumption in Henan Province

	2001 (Project appraisal)	2003	2012	2003/2012
Coal	**85.9%** Household N/A Industrial N/A	**86.7%** Household 6.7% Industrial 80.0%	**83%** Household 3% Industrial 80%	Total **-3.7%** Household -3.7% Industrial +9%
Petroleum	10.1%	1.9%	3.9%	**+2.0%**
Hydro	2%	2.0%	3.8%	**+1.8%**
Natural gas	2%	9.4%	11.0%	**+1.6%**

Source: 2001 data by JICA, all others from Henan Province's response to questionnaire.

3.1.2.2 Relevance of the selection of sub-projects

The sub-projects were chosen on the basis of geographical conditions relative to the West-East Pipeline route, local industrial structure, energy consumption pattern, air pollution situation and conditions for conversion to natural gas. Henan Province is a major producer of coal. The project appraisal rightly included, as criteria for the selection, consideration on the expected unemployment and other social costs of converting to natural gas.

Of the eleven cities that applied for the project, five were chosen. Since the supply of natural gas from the West-East Pipeline was a prerequisite condition to the project, geographical proximity gave Jiaozuo a preferred position. Likewise, cities geographically close to the sub-pipeline, which by then had become a definitive project, were leading candidates. Industrial structure and air pollution situation were also important criteria for the selection. Among the five cities finally chosen, Jiaozuo and Pingdingshan were highly industrial; in both cities secondary industry accounted for more than 50% of the economy at the time of project appraisal.

Consumption of fossil fuels particularly in the industrial sector was rising fast, which aggravated the air pollution problem. Concentration of major air pollutants (SO_2, NOx, and TSP) failed to meet Grade II at the time of project appraisal, and especially the TSP data indicated the high concentration exceeding the Grade III standard. With regard to Pingdingshan, coal was mined by small township and village enterprises. The city was promoting a plan to reduce the number of such coal mines and integrate them into a large industry. Accordingly, it was judged that conversion to natural gas by this project would entail little unemployment or other social costs in the coal mining sector of Pingdingshan.

Cities of Xinyang and Zhumadian had high ratio of agrarian, but urbanization and industrialization were progressing steadily. Both were more than 95% dependent on coal. It was feared that unless harnessed the air quality would deteriorate to a level worse than Grade II. In all, there was a high priority for all the five cities to convert to natural gas.

Subsequent to the March 2003 signing of the Loan Agreement, the city of Luohe was withdrawn from the list of five cities in the project. Today there are no written records about the background and reasons for the withdrawal, and our interviews did not produce any reliable information. From the perspective of project management, it is expected that such a major development in the project execution be grasped promptly and its justification examined. If possible, the sub-project should have been filled by a substitute city, so that the initial objectives of the project would be little affected. It is important that the project management system should ensure written reporting of such major decisions as the Luohe withdrawal, with clear written statements of the reasons and background.

Table 4: Share of secondary industry in the economies of Henan and the cities involved

	At appraisal (2002)	At ex-post evaluation (2011) (percentage point change)
Henan	46%	57% (+11%)
Jiaozuo	56%	69% (+13%)
Pingdingshan	56%	70% (+14%)
Xinyang	37%	43% (+6%)
Zhumadian	37%	43% (+6%)

Source: Henan Provincial Government, responses to questionnaire to the project implementation units.
Note: At appraisal figure of Xinyang is that of 2003.

Table 5: Coal use and air quality of the four cities at project appraisal

	Coal consumption	Dependency on coal	Air quality
Jiaozuo	9.05 million t/y (2002)	74.5%	SO_2: Grade III NOx: Grade II TSP: Out*
Pingdingshan	1.50 million t/y (2001)	97.6%	SO_2: Grade II NOx: Grade II TSP: Out*
Xinyang	1.55 million t/y (2000)	99.8%	SO_2 : Grade I NOx: Grade I TSP: Grade II
Zhumadian	1.87 million t/y (2001)	95.3%	SO_2 : Grade II NOx: Grade I TSP: Grade III

Source: Henan government response to questionnaire, coal consumption and dependency ratio of Jiazuo from response to questionnaire to the project implementation units.
Note: "Out" means concentrations in excess of Grade III standard.

3.1.3 Relevance to Japan's ODA Policy

Environmental protection was an area of focus in the Country Assistance Program for China effective at the time of project appraisal, the Medium-Term Strategy for Overseas Economic Cooperation Operations then in effect and the 2002 Country-Specific Strategy. The country-specific 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 on the air environment front. 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 Henan 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[8] (Rating: ②)

Here this evaluation use the same project evaluation indicators as were used in the project appraisal, namely, natural gas delivery volume, household conversion ratio[9] and air pollutants (SO_2, NOx and TSP) reduction. The appraisal set out target figures for these effectiveness 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 effectiveness 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. In specific terms, this translates into 2012 for Jiaozuo, 2011 for Pingdingshan, 2009 for Xinyang and 2011 for Zhumadian.

3.2.1 Quantitative Effects (Operation and Effect Indicators)

(1) Natural gas delivery volume

Total natural gas delivery volume per day to the four cities was 1,212,198 m^3 against the target figure of 3,324,247 m^3, representing an achievement rate of 36%. No sub-projects achieved the respective targets; the achievement ratios were 35% for Jiaozuo, 73% for Pingdingshan, 6% for Xinyang and 64% for Zhumadian. The reason for the extremely low achievement rate of Xinyang partly lies in the plan submitted at the time of appraisal where the natural gas delivery amount was supposed to jump up immediately after the facilities were completed. While the other three cities projected gradual increase for Years 1, 2 and 7, Xinyang alone set same target figures for Years 2 and 7. There was in fact no such rapid increase by Year 2. Nevertheless, the delivery to Xinyang in Year 5 or 2012 did amount to 178,987 m^3, representing an achievement ratio of 23% against the Year 7 target.

Table 6: Natural gas delivery

(Unit: m^3/d)

Delivery	Target amount in Year 2	Actual data for Year 2	Achievement ratio	Recent data (Actual in 2012)
Four cities total	**3,324,247**	**1,212,198**	**36%**	**1,761,274**
Jiaozuo	1,638,873	572,932 (2012)	35%	572,932
Pingdingshan	300,752	218,100 (2011)	73%	491,300
Xinyang	795,123	46,646 (2009)	6%	178,987
Zhumadian	589,499	374,520 (2011)	64%	518,055

Source: Target figures from JICA document at appraisal; actual data from responses of the cities to questionnaire.
Note: Data of Zhumadian from the response by the project implementation unit.

[8] Sub-rating for Effectiveness is to be put with consideration of Impact.
[9] Number of households using natural gas as a ratio to number of total households

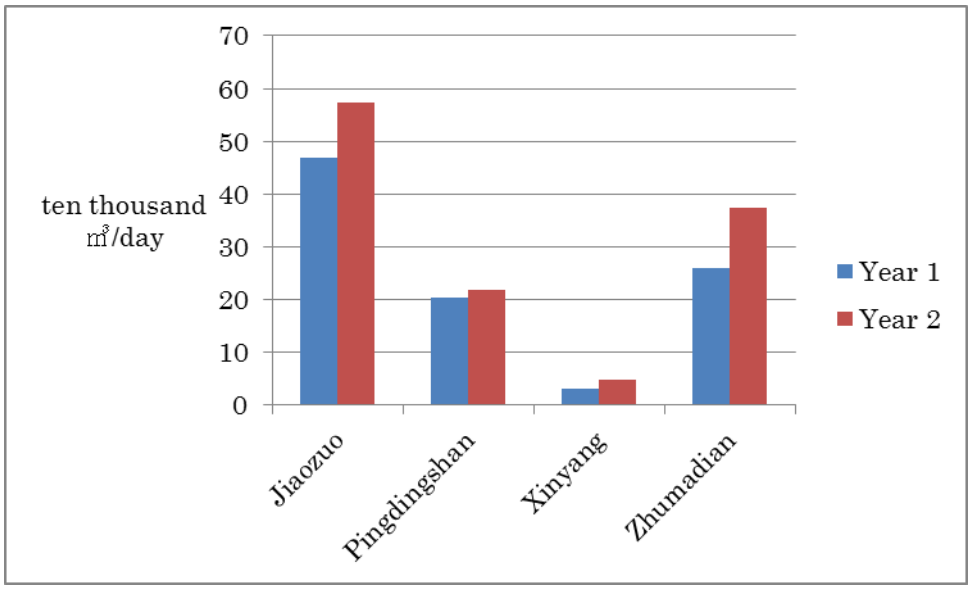

Figure 3: Progress of natural gas delivery by sub-project

Reasons for the non-achievement vary from one city to another, but in general terms they included in the descending order of impact strength: 1) insufficient natural gas supply from the West-East Pipeline, 2) Setting of prioritized areas for natural gas supply in the national policy, and 3) heavy cost burden for equipment modification to convert to natural gas. Looking ahead, use of natural gas is expected to increase widely, because the supply deficiency is being addressed steadily and the new policy introduced in 2012 gives priority to industrial and transportation sectors which had been subjected to supply restrictions.

1) Insufficient natural gas supply from the West-East Pipeline to the Project

The natural gas is transported by Petro China or other supply companies from the gas field, delivered to the city gates of the cities in Henan Province, and then distributed to users through the facilities constructed by this project. The facilities built under this project are in essence "relay" facilities, the effective use of which is totally dependent on the successful construction of the pipeline from the gas fields and stable supply of natural gas.[10] During the two years beginning with 2004 when the West-East Pipeline was completed and the natural gas supply began, mega cities of China were given preferential treatment in the supply of natural gas over cities such as those in Henan Province. Import of liquefied natural gas (LNG) was begun in 2006 to supplement domestic production. Supply by West-East Pipeline II started in 2008. It was only in 2011 that the cities participating in the project began to receive stable supply. Before then, the cities had to implement the sub-project by limiting the planned number of users

[10] The supply availability of natural gas depends on the national development policy, natural gas utilization policy, securing of natural gas sources in and out of the country, new pipeline construction plans and supply availability of LNG and other non-conventional natural gas. At the time of project appraisal, it was clearly understood that the execution of this project was based on construction of the West-East Pipeline.

to be converted to natural gas and the project implementation schedules in general in light of the ceiling supply quantities that Provincial Government set for household, industrial and transportation sectors. These restriction forced delays in project execution, which in turn adversely affected the achievement ratios in natural gas delivery.

- Pingdingshan

Table 7 summarizes the actual deliveries in comparison with the agreed quantity. The delivery Pingdingshan received in 2005 was less than 25% of the project target and less than half the quantity that was agreed in the 2001 Letter of Agreement with PetroChina.[11] The major reason was the nationwide supply shortage against the brisk demand. Starting with 2006, LNG was supplied and around 2008 imports from Central Asia began to be available by the opening of West-East Pipeline II. Supply shortage situation improved gradually.[12] By around 2011 fairly stable supply became a reality through Pipeline I and II altogether, which made it possible to expand natural gas supply in the city. In 2012, the Year 3 from the sub-project completion, the delivery quantity grew 125% to 491,300 m^3 per day, fulfilling the target set for Year 7 from the project completion.

- Zhumadian

Zhumadian was also adversely affected by the constraints of West-East Pipeline I supply shortage from the start of service. In Year 2, or 2011, the city received only around 70% of the quantity agreed in the Letter of Intent and to be used as target for the project. Subsequently, the opening of Pipeline II made the supply more stable. According to the Project Implementation Unit, the delivery has been growing at an annual average rate of around 6%. If continued, this growth rate should allow the city to exceed the Year 2 target of 589,499 m^3 per day in Year 6 or 2015.

Table 7: Pingdingshan and Zhumadian: Letter of Intent[13] figures and the actual

(Unit: ten thousand m^3/d)

Pingdingshan	2005	2006	2007	2008	2009	2010	**2011**	2012
Letter of Intent	13.0	14.0	15.1	16.5	17.2	18.3	—	—
Actual delivery	5	11.6	17.7	17.6	19.3	20.3	21.8	49.1
Project target	—	—	—	—	—	23.3	30.3	—

[11] A Letter of Intent exchanged between PetroChina, the supplier of West-East Pipeline gas, and the project implementation unit prior to the Loan Agreement. It established natural gas supply quantity, supply pressure and other terms.

[12] With the rise in primary energy demand in China, the demand for natural gas also showed a considerable growth. Demand began to exceed supply in 2007 and the gap has been widening year by year. The shortage amounted to 12.2 billion m^3 in 2010 and 39.4 billion m^3 in 2012. The supply/demand gap is made up by imports of LNG and supply by pipeline from Central Asia. In 2012, LNG imports reached some 20.3 billion m^3 and imports through pipeline 20.9 m^3. Combined, they account for around 30% of the demand.

[13] Pingdingshan and Zhumadian both signed Letters of Intent with PetroChina in May 2001.

Zhumadian	2003	2004	2005	2006	2007	2008	2009	2010	**2011**	2012
Letter of Intent	16.0	22.0	36.0	47.0	55.0	—	—	—	—	—
Actual delivery	—	2.4	3.3	4.4	10.8	16.0	21.4	25.8	37.5	51.8
Project target	—	—	—	—	—	—	—	35.0	58.0	—

Source: Target figures from JICA document at appraisal; actual data from responses to questionnaire

- Jiaozuo

In the case of Jiaozuo, the supply shortage was to an extent compensated by diversification of supply sources. The original plan assumed a supply of around 600 million m^3 in 2010 so as to achieve the project delivery target, but the city was able to contract an annual quantity of 47 million m^3 with PetroChina for the period 2005 - 2015. In the sub-project diversification of supply source was implemented to address the natural gas supply shortage problem of West-East Pipeline. Methane supply was begun in 2007 from Ancai Energy and in 2011 by Yutong Gas. With these new sources, however, the total supply in 2012 was 177 million m^3, still representing a shortage of some 48 million m^3 against the demand of 225 million m^3.

- Xinyang

Xinyang did not suffer from supply shortage since the supply was begun in 2007[14].

2) Natural gas supply recipients prioritized by national policy

The Natural Gas Utilization Policy that the National Development and Reform Commission promulgated in 2007 divided the uses of natural gas into four groups of city gas, industrial fuel, power generation and chemical industry and ranked the order of priority into Prioritized, Permitted, Restricted and Banned. The objective was to promote rational development and utilization of the limited resource. Use as city gas, which pertains to household, was prioritized. In each of the sub-projects distribution of city gas to the household was given a priority, and supply to the industrial sector was regulated. Along with the natural gas conversion, all the cities including the cities did not suffer from natural gas supply shortage have been modernizing the industrial system from the old energy consuming type to more stable economical, safe, clean and energy saving type according to the national policies. The delay in system renewal affected to natural gas conversion in the industrial sector and impeded the growth of overall delivery volume. Xinyang was the hardest hit by this turn of events. Conversion in the industrial sector is still far below the target because the sector is undergoing a major structural change pursuant to the government initiative and some firms were forced to close or suspend their operations. The

[14] According to a response to our questionnaire to the project implementing unit

government is going to promote use of natural gas in the processing and manufacturing sectors as a measure to stabilize the economy.

3) Cost burden for equipment modification to convert to natural gas

In cases, the high cost of necessary modification of existing equipment for conversion to natural gas proves to be a discouraging factor. When the conversion is from city gas, it suffices to reinforce the gas pipe already in use and to replace the meter. In the case of conversion from coal, heavy oil or some other fossil fuel, however, it is necessary to install a pipeline from the pressure governing station to the company premise and replace most of the existing equipment and facilities. The high cost of such large scale modification makes small and medium-sized enterprises give a second thought, even though they may be seriously interested in conversion to natural gas. For instance, a steel pipe maker in the intensive industrial zone of Jiaozuo had a plan to use 40,000 m^3 of natural gas a year, but gave up the idea because it was found that totally 7 million yuan investment would be required, that is to say, 5 million yuan for installation of 2.5 kilometer-long pipeline to take in natural and 2 million yuan for medication of its own existing facilities. Industrial sector potential users must bear the entire cost of conversion to natural gas. Jiaozuo city government estimates that firms accounting for 43% of the planned delivery have given up on account of the modification cost and other financial reasons.[15]

Among the seven large users of natural gas that were identified in our questionnaire survey and interviews in Pingdingshan, Jiaozuo and Zhumadian, the conversion cost varied considerably from 100,000 yuan to 50 million yuan. The firm that spent 50 million yuan was a large electric cord maker in Pingdingshan who used as much as 24.74 million m^3 of natural gas a year. The conversion to natural gas brought to the company an annual saving of 20 million yuan (from 80 million yuan to 60 million yuan) in the fuel cost. With a payoff period of 2 years and a half, the conversion was an ideal investment. But for many others, especially SMEs, it is not easy to finance the investment and it takes many years to recover the investment because their natural gas requirement is not very large. Conversion is thus often given a second thought for cost versus benefit reasons.

Looking at the latest situation and ahead, the constraint of natural gas supply shortage (Non-achievement reason 1) has been in the process of significant amelioration. Meanwhile, the issue of prioritized supply of natural gas (Reason 2) continues to be dependent on national plans. The current natural gas delivery projections of the sub-project are based on the 12th Five-Year Plan. As the Natural Gas Utilization Policy was promulgated in 2007 and amended in 2012, unpredictable policy changes could take place and leave

[15] Response to our questionnaire to and interview with representative of Jiaozuo project implementing unit.

direct impact on this project. The 2012's amendment showed the direction for promoting efficient natural gas utilization by dividing Prioritized categories from four to twelve, and regarding utilization of natural gas at power generation, construction of natural gas power plants that used to be Restricted in the 2007 policy move up to Permitted group with partial exceptions[16]. If the restrictions on the use of natural gas at thermal power stations are lifted, the delivery volume can go up considerably because each power station consumes quite a large volume of natural gas. With regard to Reason 3) the cost of conversion, policy change to create government subsidies would possibly be a substantial encouragement to conversion to natural gas.

(2) Household conversion ratio

The overall household conversion ratio to natural gas in the four cities was 39%, representing an achievement ratio of 63% against the planned target of 62%. This is much higher than the achievement ratio of natural gas delivery volume (36%). This reflects the preferential treatment given to the household sector by the sub-project executing agencies in accordance with the central government's policy of prioritizing household uses in the context of limited supply availability of natural gas. By sub-project, the household natural gas conversion ratio was: 90% in Jiaozuo, 25% in Pingdingshan, 20% in Xinyang and 22% in Zhumadian. Jiaozuo met the target figure and Pingdingshan did almost likewise. Even though the conversion ratio in Xinyang was only 34% of the target, it has gone up to 51% by 2012, meaning that the Year 2 target was nearly achieved in Year 5. The ratio in Zhumadian was 30% of the target. Xinyang and Zhumadian each deployed the project in rural part of the city. As will be detailed later in this report, rural area has a difficulty of its own in terms of conversion to natural gas. Zhumadian had a different reason for the poor performance. The city's urban population almost tripled from 920,000 to 2.8 million between 2002 and 2011. Construction of urban infrastructure including natural gas distribution simply has failed to catch up with such a tremendous population increase. Nevertheless, the household conversion ratio in Zhumadian reached 27% in 2012, an increase of over 20% from the previous year.

[16] Cogeneration system is categorized to Priortized, base load power plants utilizing natural gas in the provinces having large coal bases including Shaanxi, Nei Mongol, Shanxi, Anhui are categorized to Prohibited group (excluding thermal power plants using coal bet gas)

Table 8: Natural gas household conversion ratio

Conversion ratio	Target in Year 2	Actual in Year 2	Achievement ratio	Recent Data (Actual in 2012)
Four cities average	**62%**	**39%**	**63%**	**52%**
Jiaozuo	76%	90% (2012)	118%	90%
Pingdingshan	31%	25% (2011)	82%	41%
Xinyang	59%	20% (2009)	34%	51%
Zhumadian	81%	22% (2011)	27%	27%

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

The household conversion ratio does not necessarily correspond to the natural gas delivery volume. The reasons why in Jiaozuo and Xinyang the delivery volume has not grown much despite the good growth in household conversion ratio include: (1) in rural areas people live apart from each other and the installation of natural gas distribution lines is costly and hence progresses only slowly, (2) conventional fuels tend to be still used even though natural gas has been made ready for use, (3) discrepancy between the actual demand and the reported household conversion ratio, that is to say, there are more residents on the registry book than those who actually live there. The nominal household conversion ratio may go up, but in fact, there are not so many people who are consuming natural gas. These reasons are discussed in detail below.

1) Pipelines installation cost in rural areas

Xinyang and Zhumadian are basically agrarian regions both with a share of over 25% occupied by the primary industry. The ODA loan project pertains to eight counties in Xinyang and one city and nine counties in Zhumadian. Installation of pipeline to counties and extension of natural gas service was a big challenge. From the facilities constructed by the ODA financing located in the center of a county, long-distance pipelines had to be laid out with own financing by the gas supplier or a developer because people live farther apart from each other than in urban areas. More often than not, construction work has been postponed because of the large investment required for the pipeline installation.

The Henan Provincial Government, while facilitating urbanization, is promoting a project named “New Farm Village Construction” to attract people back to farm villages. The project aims to build urban concentrations of no more than 100,000 people each to vitalize agriculture and bring farmers closer together. The new project is expected to move forward natural gas pipeline installation more efficiently than before.[17]

[17] From the interviews with representatives of the project implementation units of Xinyang and Zhumadian

2) Continued 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 not change in lifestyle. However, the story is different in rural areas where a 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. In addition, straws collected from farms as agricultural wastes continue to be used as free-of-cost fuel.

3) Discrepancy between population census and actual residence

As Table 9 shows, there are discrepancies between the registered population and the actual inhabitants, especially in Xinyang and Zhumadian (see the highlighted cells). Even though natural gas has been made available for use, there are no people who actually live in the house. As a result, the delivery volume of natural gas does not go up in proportion to the rise in household conversion ratio. Since the statistical numbers shown in the Table include urban population, the real absence rate in rural counties is higher. Interviews with representatives of the project implementation units suggested that around 30% are absence in both of the two cities.

Table 9: Absence rate in Henan Province[18] (Unit: x 10^3)

	Total population	Residing population	Absence rate
Henan Province	10543	9404	10.8%
Jiaozuo	365.78	352	3.8%
Pingdingshan	534.66	492.91	7.8%
Xinyang	855.21	639.78	25.2%
Zhumadia	891.65	693.67	22.2%

Source: National Economic and Social Development Statistics Bulletin 2012 of Henan Province and the cities concerned

In summary, the household sector was given the highest priority even at the time of shortage of domestic natural gas supply. As a result, the planned target of household conversion ratio was realized in one of the cities and nearly realized in another. Even in Zhumadian that failed to achieve the target, pipeline installation work under the ODA loan has been completed in the city area. Supply can start as soon as the branch lines to each household are laid out. In other words, a key to natural gas utilization there is whether roads,

[18] Since no absence population statistics were available, the difference between the total population (registered population) and the residing population (the number of people who actually live there) is used to compute the absence rate.

potable water, electric power and other accompanying infrastructure services will be made available to enable people to live there.

(3) Major pollutants reduction

The third indicator for the evaluation of project effectiveness is reduction of major air pollutants (SO_2, NOx, and TSP)[19] The reduction volume is calculated by multiplying the quantity of the fossil fuel replaced by natural gas by the pollutants emissions per unit[20] and then subtracting the emissions by natural gas. The replaced fuels include: household use coal, industrial coal and commercial purpose coal. Some sub-project entities include diesel fuel and other fossil fuels, too.

As Table 10 shows, the overall reductions of major air pollutants (SO_2, NOx, and TSP) against the planned figures were: SO_2: 48%, NOx: 53%, and TSP: 59%. Pingdingshan was the only city that surpassed the target and did so with respect to every one of the major pollutants. Jiaozuo and Zhumadian reached 50 – 70% and Xinyang achieved less than 10% only

Xinyang was successful in achieving good household conversion ratio, but in terms of pollutants reduction the delay in the industrial sector conversion prevented from achieving similarly good performance because industrial sector emits much larger amounts of air pollutants. The project implementation unit plans to increase efforts in penetrating into industrial customers.

Table 10: Major pollutants reductions

Four cities total	Target (Year 2)	Actual (Year 2)	Achievement ratio
SO_2 emission reduction (t/y)	63,360	30,205	**48%**
NOx emission reduction (t/y)	13,898 *	7,412	**53%**
TSP emission reduction (t/y)	29,996	17,691	**59%**

*: During the interview with the representative of the Xinyang project implementing unit, correction was made to the NOx target. This Table shows the corrected figure.

[19] The reduction achieved by shifting from burning of coal and other fossil fuels that emit serious pollutants to natural gas which is a clean energy source with hardly any emission of pollutants.
[20] The quantities of pollutants to be reduced are defined in the feasibility study, but each sub-project implementing entity uses different calculation equations.

Jiaozuo	Target (Year 2)	Actual (2011)	Achievement ratio	Recent data (Actual in 2012)
SO_2 emission reduction (t/y)	45,152	21,923	**49%**	21,923
NOx emission reduction (t/y)	3,256	2,065	**63%**	2,065
TSP emission reduction (t/y)	14,300	13,403	**49%**	13,403

Pingdingshan	Target (Year 2)	Actual (2011)	Achievement ratio	Recent data (Actual in 2011)
SO_2 emission reduction (t/y)	3,510	3,914	**112%**	3,914
NOx emission reduction (t/y)	1,160	1,462	**126%**	1,462
TSP emission reduction (t/y)	4,860	7,244	**149%**	7,244

**: Recent data provided the Pingdingshan project implementing unit was the actual data in 2011.

Xinyang	Target (Year 2)	Actual (2011)	Achievement ratio	Recent Data (Actual in 2012)
SO_2 emission reduction (t/y)	7,230	478	**7%**	1,522
NOx emission reduction (t/y)	4,410**	293	**7%**	932
TSP emission reduction (t/y)	6,000	298	**5%**	951

***: NOx target for Xinyang was stated as "280 t/y" in the project appraisal document. Correction was made during the interview with the representative of the project implementing unit. Achievement ratio in this Table uses the corrected target.

Zhumadian	Target (Year 2)	Actual (2011)	Achievement ratio	Recent Data (Actual in 2012)
SO_2 emission reduction (t/y)	7,468	3,889	**52%**	5,830
NOx emission reduction (t/y)	5,072	3,592	**71%**	5,391
TSP emission reduction (t/y)	4,836	3,193	**66%**	4,795

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

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 impacted 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 have been taken at each sub-project location. These measures have been instrumental in promoting the effectiveness[21] of the project by reducing the amount of coal consumption.

[21] The volumes of coal consumption reduced are represented in figures obtained from the responses to questionnaire sent to each sub-project entity.

Table 11: Compulsory and Preferential Measures Implemented in Each Sub-project and Their Impacts

Reduction	Compulsory Measures	Preferential Measures
Jiaozuo 1.54 million tons (2012)	- Since 2005, fines have been imposed on the violators of the restrictions on pollutant emissions for coal boilers and restaurants in the centre of the city. - Enforcement measures such as closure/relocation of pollutant emission factories and change of their production items have been taken in conjunction with other anti-pollution measures.	- Whenever boilers or restaurants in the centre of the city were to implement conversion to natural gas, fines for pollutant emissions were reduced as a preferential measure.
Pingdingshan 35 thousand tons (2012)	- Enforcement measures were taken on the use of coal boilers in the centre of the city. - When the amount of pollutant emissions by an enterprise exceeded the standards stipulated in Article 48 of the "Chinese Air Pollution Control Act", the department in charge of the environmental protection in the county government or higher level administrative entities imposed the fines ranging from 10,000 to 100,000 yuan on that enterprise.	None
Xinyang 23.1 thousand tons (2012)	- Time-limited corrective and enforcement measures have been taken on polluting enterprises. If a certain enterprise did not meet the set standards, penalties such as a ban on the use of water and electricity and cancellation of the business permit were imposed. - Based on the emissions reduction target for pollutants, the environmental protection authorities have conducted monthly inspection	- The enterprises participating in technology development projects in clean energy and energy conservation including conversion to natural gas are eligible for special subsidies by applying to the Development and Reform Commission.

	and assessment of enterprises, and then ultimately decided on the suspension of their production or operation. With regard to pollutant emissions, the standards were applied to all enterprises except those in the metalworking industry in accordance with the "Fifteen Kinds of Small Businesses"[22], and as a result, approximately 10 businesses in the city were suspended for operation. - In accordance with the "New Five Kinds of Small Businesses[23]", operators of small-scale generators and coal boilers were also regulated and subjected to closure. - In authorising new construction projects, the inspection criteria for environmental assessment have been strengthened in relation to design, construction and operation. As a result, construction projects that did not meet the environmental protection standards have been rejected.	
Zhumadian N/A	- For the enterprises that did not satisfy the emissions standards for air pollutants provided in the energy conservation/emissions reduction index enacted by the provincial government, the city authority ordered suspension or rectification of operation.	None

[22] Notification by the city of Xinyang "Bill for Air Pollutant Emissions Reduction" (2010). This provides specific orders and measures for improving the pollution sources.
[23] Similar notification as above. This one additionally subjects small-scale enterprises to orders and measures for environmental pollutant reduction.

Figure 4: Coal boiler facility (Xinyang)

Figure 5: Thermal power plant (Xinyang)

2) Natural gas conversion

When large-scale fixed pollutant emission sources like factories or other facilities are to convert from coal to natural gas, such conversion will significantly contribute to improving the concentrations of air pollutants. In Pingdingshan and Xinyang, conversion from coal to natural gas by polluters who had previously been using large quantities of fossil fuel has contributed positively to the reduction of pollutant emissions. In Pingdingshan, the conversion to natural gas for the boilers at China Pingdingshan coal mine Shenma Group Lianzibu Company and the heating furnace at Hebei Iron and Steel Group Wuyang Company has slashed SO_2 and NOx emissions. In Xinyang, the natural gas conversion for porcelain furnace at Shushan Gaosheng Porcelain Company was implemented through compulsory measures, and this led to reduction of SO_2 and NOx emissions.

In an interview with the provincial government, thermal power plants were also cited as pollution sources. As Henan Province is a coal producing region, coal is the most frequently used fuel in thermal power stations. As compared with the year 2002, the number of thermal power stations doubled by the year 2012 in three cities except for the city of Xinyang which has none of it. Meanwhile, as an environmental measure for power stations, the "Thermal Power Station Air Pollutant Emissions Standard Law (GB13223-2003)" enacted in 2003 and the revised version of the law (GB13223－2011) has mandated the installation of desulphurisation equipment. The data both on the amount of pollutant emissions as a result of the increase in the number of power stations and on the inhibitory effect by environmental measures were not obtained. However, as described in the Impact section, the Project Implementation Unit has commented that the negative impact was large. If individual cities are exempted from the restrictions pursuant to the "Natural Gas Utilisation Policy (2007, revised in 2012)", each city may proceed with its own plan to convert thermal power stations to natural gas.

3) Price difference between natural gas and other fuels (refer to Attachment 3)

When fuel prices in the industrial sector are compared in terms of calorific equivalent, coal gas was 0.1 to 0.4 yuan cheaper than natural gas across Henan Province between 2008 and 2012, but the prices became the same in 2013. In Pingdingshan, the coal gas price had

been 0.1 to 0.19 yuan cheaper before it equalled the natural gas price in 2013. Coal was far less expensive than natural gas, with the price of the former being less than a third of that of the latter in the industrial sector in Henan Province, and in the case of Pingdingshan, as much as a tenth[24]. Although conversion to natural gas is advantageous because the absence of smoke and soot reduces machinery maintenance costs, the gap in the fuel prices was a major hindrance factor in addition to the expenses for equipment installation and refurbishment.

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.

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. The index set at the time of appraisal was the concentrations of air pollutants (SO_2/NO_2/TSP/PM10/CO), and only Xinyang satisfied national ambient air quality grade II. Even at the time of evaluation, the cities other than Xinyang did not meet the grade II criteria. Jiaozuo failed to achieve the target values of all categories except NO_2 and Pingdingshan failed for NO_2 and Zhumadian failed for TSP (refer to Attachment 4).

Across Henan Province, the emissions of SO_2 started to decline after peaking in 2006, and have levelled off since 2009, whereas the emissions of NOx have been increasing. The emissions of TSP, on the other hand, have been reduced by a substantial margin since 2006. Consequently, though the emissions varied depending on the substance, the reduction ratio owing to this project was 1.99% for SO_2, 0.46% for NOx, and 2.55 for TSP. These figures are by no means small as compared with the Government's targets, and thus the project is considered to have contributed to the improvement of air environment (refer to Attachment 5).

[24] Response data to the "Trial Balance Sheet for Natural Gas Conversion Plans, August 2002"; Wuhu, Anhui.

Table 12: Total Emissions of Major Air Pollutants in Henan Province

(Unit: tons/year)

	2002	2003	2004	2005	2006
SO_2	937,230	1,038,928	1,256,011	1,624,530	1,624,383
NOx	N/A	N/A	N/A	N/A	1,043,248
TSP	1,364,944	1,392,868	1,487,181	1,632,765	1,360,578
	2007	2008	2009	2010	2011
SO2	1,563,900	1,452,001	1,355,001	1,338,701	1,370,504
NOx	1,103,447	1,126,716	1,193,067	1,212,395	1,665,363
TSP	1,127,567	900,259	846,154	773,484	668,216

Source: Responses to our questionnaire to the Henan Provincial Government (Second Field Survey).

The possible factor behind the sluggish improvement of air environment is considered to be the increase in coal consumption and number of automobiles associated with the population increase and the economic growth.

When seeing the emission volume of SO_2, NOx and TSP by fuel type, as the table below shows, the industrial coal has a strong impact on the emission of SO_2 and TSP, while the much of NOx comes from gasoline (see the highlighted parts in the table). According to the Project Implementation Unit, the major polluters were, in the descending order of the impact, the use of fossil fuel at thermal power stations, use of fossil fuel at large-scale factories and automobile exhaust. As described in the relevance section, the most major factor was the increase in coal consumption at thermal power stations and large-scale factories in connection with the increase in demand of primary energy. Each factor is described as below:

Table 13: Air Pollutant Emissions by Fuel Type

Emissions per 1 ton of coal calorific equivalent	SO_2 (Kg/ton)	NOx (Kg/ton)	TSP (Kg/ton)
Household 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
Heavy oil 0.48 tons	4.8	8.16	0.456
Coal gas1282 m^3	0.77	2.6	0
Natural gas 537 m^3	0.097	0.097	0

Source: JICA's data at appraisal

Note: Equivalent values recalculated for each substance by the evaluator based on the natural gas conversion trial balance prepared by JICA (August 2002).

1) Primary energy consumption quantity

The quantities of energy consumption in 2005 and 2011 were compared in each sub-project city. Table 14 shows that the primary energy demand has been increasing in the three cities except Pingdingshan since 2005. Although the coal consumption in the

household sector has been decreasing in the cities other than Jiaozuo, the overall coal consumption has been in an increasing trend, with the continuous growth of industrial use quantity.

Table 14: Ratio of Primary Energy Consumption (2005 to 2011)

	Primary energy	Coal			Natural gas	Gasoline	Coal gas
		Overall	Household	Industrial			
Henan	158%	96%	49%	100%	113%	N/A	N/A
Jiaozuo	132%	141%	141%	141%	818%	115%	N/A
Pingdingshan	93%	228%	57%	230%	408%	148%	193%
Xinyang	115%	107%	N/A	107%	156%	N/A	N/A
Zhumadian	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Source: Questionnaire responses.

2) Number of automobiles

Number of automobiles has been sharply increasing in all the sub-project cities. In Pingdingshan, it increased by 369% from 109,000 in 2002 to 400,000 in 2011. In Xinyang, it more than tripled from 299,000 in 2006 to 902,000 in 2011. In particular, car exhaust contains more NO_2 than other pollution sources, and thus it is considered to have had an impact on the NO_2 concentrations in Pingdingshan. Of the overall number of automobiles, diesel vehicles[25] accounted for 74.2%, and this is also likely to have affected the outcome (see Table 16)[26]. Although in Pingdingshan and Xinyang, natural gas conversion of the vehicles is going on, the majority of the converted vehicles are for public transport such as taxies and buses[27], which account for merely 0.6% and 2.77% respectively of the overall number of vehicles. Therefore, their impact on air environment improvement has been almost negligible.

Table 15: Number of Automobiles in Each City

(Unit: x 10^4)

	Jiaozuo	Pingdingshan	Xinyang	Zhumadian
2002	43.3	10.9	29.9	N/A
2011	61.8	40.0	90.2	11.7
Growth rate	143%	369%	302%	

Source: responses to questionnaire.

Note: Due to absence of 2002 data in Xinyang, values in 2006 are used.

[25] According to the Chinese Almanac of Measures against Automobile Pollution (fiscal 2010), the amount of NOx emissions across China was 5.298 million tons. The emission volume by fuel type was 2.042 million tons (38.6%) from gasoline vehicles, 3.159 million tons from diesel vehicles (59.6%), and 97 thousand tons from natural gas vehicles (1.8%). This means that the emissions from diesel vehicles accounted for approximately 60%.

[26] According to interviews with the Project Implementation Unit, vehicles for public transport are being given priority to natural gas conversion, and thus natural gas conversion of vehicles for industrial transportation is delayed.

[27] Interview with project implementation unit.

Table 16: Breakdown of Fuel Types and Number of Automobiles

(Unit: x 10^4)

Pingdingshan	Gasoline	Diesel	Natural gas	Total number
2002 Number	2.80	8.05	0	10.85
Ratio	25.8%	74.2%	0%	—
2011 Number	10.13	29.67	0.21	40.01
Ratio	25.3%	74.2%	0.6%	—

Source: Pingdingshan city responses to questionnaire.

Xinyang	Gasoline	Diesel	Natural gas	Total number
2006 Number	26.6	3.2	0.1	29.9
Ratio	88.96%	10.70%	0.33%	—
2011 Number	78.3	9.4	2.5	90.2
Ratio	86.81%	10.42%	2.77%	—

Source Xinyang city responses to questionnaire.

3.3.1.2 Residents' awareness of air improvement

In order to ascertain the qualitative impacts of this project on people's livelihood and environment, a questionnaire survey was conducted targeting 25 residents of Jiaozuo, Pingdingshan and Zhumadian who reside in apartment complexes near the large-scale industrial establishments that had implemented natural gas conversion. The results are as follows:

(1) Status of natural gas utilisation

Asked for what reason they had opted to convert to natural gas, 87% of the residents cited the convenience, saying that "natural gas is more convenient", followed by "natural gas is good for air environment" at 76% and "natural gas is cheaper" at 57% (Figure 4). Of all the households, 95% was using natural gas for cooking utensils, and 83% for hot water supply equipment. Since the introduction of natural gas, 96% felt that "life has become more convenient (Figure 5)", and 72% said that the time of using appliances[28] became shorter(Figure 6). In terms of costs, 71% responded that "natural gas is cheaper" (Figure 8). In addition, 80% and 88% of the respondents answered that the introduction of natural gas has been beneficial to health and environment, respectively (Figure 7 and 9).

[28] Appliances in general used for cooking, facilities, heating, etc.

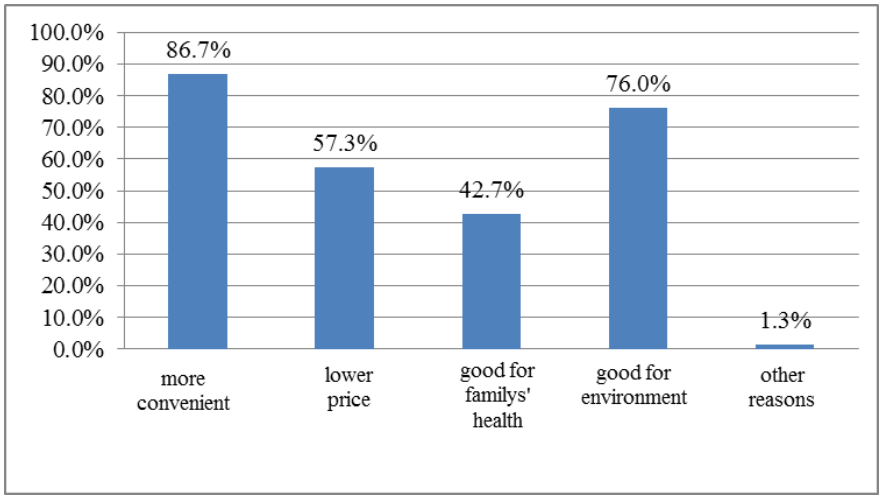

Figure 6: Reasons for Converting to Natural Gas

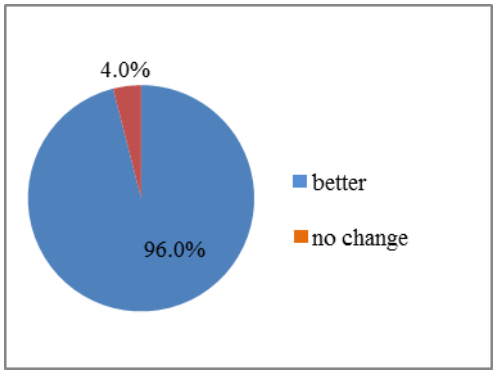

Figure 7: Changes of Convenience by Natural Gas Conversion

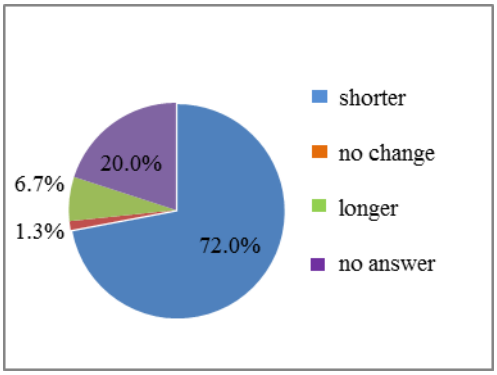

Figure 8: Time of Using Appliances by Natural Gas Conversion

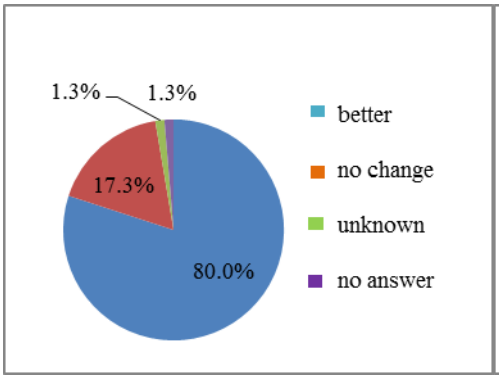

Figure 9: Changes of Health Condition by Natural Gas Conversion

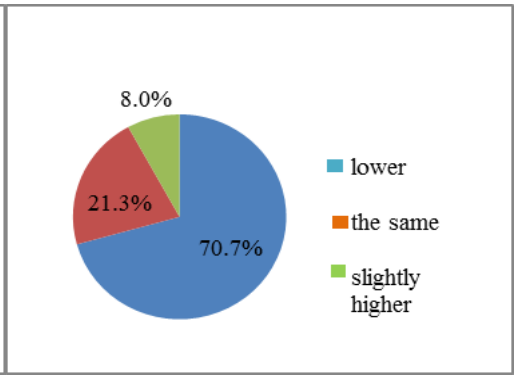

Figure 10: Changes of Primary Energy Bills by Natural Gas Conversion

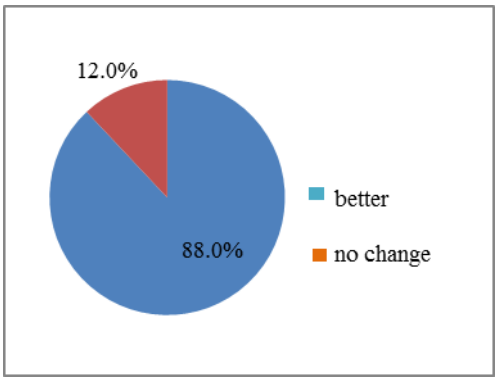

Figure 11: Changes of Environment by Natural Gas Utilisation

(2) Awareness of air improvement

Asked about the air environment, 89% responded that it has improved either significantly or to some extent as compared with 10 years ago. Conversion from coal to natural gas was mentioned as a reason for the improvement (Figure 10).

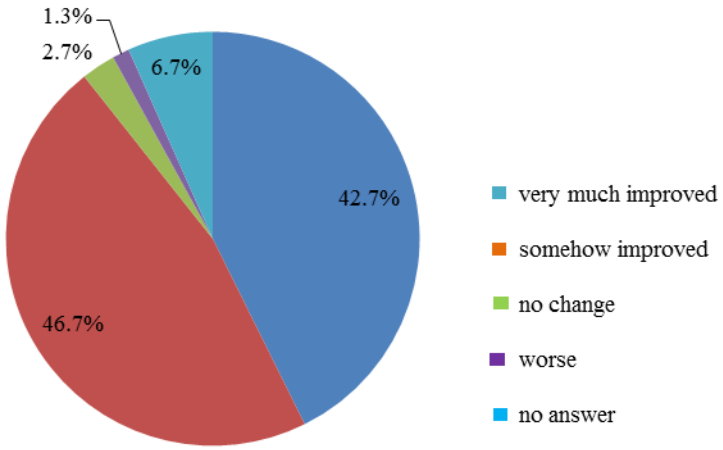

Figure 12: Comparison of Air Environment between Now and 10 Years Ago

(3) Changes in living environment

As many as 93.4% of the respondents answered that many aspects of their daily life such as transportation and utilities have become more convenient either significantly or to some extent as compared with 10 years ago thanks to natural gas conversion. They responded in this way because they no longer needed to replace cylinders of liquefied petroleum gas (LPG) as natural gas is now being directly drawn indoors, and because they no longer needed to worry about gas accidents and poisoning, as well as fuel shortage (Figure 11).

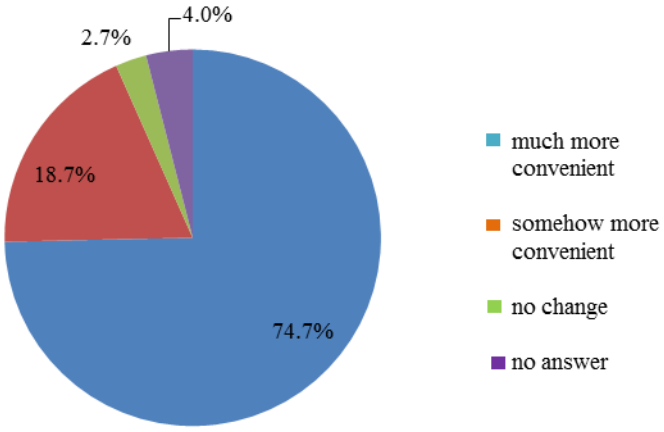

Figure 13: Comparison of Living Environment between Now and 10 Years Ago

Considering the small number of samples, this result does not necessarily represent the views of all the beneficiaries of this project. With that said, the result has observed that some residents in the sub-project areas are cognizant of the contribution of natural gas to living environment from the perspectives of air quality, convenience, health, and environment. Therefore, the project has been effective to a certain extent.

Figure 14: Customer Centre (Pingdingshan)

Figure 15: Large-scale User Facility (Jiaozuo)

3.3.2 Other Impacts

3.3.2.1 Economic impacts on industrial users

In order to ascertain the reasons for natural gas conversion and the use status of equipment, a questionnaire survey was conducted in cooperation with seven enterprises in Jiaozuo, Pingdingshan and Zhumadian that were using natural gas on a large scale. As a result, it emerged that they had previously been using heavy oil, coal and coal gas before converting to natural gas. As the reasons for the conversion, all companies cited possible impacts on the environment, and 85% and 70% referred to its convenience and inexpensive prices, respectively. The costs incurred for converting to natural gas varied from 100,000 yuan to 50 million yuan. The company that had spent 50 million yuan needed 2.5 years to

recover the expenditures for the equipment modification, but almost all the other companies managed to do so within a year. Concerning the expenses before and after the introduction of natural gas, four companies responded, two of which reported that they were able to curtail the fuel expenses by 25% and 30% thanks to conversion from heavy oil and coal, respectively. One company, which had converted from anthracite, incurred 15% more fuel expenses, but the maintenance costs were slashed by 95%. However, a company that had converted from coal boiler steam had to shoulder 40% more fuel expenses and 30% more maintenance costs. As evidenced by these examples, natural gas conversion does not necessarily bring about cost reduction to all companies. In terms of the environment, however, all the respondents acknowledged the contribution to the pollutant reduction, thus indicating a high environmental impact. Having said that, one needs to take into account the fact that the number of the samples is small, as well as the fact that all the companies sampled were large enterprises that consume 70,000 to 150 million m^3 per year of natural gas. Therefore, this data does not necessarily represent all the industrial users of this project.

3.3.2.2 Land acquisition and resettlement

The total area of the sites acquired in the four cities for this project has increased to 78.58 hectares from the 55.9 hectares expected at the planning (140% increase). The amount for the acquisition also increased from the planned 1.523 million yuan to 2.1093 million yuan (138% increase). Both the acquired area and the amount increased because approximately four times more than the planned area was required due to the landscape of Xinyang which is surrounded by rivers in the east and where the bridges and railways are located in a complex way. It was necessary to select project sites while avoiding these constructions. Although the idle sites or those for construction purposes could be acquired at cheaper prices than planned, in Zhumadian, farmlands should have been acquired because the construction sites were officially designated in the city's urban development plan. Since it was necessary to compensate for agricultural produce, the costs incurred ended up being nearly twice as much as initially expected.

In each sub-project, the candidate sites for construction were selected, and then applications were submitted to the construction department of the city government. Subsequently, based on the applications, the adjustments between the city government and the local government that owns the land were made. Although the screening and adjustment by the city government went smoothly, but only in Jiaozuo, the adjustment between the local government and small townships and villages took time, resulting in a delay in the construction schedule. With only about a third of the planned area acquired, the initial plan was to purchase the land at 21,000 yuan per hectare. However, the negotiations with the local government on the land price proceeded with difficulties, and ultimately, the price rose to 86,000 yuan per hectare. No relocation of the residents was necessary as uninhabited land

was selected in all four cities.

Table 17: Land Acquisition in Each Sub-project

	At planning			At evaluation		
	Acquired area	Amount (x 10^4 yuan)	Main usage before acquisition	Acquired area	Amount (x 10^4 yuan)	Relocation or compensation
Total in four cities	55.9 hr	152.3	-	78.58 hr	210.93	-
Jiaozuo	6.7 hr	13.79	Construction	2.33 hr	20.36	None
Pingdingshan	2.9 hr	50.4	Administration	3.48 hr	31.56	None
Xinyang	9.9 hr	27.01	Unused	36.37 hr	27.01	None
Zhumadian	36.4 hr	61.1	Agriculture	36.4 hr	132	Compensation for agricultural produce

Source: Questionnaire response

3.3.2.3 Impact on the natural environment

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

As above, the levels of achievement varied depending on the supply status of natural gas, as well as the preferential and compulsory measures for natural gas conversion by each city government. In the four cities as a whole, the achievement rate of natural gas transportation volume was 36% and, with regard to the household conversion ratio, as a result of the government's preferential measures for the household sector, 63% of the target has been achieved. The achievement rate of pollutant reduction was 56% (SO_2: 48%, NOx: 53%, and TSP: 57%) and it is shown that the conversion to natural gas has contributed to the improvement of the air environment. As such, a certain effect has been observed in this project, and thus its effectiveness has been fair.

3.4 Efficiency (Rating: ②)

3.4.1 Project Outputs

The plans and achievements in this project are as follows. With the exception of the fact that the number of target cities was reduced from five to four, the project was implemented almost as planned.

Table 18: Output List

	Plans	Actuals
Jiaozuo	Supply areas: 5 areas Gate stations: 4 locations Pipeline: 454.88 km (high-pressure pipes: 60.34 km, medium-pressure pipes: 394.54 km) Gas holders: 9 units SCADA: 5 units	Almost as planned Due to changes in the storage method, construction of gas holders was cancelled.
Luohe	Supply areas: 2 areas Gate stations: 1 location Pipeline: 166.15 km (medium-pressure pipes: 93.6km km, low-pressure pipes: 72.55 km) Gas holders: 2 units SCADA: 1 unit Natural gas stations: 4 locations	Cancelled
Pingdingshan	Supply areas: 4 areas Gate stations: 2 locations Pipeline: 910.51 km (high-pressure pipes: 133.26 km, medium-pressure pipes: 177.25 km, low-pressure pipes: 600 km) SCADA: 1 unit	As planned
Xinyang	Supply areas: 8 areas Gate stations: 10 locations Pipeline: 1,346.6 km (high-pressure pipes: 317.6 km, medium-pressure pipes: 451 km, low-pressure pipes: 578 km) Gas holders: 15 units SCADA: 1 unit Natural gas stations: 33 locations	Almost as planned Due to changes in the storage method, construction of gas holders was cancelled.
Zhumadian	Supply areas: 10 areas Gate stations: 10 locations Pipeline: 1,398.25 km (high-pressure pipes: 293.6 km, medium-pressure pipes: 984.4 km, low-pressure pipes: 120.25 km) Gas holders: 3 units SCADA: 2 units	Almost as planned Due to changes in the storage method, construction of gas holders was cancelled.

The storage method was changed in the sub-projects in Jiaozuo, Xinyang and Zhumadian. At the time of appraisal, spherical gas holders were planned to be built, but this plan was later cancelled as it was decided that gas be stored in the distribution pipes. This was because the enhanced technology for the inner part of the distribution pipe made it possible to store gas in the pipes with higher pressure applied. As a result, the land planned for gas holder

construction became no longer necessary, and the expenses for the construction and maintenance of gas holders were saved as well.

Figure 16: SCADA (Pingdingshan)

Figure 17: Piping in a gate station (Jiaozuo)

3.4.2 Project Inputs

3.4.2.1 Project Costs

The total project cost was planned to be 36,388 million yen (of which the ODA loan portion was 19,295 million yen). The total project cost with the project cost in Luohe subtracted was 34,834 million yen (of which the ODA Loan portion was 18,524 million yen). As compared to this, the actual expense was 35,367 million yen (of which the ODA loan portion was 19,174 million yen), 102% more than planned.

Of all the sub-projects, only the one in Jiaozuo exceeded the planned expenditure by more than 10% (for details, see Attachment 1). Since it was decided that a new technology development zone would be constructed in the south of the city where the construction of the pipeline had been scheduled, it was necessary to change the pipeline construction plan to avoid that area. This change in the construction plan led to the supply of natural gas through the main pipeline of the West-East Pipeline, and to accommodate such changes in the gas pressure and routes, it was necessary to procure new facilities and equipment. Consequently, the cost was higher than planned.

3.4.2.2 Project Period

As compared with the planned period between March 2003 and December 2008 (72 months), the actual project period was between March 2003 and December 2010 (96 months/133% longer than planned). The actual project period in each city was 96 months (133% longer than planned) in Jiaozuo, 84 months in Pingdingshan (175% longer than planned), 60 months in Xinyang (125% longer than planned), and 84 months in Zhumadian (175% longer than planned) (for details, see Attachment 2).

In Pingdingshan, the actual project period far exceeded the plan. The reason was that in some counties, the issuance of operation permits from the local government at the site which

are necessary for public works project was delayed, and thus the completion of construction project was behind the schedule. In Zhumadian, the allocation of supply by the West-East Pipeline was smaller than planned from 2004 to 2006. Therefore the project within the city was prioritised and construction of the facilities started from the centre of the city. For this reason, the construction works in the country areas were delayed, which lagged behind the overall progress of the project.

The reason for the delay in Jiaozuo and Xinyang, where the project took a bit longer than planned, was as follows: In Jiaozuo, the urban planning in the city district was changed after the approval of the FS. As a result, the high-pressure pipes and gate stations which bring in the natural gas from the main pipe line had to be relocated, thus resulting in a delay. Meanwhile, the delay in Xinyang was attributable to the landscape of the city surrounded by the rivers in the east and where bridges and railways are located in a complex way. The construction had to be done by avoiding these structures, and this led to the prolongation of the construction works period. Furthermore, due to high rainfall in this region, additional reinforcement to the constructions was necessary. These factors are also the reason for more difficult construction works than estimated in the feasibility study, which resulted in the slower progress of the project construction.

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 evaluation. The sub-projects of Pingdingshan, Xingyang, and Zhumadien yielded positive earnings, though the rates for Jiazuo was lower than those at the time of appraisal. This was because the sales of natural gas had been lower than expected.

Table 19: Financial Internal Rate of Return

	At appraisal	At ex-post evaluation
Jiaozuo	4.5%	Negative
Pingdingshan	5.0%	7.0%
Xinyang	3.4%	3.3%
Zhumadian	3.8%	3.6%

Source: The rates at the time of appraisal are excerpted from a JICA's document at the time of appraisal, and those at the time of evaluation were recalculated by the evaluator based on the questionnaire responses.

As 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, the ODA Loan Monitoring Office was established under the decision-making and instructive body for important matters and also as a secretariat. At the time of evaluation, the Banking Department of the Henan Financial Agency assumed responsibility to reimburse the funds pertaining to the project and supervise the administrative operation. The Project Implementation Unit was placed under the supervision of the Development and Reform Commission of each city, whereas the Environmental Protection Agencies of the province and each city took charge of environment-related matters. The implementation of each sub-project was inspected on a regular and irregular basis, and thus the supervisory structure is functioning without problems.

(2) Project Implementation Units

There have not been any change of the implementation bodies since the time of appraisal, but three organisations have changed their names. And in Pingdingshan, the funding structure of its implementation body has been altered. All the project implementation units have been supplying city gases such as coal gas and LPG before this project, and in urban areas, they have also been supplying natural gas through the same pipelines by implementing some repairs and replacements to them. With the project implementation units having the experience of operating and managing gas supply facilities, the conversion proceeded smoothly without any accidents in the facilities.

Table 20: Name of the Project Implementation Units

Implementation site	Name at the time of appraisal	Name at the time of ex-post evaluation	Organisation form
Jiaozuo	Jiaozuo Gas and Heating Power General Company	Jiaozuo Zhongyu Gas Co., Ltd.	State-owned company in Jiaozuo[29]
Pingdingshan	Pingdingshan Gas General Company	Pingdingshan Gas Limited Company	State-owned monopoly → state-owned company whose stocks are owned by the city
Xinyang	Xinyang Hongchang Pipeline & Gas Co., Ltd.	Unchanged	Private stock company
Zhumadian	Zhongyuan Gas & Chemical Industry Co., Ltd.	Henan Lantian Group	Private stock company

3.5.2 Technical Aspects of Operation and Maintenance

(1) Executing Agency

Under the supervision of the provincial government, each city government assumes responsibility for the construction and inspection of the facilities and environmental management. For the inspection and safety management of the facilities, the Construction Bureau conducts on-site investigations on a regular and irregular basis, giving detailed instructions on administrative duties such as parts replacement. With regard to safety management, the city police gives cooperation in security of the facilities and the fire department are conducting the guidance for fire prevention. For environment-related matters, the Environment Bureau of each city conducts on-site monitoring. With the collaboration of provincial- and city-level officials, entities with special expertise are taking charge of the administrative management of the project, and no problems have been observed with their technological capabilities.

(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,

[29] State-run enterprises whose ownership and management were separate were changed to state-owned companies. This change was aimed at establishing an efficient and modern corporate structure congruous with the market economy by procuring funds through the introduction of stock-based systems with the government ownership as a prerequisite condition.

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 project 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 investigation 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.

Figure 18: Security Room within Gate Station (Zhumadian)

Figure 19: Environment around Facilities (Jiaozuo)

3.5.3 Financial Aspects of Operation and Maintenance

The system for collecting the fee for natural gas is established and the fee recovery ratio is almost 100%, and thus no adverse effects have been observed regarding the finance. The retail price[30] for the end users is determined by adding suppliers' profit onto the regulatory price set out by the Government's Price Bureau. The price settings vary from sector to sector. The user prices for the civilian sector are set at below or slightly above the cost. The losses if

[30] 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

any are covered by the revenues of the transport and industrial sectors.

The primary financial index, especially current account balance for the project implementation units has been increasing and the project is stably operated. Therefore, there exists no problem for the sustainability viewed from the financial aspect (see Attachment 6). The self-capital ratios of all four cities have significantly fallen down to around 20%. This is due to the increase in the investment in the facilities and the project. The project is currently going through the growing stage where natural gas related facilities are continuously expanded. The financial indicators of the companies are stable and there is no financial problem.

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

Figure 20: Emergency Command Room (Pingdingshan)

Figure 21: No Fire Allowed Sign (Xinyang)

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

In order to improve the air environment, the Chinese Government has established a goal of increasing the use ratio of a clean energy source, i.e. natural gas, thereby reducing the total emissions

of pollutants. At the time of appraisal, of the four candidate cities in Henan Province, three cities, Pingdingshan, Xinyang and Zhumadian, were more than 90 per cent dependent on fossil fuels such as coal for primary energy, and even Jiaozuo had a dependence ratio of almost 80 per cent. Amid such circumstances, the deterioration of the air environment was becoming a serious issue. This project was intended to improve the air environment by streamlining the natural gas supply facilities in each city in concert with the inauguration of the West-East Pipeline national project. The relevance of this project, therefore, is high. Although the project was affected by the shortage of natural gas supply by the West-East Pipeline in its early stage, the problem is being gradually resolved thanks to the opening of the second pipeline and securing of other supply sources. With the constructed facilities, supply of and conversion to natural gas has been steadily progressing and though there has been no obvious improvement for the air environment, the project has promoted the reduction of air pollutants by converting fossil fuels to natural gas, thereby contributing to the improvement of the air environment. Thus the effectiveness and impact of the project is considered to be fair. In light of the fact that the project was delayed due to changes in city planning and other factors, and the fact that the project costs slightly exceeded the planned budget, the efficiency of the project is considered to be fair. No organisational, technological or financial problems have been observed with the natural gas supplier in each city. There are also systems in place for operational management, environmental monitoring and safety control, and thus the sustainability of the project is high.

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

4.2 Recommendations

4.2.1 Recommendations to the Executing Agency

Due to the shortage of natural gas supply to the sub-project cities, the project implementation units had to limit the natural gas conversion in areas and business entities, where the conversion should have been promoted otherwise. Naturally, this had a significant adverse effect on the achievement of the project target. As the natural gas operation expanded, the supply shortage became an issue that each and every project implementation unit had to address. To cope with the ever-growing demand for natural gas, the project implementation units have either considered or already started purchasing from the natural gas pipelines or suppliers other than the West-East. In addition to diversifying supply sources of natural gas, increase in the number of natural gas types is also being considered. In this context, coal-derived gas detoxified through state-of-the-art technology and others are coming into spotlight. Accordingly, the implementation units need to secure multiple natural gas sources to keep stable supply, and at the same time should clearly demonstrate how the limited resources of domestic natural gas will be utilised in an efficient manner. To promote these initiatives, it is deemed desirable to support such efforts.

4.2.2 Recommendations to JICA

None in particular

4.3 Lessons Learned

(1) In choosing indexes for the effectiveness and impact of a project at the time of the planning, it is desirable to select the ones that more clearly reflect the effectiveness of the project. In this project, the concentration of air pollutants was set as the index for the project impact. However, as the air quality changes involves numerous factors such as primary energy demand, operation status of thermal power stations, and the number of automobiles, it is difficult to precisely estimate the degree of the project impact by using the concentration as an index. Therefore, instead of the concentration, monitoring the reduction amount of air pollutants across Henan Province, along with their major air pollutant emission amount, allows the analysis of the level of contribution of this project. This also makes it possible to grasp the state of the air environment across Henan.

When calculating the reduction amount of pollutants, which is the index for the effectiveness of this project, even though the basic fossil fuels for the calculation are household and industrial coals, whether or not to include other fuels such as diesel etc. was decided in a different way at each sub-project's option. At the time of appraisal, the emissions per unit of the major pollutants and environmental measures against the pollutants are prepared but they cannot be the same after a decade and it is difficult to obtain the exact figures with the scientific preciseness. For this reason, instead of the reduction amount that requires complex calculations, it is more simple and easier for understanding to set as the index the conversion quantities to natural gas from the fuels such as coal (household, industrial and commercial), gasoline, diesel, kerosene, urban gas (coal gas), and liquefied petroleum gas (LPG). As above, it is preferable that the data, if possible "primary" data, which are regularly recorded by the project implementation unit as part of the operation, are set as the index for the project impact.

(2) In China, the domestic production of natural gas could not keep up with the demand, and thus there had been a supply shortage until sufficient quantity was imported. Also in this project, the supply was restricted in the first few years. During that period, the household sector were prioritised while conversion in the industrial sector was restricted, thus resulting in a delay in the achievement of the project target. It is, however, important to keep in mind that even after the supply of natural gas is stabilised, political measures should be taken appropriately to promote the reduction of fossil fuels and conversion to natural gas. In Pingdingshan, comprehensive and strict regulations were put in place for coal boilers in the centre of the city. As a result, the delay in the industrial sector was recovered, and the target amount of natural gas transportation was achieved in 2012. As above, in implementing projects that are largely dependent upon national development

programmes and energy policies, it is imperative for the government to take timely and appropriate compulsory and preferential measures towards promoting conversion.

End of Document

Comparison of the Original and Actual Scope of the Project

Item	Original	Actual
1.Projects Output		
Jiaozuo	Gate stations: 4 locations Pipeline: 454.88 km (high-pressure pipes: 60.34 km, medium-pressure pipes: 394.54 km) Gas holders: 9 units SCADA: 5 units	The construction of gas holders was cancelled because natural gas was stored in the underground pipelines. The others were almost as planned.
Pingdingshan	Gate stations: 2 locations Pipeline: 910.51 km (high-pressure pipes: 133.26 km, medium-pressure pipes: 177.25 km, low-pressure pipes: 600 km) SCADA: 1 unit	As planned
Xingyang	Gate stations: 10 locations Pipeline: 1,346.6 km (high-pressure pipes: 317.6 km, medium-pressure pipes: 451 km, low-pressure pipes: 578 km) Gas holders: 15 units SCADA: 1 unit	The construction of gas holders was cancelled because natural gas was stored in the underground pipelines. The others were almost as planned.
Zhumadian	Gate stations: 10 locations Pipeline: 1,398.25 km (high-pressure pipes: 293.6 km, medium-pressure pipes: 984.4 km, low-pressure pipes: 120.25 km) Gas holders: 3 units SCADA: 2 units	The construction of gas holders was cancelled because natural gas was stored in the underground pipelines. The others were almost as planned.

2. Project Period	March 2003-December 2008 (72 months)	March 2003-December 2010 (96 months)
3. Project Costs Amount paid in Foreign currency Amount paid in Local currency Total Japanese ODA loan portion Exchange rate	 19,295 million yen 17,093 million yen (1,140 million yuan) 36,388 million yen 19,295 million yen 1yuan = 15 yen (As of March 2003)	 19,174 million yen 16,193 million yen (1,156 million yuan) 35,367 million yen 19,174 million yen 1 yuan = 14.0094 yen (Average between March 2003-December 2010) Source: PACIFIC Exchange rate service University of British Colombia

Attached Documents

Attachment 1: Project Expenditure

	Plan			Actual			
	Foreign currency (million yen)	Domestic currency (million yuan)	Total (million yen)	Foreign currency (million yen)	Domestic currency (million yuan)	Total (million yen)	Plan ratio
Jiaozuo	3,002	189.25	5,841	3,864	207.48	6,771	116%
Luohe	771	52.23	1,554	Cancelled			
Pingdingshan	2,233	76.62	3,382	2,133	75.53	3,192	94%
Xinyang	6,441	489.39	13,782	6,329	502.79	13,373	97%
Zhumadian	6,848	332.04	11,829	6,848	370	12,031	102%
Total in 5 cities	19,295	1,139.53	36,388				97%
Total in 4 cities	18,524	1,087.30	34,834	19,174	1,156	35,367	102%

Exchange rate: 1 yuan = 15 yen at the time of planning.
1 yuan = 14.0094 yen at the time of evaluation, average during the project period (March 2003-December 2010).
Source: PACIFIC Exchange rate service University of British Colombia.

Attachment 2: Plan/Achievement Difference of the Project Period

(Unit: Months)

	Plan		Actual		Difference
Total	March 2003-December 2008	72	March 2003-December 2010	96	133%
Jiaozuo	March 2003-December 2008	72	March 2003-December 2010	96	133%
Pingdingshan	March 2003-December 2006	48	March 2003-December 2009	84	175%
Xinyang	March 2003-December 2006	48	March 2003-December 2007	60	125%
Zhumadian	March 2003-December 2006	48	March 2003-December 2009	84	175%

Note: A project period is defined as starting at the signing of L/A and completing at the validation of the Henan government.
In Xinyang and Zhumadian, some construction works were still underway after the validation. Therefore, based on the construction schedule responded to the questionnaire, the month when all the relevant works defined as within the scope of this project completion was regarded as the completion month.

Attachment 3: Changes in Fuel Prices by Type

Price Comparison of Urban Gas per Calorific Value (Henan Province)

(Unit: yuan/MKcal)

	Natural gas			Coal gas	
	Civilian	Industrial	Transport	Household	Industrial
2008	0.19	0.3	0.4	0.22	0.29
2009	0.23	0.3	0.4	0.22	0.29
2010	0.23	0.3	0.4	0.22	0.29
2011	0.23	0.33	0.43	0.22	0.29
2012	0.27	0.33	0.43	0.22	0.29
2013	0.27	0.33	0.43	0.22	0.33

Source: Henan Province questionnaire response.
Note: Calculated on the assumption that the calorific value is 8,400kcal/m^3 for natural gas, 7,000 kcal/kg for coal and 12,000 kcal/kg for LPG gas.

Price Comparison of Urban Gas per Calorific Value (Pingdingshan)

(Unit: yuan/MKcal)

	Natural gas			Coal gas	
	Civilian	Industrial	Transport	Household	Industrial
2005		0.2		0.19	0.19
2006	0.25	0.22		0.19	0.19
2007	0.22	0.23		0.19	0.19
2008	0.22	0.27	0.38	0.19	0.19
2009	0.22	0.27	0.37	0.21	0.24
2010	0.23	0.3	0.4	0.26	0.33
2011	0.24	0.32	0.39	0.26	0.33
2012	0.26	0.32	0.37	0.26	0.33
2013	0.26	0.33	0.42	0.26	0.33

Source: Pingdingshan questionnaire response.

Note: Calculated on the assumption that the calorific value is 8,400kcal/m^3 for natural gas, 7,000 kcal/kg for coal and 12,000 kcal/kg for LPG gas.

Price Comparison of Urban Gas per Calorific Value (Xinyang)

(Unit: yuan/MKcal)

	Natural gas			LPG gas
	Civilian	Industrial	Transport	Household
2007	0.637	0.637	0.721	0.978
2008	0.637	0.637	0.721	1.142
2009	0.637	0.637	0.721	1.195
2010	0.637	0.748	0.79	1.254
2011	0.637	0.748	0.79	1.33
2012	0.637	0.748	0.79	1.413

Source: Xinyang questionnaire response.

Note: Calculated on the assumption that the calorific value is 8,400kcal/$m^3$for natural gas, 7,000 kcal/kg for coal and 12,000 kcal/kg for LPG gas.

Attachment 4: Project Impacts

Ambient Air Quality Standards (GB3095-enacted in 1996)*

Annual average (g/m^3)	Japanese standards**	Grade I	Grade II	Grade III
SO_2 (sulphur dioxide)	0.04	0.02	0.06	0.10
TSP (total suspended particulate matter)	0.10	0.08	0.20	0.30
NO_2 (nitrogen dioxide)	0.04-0.06	0.04	0.04	0.08
PM10 (airborne suspended particulate matter	0.04	0.04	0.10	0.15
CO (carbon monoxide)	10	4.0	4.0	6.0

*: The ambient air quality standards (GB3095-2012) were not changed. The target achievement year is designated for each city.

**: Daily average of hourly values.

Improvement of Air Pollutant Concentrations in Sub-projects

The values exceeding the targets are highlighted, and the values that have increased from the previous year are shown with upward arrows at right side.

(Unit: mg/m^3)

Jiaozuo

Observatory averages Grade II

Yearly average	10th target (2005)	11th target (2010)	2002	2005	2010
SO_2	0.06	0.06	0.047	0.042	0.064↗
TSP	0.2	0.2	0.478	0.43	0.4
NO_2	0.04	0.04	0.046	0.042	0.031
PM10	0.1	0.1	5.0	5.0	5.0
CO	4	4	6	5	6

Source: Jiaozuo questionnaire response.

Pingdingshan The observatory near Pingdingshan Municipal Science and Technology Bureau, Urban construction road

Targets: 10th-12th grade II standards

Yearly average	10th target (2005)	11th target (2010)	2002	2005	2010
SO_2	0.06	0.06	0.054	0.067↗	0.059↗
TSP	0.2	0.2	0.191	0.147	0.094
NO_2	0.04	0.04	0.042	0.043↗	0.042
PM10	0.1	0.1	0.191	0.147	0.094
CO	4	4	N/A	N/A	N/A

Source: Pingdingshan questionnaire response.

Xinyang City ambient air quality Pingqiao Observatory

Targets: 10th grade II , 11th-12th grade II standards

Yearly average	10th target (2005)	11th target (2010)	2002	2005	2010
SO_2	0.06	0.06	0.02	0.028↗	0.03↗
TSP	0.2	0.2	0.08	N/A	N/A
NO_2	0.04	0.04	N/A	0.018	0.018
PM10	0.1	0.1	N/A	0.073	0.098↗
CO	4	4	N/A	N/A	N/A

Source: Xinyang questionnaire response. Due to absence of 2002 data, figures from the Henan Provincial Government questionnaire response in 2001 are shown instead (for SO_2 grade I and TSP grade II).

Zhumadian City Observatory Caiyin (15 km south of a sub-project company)
Targets: 10th grade II

Yearly average	10th target (2005)	11th target (2010)	2004	2005	2010
SO_2	0.06	0.06	0.05	0.053↗	0.037
TSP	0.2	0.2	N/A	N/A	N/A
NO_2	0.04	0.04	0.033	0.037↗	0.028
PM10	0.1	0.1	0.078	0.083↗	0.106↗
CO	4	4	N/A	N/A	N/A

Source: Zhumadian questionnaire response.

Attachment 5: Degree of Contribution to the Reduction of Air Pollutant Emissions

Reduction of air pollutants in the four sub-project cities

(Unit: tons/year)

	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
SO_2	N/A	N/A	1,717	5,157	6,569	8,387	9,959	12,359	17,636	27,209
NOx	N/A	N/A	469	983	1,345	2,192	2,416	3,128	4,432	7,626
TSP	N/A	N/A	725	1,765	2,208	3,285	4,413	5,945	9,524	17,035

Contribution ratio of sub-projects to the total reduction in Henan Province

	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
SO_2	N/A	N/A	0.14%	0.32%	0.40%	0.54%	0.69%	0.91%	1.32%	1.99%
NOx	N/A	N/A	N/A	N/A	0.13%	0.20%	0.21%	0.26%	0.37%	0.46%
TSP	N/A	N/A	0.05%	0.11%	0.16%	0.29%	0.49%	0.70%	1.23%	2.55%

Attachment 6: Major Financial Indexes

Jiaozuo Financial Index (Averages between 2010 and 2012)

	At appraisal	At ex-post evaluation	Difference
Total capital profit ratio (%)	N/A	3.4%	
Operating profit ratio (%) Profit ratio before tax (%)	3.6% 0.4%	6.8% 8.2%	3.2% 7.8%
Ratio of current income to current expense	89.7%	128.6%	38.9%
Self-capital ratio (%)	66.9%	19.5%	∆47.4%

Pingdingshan Financial Index (Averages between 2010 and 2012)

	At appraisal	At ex-post evaluation	Difference
Total capital profit ratio (%)	N/A	2.2%	
Operating profit ratio (%) Profit ratio before tax (%)	△0.3% △0.5%	3.7% 3.6%	4.0% 4.1%
Ratio of current income to current expense	114.9%	305.4%	194.6%
Self-capital ratio (%)	77.5%	28.3%	△49.2%

Xinyang Financial Index (Averages between 2010 and 2012)

	At appraisal	At ex-post evaluation	Difference
Total capital profit ratio (%)	N/A	1.2%	
Operating profit ratio (%) Profit ratio before tax (%)	9.7% 9.1%	25.8% 22.4%	16.1% 13.3%
Ratio of current income to current expense	173.0%	296.1%	123.1%
Self-capital ratio (%)	65.0%	25.3%	△39.7%

Zhumadian Financial Index (Averages between 2019 and 2011)

	At appraisal	At ex-post evaluation	Difference
Total capital profit ratio (%)	N/A	1.1%	
Operating profit ratio (%) Profit ratio before tax (%)	11.3% 14.0%	4.6% 4.8%	△6.7% △9.2%
Ratio of current income to current expense	119.2%	135.7%	16.5%
Self-capital ratio (%)	39.3%	18.4%	△20.5%

Source: The data at the time of appraisal were extracted from the financial analysis evaluation reports of the project implementation units (PIUs).
Data at ex-post evaluation are obtained from the financial statements submitted by the project implementation units.

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