Initial Environmental Examination (Update)

Project Number: 51418-001
October 2018

Proposed Loan for People's Republic of China: Air Quality Improvement in the Greater Beijing–Tianjin–Hebei Region—Shandong Clean Heating and Cooling Project (Shanghe Coal-Free Clean Heating Demonstration Component)

Prepared by Jinan Heating Group for the Asian Development Bank

CURRENCY EQUIVALENTS

(as of 12 September 2018)

Currency Unit	–	Chinese Yuan (CNY)
CNY1.00	=	€ 0.1258
€1.00	=	CNY 7.9482

ABBREVIATIONS

ADB	Asian Development Bank
AP	Affected Person
AQI	Air Quality Index
CHP	Combined heat and power
EA	Executing Agency
EHS	Environment, Health and Safety
EIA	Environmental Impact Assessment
EMoP	Environmental Monitoring Plan
EMP	Environmental Management Plan
EMS	Environmental Monitoring Station
EPB	Environmental Protection Bureau
EPL	Environmental Protection Law
FSR	Feasibility Study Report
FGD	Flue-gas Desulfurization
GDP	Gross Domestic Product
GHG	Green House Gas
GIP	Good International Practice
GIIP	Good International Industrial Practice
GRM	Grievance Redress Mechanism
HSP	Heat source plant
IA	Implementing Agency
IEE	Initial Environmental Examination
IT	Interim Target
JHG	Jinan Heating Group
JTPC	Jinan Thermal Power Co,. Ltd
MAC	Maximum Acceptable Concentration
MEE	Ministry of Ecology and Environment
MEP	Ministry of Environmental Protection
MSDS	Material Safety Data Sheet
PAM	Project Administration Manual
PCR	Physical Cultural Resources
PPE	Personnel Protective Equipment
PPTA	Project Preparatory Technical Assistance

PRC	People's Republic of China
SCADA	Supervisory Control and Data Acquisition
SPG	Shandong Provincial Government
SPS	Safeguard Policy Statement, ADB
TA	Technical Assistance
WB	World Bank
WHO	World Health Organization
WWTP	Wastewater treatment plant

WEIGHTS AND MEASURES

BOD_5	Biochemical Oxygen Demand, five days
$CaCO_3$	Calcium Carbonate
cm	Centimeter
CO_2	Carbon Dioxide
COD	Chemical Oxygen Demand
dB(A)	A-weighted sound pressure level in decibels
DO	Dissolved Oxygen
kg	Kilogram
km	Kilometer
kWh	Kilowatt Hour
Leq	Equivalent Continuous Noise Level
m	Meter
m/s	Meters per Second
m^2	Square Meters
m^3	Cubic Meters
mg/l	Milligrams per Liter
mg/m^3	Milligrams per Cubic Meter
$\mu g/m^3$	Micrograms per Cubic Meter
NO_x	Nitrogen Oxides
^oC	Degrees Celsius
O_3	Ozone
pH	A measure of the acidity or alkalinity of a solution
PM	Particulate Matter
PM_{10}	Particulate Matter smaller than 10 micrometers
$PM_{2.5}$	Particulate Matter smaller than 2.5 micrometers
RT	Refrigerating Ton
SO_2	Sulfur Dioxide
t/h	Tons per Hour

TSP	Total Suspended Particulates

NOTES

(i) In this report, "$" refers to US dollars and "€" refers to Euro.

(ii) This document has been prepared following ADB's Safeguard Policy Statement 2009.

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EXECUTIVE SUMMARY

A. Introduction

1. This Initial Environmental Examination (IEE) report has been prepared for the proposed Shanghe Coal-Free Clean Heating Demonstration Component of the Shandong Clean Heating and Cooling Project (the Project) in Shandong Province of the People's Republic of China (PRC). The proposed Project is the fourth in a multi-year multi-sectoral Asian Development Bank (ADB) support for air quality improvement in the greater Beijing–Tianjin–Hebei (BTH) region.

2. This component aims to build Shanghe as a "coal-free," clean heating pilot county, the first-of-its-kind in Shandong Province. This will be achieved in more densely populated areas by forming a modernized heat supply system in the urban and semi-urban areas. In rural area of Shanghe County, the component will use individual electric clean heating equipment to replace existing small coal stoves. To improve heating efficiency, the component will implement energy saving transformation for buildings and houses in urban and rural areas of Shanghe.

3. This component will be implemented in urban, semi-urban and rural areas of Shanghe County. The component will reduce coal combustion for urban heating, contributing to better air quality in Shanghe County.

B. Policy, Legal and Administrative Framework for Environmental Impact Assessment

4. Environmental impact assessment (EIA) procedures have been established in the PRC for over 20 years. Domestic EIA studies are required to be undertaken by relevant PRC environmental laws and regulations. National and local legal and institutional frameworks for EIA review and approval ensure that proposed projects are environmentally sound, designed to operate in line with applicable regulatory requirements, and are not likely to cause significant environment, health, social, or safety hazards.

5. ADB's Safeguard Policy Statement (SPS) 2009 has also been carefully considered. All applicable requirements of the SPS 2009 have been addressed in the IEE.

C. Implementation Arrangements

6. Shandong Provincial Government (SPG) will be the executing agency (EA) and responsible for overall guidance during project preparation and implementation. Jinan Heating Group (JHG), a state-owned company will be the implementing agency (IA) and responsible for implementing the component and administering and monitoring contractors and suppliers. A project management office (PMO) by the Jinan Municipal Bureau of Housing and Urban-rural Development will be responsible for day-to-day management of the Project.

D. Project scope

7. In urban area of Shanghe, this component will: (i) provide district heating to 5.5015 million m^2 by natural gas, heat pumps and deep-well geothermal energy; (ii) install 6.57 km primary and 204.78 km secondary district heating pipeline network; (iii) install one 42 MW gas fired boiler to replace the existing 58 MW coal fired boiler; and (iv) implement energy saving transformation for existing old residential buildings with an area of 660,400 m^2 through replacing thermal insulation materials for the exterior walls, and replacing single-layer glass wind with double glazing.

8. In semi-urban area of Shanghe, this component will: (i) provide district heating to 2.0134 million m^2 by natural gas and deep-well geothermal energy in ten towns; and (ii) install 25.72 km primary and 75.46 km secondary district heating pipeline network.

9. In rural area of Shanghe, this component will: (i) provide heating to five new kindergartens with a heating area of 9,300 m^2 by air source heat pumps; (ii) implement clean heating transformation for 80,000 households with a heating area of 4 million m^2 through replacing coal stoves by clean heating devices; and (iii) implement energy saving transformation for 30,000 households by adding an insulation curtain to windows and roof insulation layers.

E. Construction Schedule

10. The total construction period for the Project will be approximately 5 years from 2018 t0 2022.

F. Description of the Environment

Location and Topography

11. The component is located in Shanghe County of Jinan City, Shandong Province. Jinan City, with a total area of 1,162 km^2, is located at the north shore of the Yellow River, bordering Hebei Province in north. It is located at east longitude 116°58'- 117°26' and northern latitude 37°06 '- 37°32' and it is the north gate of Jinan. Dezhou City is in west and Binzhou City is in east of Shanghe County.

12. Shanghe County is part of alluvial plain in north China. There is no any mountain or hill in Shanghe. Within the Shanghe County, the topography is generally flat, sloping slightly downwards from the east to the west. The highest elevation above sea level is in Xiaoshi Village with a height of 17.10 m while the lowest elevation is in Hongmiao Village with a height of 8.94 m

Meteorology and Climate

13. Shanghe has a temperate continental climate with four distinct seasons. It is dry in the spring, hot and rainy in the summer, cool in the autumn, and dry and cold in the winter. The average annual temperature in Shanghe is 12.6°C, the average summer average temperature is 25.6°C and the maximum recorded summer temperature was 40.5°C. The average temperature in the 4 coldest months of winter is below 0°C, and the lowest maximum recorded temperature is -22.6°C.

Geothermal energy

14. Shanghe's geothermal resource is generally located at the depth of 1,000–1,500 meters with water temperature of 48°C–60°C. The heating yield of a single well is about 500–2,000 m^3 per day based on the richness of underground water. The total exploitable geothermal resource is about 29.871×10^{17}J, equivalent to 101.89 million tce, theoretically this is sufficient to supply the heating demand for the entire Shanghe.

Water Resources

15. Annual average surface water resource of Shanghe is 250.06 million m^3 and underground freshwater resource is 117.63 million m^3. The total water resource is 367.69 million m^3. The

population in Shanghe was 579,500 in 2017 and the per capita water resource is only 635 m^3 in 2017. To provide adequate water to its people, Shanghe started to source drinking water from Yellow River since 2009.

Ecological and Sensitive Resources

16. The component site is located in urban area, semi-urban area and rural area of Shanghe County. Surrounding land uses include residential and commercial areas with little or no vegetation cover. There are no known rare or endangered flora or fauna, parks, nature reserves or areas with special national, regional or local ecological significance within or adjacent to the component site.

Socioeconomic Conditions

17. Shanghe County is comprised of eleven towns and one street (urban area) with a total area of 1,162 km^2. Total population of Shanghe was 579,500 by the end of 2017.

18. There are 13 ethnicities in Shanghe including Hui, Mongolian and Manchu. However, the ethnic minorities only account for 1.38% of the total population while the rest is Han ethnicity. None of the ethnic groups will be affected by the component implementation.

19. In 2017, Shanghe's GDP was CNY 20.39 billion, of which the primary sector accounted for 24.0% or CNY 4.89 billion; the secondary sector accounted for 39.6% or CNY 8.08 billion; and the tertiary sector accounted for 36.4% or CNY 7.42 billion. GDP per capita is 35,188 CNY. Disposable personal income of Shanghe in 2017 was 16,988 CNY, in urban area was 25,870 CNY and in rural area of was 13,738 CNY.

Physical Cultural Resources

20. Jinan has a rich history, but Shanghe is not famous for its history. In the past, Shanghe is known as it agriculture due to is flat terrain and fertile soil. However, the component activities are all on long developed sites within highly developed and modified environment. There are no known PCRs in component site or in a radius of 500 m from the component site and within the airshed that could be affected by the component.

G. Anticipated Impacts and Mitigation Measures

21. Anticipated positive and negative environmental impacts of the proposed component were assessed based on the domestic Feasibility Study Report (FSR), domestic EIA report, a technical due diligence review of the component undertaken by ADB PPTA specialists; public consultations led by IA and assisted by ADB PPTA consultants; and site visits, surveys and consultations undertaken by ADB PPTA consultants.

22. Pre-construction, construction and operation phases were considered separately. The results of the assessment indicate that during the pre-construction phase environmental issues are very limited and are mostly associated with ensuring appropriate incorporation of mitigation measures into the project design.

23. Potential negative environmental impacts during construction phase are short-term and localized, and are associated with soil erosion, construction noise, fugitive dust, solid waste, wastewater, disruption of traffic and community services, and risks to workers and community

health and safety. These can be effectively mitigated through good construction and health and safety practices.

24. Potential negative impacts during operation phase are associated with air pollutants emission, solid waste, wastewater, noise, and health and safety risks to workers and community. These can be effectively mitigated through good operation of the facility equipment, including air pollution control equipment, and health and safety practices.

25. Potential positive operation phase impacts are significant and long-term and are associated with emissions reductions compared to equivalent heat through traditional coal-fired sources. When compared to the equivalent production of heat generation through traditional coal-fired sources, once operational, the component will: (i) result in annual energy savings equivalent to 111,748 tons of coal equivalent (tce), thereby providing a global public good by avoiding the annual emission of 391,526.6 tons of CO_2; (ii) improve local air quality through the estimated annual reduction of emissions of SO_2 by 598.6 tons, NOx by 258.3 tons, and PM by 881.2 tons; and (iii) eliminate the negative impacts of coal transportation through urban areas by truck or train.

H. Alternative Analysis

26. The existing system in urban area of Shanghe is a large scale district heating system driven by coal-fired heat source plants or CHP plants. However, the expansion of the existing coal-based district heating system to meet the increasing demand is not an option as Shanghe has been experiencing significant pollution problems in the winter heating seasons including hazy skies and high levels of particulates.

27. There are several heat sources options for district heating, including CHP plants, large coal, natural gas or biomass-fired heat source plants (HSPs), solar energy, wind energy, industrial or residential waste heat, geothermal energy, and heat pumps.

28. Overall, the component has selected the most appropriate fuel type and heat sources based on Shanghe's resources.

29. Implementation of the component will: (i) improve energy consumption structure; (ii) significantly reduce coal consumption; (iii) improve air quality; and (iv) reduce greenhouse gas (GHG) emissions.

I. Information Disclosure and Public Consultations

30. Domestic EIA Institute has undertaken one round of public consultation and two rounds of information disclosure in accordance with the Interim Guidelines on Public Consultation for EIA (2006) during domestic EIA process.

31. According to ADB SPS's requirements, The JHG held 12 separate public consultation meetings from March – April 2018 during the preparation of the IEE. 12 public consultation meetings were held in urban area of Shanghe (two meetings), Yuhuangmiao Town, Yinxiang Town, Huairen Town, Zhenglu Town, Jiazhuang Town, Baiqiao Town, Sunji Town, Hanmiao Town, Shahe Town, and Zhangfang Town.

32. A public project information notice was posted in the nearby communities for one weeks prior to the meetings. Nearby residents were invited to the meetings. During the meetings, information on the component construction content and status was presented by JHG while

information on potential environmental impacts and proposed mitigation measures, GRM requirements of ADB and component benefits was presented by social consultant and environmental consultant. Questions and subsequent discussions focused on environmental issues of the component and benefits of the component especially clean district heating and employment promotion. During the meetings, most of the participants believed that the component can provide a clean district heating service and can improve your living quality of them provide more job opportunities to the nearby communities and 90.6% of participants supported the component.

33. During the public consultant meetings, a total of 267 questionnaires were distributed and 267 completed questionnaires were received. The main contents of the questionnaire are potential impacts and mitigation measures.

34. 92.1% of the respondents work within a 5 km radius of the component while 89.9% live within a 5 km; 48.7% of respondents knew about the component either from other persons, newspapers or information signs, and 80.1% of respondents indicated that they were already familiar with the project benefits after the introduction of the component. 58.1% of the participants were female. The top three environment issues respondents identified in their neighborhoods are air quality (58.1%), noise (28.1%) and surface water (25.5%). Dust (29.6%) and noise (24.3%) were identified as the top two issues during the construction period. Air pollution and noise were identified as the top two issues during the operation phase. However, most participants also indicated that potential environmental impacts during construction period and operation period can be appropriately mitigated.

35. Overall support for the project is very strong. 76.8% of the respondents indicated that the component will improve local economic development; 88.0% indicated that the component will improve quality of life; and 90.6% of respondents indicated that they support the proposed component.

36. Meaningful consultation will continue throughout detailed design, construction, and operation phases, including information disclosure by the project proponent and posting of project information on community notice boards.

J. Grievance Redress Mechanism

37. A component-level grievance redress mechanism (GRM) has been established to receive and facilitate resolution of complaints during the construction and operation phases. The GRM includes procedures for receiving grievances, recording/documenting key information, and evaluating and responding to the complainants in a reasonable timeframe. Any concerns raised through the GRM will be addressed quickly and transparently, and without retribution to the affected persons.

K. Environmental Management Plan (EMP)

38. A comprehensive EMP has been developed to ensure: (i) implementation of identified mitigation and management measures to avoid, reduce, mitigate, and compensate for anticipated adverse environment impacts; (ii) implementation of monitoring and reporting against the performance indicators; and (iii) compliance with the PRC's relevant environmental laws, standards and regulations and the ADB's SPS 2009. The EMP includes an environment monitoring plan (EMoP) to monitor the environmental impacts of the component and assess the effectiveness of mitigation measures, and a capacity building and training program focused on

health, safety and environment. Organizational responsibilities and budgets are clearly identified for implementation, monitoring and reporting. The EMP is presented in Appendix I.

L. Risks and Key Assurances

39. The IA has limited experience in ADB's projects. To support effective implementation of the project EMP, (i) a full-time Environment and Social Officer will be appointed in the PMO; (ii) a part-time loan implementation environmental consultant (LIEC) will be recruited to support the PMO; (iii) pre-construction readiness monitoring and defined roles and responsibilities of all relevant agencies have been included in the EMP; and (iv) staff will receive training on ADB's environment safeguard requirements and EMP implementation.

M. Conclusion

40. Through the environmental assessment process, it is concluded that the component has: (i) selected appropriate technologies to improve energy structure and reduce the emission of pollutants; (ii) identified potential negative environment impacts and established mitigation measures; (iii) received public support from the component beneficiaries and affected people; (iv) established project-level GRM procedures; and (v) prepared a comprehensive EMP including environmental management and supervision structure, environmental mitigation and monitoring plans, and capacity building and training.

41. Overall, any minimal adverse environmental impacts associated with the component can be prevented, reduced, or minimized through the appropriate application of mitigation measures. It is therefore recommended that: (i) the component is classified as environment category B; and (ii) the component will be supported by ADB, subject to the implementation of the commitments contained in the EMP and allocation of appropriate technical, financial and human resources by the borrower to ensure these commitments are effectively and expediently implemented.

I. INTRODUCTION

A. The Project

1. This IEE report has been prepared for the proposed Shanghe Coal-Free Clean Heating Demonstration Component of the Shandong Clean Heating and Cooling Project (the Project) in Shandong Province of the PRC. The proposed Project is the fourth in a multi-year multi-sectoral ADB support for air quality improvement in the greater BTH region.

2. This component aims to build Shanghe as a "coal-free," clean heating pilot county, the first-of-its-kind in Shandong Province. This will be achieved in more densely populated areas by forming a modernized heat supply system in the urban and semi-urban areas. In rural area of Shanghe County, the component will use separate clean heating equipment by electricity to replace existing small coal stoves. To improve heating efficiency, the component will implement energy saving transformation for buildings and houses in urban and rural areas of Shanghe.

3. This component will be implemented in urban, semi-urban and rural areas of Shanghe County. In urban area of Shanghe, this component will: (i) provide district heating to 5.5015 million m^2 by natural gas, heat pumps and deep-well geothermal energy; (ii) install 6.57 km primary and 204.78 km secondary district heating pipeline network; (iii) install one 42 MW gas fired boiler to replace the existing 58 MW coal fired boiler; and (iv) implement energy saving transformation for existing old residential buildings with an area of 660,400 m^2 through replacing thermal insulation materials for the exterior walls, and replacing single-layer glass wind with double glazing.

4. In semi-urban area of Shanghe, this component will: (i) provide district heating to 2.0134 million m^2 by natural gas and deep-well geothermal energy in ten towns; and (ii) install 25.72 km primary and 75.46 km secondary district heating pipeline network.

5. In rural area of Shanghe, this component will: (i) provide heating to five new kindergartens with a heating area of 9,300 m^2 by air source heat pump; (ii) implement clean heating transformation for 80,000 households with a heating area of 4 million m^2 through replacing coal stoves by clean heating devices; and (iii) implement energy saving transformation for 30,000 households by adding an insulation curtain to windows and roof insulation layers.

6. The component will reduce coal combustion for urban heating, contributing to better air quality in Shanghe County.

7. The component will be implemented through four outputs:

(i) **Output 1**: Provide clean district heating in urban and semi-urban areas of Shanghe by natural gas, deep-well geothermal energy and heat pump. Total heating area in urban and semi-urban areas of Shanghe will be 7.5149 million m^2. Provide clean heating to 4,009,300 m^2 in rural area of Shanghe by heat pumps, gas heaters, carbon crystal plate radiators and heat-storage radiators.

(ii) **Output 2**: 32.29 km of primary and 280.24 km of secondary district heating pipeline network will be constructed to provide district heating to 7.5147 million m^2 in urban and semi-urban areas of Shanghe. The pipe networks will utilize two-pipe system. One is water supply pipe and another is water return pipe.

(iii) **Output 3**: Implement energy saving transformation for existing old residential buildings with an area of 660,400 m^2 in urban area of Shanghe through replacing thermal insulation materials for the exterior walls, and replacing single-layer glass wind with double glazing and 30,000 households in rural area of Shanghe through replacing coal stoves by clean heating devices with an estimated area of 1.5 million m^2; and

(iv) **Output 4**: Strengthened capacity to install and maintain clean heating technologies. The component activities will employ women and include awareness raising about the benefits of clean energy targeted toward women who are often responsible for domestic upkeep.

B. Introduction of Borrower

8. Shandong Provincial Government (SPG) will be the executing agency (EA) and responsible for overall guidance during project preparation and implementation. Jinan Heating Group (JHG), a state-owned company will be the implementing agency (IA) and responsible for implementing the component and administering and monitoring contractors and suppliers. A project management office (PMO) led by the Jinan Municipal Public Utilities Bureau, involving Shandong Provincial Department of Housing and Urban-rural Development, Department of Finance, PDRC, Jinan Municipal DRC, Jinan Municipal Bureau of Finance will be responsible for day-to-day management of the project.

9. JHG was merged from four state-owned district heating companies in Jinan in 2007. Now JHG belongs to Jinan City Investment Group Co. Ltd and its main businesses are district heating and power, steam and hot water supply. JHG is responsible for district heating supply in eastern part in Jinan urban area, Jiyang County, Shanghe County and Zhangqiu District.

10. JHG has a registered capital of 600 million CNY and total assets of 9.416 billion CNY. JHG has 5 branch companies, 12 sub-companies and one pipeline network company. At the end of 2017, JHG has 2,134 employees and districting area of 1.1 billion m^2. JHG now has 5 heat source plants (HSPs), one thermal power plant, 20 coal fired boilers with a capacity of 1,900 t/h and a total heating pipe network length of 3,149 km.

C. Report Purpose

11. ADB's environmental safeguard requirements are specified in the SPS 2009. The component has been screened and classified as Environment Category B, requiring the preparation of an IEE (this report) including an EMP. The EMP is presented in **Appendix I**.

D. Approach to report Preparation

12. This report has been prepared based on a domestic Feasibility Study Report (FSR); domestic EIA report; a technical due diligence review of the FSR undertaken by ADB project preparatory technical assistance (PPTA) consultants; public consultations with key stakeholders and affected persons attended by PPTA consultants; and site visits, surveys, consultations undertaken by ADB PPTA environmental consultants and ADB mission discussions with the IA and relevant government agencies.

E. Report Structure

13. This IEE report consists of an executive summary, nine chapters and one appendix. The report is structured as follows:

Executive Summary
Summarizes critical facts, significant findings, and recommended actions.

I Introduction
Introduces the proposed component, report purpose, approach to EIA preparation and EIA structure.

II Policy, Legal, and Administrative Framework
Discusses PRC's and ADB's environmental assessment legal and institutional frameworks, status of approval of the domestic EIA reports, and applicable environmental guidelines and standards.

III Description of the Project
Describes the project rationale, scope, components, location, key features, implementation arrangements, budget and time schedule.

IV Description of the Environment
Describes relevant physical, biological, and socioeconomic conditions within the component area.

V Anticipated Environmental Impacts and Mitigation Measures
Describes impacts predicted to occur as a result of the component and identifies the mitigation measures which will be implemented.

VI Analysis of Alternatives
Presents an analysis of alternatives undertaken to determine the best way of achieving the component objectives while minimizing environmental and social impacts.

VII Information Disclosure, Consultation, and Participation
Describes the process undertaken for engaging stakeholders and carrying out information disclosure and public consultation.

VIII Grievance Redress Mechanism
Describes the component grievance redress mechanism (GRM) for resolving complaints.

IX Conclusion and Recommendation
Presents conclusions drawn from the assessment and recommendations.

Appendix

14. Appendix I presents the EMP, including required construction and operation phase environmental mitigation measures, EMoP, reporting requirements, and capacity building. Other appendices present supporting documentation and approvals, due diligence of existing facilities, and coal and emission reduction factors and calculations.

Figure I-1: Jinan City, Shandong Province

II. POLICY, LEGAL AND ADMINISTRATIVE FRAMEWORK

15. This IEE has been prepared in accordance with both the PRC's national and local environmental legal and institutional framework and environmental assessment requirements, and applicable ADB policies, requirements and procedures.

A. Applicable ADB Policies, Regulations and Requirements

16. The major applicable ADB policies, regulations, requirements and procedures for environmental assessment are the *Safeguard Policy Statement* (SPS, 2009) and the *Environmental Safeguards – A Good Practice Sourcebook* (2012), which jointly provides the basis for this IEE. The SPS promotes good international practice as reflected in internationally recognized standards such as the World Bank Group's Environment, Health and Safety (EHS) Guidelines.

17. The SPS establishes an environmental review process to ensure that projects undertaken as part of programs funded through ADB loans are environmentally sound, are designed to operate in line with applicable regulatory requirements, and are not likely to cause significant environment, health, social, or safety hazards.

18. At an early stage in the project cycle, typically the project identification stage, ADB screens and categorizes proposed projects based on the significance of potential project impacts and risks. A project's environment category is determined by the category of its most environmentally sensitive component, including direct, indirect, induced, and cumulative impacts. Project screening and categorization are undertaken to:

i) reflect the significance of the project's potential environmental impacts;

ii) identify the type and level of environmental assessment and institutional resources required for the safeguard measures proportionate to the nature, scale, magnitude and sensitivity of the proposed project's potential impacts; and,

iii) determine consultation and disclosure requirements.

19. ADB assigns a proposed project to one of the following categories:

i) **Category A.** Proposed project is likely to have significant adverse environmental impacts that are irreversible, diverse, or unprecedented; impacts may affect an area larger than the sites or facilities subject to physical works. A full EIA including an EMP is required.

ii) **Category B**. Proposed project's potential environmental impacts are less adverse and fewer in number than those of category A projects; impacts are site-specific, few if any of them are irreversible, and impacts can be readily addressed through mitigation measures. An IEE, including an EMP, is required.

iii) **Category C**. Proposed project is likely to have minimal or no adverse environmental impacts. No EIA or IEE is required although environmental implications need to be reviewed.

iv) **Category FI**. Proposed project involves the investment of ADB funds to, or through, a financial intermediary.

20. The component has been classified as environment category B and thus an IEE is required.

21. The SPS 2009 requires a number of additional considerations, including: (i) project risk and respective mitigation measures and project assurances; (ii) project-level grievance redress mechanism; (iii) definition of the project area of influence; (iv) physical cultural resources damage prevention analysis; (v) climate change mitigation; (vi) occupational and community health and safety requirements (including emergency preparedness and response); (vii) economic displacement that is not part of land acquisition; (viii) biodiversity conservation and natural resources management requirements; (ix) provision of sufficient justification if local standards are used; (x) assurance of adequate consultation and participation; and (xi) assurance that the EMP includes an implementation schedule and measurable performance indicators. These requirements, which may not be covered in the domestic EIA, have been considered, and all applicable environmental requirements in the SPS 2009 are covered in this IEE.

22. During the design, construction, and operation phases of a project, the SPS also requires the borrower to follow environmental standards consistent with good international practice (GIP), as reflected in internationally recognized standards such as the World Bank Group's *EHS Guidelines*.[1] The *EHS Guideline*s contain discharge effluent, air emissions, and other numerical guidelines and performance indicators as well as prevention and control approaches that are normally acceptable to ADB and are generally considered to be achievable at reasonable costs by existing technology. When host country regulations differ from these levels and measures, the borrower is to achieve whichever is more stringent. If less stringent levels or measures are appropriate in view of specific project circumstances, the borrower is required to provide justification for any proposed alternatives.

B. PRC Environmental Legal Framework

23. The environmental protection and management system in the PRC consists of a well-defined hierarchy of regulatory, administrative and technical institutions. At the top level the People's Congress of the PRC has the authority to pass and revise national environmental laws; the Ministry of Ecology and Environment (MEE, former Ministry of Environmental Protection) under the State Council promulgates national environmental regulations; and the MEE either separately or jointly with the Administration of Quality Supervision, Inspection and Quarantine issues national environmental standards. Provincial and local governments can also issue provincial and local environmental regulations and guidelines in accordance with the national ones. In addition, national and local five-year environmental protection plans form an important part of the legal framework.

24. Key applicable PRC environmental laws are listed in **Table II-1** including associated regulations and decrees that support their implementation. Guidelines for EIA implementation are listed in **Table II-2**.

25. The most far-reaching law on pollution prevention and control is the Environmental Protection Law (EPL) (1989, amended 2014, effective 2015 and item 2 in **Table II-1**), which sets

[1] The guidelines applied for this component are Environmental, Health, and Safety (EHS) General Guidelines, EHS Guidelines for Geothermal Power Generation, EHS Guidelines for Thermal Power Generation, and EHS Guidelines for Construction and Decommissioning. These guidelines can be found at http://www.ifc.org/ehsguidelines

out key principles for the country's pollution control system, including the policy known as the "Three Simultaneities Policy" [2], the application of pollution levies, and requirements for EIA. The implementation of the "Three Simultaneities Policy" was further strengthened by decrees on its implementation (items 28 and 30) and the Construction Project Environmental Protection Management Regulation (item 19).

26. The amended EPL further defines enforcement and supervision responsibilities for all levels of environmental protection authorities, imposes stricter obligations and more severe penalties on enterprises and construction units regarding pollution prevention and control, and allows for environmental public interest litigation including through nongovernment organizations. The procedures and requirements for the technical review of EIA reports by authorities have been specified (**Table II-1** item 4), and environmental inspection and enforcement on design, installation, and operation of project-specific environmental protection and control measures are regulated under the "Three Simultaneities Policy" (**Table II-1** items 5, 15, 25, 26, and 28).

27. Public participation and environmental information disclosure provisions are among the most significant changes introduced in the amended EPL, further supported by the decrees on the preparation of EIA summaries for public disclosure (item 26), information disclosure on construction project EIAs by government (item 24), method for public participation in environmental protection (item 22), and technical guidelines for public participation in EIAs.

28. For grievance redress, a hotline number (12369) was established in March 2011 at each level of environmental protection authority throughout the country for receiving and resolving environmental complaints, in accordance with the Management Measures for Operation of the Environmental Complaint Hotline (MEP Decree 2010 No. 15 [item 29]).

29. The PRC also provides protection for community health and occupational health and safety through the Labor Law (1994) (item 13), the Occupational Disease Prevention and Control Law (2001) (item 5), PRC Safety Production Law (item 4), State Administrative Regulations of Safety Production (item 18) and environmental and hygiene standards for construction sites.

Table II-1: Applicable PRC Environmental Laws, Regulations, and Decrees

No.	Laws	Year Issued/Updated
1	National Environmental Impact Assessment Law	2016
2	Environmental Protection Law	2015
3	Atmospheric Pollution Prevention and Control Law	2015
4	Safety Production Law	2014
5	Occupational Disease Prevention and Control Law	2011
6	Water and Soil Conservation Law	2011
7	Water Pollution Prevention and Control Law	2010

[2] The "Three Simultaneities Policy" requires the design, construction, and operation of pollution control and treatment facilities to occur simultaneously with the project design, construction, and operation.

8	Urban and Rural Planning Law	2008
9	Solid Waste Pollution Prevention and Control Law	2005
10	Water Law	2002
11	Cultural Relics Protection Law	2002
12	Noise Pollution Prevention and Control Law	1999
	Regulations	
13	Labor Law	1995
14	Atmospheric Pollution Prevention and Control Action Plan (State Council Announcement No. 37)	2013
15	Policy on Integrated Techniques for Air Pollution Prevention and Control of Small Particulates (MEP Announcement No. 59)	2013
16	Planning Environmental Impact Assessment Regulation	2009
17	Cultural Relics Protection Law Implementation Regulation	2003
18	State Administrative Regulations of Safety Production	2003
19	Construction Project Environmental Protection Management Regulation	1998
20	Wild Plant Protection Regulation	1996
	Decrees and Announcements	
21	Directory for the Management of Construction Project EIA Categorization (MEP Decree 2017-44)	2017
22	Measures for Public Participation in Environmental Protection (MEP Decree 2015-35)	2015
23	Management Measures for Environmental Impact Post Assessment of Construction Projects (on trial) (MEP Decree 2015-37)	2015
24	Government Information Disclosure of Construction Project EIA (on trial) (MEP Announcement No. 103)	2013
25	Measures for Environmental Supervision (MEP Decree 2012-21)	2012
26	Requirement for Preparation of EIA Report Summary (MEP Announcement 2012-51)	2012
27	Strengthening of EIA Management for Prevention of Environmental Risk (MEP Announcement 2012-77)	2012
28	Opinion from the State Council on Important Tasks for Strengthening Environmental Protection (State Council Announcement 2011-35)	2011
29	Management Measures for Operation of the Environmental Complaint Hotline (MEP Decree 2010-15)	2010
30	Management Procedures for the Supervision, Inspection and Environmental Acceptance of Construction Projects under the “Three Simultaneities” (on trial) (MEP Announcement 2009-150)	2009
31	Specifications on the Management of Urban Construction and Demolition Waste (Ministry of Construction Decree 2005-139)	2005
32	Management Measures for Inspection and Acceptance of Environmental Protection at Construction Project Completion (MEP Decree 2001-13)	2001

Source: ADB PPTA consultants.

C. PRC Environmental Impact Assessment Framework and Procedures

30. **EIA administrative framework.** The administrative framework for EIA in the PRC consists of national, provincial, and local (city and county) environmental protection authorities. The national authority is the MEE, which promulgates laws, regulations, administrative decrees, technical guidelines, and environmental quality and emission standards on EIA and pollution prevention and control. At the provincial level, there are environmental protection departments (EPDs), which act as gatekeepers for EIA and pollution prevention and control in the provinces. They are often delegated authority by the MEE to review and approve EIA reports for development planning and construction projects, except for those projects with national interest and those that cross provincial boundaries. The local (city or county level) environmental protection bureaus (EPB) enforce environmental laws and conduct environmental monitoring within city or county limits. Local EPBs can also be delegated the authority to approve EIA reports by the provincial EPDs. EPDs and EPBs are supported by environmental monitoring stations (EMS), which are subsidiaries of EPDs or EPBs and are qualified entities to carry out environmental monitoring.

31. The former MEP's "Guideline on Jurisdictional Division of Review and Approval of EIAs for Construction Projects" (2009) defines which construction project EIAs require former MEP review and approval, and which EIAs are delegated to the provincial EPDs.

32. The PRC has a qualification and registration system for EIA and only qualified and registered institutes and individuals are allowed to prepare EIAs. Under MEP Decree 2015-36, as of 1 November 2015 qualified institutes for conducting EIAs for construction projects in the PRC can no longer be a subsidiary of an environmental authority responsible for approving EIAs.

33. **EIA legal framework**. EIA is governed by the Environmental Impact Assessment Law (2016) (**Table II-1** item 1), covering EIAs for (i) plans (such as new development areas and new industrial parks) and strategic environmental assessments (SEA), and (ii) construction projects. This was followed by the promulgation of two regulations: the Construction Project Environmental Protection Management Regulation (1998) (item 19) and the Planning Environmental Impact Assessment Regulation (2009) (item 16), both of which require early screening and environmental categorization.

34. **EIA procedures.** EIA procedures have been established in the PRC for over 20 years. In 2008, former MEP issued "Management Guideline on EIA Categories of Construction Projects" (revised 2017). Under MEE decree, Directory for the Management of Construction Project Environmental Impact Assessment Categorization (MEP Decree 2017-44) (item 21) provides detailed EIA requirements for 50 sectors and 192 subsectors and classifies EIAs for construction projects into three categories with different reporting requirements based on the "significance" of potential environmental impact due to the project and the environmental sensitivity[3] of the project site as described in the directory. The directory provides detailed EIA requirements for 50 sectors and 192 subsectors:

[3] Environmentally-sensitive areas are defined in the Decree, and include (i) nature reserves and protected areas, scenic areas, world cultural and natural heritage sites, drinking water source protection zones; (ii) basic farmland and grassland, forest parks, geological parks, important wetland, natural woodland, critical habitats for endangered plant and animal species, important aquatic spawning/nursery/wintering/migration grounds, regions suffering from water resource shortage, serious soil erosion areas, desertification protection areas, eutrophic water bodies; and (iii) inhabited areas with major residential, health care, scientific research, and administration functions, cultural heritage protection sites, and protection areas with historical, cultural, scientific, and ethnic values.

(i) **Category A:** projects with significant adverse environmental impacts, for which a full EIA report is required;

(ii) **Category B:** projects with adverse environmental impacts which are of a lesser degree and/or significance than those of Category A, for which a simplified tabular EIA report is required; and

(iii) **Category C:** projects unlikely to have adverse environmental impacts, for which an EIA registration form is required.

35. A full EIA report for category A and a simplified tabular EIA report for category B are similar to ADB's EIA and IEE reports, respectively. The registration form of an EIA is similar to an ADB Category C project.

36. **EIA follow-up actions.** In 2015, the MEP issued decree Management Measures for Environmental Impact Post Assessment of Construction Projects (MEP Decree 2015-37, item 23 of **Table II-1**). Under this decree, a trial program was implemented on 1 January 2016 requiring follow-up actions 3 to 5 years after commencement of project operation for large infrastructure and industrial projects or projects located in environmentally-sensitive areas. These actions include environmental monitoring and impact assessment to verify the effectiveness of environmental protection measures and to undertake any corrective actions that might be needed. The decree also specifies that the institute that did the original impact assessment for the project cannot undertake environmental impact post-assessment for the same project.

37. **EIA guidelines.** The MEE has issued a series of technical guidelines for preparing EIAs (**Table II-2**). These include impact assessment guidelines on general EIA implementation and principles, atmospheric environment and ambient air quality, noise, surface water, groundwater, ecology and regional biodiversity, biodiversity monitoring, quality management on environmental monitoring, and public participation.

Table II-2: Applicable PRC EIA guidelines

No.	Guideline	Date
1	HJ 192-2015 Technical Criterion for Ecosystem Status Evaluation	2015
2	HJ 130-2014 Technical Guidelines for Planning EIA - General Principles	2014
3	HJ 663-2013 Technical Regulation for Ambient Air Quality Assessment (on trial)	2013
4	HJ 2.1-2011 Technical Guidelines for EIA – General Program	2011
5	HJ 19-2011 Technical Guidelines for EIA – Ecological Impact	2011
6	HJ 616-2011 Guidelines for Technical Review of EIA on Construction Projects	2011
7	HJ 623-2011 Standard for the Assessment of Regional Biodiversity	2011
8	HJ 630-2011 Technical Guideline on Environmental Monitoring Quality Management	2011
9	Technical Guidelines for EIA - Public Participation (public comment version), (Jan. 2011)	2011
10	HJ 610-2011 Technical Guidelines for EIA – Groundwater Environment	2011

11	HJ 2.4-2009 Technical Guidelines for EIA – Acoustic Environment	2009
12	HJ 2.2-2018 Technical Guidelines for EIA – Atmospheric Environment	2018
13	HJ/T 393-2007 Technical Specifications for Urban Fugitive Dust Pollution	2007
14	JG/J 146-2004 Environmental and Hygiene Standards for Construction Sites	2004
15	HJ/T 2.3-1993 Technical Guidelines for EIA – Surface Water Environment	1993

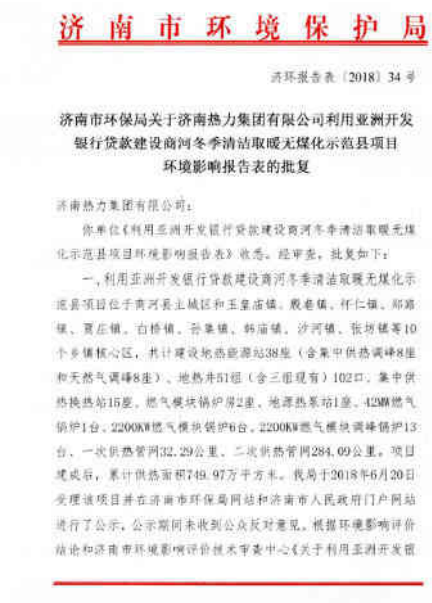
Source: ADB PPTA consultants.

D. Project Domestic EIA Report

38. Under MEE Decree on Management Guideline on EIA Categories of Construction Projects (MEP Decree 2017-44), the component requires a tabular EIA report. The domestic EIA report covering all components of the project was prepared by Shandong Environmental Protection Research and Design Institute. The company is certified by the MEE to undertake category A, B, and C assessments.

39. The domestic EIA report for the Shanghe component was disclosed on by Jinan EPB's website from August 16, 2018 to August 24, 2018 (the link is http://jnepb.jinan.gov.cn/art/2018/8/16/art_10495_2465500.html). After the public disclosure, the domestic EIA report was formally approved by Jinan EPB on August 16 2018. The EIA approval is presented in **Figure II-1**.

Figure II-1: Domestic EIA approval.



济南市环境保护局

济环报告表〔2018〕34号

济南市环保局关于济南热力集团有限公司利用亚洲开发银行贷款建设商河冬季清洁取暖无煤化示范县项目环境影响报告表的批复

济南热力集团有限公司：

你单位《利用亚洲开发银行贷款建设商河冬季清洁取暖无煤化示范县项目环境影响报告表》收悉。经审查，批复如下：

一、利用亚洲开发银行贷款建设商河冬季清洁取暖无煤化示范县项目位于商河县玉皇庙镇、殷巷镇、怀仁镇、郎君镇、贾庄镇、白桥镇、孙集镇、韩庙镇、沙河镇、张坊镇等10个乡镇核心区，共计建设地热能源站38座（含集中供热调峰8座和天然气调峰8座）、地热井51组（含三组现有）102口，集中供热换热站15座，燃气模块锅炉房2座、地源热泵站1座、42MW燃气锅炉1台、22000kW燃气模块锅炉6台、22000kW燃气模块调峰锅炉13台、一次供热管网32.29公里、二次供热管网284.09公里。项目建成后，累计供热面积749.97万平方米。我局于2018年6月20日受理该项目并在济南市环保局网站和济南市人民政府门户网站进行了公示。公示期间未收到公众反对意见。根据环境影响评价结论和济南市环境影响评价技术审查中心《关于利用亚洲开发银

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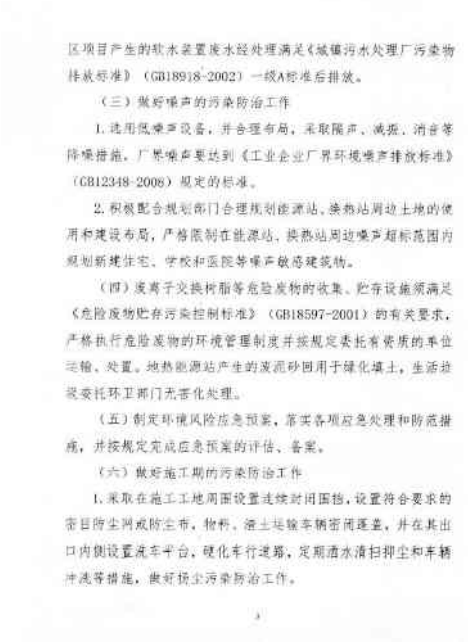

区项目产生的软水装置废水经处理满足《城镇污水处理厂污染物排放标准》（GB18918-2002）一级A标准后排放。

（三）做好噪声的污染防治工作

1.选用低噪声设备，并合理布局，采取隔声、减振、消音等降噪措施，厂界噪声要达到《工业企业厂界环境噪声排放标准》（GB12348-2008）规定的标准。

2.积极配合规划部门合理规划能源站，换热站周边土地的使用和建设布局，严格限制在能源站、换热站周边噪声超标范围内规划新建住宅、学校和医院等噪声敏感建筑物。

（四）废离子交换树脂等危险废物的收集、贮存设施须满足《危险废物贮存污染控制标准》（GB18597-2001）的有关要求，严格执行危险废物的环境管理制度并按规定委托有资质的单位运输、处置。地热能源站产生的废泥砂回用于绿化填土，生活垃圾委托环卫部门无害化处理。

（五）制定环境风险应急预案，落实各项应急处理和防范措施，并按规定完成应急预案的评估、备案。

（六）做好施工期的污染防治工作

1.采取在施工工地周围设置连续封闭围挡，设置符合要求的密目防尘网或防尘布，物料、渣土运输车辆密闭运盖，并在其出口内侧设置洗车平台，硬化车行道路，定期洒水清扫抑尘和车辆冲洗等措施，做好扬尘污染防治工作。

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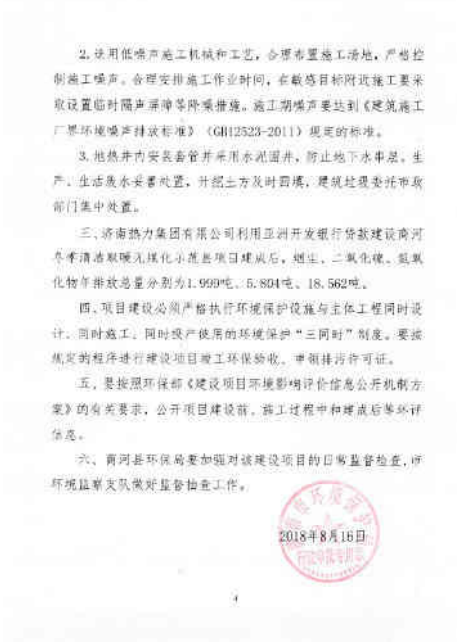

2.选用低噪声施工机械和工艺，合理布置施工场地，严格控制施工噪声。合理安排施工作业时间，在敏感目标附近施工要采取设置临时隔声屏障等降噪措施。施工期噪声要达到《建筑施工厂界环境噪声排放标准》（GB12523-2011）规定的标准。

3.地热井内安装套管并采用水泥固井，防止地下水串层。生产、生活废水妥善处置，井组三方及时回填，建筑垃圾委托市政部门集中处置。

三、济南热力集团有限公司利用亚洲开发银行贷款建设南河尔雅清洁取暖天然气化小范围项目建成后，烟尘、二氧化硫、氮氧化物年排放总量分别为1.999吨、5.804吨、18.562吨。

四、项目建设必须严格执行环境保护设施与主体工程同时设计、同时施工、同时投产使用的环境保护“三同时”制度。要按规定的程序进行建设项目竣工环保验收，申领排污许可证。

五、要按照环保部《建设项目环境影响评价信息公开机制方案》的有关要求，公开项目建设前、施工过程中和竣后等环评信息。

六、南河县环保局要加强对该建设项目的日常监督检查，市环境监察支队做好监督抽查工作。

2018年8月16日

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E. Relevant International Agreements

40. The PRC has signed a number of international agreements regarding environmental and biological protection. Those which have potential application to the component are listed in Table II-3.

Table II-3: Applicable international agreements

No.	Agreement	Year	Purpose
1	Ramsar Convention on Wetlands of International Importance Especially as Waterfowl Habitat	1975	Preventing the progressive encroachment on and loss of wetlands for now and the future
2	Convention Concerning the Protection of the World Cultural and Natural Heritage	1986	Conserving cultural and natural heritage sites.
3	Convention on Biological Diversity	1993	Conservation and sustainable use of biodiversity.
4	UN Framework Convention on Climate Change	1994	Stabilizing greenhouse gas (GHG) concentrations in the atmosphere at a level that will prevent anthropogenic induced climate change.
5	United Nations Convention to Combat Desertification in Those Countries Experiencing Serious Drought and/or Desertification	1996	Fighting against desertification and mitigating the effects of drought.
6	Kyoto Protocol	2002	Controlling emissions of

No.	Agreement	Year	Purpose
			anthropogenic GHGs in ways that reflect underlying national differences in GHG emissions, wealth, and capacity to make the reductions.
7	Stockholm Convention on Persistent Organic Pollutants	2004	Safeguarding human health and the environment from persistent organic pollutants (POPs), ascertaining sound management of stockpiles and wastes that contain POPs, and taking measures to reduce or eradicate releases from intentional production and use of POPs.
8	Paris climate agreement	2015	Dealing with greenhouse gas emissions mitigation, adaptation and finance starting in the year 2020.
9	Minamata Convention on Mercury	2017	A global treaty to protect human health and the environment from the adverse effects of mercury.

Source: ADB PPTA consultants.

F. Applicable PRC Environmental Standards

41. **PRC environmental standards**. Standards issued by the MEE generally consist of environmental quality (ambient) standards applicable to the receiving environment and emission standards applicable to the pollution source. The former includes standards for ambient air quality, noise and vibration, surface water, groundwater, soil, etc. The latter includes standards for integrated wastewater discharge, construction and community noise, odor and air pollutants, etc. (**Table II-4**).

Table II-4: Applicable PRC environmental standards

No.	Standard	Code/Date
1	Ambient Air Quality Standards	GB 3095-2012
2	Quality Standards for Ground Water	GB/T 14848-2017
3	Environmental Quality Standards for Surface Water	GB 3838-2002
4	Environmental Quality Standards for Noise	GB 3096-2008
5	Environmental Quality Standards for Soil	GB 15618-1995
6	Noise Standards for Construction Site Boundary	GB 12523-2011
7	Noise Standards for Industrial Enterprises at Site Boundary	GB 12348-2008
8	Emission standards for Odor Pollutants	GB 14554-93
9	Air Pollutant Integrated Emission Standards	GB 16297-1996
10	Integrated Wastewater Discharge Standards	GB 8978-1996

11	Emission Standard for Community Noise	GB 22337-2008
12	Standard of Environmental Vibration in Urban Area	GB 10070-88
13	Technical Specifications for Regionalizing Environmental Noise Function	GB/T 15190-2014
14	Standard for Flood Control	GB 50210-94
15	Limits and Measurement Methods for Crankcase Pollutants from Heavy-duty Vehicles Equipped with Pressure Ignition Engines	GB 11340-2005
16	Emission Limits and Measurement Methods for Exhaust Pollutants from Vehicle Compression-Ignition and Gas Fueled Ignition Engines	GB 17691-2005
17	Limits and Measurement Methods for Exhaust Pollutants from Vehicles Equipped with Ignition Engines	GB 18285 -2005
18	Limits and Measurement Methods for Emissions from Light Duty Vehicles	GB 18352-2005

Source: ADB PPTA Consultant and domestic EIA report.

42. As noted above, ADB's SPS requires borrowers to follow environmental standards consistent with good international practice as reflected in internationally recognized standards such as the World Bank Group's EHS Guidelines. When host country regulations differ from these levels and measures, the borrower is to achieve whichever is more stringent. If less stringent levels or measures are appropriate in view of specific project circumstances, the borrower/client is required to provide justification for any proposed alternatives. Both PRC standards and EHS guidelines are used in this assessment as described below.

1. Ambient Air Quality Standards

43. Ambient air quality limits are intended to indicate safe exposure levels for the majority of the population, including the very young and the elderly, throughout an individual's lifetime. Limits are given for one or more specific averaging periods, typically one-hour average, 24-hour average, and/or annual average. The PRC's recently updated *Ambient Air Quality Standards (*GB3095-2012) has two classes of limit values; Class 1 standards apply to special areas such as natural reserves and environmentally sensitive areas, and Class 2 standards apply to all other areas, including urban and industrial areas. The PRC standards for Class 2 areas are applicable for the project.[4]

44. The World Health Organization (WHO) Air Quality Guidelines are recognized as international standards and are adopted by the World Bank Group's EHS Guidelines. In addition to guideline values, interim targets (IT) are given for each pollutant by the WHO as incremental targets in a progressive reduction of air pollution. The WHO guidelines and corresponding PRC standards are presented in **Table II-5**.

45. From a review of **Table II-5**, it can be observed that:

- For TSP, there are PRC standards but no corresponding WHO guidelines.

[4] On 29 February 2012, the China State Council passed the roadmap for ambient air quality standards with the aim of improving the living environment and protecting human health. The Ambient Air Quality Standards (GB 3095-2012) prescribes the first-ever limits for $PM_{2.5}$. It also modified the previous area classifications by combining Class III (special industrial areas) with Class II (residential, mixed use areas).

- For PM_{10}, PRC Class 2 annual average and 24-hour average standards meet WHO IT-1 guidelines (there are no 1-hour average standards or guidelines for either PRC or WHO).
- For $PM_{2.5}$, PRC Class 2 annual and 24-hour standards meet WHO IT-1 guidelines (there are no 1-hour standards or guidelines for either PRC or WHO).
- For SO_2, WHO only has a 24-hour average guideline (0.125 mg/m^3), which is slightly lower than the PRC standard (0.150 mg/m^3). However, SO_2 levels are low in the component area, and the component will only contribute low levels of SO_2, so the very minor difference is inconsequential.
- For NO_2, the PRC standard is equivalent to the WHO annual average guidelines, there is no WHO 24-hour average guideline; and the 1-hour average PRC standard is equivalent to the WHO guideline.
- For O_3, the PRC class I 1-hour average standard is equivalent to the WHO 1-hour average guideline and PRC 1-hour average class II standard is equivalent to the WHO IT-1 1-hour average guideline.
- For CO, there are PRC standards but no corresponding WHO guidelines.

Table II-5: PRC Ambient Air Quality Standards and WHO ambient air quality guidelines, μg/m^3

Air Quality parameter	Averaging period	PRC Ambient Air Quality Standard		WHO/EHS Guidelines	
		Class I	Class II	Interim Targets	Air quality guideline
TSP	annual	80	200	NA	NA
	24-hour	120	300	NA	NA
PM_{10}	annual	40	70	30-70	20
	24-hour	50	150	75-150	50
$PM_{2.5}$	annual	15	35	15-35	10
	24-hour	35	75	37.5-75	25
SO_2	annual	20	60	NA	NA
	24-hour	50	150	50-125	20
	1-hour	150	500	NA	NA
NO_2	annual	40	40	NA	40
	24-hour	80	80	NA	NA
	1-hour	200	200	NA	200
O_3	8-hour	100	160	160	100

	1-hour	160	200	NA	NA
CO	24-hour	4,000	4,000	NA	NA
	8-hour	NA	NA	NA	NA
	1-hour	10,000	10,000	NA	NA

Note: NA= not applicable.
Source: WHO Air Quality Guidelines (2006) in IFC EHS Guidelines (2007), and PRC GB 3095-2012.

46. Overall the PRC standards show a high degree of equivalency to the WHO guidelines or IT-1 values and are adopted for use in this IEE report.

2. Boiler Emissions

47. **Table II-6** presents the relevant PRC national boilers emission standard compared with relevant international standards (*EHS Guidelines for thermal power plants*). The Shandong Provincial standards are more stringent than the *EHS Guidelines*, and the Shandong Provincial standards are applicable to the component.

Table II-6: Relevant Shandong Emission Standards for gas fired boilers and Relevant International Guidelines

Parameter	***Integrated Emission Standard of Air Pollutants for Shandong Province*** (Table 2 of dB 37/2376-2013)	**EHS General Guidelines for** Small Combustion Facilities Emissions Guidelines	**Comparison**
Stack Height	Stack height is determined according to the requirements in the approved EIA, and must be > 8 m.	Design stack height according to Good International Practice (GIP) to avoid excessive ground level concentrations and minimize impacts.	PRC standard meets GIP
PM	10 mg/Nm^3	NA	No EHS guideline.
SO_2	50 mg/Nm^3	NA	No EHS guideline.
NO_x	100 mg/Nm^3	320 mg/Nm^3	PRC standard is more stringent than the EHS guidelines

Source: WHO EHS Guideline for Thermal Power Plant and PRC dB37/2376-2013.

3. Surface Water

48. PRC's *Surface Water Ambient Quality Standard* (GB3838-2002) defines five water quality categories for different environmental functions. For example, Category I is the best, such as water at sources of rivers and National Nature Reserves. Category V is the worst quality, suitable only for agricultural and scenic water uses. Because the component is located all over Shanghe County, Based on information collection and site visit, the surface water bodies near the component site are Qingyuan Reservoir, Tuhai River, Dehui River and branches of Tuhai River

and Dehui River. Category II water quality standard (see **Table II-7**) is applicable for Qingyuan Reservoir which is used drinking water, Category IV water quality standard is applicable for Dehui River which is used as landscape water and Category V water quality standard is applicable for Tuhai River which is used as agricultural water. There are no applicable EHS guidelines or target for water quality in this context, and the PRC standard is adopted for use in this IEE report.

Table II-7: Applicable surface water standards. Unit: mg/l, pH excluded

No.	Parameter	Water Quality Category				
		I	II	III	IV	V
1	pH	6-9	6-9	6-9	6-9	6-9
2	Dissolved Oxygen	90% saturation or ≥7.5	≥6	≥5	≥3	≥2
3	COD_{Mn}	≤2	≤4	≤6	≤10	≤15
4	COD_{Cr}	≤15	≤15	≤20	≤30	≤40
5	BOD_5	≤3	≤3	≤4	≤6	≤10
6	NH_3-N	≤0.15	≤0.5	≤1.0	≤1.5	≤2.0
7	TP	≤0.02	≤0.1	≤0.2	≤0.3	≤0.4
	For lakes and reservoirs	≤0.01	≤0.025	≤0.05	≤0.1	≤0.2
8	TN (N for lakes and reservoirs)	≤0.2	≤0.5	≤1.0	≤1.5	≤2.0
9	Copper	≤0.01	≤1.0	≤1.0	≤1.0	≤1.0
10	Zinc	≤0.05	≤1.0	≤1.0	≤2.0	≤2.0
11	Fluoride	≤1.0	≤1.0	≤1.0	≤1.5	≤1.5
12	Selenium	≤0.01	≤0.01	≤0.01	≤0.02	≤0.02
13	Arsenic	≤0.05	≤0.05	≤0.05	≤0.1	≤0.1
14	Total Mercury	≤0.00005	≤0.00005	≤0.0001	≤0.001	≤0.001
15	Cadmium	≤0.001	≤0.005	≤0.005	≤0.005	≤0.01
16	Hexavalent Chromium	≤0.01	≤0.05	≤0.05	≤0.05	≤0.1
17	Lead	≤0.01	≤0.01	≤0.05	≤0.05	≤0.1
18	Cyanide	≤0.005	≤0.05	≤0.2	≤0.2	≤0.2
19	Volatile Phenol	≤0.002	≤0.002	≤0.005	≤0.01	≤0.1
20	Sulfide	≤0.05	≤0.1	≤0.2	≤0.5	≤1.0

21	Petroleum	≤0.05	≤0.05	≤0.05	≤0.5	≤1.0
22	Anionic surfactant	≤0.2	≤0.2	≤0.2	≤0.3	≤0.3
23	Coliforms	≤200	≤2000	≤10000	≤40000	≤40000

Source: PRC GB3838-2002.
Note: COD_{Mn} = permanganate index; CODcr = chemical oxygen demand; BOD_5 = 5 days biochemical oxygen demand; NH_3-N= ammonia nitrogen; TP = Total Phosphorus; TN = Total Nitrogen.

4. Groundwater

49. PRC's *Groundwater Water Ambient Quality Standard* (GB/T14848-2017) also defines a number of water quality categories for different environmental functions. There is no ground drinking water source in Shanghe because Shanghe County now sources drinking water from Yellow River and Qingyuan Reservoir and Qingyuan Reservoir extracts water from Yellow River. In rural and semi-urban area of Shanghe, shallow-groundwater is primarily used for agriculture, thus the Category III standard is applicable (**Table II-8**). There is no equivalent standard recommended in the *EHS Guidelines,* and the PRC standard is adopted for use in this IEE report.

Table II-8: Applicable groundwater standards

No.	Parameter	Unit	Category III Standard
1	pH	-	6.5-8.5
2	COD_{Mn}	mg/l	3.0
3	Sulfate	mg/l	250
4	Chloride	mg/l	250
5	Volatile Phenols	mg/l	0.002
6	Total hardness ($CaCO_3$)	mg/l	450
7	Nitrate NO_{3-}	mg/l	20
8	Nitrite NO_{2-}	mg/l	1.0
9	NH_3-N	mg/l	0.5
10	Molybdenum	mg/l	0.2
1	Cyanide	mg/l	0.05
12	Cadmium	mg/l	0.005
13	Chromium VI	mg/l	0.05
14	Arsenic	mg/l	0.01
15	Zinc	mg/l	1.0

No.	Parameter	Unit	Category III Standard
16	Fluoride	mg/l	1.0
17	Lead	mg/l	0.01
18	Iron	mg/l	0.3
19	Manganese	mg/l	0.1
20	Copper	mg/l	1.0
21	Selenium	mg/l	0.01
22	Benzene	mg/l	0.01
23	Methylbenzene	mg/l	0.7
24	Total coliforms	/L	3.0
25	Colony forming unit	/L	100
26	Mercury	mg/l	0.001
27	Total dissolved solid	mg/l	1000

Source: PRC GB/T14848-2017.
Note: COD_{Mn} = permanganate index; CODcr = chemical oxygen demand; BOD_5 = 5 days biochemical oxygen demand; NO_3- = Nitrate; NO_2- = Nitrite; NH_3-N= ammonia nitrogen; TP = Total Phosphorus; TN = total nitrogen.

5. Wastewater Discharge

50. **Table II-9** presents the relevant PRC wastewater discharge standards. The *EHS Guidelines* indicate that wastewater discharged to public or private wastewater treatment systems should: meet the pretreatment and monitoring requirements of the sewer treatment system into which it discharges; not interfere, directly or indirectly, with the operation and maintenance of the collection and treatment systems, or pose a risk to worker health and safety, or adversely impact characteristics of residuals from wastewater treatment operations; and be discharged into municipal or centralized wastewater treatment systems that have adequate capacity to meet local regulatory requirements for treatment of wastewater generated from the project.

51. The gas fired boilers of the component will discharge wastewater to the municipal sewer systems for treatment at nearby wastewater treatment plant (WWTP) of Shanghe. Gas fired boilers in Shanghe urban area will discharge wastewater to Shanghe WWTP and gas fired boiler in Yuhuangmiao Town will discharge wastewater to Shanghe Fangyuan WWTP. The wastewater discharges will be required to meet Class B maximum acceptable concentrations (MACs) in *Wastewater Quality Standards for Discharge to Municipal Sewers* (GB/T 31962-2015), and the WWTP discharges are required to meet Class 1A of *Discharge Standard of Pollutants for Municipal Wastewater Treatment Plants* (GB 18918-2002).

Table II-9: PRC *Wastewater Quality Standards for Discharge to Municipal Sewers*

No.	Pollutant	Maximum acceptable concentration (MAC) mg/L (except pH and chromacity)
		Class B
1	pH	6.5-9.5
2	SS	400
3	COD	500
4	Ammonia nitrogen	45
5	TDS	2000
6	Chromacity	70
7	BOD	350
8	Total phosphorus	8

Source: PRC GB/T 31962-2015.

6. Noise

52. **Table II-10** presents the relevant PRC *Urban Noise Standards* compared with relevant international guidelines from the WHO (as presented in the *EHS Guidelines*). The classes within the standards are not directly comparable, but the PRC Category I standards are equivalent to WHO Class I standards, Category II standards are less stringent than WHO Class I standards and Category II and III standards are stringent than WHO Class II standards. Because Category II standard is applicable to the component area and Category I standard is applicable to the nearby sensitive receptors, Category II for component area and Category I for sensitive receptors are utilized in this IEE report.

Table II-10: **PRC *Environmental Quality Standards for Noise* (GB3096-2008) and relevant international guidelines**

PRC Standards Leq dB(A)			International Standards One Hour Leq dB(A)		Comparison
Category	**Day** 06-22h	**Night** 22-06h	**Day** 07-22h	**Night** 22-07h	
0: Areas needing extreme quiet, such as special health zones	50	40	WHO Class I: residential, institutional, educational: 55 WHO Class II: industrial, commercial: 70	WHO Class I: Residential, institutional, educational: 45 WHO Class II: Industrial, Commercial: 70	Classes are not directly comparable, but PRC Class II standards exceed WHO Class II standards. PRC standards are utilized in this report.
I: Mainly residential; and cultural and educational institutions	55	45			
II: Mixed residential, commercial and industrial areas	60	50			
III: Industrial areas	65	55			
IV: Area on both sides of urban trunk roads	70	55			

Source: WHO Noise Quality Guidelines (1999) in IFC EHS Guidelines (2007), and PRC GB3096-2008.

53. **Table II-11** presents the relevant PRC and international standards (US EPA, there no such WHO or *EHS Guidelines* standards) for on-site construction noise. The PRC standards are more stringent than international guidelines and are utilized in this IEE report. The PRC's Emission Standard of Environmental Noise for Boundary of Construction Site (GB12523–2011) regulates construction noise, limiting construction noise levels at the construction site boundary to 70 dB(A) in the day time (06:00–22:00 hours) and 55 dB(A) at night (22:00–06:00 hours). At the sensitive receptors, noise emission should comply with 55 dB(A) during day time and 45 dB(A) during night time.

Table II-11: **PRC *Noise Emission Standard for Construction Site Boundary* (GB12523-2011) and relevant international guidelines**

Day Leq dB(A)	Night Leq dB(A)	International Standards Leq dB(A)	Comparison
70	55	US EPA: 85 (day, 8-hour exposure)	IFC EHS Guideline: Occupational Health and Safety: 85 (Equivalent level LAeq,8h) 110 (Maximum LAmax, fast)

Source: US EPA, IFC Occupational Health and Safety standard and PRC GB 12523-2011.

54. During operation noise at site boundaries should comply with Class II of the PRC *Industrial Enterprise Boundary Noise Emission Standard* (GB12348-2008) (**Table II-12**). At the sensitive receptors, noise emission should comply with 55 dB(A) during day time and 45 dB(A) during night time (**Table II-10**).

Table II-12: PRC *Noise Emission Standard for Construction Site Boundary* (GB12348-2008) and relevant international guidelines

Standard Type	Standard Value Leq dB(A)	
	Day	Night
Class 2	60	50

Source: PRC GB 12348-2008.

III. PROJECT DESCRIPTION

A. The Project

55. This component aims to build Shanghe as a "coal-free," clean heating pilot county, the first-of-its-kind in Shandong Province. This will be achieved in more densely populated areas by forming a modernized heat supply system in the urban and semi-urban areas. In rural area of Shanghe County, the component will use individual electric heating equipment and natural gas to replace existing small coal stoves. To improve heating efficiency, the component will implement energy saving transformation for buildings in urban and rural areas of Shanghe.

56. This component will be implemented in urban, semi-urban and rural areas of Shanghe County. In urban area of Shanghe, this component will: (i) provide district heating to 5.5015 million m^2 by natural gas, heat pumps and geothermal energy; (ii) install 6.57 km primary and 204.78 km secondary district heating pipeline network; (iii) install one 42 MW gas fired boiler to replace the existing 58 MW coal fired boiler; and (iv) implement energy saving transformation for existing old residential buildings with an area of 660,400 m^2 through replacing thermal insulation materials for the exterior walls, and replacing single-layer glass wind with double glazing.

57. In semi-urban area of Shanghe, this component will: (i) provide district heating to 2.0134 million m^2 by natural gas and geothermal energy in ten towns; and (ii) install 25.72 km primary and 75.46 km secondary district heating pipeline network.

58. In rural area of Shanghe, this component will: (i) provide heating to five new kindergartens with a heating area of 9,300 m^2 by air source heat pumps; (ii) implement clean heating transformation for 80,000 households with a heating area of 4 million m^2 through replacing coal stoves by clean heating devices; and (iii) implement energy saving transformation for 30,000 households with an estimated area of 1.5 million m^2 by adding an insulation curtain to windows and roof insulation layers.

59. The component will be implemented through four outputs:

(i) **Output 1**: Provide clean district heating in urban and semi-urban areas of Shanghe by natural gas, geothermal energy and heat pumps. Total heating area in urban and semi-urban areas of Shanghe will be 7.5149 million m^2. Provide clean heating to 4,009,300 m^2 in rural area of Shanghe by heat pumps, gas heaters, carbon crystal plate radiators and heat-storage radiators.

(ii) **Output 2**: 32.29 km of primary and 280.24 km of secondary district heating pipeline network will be constructed to provide district heating to 7.5147 million m^2 in urban and semi-urban areas of Shanghe. The pipe networks will utilize two-pipe system. One is water supply pipe and another is water return pipe.

(iii) **Output 3**: Implement energy saving transformation for existing old residential buildings with an area of 660,400 m^2 in urban area of Shanghe and 30,000 households in rural area of Shanghe with an estimated area of 1.5 million m^2; and

(iv) **Output 4**: Strengthened capacity to install and maintain clean heating. The component activities will employ women and include awareness raising about the benefits of clean energy targeted toward women who are often responsible for

domestic upkeep.

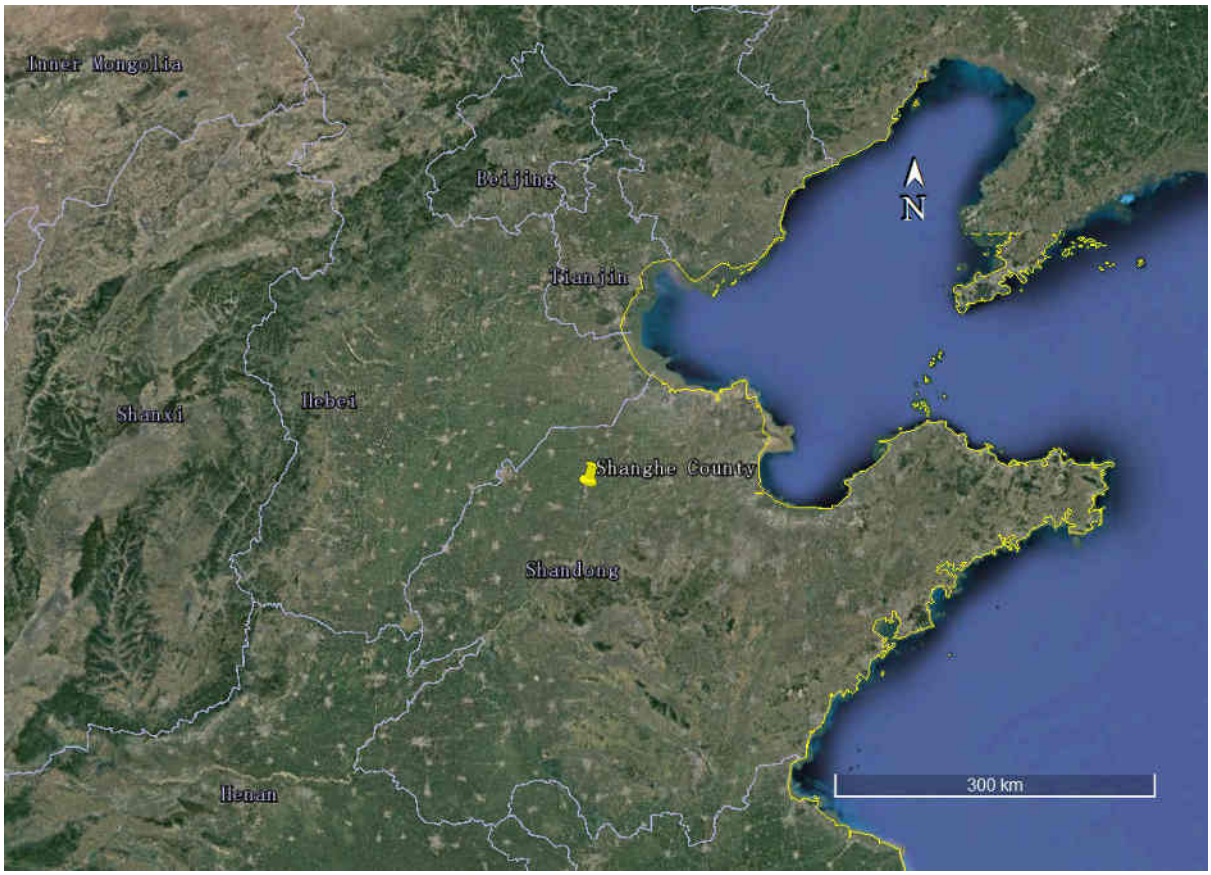
60. The component impact will be reduced coal consumption, improved air quality and reduced greenhouse gas emissions in Shanghe County. The outcome will be improved energy efficiency, a cleaner environment in Shanghe County and a reduction in cases of respiratory and heart diseases.

B. Project Location

61. The component will be implemented at Shanghe County of Jinan which is located on the central and western areas of Shandong Province (**Figure III-1**). Jinan is capital city of Shandong Province and is comprised of seven urban districts and three rural county-level cities. Shanghe County is comprised of eleven towns and one street (urban area).

62. The component is located in Shanghe County of Jinan City, Shandong Province. Jinan City, with a total area of 1,162 km^2, is located at the north shore of the Yellow River, bordering Hebei Province in north. It is located at east longitude 116°58'- 117°26' and northern latitude 37°06 '- 37°32' and it is the north gate of Jinan. Dezhou City is in west and Binzhou City is in east of Shanghe County.

Figure III-1: Component location in Shandong Province

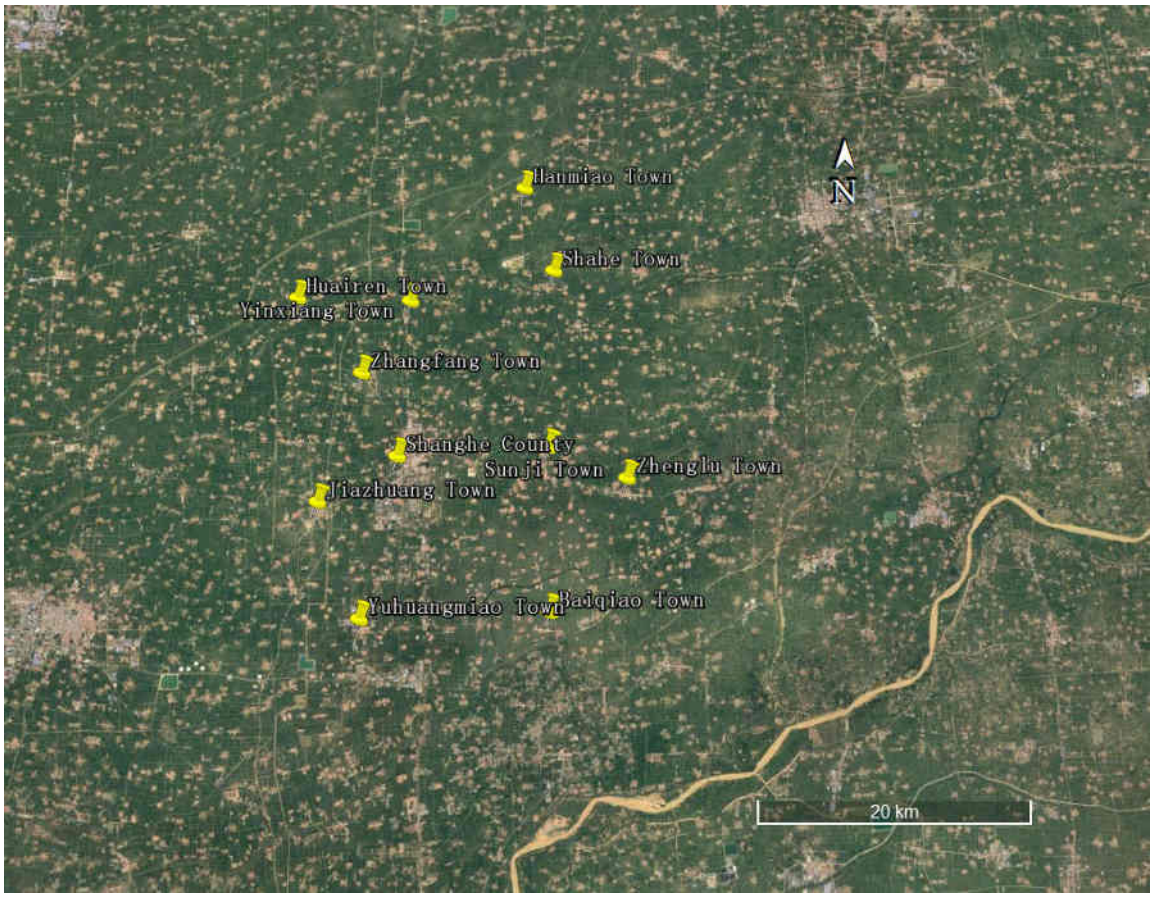


Source: Google earth, 2018

63. The component is located Xushang Street (urban area), Yuhuangmiao Town, Yinxiang

Town, Huairen Town, Zhenglu Town, Jiazhuang Town, Baiqiao Town, Sunji Town, Hanmiao Town, Shahe Town and Zhangfang Town of Shanghe County (**Figure III-2**).

Figure III-2: Component location



Source: Google earth, 2018.

C. Project Rational

64. Jinan, the capital city of Shandong Province, is situated in the northeastern part of PRC. The winter temperature drops to as low as –19 degree Celsius (°C), and sub-zero temperatures typically last for 4 months a year; under this climate heating service is an essential requirement for sustaining people's livelihoods. Heat demand in Jinan is increasing substantially due to rapid ongoing urban expansion. Current district heating coverage in Jinan is approximately 147 million m^2, compared to 87.6 million m^2 in 2012.

65. The existing heating system in Jinan is a large-scale district heating system driven by coal-fired HSPs or CHP plants. However, the expansion of the existing coal-based district heating system to meet the increasing demand is not an option as Jinan has been experiencing significant pollution problems in the winter heating seasons including hazy skies and high levels of particulates.

66. Shandong Province is one of the most important regional economies in the PRC. Its provincial capital, Jinan, is a key economic, political, and transportation center in northern PRC.

In 2017, Shandong's economy was ranked the third, contributing 8.79% of the country's total gross domestic product (GDP).

67. In 2017, Shandong's economy grew at 8.46%, among the highest growth rates in the PRC. However, the province's economic growth is energy intensive, highly polluting, and overwhelmingly dependent on coal, especially for heavy industry and winter space heating. Heavy industry accounts for 68% of the province's industrial output, which is led by chemical production, agro-processing, machinery manufacturing, textiles, and smelting. Its power generation is almost exclusively coal-based.[5] Shandong Province alone consumes 10% of the PRC's total energy consumption. 79.3% of Shandong's primary energy mix is from coal, which makes it the PRC's largest consumer of coal. The province's coal consumption has steadily increased between 2011 and 2015, whereas the entire country has reduced its consumption between 2013 and 2015.[6]

68. As a result, the province is a substantial contributor of air pollution in the Greater BTH region. Jinan City is one of the cities with severe air pollution in the Greater BTH region. In 2017, Jinan ranked 65 among 74 major cities in the PRC, and first in Shandong Province for poorest air quality. Raw coal combustion produces lots of particulate matter and carbon dioxide. The average annual concentration of PM_{10} was measured at 130 micrograms per cubic meter (μg/m³) and particulate matter less than 2.5 microns in diameter ($PM_{2.5}$) was measured at 63 μg/m^3. These concentrations were nearly double the national air quality category II standards (70 μg/m³ and 35μg/m³) and more than six times the level recommended by the World Health Organization (20 μg/m³ and 10 μg/m³).[7] Annual concentration levels of other pollutants such as sulfur dioxide (SO_2) at 25 μg/m³ which is compliance with national air quality standard (60 μg/m³), and nitrogen dioxide (NO_2) is 46 μg/m³ which is worse than national air quality standard (40 μg/m³). Exposure to high levels of particulate matter and other air pollutants are associated with health risks such as cardiovascular and respiratory disease.

69. Restructuring the country's energy mix to combat air pollution is at the forefront on the government's agenda for transforming the PRC's economic growth model from an export-driven economy to a consumption-led, low-carbon one. The PRC's 13th Five-Year Plan (2016-2020) coins this goal as transforming the PRC into an "ecological civilization", guided by principles of environment, innovation, sustainability, and inclusive growth. To this end, the Plan includes targets for air quality and $PM_{2.5}$ levels in large cities and for the reduction of energy and carbon intensity. The 13th Five-year Plan builds on the Comprehensive Action Plan for Air Pollution Prevention and Control 2013–2017 (CAAP), which set the strictest air quality measures and targets to date on SO_2, NOx, $PM_{2.5}$, and volatile organic compounds nationally, and for the BTH region. More recently, MEE introduced the Work Program for Air Pollution Control (2017) in the BTH Region and its Surrounding Areas. The program aims to implement strict pollution control measures in 28 cities, of which 7 are located in Shandong province. The program emphasizes the importance to reduce winter raw coal burning for heating supply in urban, semi-urban and rural areas of the BTH region.

70. Coal-based heating is the major cause of rising level of outdoor and indoor air pollution during the winter. According to *Particulate matter (PM) source analysis result in Jinan in 2017* by Jinan EPB, 24.6% of $PM_{2.5}$ and 17.4% of PM_{10} are from coal combustion. According to *Jinan Action Plan (2017-2020) for Clean District Heating Pilot Cities in Northern China*, boilers with a capacity less than 35 t/h are prohibited in Jinan City from 2018. Thus, other alternatives to meet

[5] HKTDC Research. Shandong: Market Profile. Accessed March 22, 2018.

[6] Yiqing Zhang, Chuangeng Liu, Ke Li, Yong Zhou. 2018 Strategy on China's regional coal consumption control: A case study of Shandong province, *Energy Policy*. 112. pp. 316–327.

[7] Jinan EPB, 2017. The 2017 Bulletin on the Jinan Municipal Air Quality. Jinan.

the growing heat demand are urgently required.

71. Although the district heating area in Jinan has increased a lot, there are still many communities in Jinan urban area which are not connected to existing heating system of Jinan. Small coal fired boilers are used in these communities for heating. Based on Clean District Heating Pilot City Action Plan in Jinan (2017-2020), these small coal fired boilers will be dismantled before 2020. These communities will be connected to the existing heating system of Jinan in the future; removable and small equipment is a good choice.

72. Instead of a conventional large scale heating system, the component aims to provide district heating by deep-well geothermal energy, gas fired boilers, electric heat pumps and gas modular boilers. The component is more flexible allowing (i) the use of different clean and renewable energy sources; and (ii) after the communities are connected to district heating network, the boilers and heat pump units can be removed and used in other communities.

73. When compared to the equivalent production of heat generation through traditional coal-fired sources, once operational, the component will: (i) result in annual energy savings equivalent to 111,748 tce, thereby providing a global public good by avoiding the annual emission of 391,526.6 tons of CO_2; (ii) improve local air quality through the estimated annual reduction of emissions of SO_2 by 598.6 tons, NOx by 258.3 tons, and PM by 881.2 tons; and (iii) eliminate the negative impacts of coal transportation through urban areas by truck or train.

D. Project Scope

74. The components are summarized in **Table III-1**.

Table III-1: Project Components and Key Features

No.	Component	Characteristics and Special Features
1	Urban area part	Provide district heating to 5.5015 million m^2 by natural gas, heat pumps and deep-well geothermal energy. Build fifteen geothermal heating stations, two gas modular boiler stations, one ground source heat pump station and two air source heat pump stations. Install 6.57 km primary and 204.78 km secondary district heating pipeline network. Pipe diameters of primary pipeline network will be from DN 300 to DN 700. Pipe diameters of primary pipeline network will be from DN 80 to DN 500. Install one 42 MW gas fired boiler to replace the existing 58 MW coal fired boiler. Implement energy saving transformation for existing old residential buildings with an area of 660,400 m^2 through replacing thermal insulation material for the exterior walls and single-layer glass windows with double glazing.
2	Semi-urban area part	Provide district heating to 2.0134 million m^2 by natural gas and deep-well geothermal energy in ten towns.

No.	Component	Characteristics and Special Features
		Install 25.72 km primary and 75.46 km secondary district heating pipeline network. Pipe diameters of primary pipeline network will be from DN 200 to DN 700. Pipe diameters of secondary pipeline network will be from DN 80 to DN 400.
3	Rural area part	Provide heating to five new kindergartens with a heating area of 9,300 m^2 by air source heat pumps. Implement clean heating transformation for 80,000 households with a heating area of 4 million m^2 through replacing coal stoves by clean heating devices. Implement energy saving transformation for 30,000 households with an estimated area of 1.5 million m^2 by adding an insulation curtain to windows and insulation layers to roofs.
4	Water treatment system	Gas fired boilers will be installed with soften water equipment to produce make up water. The technology will be iron exchange resin.
5	Water supply system	Production water and domestic water will be both from municipal water system.
6	Water drainage system	Production wastewater and domestic wastewater will be discharged to the local municipal sewage pipeline network.
7	Power distribution equipment	All district heating system will be located at existing or new communities and will utilize local power transformers.

75. The component's heating area is presented in **Table III-2**.

Table III-2: Component's heating area with heating technology

No.	Location	Technology	Heating area (1,000 m^2)
1	Urban area	Deep-well Geothermal	2,285.7
		Air source heat pumps	15
		Shallow-ground source heat pumps	10
		Gas-fired boiler	2,748.3
		Gas modular boilers	442.5
		Subtotal	5,501.5
2	Semi-urban area	Deep-well Geothermal	1,694.9
		Gas modular boilers	318.5
		Subtotal	2,013.4

		Air source heat pumps for five kindergartens	9.3
		Air-to-air heat pumps	3,000
		Air-to-water heat pumps	500
3	Rural area	Gas heaters	50
		Carbon crystal plate radiators	150
		Heat-storage radiators	300
		Subtotal	4,009.3
		Total	11,524.2

76. Key parameters of the component are summarized in **Table III-3**.

Table III-3: Project Key Parameters

No.	Parameter	Unit	Value
1	Heat supply area	1,000 m^3	11,524.2
2	Energy saving transformation area of existing buildings or rural house	million m^2	2.160,400
3	Annual power consumption	GWh	298
4	Annual natural gas consumption	Million m^3	48.6
5	Annual standard coal savings	tons	111,747

E. Implementation Arrangements

77. SPG will be the EA and responsible for overall guidance during project preparation and implementation. JHG is the IA of the component. A PMO led by the Jinan Municipal Bureau of Housing and Urban-rural Development will be responsible for day-to-day management of the project.

F. Key Project Features

78. This component covers the urban area of Shanghe County, the semi-urban area of 11 towns and 80,000 rural households. The construction period of this component is 5 years. Shanghe County is endowed with rich geothermal resource. The component will use deep-well geothermal resource as the main heat source to replace coal-fired heat source. Other clean options, such as air-source heat pumps, are selected as distributed heating source where pipeline network is not available. Gas-fired boiler will be an auxiliary heat source. Furthermore, gas modular boiler is set to provide peak load heating.

79. Key features of the component are listed below:

1. Deep-well geothermal for urban and semi-urban areas

80. The component will develop several geothermal district heating systems for newly-built, reconstructed and expanded residential areas in urban and semi-urban areas. Ninety-eight geothermal wells will be drilled (49 producing wells and 49 disposal wells; 46 wells in urban area and 52 wells in semi-urban area) and 39 heat exchange stations will be built, covering heated area of 4,068,300 m^2. The ninety-eight geothermal wells will be located at existing HESs and new HESs, which will have a safety distance to near communities. All the geothermal wells will be connected to existing municipal sewers to discharge domestic wastewater and production wastewater. Emergency pumps will be installed for treatment of well blowout. There are no groundwater wells within 500 m from these geothermal wells that are used as water source. The component will not drill through any groundwater source protection zone.

81. Shanghe sources domestic water from Yellow River. Groundwater in urban and semi-urban areas is not used for drinking water and in rural area, it is used for agricultural water, e.g. irrigation. Therefore, no aquifer for drinking water will be affected by the component.

82. Based on the geothermal survey report for northern Shanghe county (average of three test wells with depth of over 1300 m), the chemical composition of the geothermal water is as follows:

Item	Content (mg/l)	Item	Content (mg/l)
Degree of mineralization	6731.24	Permanent hardness	420.33
pH	7.8	Temporary hardness	185.15
Total hardness	605.48	Total alkalinity	185.15
K+	16.25	Cl-	2708.38
Na+	2225.00	SO42-	1301.61
Ca2+	182.36	HCO3-	255.77
Mg2+	36.45	F-	1.12
NH4+	5.50	NO3-	<0.02
Fe3+	1.30	H2SiO3	40.40
Fe2+	<0.08	Soluble H2SiO3	27.50

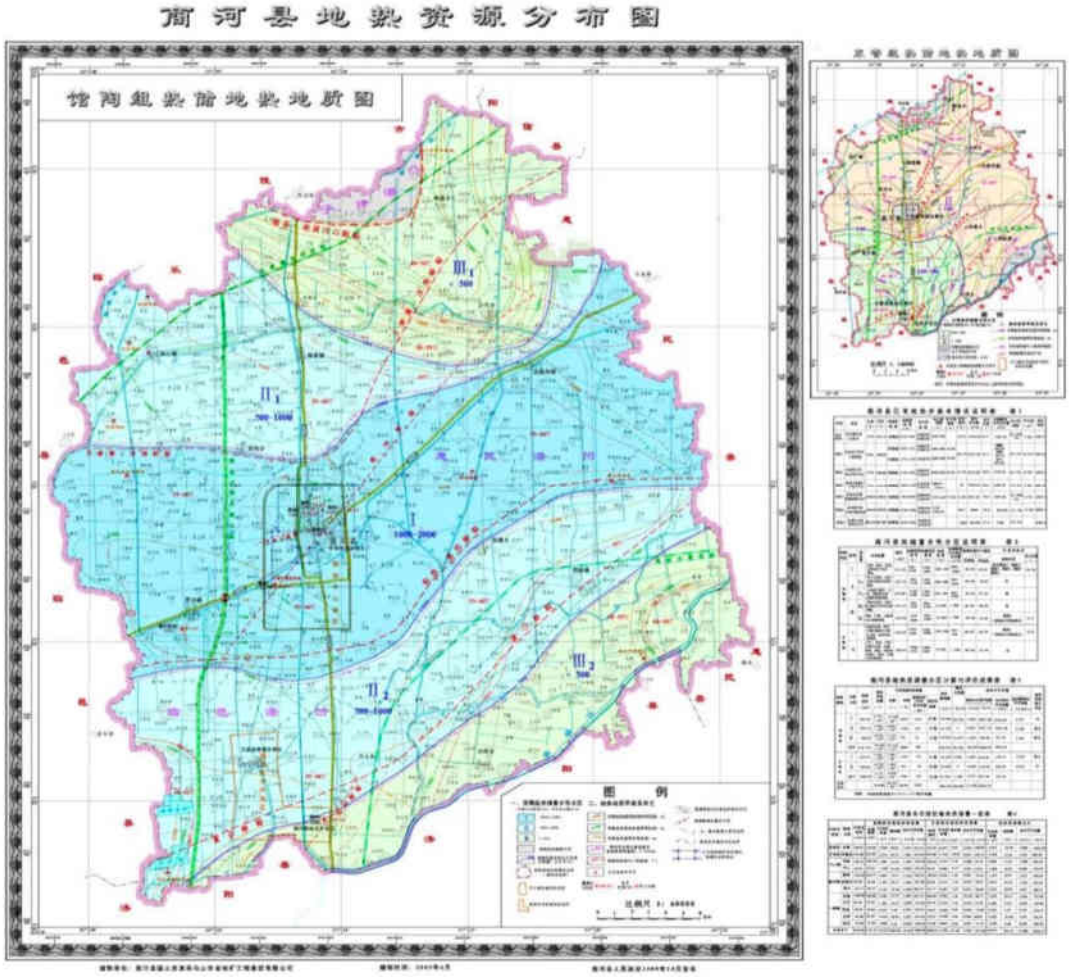
83. Main gases in the geothermal water are: CO_2 14.52 mg/l, H_2S 0.46 mg/l. Groundwater testing will be conducted for this component after drilling.

84. Well casing and pipes will be designed to avoid corrosion and leakage. Polyethylene of raised temperature resistance pipe will be used because it is a high temperature and corrosion resistance material and will be regularly changed to prevent potential leakage and corrosion of the pipes. Besides, to prevent potential leakage, sealing equipment such as expanding rubber sealing equipment will be installed to prevent groundwater at different strata to be mixed. An emergency water tank will be prepared for temporary storage of geothermal groundwater in case the injection well is blocked or leak happens due to flocculation or corrosion.

85. Shanghe's geothermal resource are generally located at the depth of 1,000–1,500 meters with water temperature of 48°C–60°C as shown in **Figure III-3**. The heating yield of a single well is about 500–2,000 m^3 per day based on the richness of underground water. The total exploitable

geothermal resource is about 29.871x10^{17}J, equivalent to 101.89 million tce, theoretically this is sufficient to supply the heating demand for the entire Shanghe.

Figure III-3: Geothermal Resource of Shanghe County



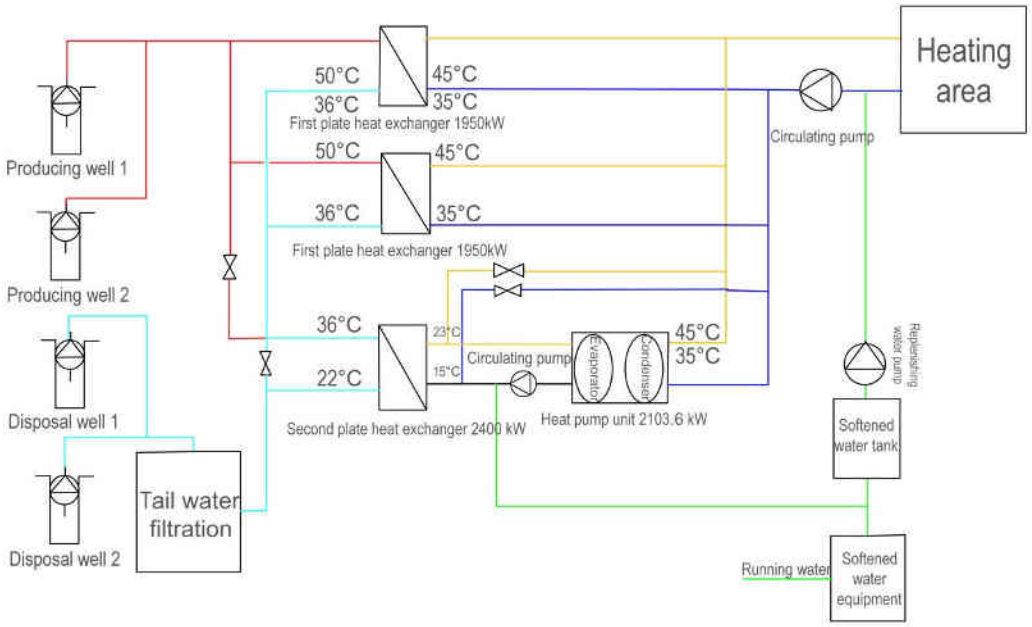
86. Shallow-ground source heating involves extracting geothermal energy from ground water at around 16°C, via heat exchange tubes buried at a depth of 80 – 120 meters, then using a heat pump to increase the temperature to around 50°C. The advantages of this technology are: (i) deep drilling technology is not necessary, and there is minimal impact on groundwater resources; (ii) the coefficient of performance (COP) of shallow-ground source heat pump is above 4, which is higher than those of air source heat pump or electric boiler, etc. (iii) detailed geothermal resource survey data is not necessary. However, this technology also has disadvantages, mainly is that multiple shallow wells may be needed to draw enough heat energy. Generally, the proportion of areas for buried tube against heating area is 1:3. Hence, it could not be used for large areas. Secondly, a large amount of electricity will still be consumed by the heat pump during the heating period. The power consumption is 39 kWh for heating per square meter per heating period (assuming 15 hours per day and 120 days per year). Thirdly, heating and cooling imbalance will lead to the decay of geothermal energy after long time of operation.

87. The other option, deep-well geothermal energy involves extracting ground water around 50°C–60°C at the depth of 1,000–2,000 meters, and heat exchanging via indirect counter current

heat exchangers for heat supply. The water extracted from ground will then be filtered and recharged back to the same level aquifer. The whole system consists of geothermal well, pump room and pipe networks, among those the water pump is the only energy-consuming equipment. Compared to shallow-ground source heat pump, deep-well geothermal energy has the tri-fold advantages of less land acquisition, stable heating and low maintenance cost. To make full use of the heat from ground water, heat pumps can be used to make the water to a higher temperature. However, the environmental risk of deep-well geothermal energy is the potential impact to underground water quantity and quality, so it is important to make sure that the extracted water is filtered and 100% recharged back. The ground water will be extracted and recharged in a closed system and no wastewater will be generated. Therefore, the component will not have impact to groundwater quantity and quality. Potential shallow-groundwater contamination will be minimized by using leak-proof well casing in the injection wells. Polyethylene of raised temperature resistance pipe will be used because it is a high temperature and corrosion resistance material and will be regularly changed to prevent potential leakage and corrosion of the pipes. Besides, to prevent potential leakage, sealing equipment such as expanding rubber sealing equipment will be installed to prevent groundwater at different strata to be mixed. Diameter of geothermal well is around 0.5 m and area of each geothermal well is around 0.2 m^2. The floor area of the geothermal station is 308 m^2 (22 m x 14 m).

88. Weighing between the two technologies explained above, the deep well geothermal energy can be used for direct district heating which is more efficient compared to shallow-ground geothermal energy, thus the component is to adopt deep well geothermal energy technology for district heating. Flow chart of the component is presented in **Figure III-6**. Running water is utilized as make up water of the secondary heating pipeline network.

Figure III-4: Water Recharge Flow Chart



2. Shallow-ground source heating and cooling in urban area

89. There are several commercial buildings with floor areas of 10,000 m^2 without heat network coverage in the urban area. These buildings need heating in winter and cooling in summer. It is

not financially viable if deep-well geothermal is used only for such small areas. Shallow-ground source heat pumps are selected to supply heat and cooling to these buildings. Following the heating or cooling load design standards for public buildings (GB50189-2015), assume the cooling load index is 70W/m^2 and heating load index is 50W/ m^2, and the cooling demand of those buildings is about 441 MWh,[8] and the heating demand is about 588MWh.[9] According to the working condition in summer, the length of the drilling holes for ground heat exchanger is designed to be 12,000-meter total (U-type heat exchanger and 80-100 meters per hole). This component plans to install an 116kW ground source heat pump and two variable frequency pumps (one as backup). Locations of these pumps is shown in **Table III-6.** Diameter of the pipe for ground source pump is 0.2m and the floor area of the ground source pump station is 65 m^2 (13 m x 5 m). The total electricity consumption of the ground source heat pumps is 126.24kW (without backup). If the system runs at a full load which will consume a total of 325,699 kWh per year (113,616 kWh in winter and 212,083 kWh in summer).

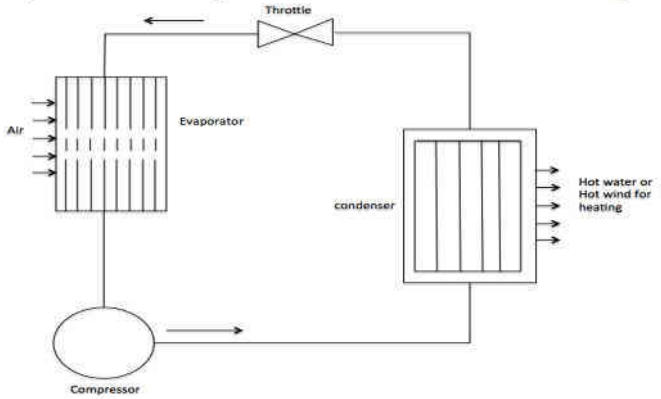
3. Heat pump

90. A heat pump is a device that absorbs heat from a source at low temperature, increases the temperature of the transferring medium containing this heat by consuming a relatively smaller amount of external high-quality energy, and then releases that heat at a higher temperature than the source. Thus, heat pumps move thermal energy in the opposite direction of spontaneous heat transfer, by absorbing heat from a colder space and releasing it to a warmer one, in the process consuming small amount of energy. This is similar in principle to an air-conditioner or refrigerator but operated in reverse to achieve heating instead of cooling.

91. Based on the different heat sources, heat pumps are classified into three types:

(i) Air source heat pump. This technology utilizes an air source to obtain low-temperature heat. Through the condenser or evaporator from traditional air conditioning equipment, the heat is extracted or released by/from the air by heat exchange. The energy is then transferred into the building by a circulation system to meet residents' demands for hot water and space heating. The air source heat pump working principle diagram is shown in **Figure III-5**.

Figure III-5: Diagram of Air Source Heat Pump



[8] Cooling period is 90 days annually and 10 hours a day. The heating area is 7,000 m^2.
[9] Heating period is 120 days annually and 14 hours a day. The heating area is 7,000 m^2.

(ii) **Water source heat pump.** The working principle of this technology is similar to an air source heat pump, except that it obtains heat from a water body such as sewage plant, lake, and industrial process water etc. A water source heat pump pushes working fluid through the piping network and this fluid absorbs the heat from the surrounding water as it goes. This allows much larger amounts of heat to be carried than the air flow through a given pipe or duct with same cross-section. This working fluid is then compressed by an electric compressor to raise the temperature. A heat exchanger can then be used at the other end to exchange heat from the working fluid, for space heating, water heating and other applications.

(iii) **Ground source heat pump.** This technology uses shallow-ground heat exchangers as a heat source or sink. Ground source heat pumps work in the same manner as other heat pumps, but exchange heat with the ground and boost it to a higher temperature using air source/water source heat pump. This heat is then used to provide heating or hot water. Ground source heat pumps are simple and often more reliable than air source heat pumps as they do not need fan or defrosting systems and can be installed inside of a building. Although a ground heat exchanger requires a higher investment cost, but the annual operational cost is lower for ground source heat pump as its efficiency is higher than the air source heat pump.

92. Essentially, the heat pump performs the same role as a boiler does in a district heating system, but transports ambient heat from air, water or the ground, rather than burning fuel to provide heat to the users. The heat pump can be driven by electricity, steam/hot water or natural gas. Electricity driven heat pumps are used widely. The steam/hot water driven heat pumps work in the same way as steam turbine. If a cheap steam/hot water available, it is a good option to adopt.

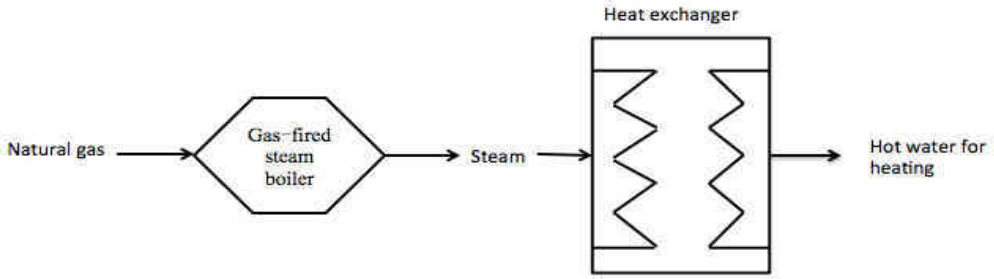
93. The air source heat pump is selected as the heat source of the building in the area where the heating pipeline network is not covered, and the geothermal resources are difficult to reach. R32 will be used in the system as a refrigerant which is not an ozone depleting substance, and it is not on ADB's Prohibited Investment Activities List (PIAL). This component has a heating area of 15,000 m^2 in the urban area and by using air source heat pumps. It will install 3×41kW heat pump units in Shanghe detention house located at north of Hongye Road and 5×19kW heat pump units in Shanghe No.6 kindergarten with a total capacity of 221.37kW. If the system runs at full load which will consume a total of 442,773 kWh per heating season.[10]

4. Gas-fired boiler to replace coal-fired boiler in the urban area

94. Although gas-fired boiler is a conventional technology, its advantages of high combustion efficiency, low emission, low maintenance cost and easy to control make it a favorable option to many heat suppliers. Due to the availability of deep-well geothermal heating, not all coal-fired boilers can be replaced by geothermal heating in the urban area, especially during peak time. This component plans to build a 42 MW gas-fired boiler as an auxiliary heat source for the deep-well geothermal heating. With this design, the entire urban area of Shanghe County can replace the coal-fired heating. The working principle of gas-fired boiler is as follows:

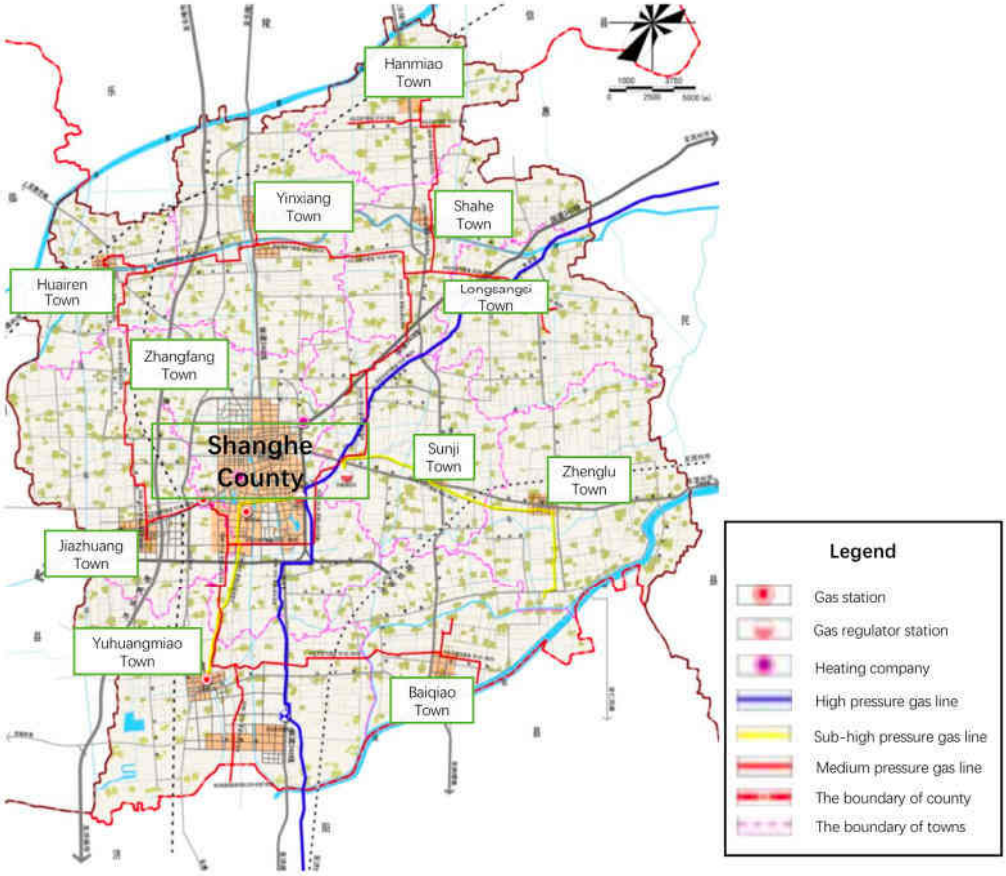
[10] In Shanghe, heating period is 120 days annually. In calculation, assume heating is supplied 24hrs a day in Shanghe detention house. In kindergartens, heating period is 90 days annually (winter vacation is 30 days). And assume heating is supplied 10hrs a day.

Figure III-6: Working Principle of Gas-fired Boiler



95. Shanghe has some advantages for using natural gas: (i) the national 'west to east gas pipeline has built a gate station at Shanghe with the supply capacity of 400,000 m^3 per day; (ii) Shanghe has two oil & gas fields with the gas reserves of 1.2 billion m^3. The gas pipeline has covered not only the urban area, but also some semi-urban areas that makes the natural gas an easy access. The layout of gas pipeline is shown in **Figure III-7**.

Figure III-7: Gas Pipelines of Shanghe



5. Gas modular boiler for urban area and Yuhuangmiao town

96. Gas modular boilers (2.2MW each as shown in **Figure III-8**) are designed as an alternative heating source to large single boilers. This component plans to build gas modular boilers as auxiliary heat sources for deep-well geothermal heating to supply heat to 761,000 m^2 of floor areas where are covered by the heating pipelines. The advantages of gas modular boiler are as follows: (i) Gas modular boiler is compact, so it is easier to transport and handle compared to the gas-fired boilers, (ii) Gas modular boiler can save more space than large boilers because of the small size, (iii) Gas modular boiler is very efficient and clean, (iv) It is easy to manage the heating output based on the heating load. The gas modular boilers are the main heat source in two regions where the geothermal sources are difficult to reach. The details for gas modular boiler installation are listed in **Table III-4**. It is estimated that the gas consumption of the gas modular boilers for a heating season is about 10.2 million m^3.[11]

Table III-4: Installation plan of gas modular boilers

Name	Total heating area (m^2)	Heat supplied by geothermal (m^2)	Number of geothermal wells	Heat supplied by gas modular boiler (m^2)	Number of gas modular boilers	Stack height (m)
37° N No. 5 Plots	140,000	0	0	140,000	3	15
37° N No. 4 Plots	128,000	87,700	2	40,300	1	12
37° N No. 2 Plots	265,000	175,400	4	89,600	2	15
37° N No. 1 Plots	232,000	175,400	4	56,600	2	15
37° N School and residential buildings	116,000	0	0	116,000	3	15
Yuyuan Community	163,000	83,000	2	80,000	2	15
Yudong South Plot	180,000	100,000	2	80,000	2	15
Kaiwen professional school East Plot	90,000	50,000	2	40,000	1	15
Kaiwen professional school West Plot	90,000	50,000	2	40,000	1	15
Apartment for government	180,200	101,70	2	78.5	2	15
Total	1,584,000	823,000	20	761,000	19	NA

[11] The heating area of gas modular boilers is 761,000 ㎡. Heating period is 120 days annually and 24hrs a day. The heat indicator is 45W/m^2. The heat value of natural gas is 85,00kcal/m^3. Based on these parameters, natural gas consumed by gas modular boilers is 10.2 million m^3 in a heating season.

Figure III-8: Installation Instruction of Gas Modular Boiler

6. Building efficiency improvement in urban area

97. This component plans to retrofit total 660,400 m^2 of buildings to improve their energy efficiency. The measures adopted include (i) replacing thermal insulation materials for the exterior walls, and (ii) replacing single-layer glass windows with double glazing. After the retrofitting, the heating demands for these building could decrease from 45W to 38W per m^2 per season. After completing this component, the heating load of urban area will reduce by 4.6228 MW.

7. Building efficiency improvement in rural area

98. This component plans to retrofit totally 1.5 million m^2 of houses with 30,000 rural households. Measures include adding an insulation curtain (**Figure III-9**) to windows and adding roof insulation layer (**Figure III-10**). The thermal insulation curtain made of plastic with an air interlayer, which has the characteristics of heat preservation, waterproof, and dustproof. In the meantime, the curtain is translucent and it will not affect daytime lighting. The roof insulation will use expended perlite or expended vermiculite to form an insulation layer. The expanded perlite is suitable for dry regions in the northern PRC as it will reduce the heat radiation.

Figure III-9: Insulation Curtain

Figure III-10: Roof Insulation Layer

8. Cleaning Heating in rural area

99. With the rural power grid retrofitting project implemented nationwide, the reliability of electricity supply has drastically improved in the rural areas of the PRC, which allows electricity an option for heating to replace raw coal burning in the rural areas. In Shanghe the reliability of electricity supply reached 99.9394% (data of 2016). The integrated distribution loss of 110kV and below is about 7.6%. The distribution loss of 10kV and below is 3.7%. Every household installed a meter to measure its consumption. The average capacity per household is 1.80kVA.

100. A survey shows that the rural residents consume about 1.5-ton raw coal per household per winter. Factors to be consider when design clean heating systems for rural residents are: (i) low investment and operational cost, and (ii) easy to operate and maintain. People prefer a heating system with the following functions: (i) generating heat very fast that can increase indoor temperature rapidly and allowing frequent switches, (ii) separate control by rooms -when heating is needed in a specific room, it can be switched off. The component plans to install 7×19kW air source heat pumps and a 1×20.5kW air source heat pump for five kindergartens in the rural areas. If the system runs at a full load, it will consume a total of 141,165 kWh per heating season.[12] Options for the 80,000 rural households mainly rely on their own choices. There are about 1,000 households have access to the gas pipeline. These households can opt to install small household gas heaters to reduce their investment cost and get hot water supply at the same time. The local

[12] In kindergartens, heating period is 90 days annually (winter vacation is 30 days). And assume heating is supplied 10hrs a day.

government will use public budget to install electric heaters for another 9,000 low-income households. Of this, 6,000 households will install heat-storage radiators (**Figure III-11**) which can take the advantages of time-of-use (TOU) tariff and shaving the power load. The heat-storage radiators keep the heat generated from the electricity in a special material. They only operate 6-8 hours during midnight and heat supply could last 24 hours per day. The remaining 3,000 households will install carbon crystal plate radiators (**Figure III-12**). The carbon crystal plate is a new type of electric heater which has 98% of electricity to heat efficiency. It generates heat in 5 minutes after turning on. This option is good for the households who have no TOU tariff scheme. The component will also install air-to-air heat pumps (**Figure III-13**) for 60,000 rural households and air-to-water heat pumps (**Figure III-14**) for 10,000 rural households.

101. **Table III-5** compares the features of these two types of heat pump. All systems installed must comply with the national standards.[13] **Table III-6** summarizes the main features of each system.

Figure III-11: Heat-storage Radiator

[13] Rural household air source heat pump should meet with the Standard for Air Source Heat Pump (cold water) in Low Temperature (GB/T25127.2-2010); household wall-mounted gas heaters should meet with the Standard for Gas Heater Hot Water Boiler (GB/T25034-2010).

Figure III-12: Carbon Crystal Plate Radiators

Figure III-13: Air-to-air Pump

Figure III-14: Air-to-water Heat Pump

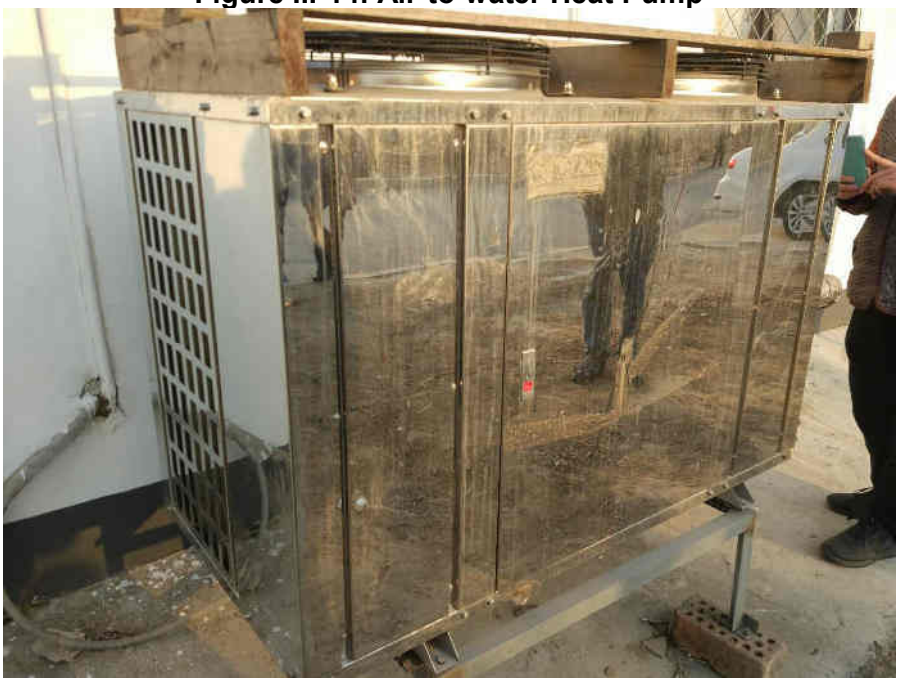


Table III-5: The comparison between air to air and air to water heat pump

Type	Air to air heat pump	Air to water heat pump
Transmission medium	R32 (not ozone depleting substance, not in the PIAL)	Hot water
Transmission tube materials	Copper	Steel or plastic
Terminal devices	Fan coil	Fan coil, radiator, or under floor heating
Advantages	This system provides heat in winter and cooling in summer, with low operating costs and a high efficiency. In the meantime, it doesn't need water tank, nor pumps	This system provides a level of environmental comfort, and ensures the temperature for multiple rooms
Disadvantages	This system can only ensure the temperature for one room	This system needs water tank and pumps. At the meantime, it has low efficiency and high cost
Unit price	CNY 6,500 (with terminal device)	CNY 12,000 (without terminal device)
Applicability	The household that doesn't have radiator and have less heating demand	The household that have radiators

Source: Technical due diligence report, 2018.

Table III-6: Main features of all heating equipment

Types	Outdoor design temperature (°C)	Water inlet temperature/ Water outlet temperature (°C)	Rated heating output (kW)	Heating input power (kW)	Energy efficiency (COP)	Noise	Gas consumption (m³/h)	Thermal efficiency	Input Voltage	Number of house holds
Air-to - air heat pumps	-12	—	4	1.81	2.2	<40 dB	—	—	—	60,000
Air-to-water heat pumps	-12	50/60	5.2	3.4	1.53	<40 dB	—	—	—	10,000
Gas heater	—	50/60	16	0.11	—	<40 dB	0.427	>90%	—	1000
Carbon crystal electric heating plate	—	—	0.8	0.82	—	—	—	>98%	220 V	3000
Electric radiator	—	—	3.2	3.27	—	—	—	>98%	220 V	6000

Source: Technical due diligence report, 2018.

9. Drilling fluid

102. In geotechnical engineering, drilling fluid is used to aid the drilling of boreholes into the earth. Often used while drilling oil and natural gas wells and on exploration drilling rigs, drilling fluids are also used for much simpler boreholes, such as water wells. The main functions of drilling fluids include providing hydrostatic pressure to prevent formation fluids from entering into the well bore, keeping the drill bit cool and clean during drilling, carrying out drill cuttings, and suspending the drill cuttings while drilling is paused and when the drilling assembly is brought in and out of the hole.

103. Drilling fluids employed during drilling activities may be water- or oil-based and may contain chemical additives to assist in controlling pressure differentials in the drill hole and to act against viscosity breakdown.

104. Compared to water-based fluid, oil-based fluid will contaminate areas of freshwater aquifers causing environmental damage and cuttings from oil-based mud are of particular concern due to the content of oil-related contaminants and may necessitate special on-site or off-site treatment in an appropriate place to isolate possible environmental contamination.

105. Oil-based fluids are expensive but are worth the cost when drilling through: (i) troublesome shales that would otherwise swell and disperse in water-based mud e.g. smectite, (ii) to drill deep, high-temperature holes that dehydrate water-based mud; (iii) to drill water-soluble zones; and (iv) to drill producing zones. There is no such area near the component site.

106. The wells of the component will be 1,000-1,500 m in depth and the temperature of ground water is around 60°C, water-based drilling will be utilized based on technical specification for geothermal well construction (DB 13/T 2571-2017) because: (i) the geothermal at the component site is stored at sandstone reservoir which will have a stable wall during drilling; and (ii) the component will use high-pressure jet drilling technology and will use high speed (75-100 m/s) fluid (water) to increase the drilling speed and clean the well and drilling pit. Water is a suitable fluid for this technology because water can help to remove the sand and slurry generated during drilling. There will be no chemicals added during the drilling process.

107. During drilling H_2S monitoring will be installed. If the level is over 5 ppm, the will be sealed and shut down. Before the drilling activities start, drilling fluid circulation system with sand and slurry removal equipment and safety system will be installed.

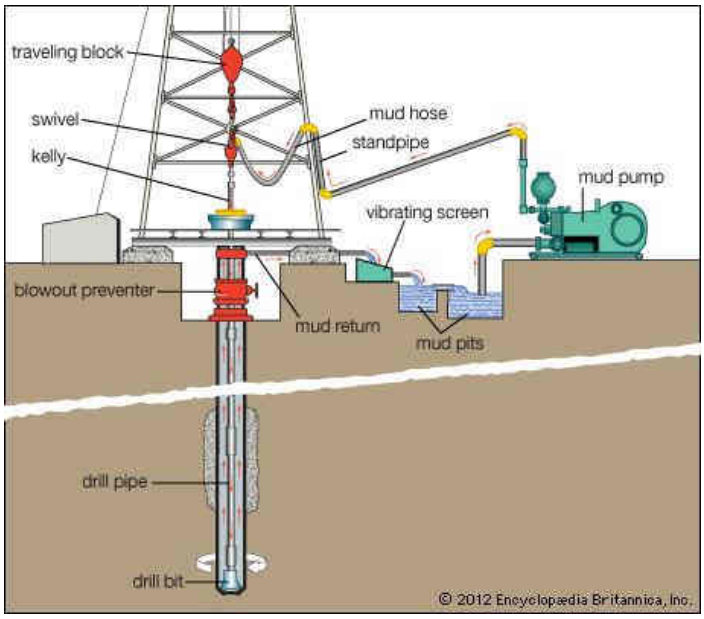
108. When drilling starts, drilling fluid circulation system will be filled up with water. After drilling pipe is pulled out for 3-5 times, the system will be filled up with water again. During drilling, slurry and cuttings will be generated. Wastewater and cuttings will be collected and toxicity assessment will be conducted. Cuttings will be reused if they are non-toxic (e.g. as construction fill) or disposed of in a landfill facility and wastewater will be discharged to municipal sewer system. If toxicity is found, cutting and wastewater will be transported for treatment by a certified company. The mud pits shown in **Figure III-15** will be lined to prevent soil and groundwater contamination.

109. The drilling speed will be controlled. If there is any accident occurs during the drilling, drilling will be stopped immediately and action plans will be implemented.

110. After the drilling is finished, the parameters of the well including water flow, temperature, depth, deflection will be monitored. Then the pipelines will be installed inside the well.

111. Slurry and cutting will be collected by drilling company. After sedimentation, wastewater will be discharged to municipal sewer following the PRC standards. Rocks and sludge will be disposed at a certified landfill site after drying.

Figure III-15: Drilling equipment



G. Component Design Details

1. District heating in urban area

112. The detailed district heating information in urban area of Shanghe is presented in **Table III-7**. Secondary pipeline information is presented in **Table III-8**.

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Table III-7: District heating information in urban area of Shanghe

Name of region	Total heating area (1,000 m^2)	Heat supplied by geothermal (1,000 m^2)	Numbers of geothermal well drilled	Heat supplied by gas modular boiler (m^2)	Numbers of gas modular boilers installed	Heat supplied by existing district heating system (1,000 m^2)	Heat supplied by heat pumps (1,000 m^2)
Rainbow Community	77.7	77.7	2	0	0	0	0
Xicheng Middle School	80.9	0	0	0	0	80.9	0
Lvdi Baihe Community	255.5	0	0	0	0	255.5	0
37 ° N No. 3 Plot	170	170	4	0	0	0	0
37 ° N No. 5 Plot	140	0	0	140	3	0	0
Shanghe activity center	43	24.2	2	0	0	18.8	0
Banjia Community	171.6	171.6	4	0	0	0	0
Xisanli West Plot	223.8	175.4	4	0	0	48.4	0
Xisanli East Plot	223.8	175.4	0	0	0	48.4	0
37 ° N No. 4 Plot	128	87.7	2	40.3	1	0	0
Minghui Community	62.7	0	0	0	0	62.7	0
Zhuangyuan Fudi	106.1	87.7	2	0	0	18.4	0
Shuian Garden	207.5	175.4	4	0	0	32.1	0
Supang Community	79.2	0	0	0	0	79.2	0
Douhe Community	70.7	0	0	0	0	70.7	0

Name of region	Total heating area (1,000 m^2)	Heat supplied by geothermal (1,000 m^2)	Numbers of geothermal well drilled	Heat supplied by gas modular boiler (m^2)	Numbers of gas modular boilers installed	Heat supplied by existing district heating system (1,000 m^2)	Heat supplied by heat pumps (1,000 m^2)
East Phoenix City	66.3	0	0	0	0	66.3	0
Xiyanghong Community	65.4	0	0	0	0	65.4	0
37 ° N No. 2 Plot	265	175.4	4	89.6	2	0	0
37 ° N No. 1 Plot	232	175.4	4	56.6	2	0	0
37 ° N School and residential buildings	116	0	0	116	3	0	0
Mengyu Community	153.6	0	0	0	0	153.6	0
Zhangzhao Community	97.4	0	0	0	0	97.4	0
Dongsanli East Plot	248.9	175.4	4	0	0	73.5	0
Dongsanli West Plot	248.9	0	0	0	0	248.9	0
Youfang West Plot	175.9	175.9	4	0	0	0	0
Youfang East Plot	175.9	0	0	0	0	175.9	0
Yiyang East Plot	248.5	0	0	0	0	248.5	0
Yiyang West Plot	248.5	87.7	2	0	0	160.8	0
Yinqiao North Plot	166.5	0	0	0	0	166.5	0
Yinqiao South Plot	249.7	175.4	4	0	0	74.3	0
Jixiechang North Plot	338.8	0	0	0	0	338.8	0

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Jixiechang South Plot	338.8	175.4	4	0	0	163.4	0
Shanghe detention house	9	0	0	0	0	0	9
Wenquan Guoji	10	0	0	0	0	0	10
Shanghe No.6 kindergarten	6	0	0	0	0	0	6
Total	5501.6	2285.7	50	442.5	11	2748.4	25

Source: FSR report, 2018.

Table III-8: Secondary pipeline information in urban area of Shanghe

Community name	Length (m)										
	DN500	N450	DN400	N350	N300	DN250	DN200	DN150	DN12	DN100	DN8
Rainbow Community	0	0	0	0	155	117	513	311	490	233	1,189
Xicheng Middle School	0	0	0	202.25	162	121	534	324	510	243	1,238
Lvdi Baihe Community	0	0	306.6	638.75	511	383	1,686	1,022	1,610	767	3,909
37 ° N No. 3 Plot	0	0	204	425	340	255	1,122	680	1,071	510	2,601
37 ° N No. 5 Plot	0	0	168	350	280	210	924	560	882	420	2,142
Shanghe activity center	0	0	0	0	0	65	284	172	271	129	658
Banjia Community	0	0	205.92	429	343	257	1,133	686	1,081	515	2,625
Xisanli West Plot	0	0	268.52	559.43	448	336	1,477	895	1,410	671	3,424
Xisanli East Plot	0	0	268.52	559.43	448	336	1,477	895	1,410	671	3,424
37 ° N No. 4 Plot	0	0	0	320	256	192	845	512	806	384	1,958
Minghui Community	0	0	0	0	0	94	414	251	395	188	959
Zhuangyuan Fudi	0	0	0	265.25	212	159	700	424	668	318	1,623
Shuian Garden	0	0	0	518.75	415	311	1,370	830	1,307	623	3,175
Supang Community	0	0	0	0	0	119	523	317	499	238	1,212
Douhe Community	0	0	0	0	0	106	467	283	445	212	1,082
East Phoenix City	0	0	0	0	0	99	438	265	418	199	1,014
Xiyanghong Community	0	0	0	0	0	98	432	262	412	196	1,001
37 ° N No. 2 Plot	265	397.5	318	662.5	530	398	1,749	1,060	1,670	795	4,055

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37 ° N No. 1 Plot	232	348	278.4	580	464	348	1,531	928	1,462	696	3,550
37 ° N School and residential buildings	0	0	0	290	232	174	766	464	731	348	1,775
Mengyu Community	0	0	0	384	307	230	1,014	614	968	461	2,350
Zhangzhao Community	0	0	0	0	195	146	643	390	614	292	1,490
Dongsanli East Plot	0	373.31	298.64	622.18	498	373	1,643	995	1,568	747	3,808
Dongsanli West Plot	0	373.31	298.64	622.18	498	373	1,643	995	1,568	747	3,808
Youfang West Plot	0	0	211.13	439.85	352	264	1,161	704	1,108	528	2,692
Youfang East Plot	0	0	211.13	439.85	352	264	1,161	704	1,108	528	2,692
Yiyang East Plot	0	372.75	298.2	621.25	497	373	1,640	994	1,566	746	3,802
Yiyang West Plot	0	372.75	298.2	621.25	497	373	1,640	994	1,566	746	3,802
Yinqiao North Plot	0	0	0	416.15	333	250	1,099	666	1,049	499	2,547
Yinqiao South Plot	0	374.54	299.63	624.23	499	375	1,648	999	1,573	749	3,820
Jixiechang North Plot	338.8	508.2	406.56	847	678	508	2,236	1,355	2,134	1,016	5,184
Jixiechang South Plot	338.8	508.2	406.56	847	678	508	2,236	1,355	2,134	1,016	5,184
Total	1,174.6	3,628.56	4,746.65	12,285.3	10,180	8,215	36,149	21,906	34,504	16,431	83,793

Source: FSR report, 2018.

113. Locations of the communities are presented in **Figure III-16**.

Figure III-16: Locations of the communities

Source: FSR report, 2018.

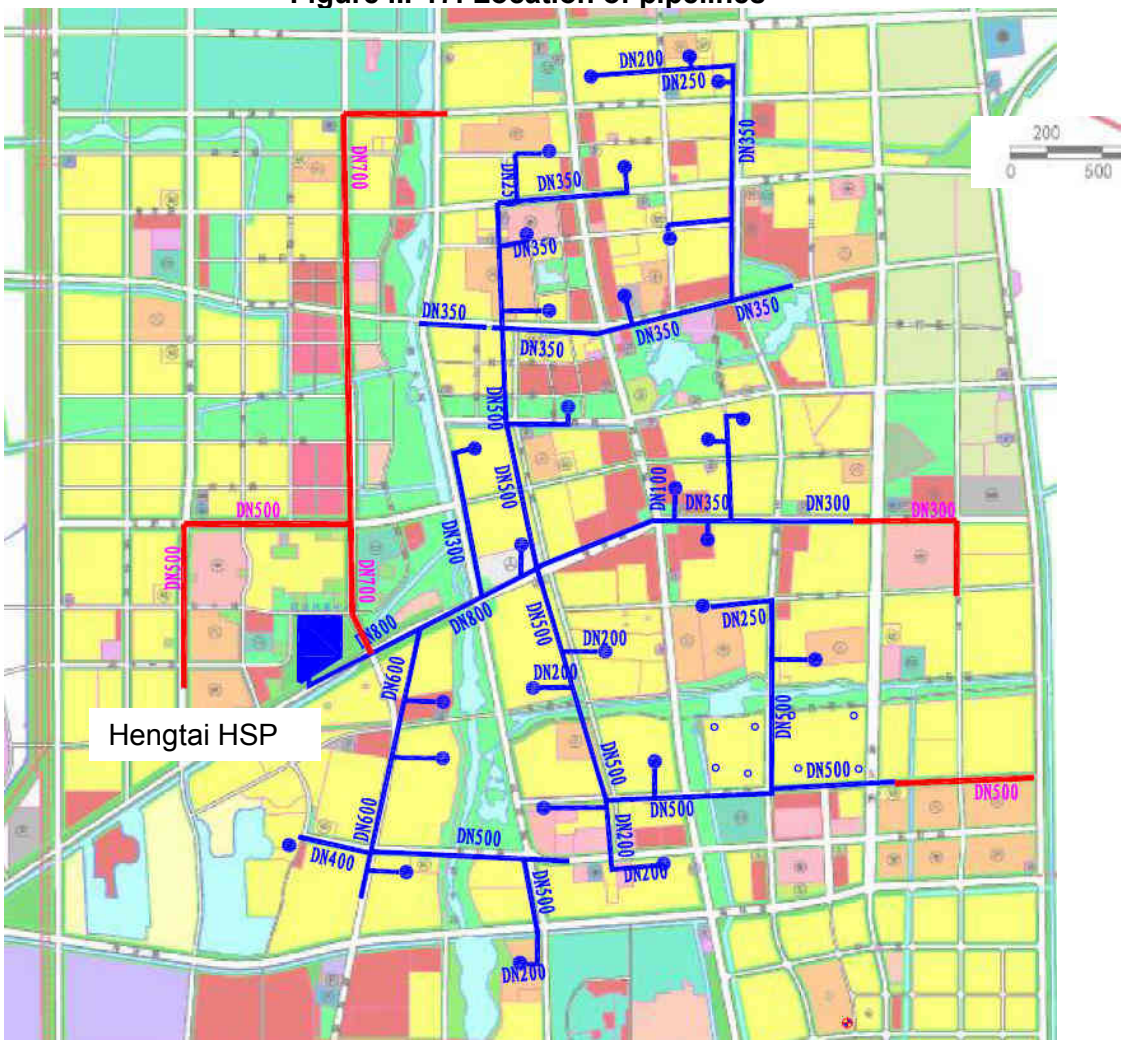
114. Primary pipeline information is presented in **Table III-9**. Locations of the pipelines are presented in **Figure III-17**.

Table III-9: Primary pipeline information in urban area of Shanghe

No.	Location	Nominal diameter (m)	Length (km)
1	Shanghe Road (from Yinhe Road to Xinyuan Road)	DN 700	2.75
2	Xinyuan Road (from Shangxi Road to Binhe Road)	DN 700	0.53
3	Baoyuan Street (from Shangxi Road to Sujia Road)	DN 500	0.84
4	Sujia Road (from Baoyuan Road to Sujia Road)	DN 500	0.83
5	Yinhe Road (from Shangdong Road to Renmin Road)	DN 300	0.52
6	Renmin Road (from Yinhe Road to Hongde Street)	DN 300	0.40
7	Huayuan Street (from Shangdong Road to Donghuan Road)	DN 500	0.70
	Total		6.57

Source: FSR report, 2018.

Figure III-17: Location of pipelines



Note: Redline is the new primary heating pipeline; blue line the existing pipeline.

Source: Domestic FSR, 2018.

115. The component will install one 42 MW gas fired boiler to replace the existing 58 MW coal fired boiler in Shanghe Hengtai Heat Source Plant (HSP). There will be another two 42 MW gas fired boilers to be installed at Hengtai HSP in the future with no timeframe confirmed, which are neither ADB financing nor part of the Project. All the three 42 MW gas fired boilers will be installed at reserved land of the existing Hengtai HSP. After the component is under operation, the existing 58 MW coal fired boiler will be stopped and used as stand by heat source which will operate only during extreme cold weather. Location of the Hengtai HSP is presented in **Figure III-17**.

2. District heating in urban area

116. The detailed district heating information in semi-urban area of Shanghe is presented in **Table III-10**. Detailed pipeline information is presented in **Table III-11**.

117. The locations of the pipelines and energy stations are presented from **Figure III-18** to **Figure III-27** .

Table III-10: District heating information in semi-urban area of Shanghe

No.	Name of town	Location	Heating area (1,000 m^2)	Heating area by geothermal (1,000 m^2)	Numbers of geothermal wells	Heating area by gas modular boilers (1,000 m^2)	Numbers of gas modular boilers
1	Yuhuangmiao Town	Yuyuan Community	163	83	2	80	2
		Yudong South Plot	180	100	2	80	2
		Yudong North Plot	87.7	87.7	2	0	0
		Kaiwen professional school East Plot	90	50	2	40	1
		Kaiwen professional school West Plot	90	50	2	40	1
		Apartment for government	180.2	101.7	2	78.5	2
2	Yinxiang Town	Zhaokuiyuan Community and surroundings	80	80	2	0	0
		Urban area	63.7	63.7	2	0	0
		Shangye Community and surroundings	87.7	87.7	2	0	0
3	Huairen Town	East urban area	63.7	63.7	2	0	0
4	Zhenglu Town	Linhai Huayuan and surroundings	175.4	175.4	4	0	0
		Urban area	63.7	63.7	2	0	0
5	Jiazhuang Town	Urban area	63.7	63.7	2	0	0
		Fudu Community	175.4	175.4	6	0	0
		Jiazhuang Baize Community	63.7	63.7	2	0	0
6	Baiqiao Town	Urban area	55.7	55.7	2	0	0

No.	Name of town	Location	Heating area (1,000 m^2)	Heating area by geothermal (1,000 m^2)	Numbers of geothermal wells	Heating area by gas modular boilers (1,000 m^2)	Numbers of gas modular boilers
		Yueqiao Community and surroundings	24	24	2	0	0
7	Sunji Town	Sunji Community and surroundings	63.7	63.7	2	0	0
		Niupu Community and surroundings	30	30	2	0	0
8	Hanmiao Town	Urban area	55.7	55.7	2	0	0
9	Shahe Town	Shahe Community and surroundings	76.7	76.7	2	0	0
		Urban area	55.7	55.7	2	0	0
10	Zhangfang Town	Urban area	24	24	2	0	0
Total			2013.4	1694.9	52	318.5	8

Source: FSR report, 2018.

Table III-11: District pipeline information in semi-urban area of Shanghe

No.	Name of town	Length of primary pipeline (m)	Length of secondary pipeline (m)
1	Yuhuangmiao Town	0	66,838
2	Yinxiang Town	3,744	3,614
3	Huairen Town	2,100	0
4	Zhenglu Town	4,350	0
5	Jiazhuang Town	2,200	2,624
6	Baiqiao Town	2,570	0
7	Sunji Town	3,680	0
8	Hanmiao Town	2,711	0
9	Shahe Town	2,550	6,239
10	Zhangfang Town	1,820	0
	Total	25,725	79,315

Source: FSR report, 2018.

Figure III-18: Location of pipelines and stations in Yuhuangmiao Town.

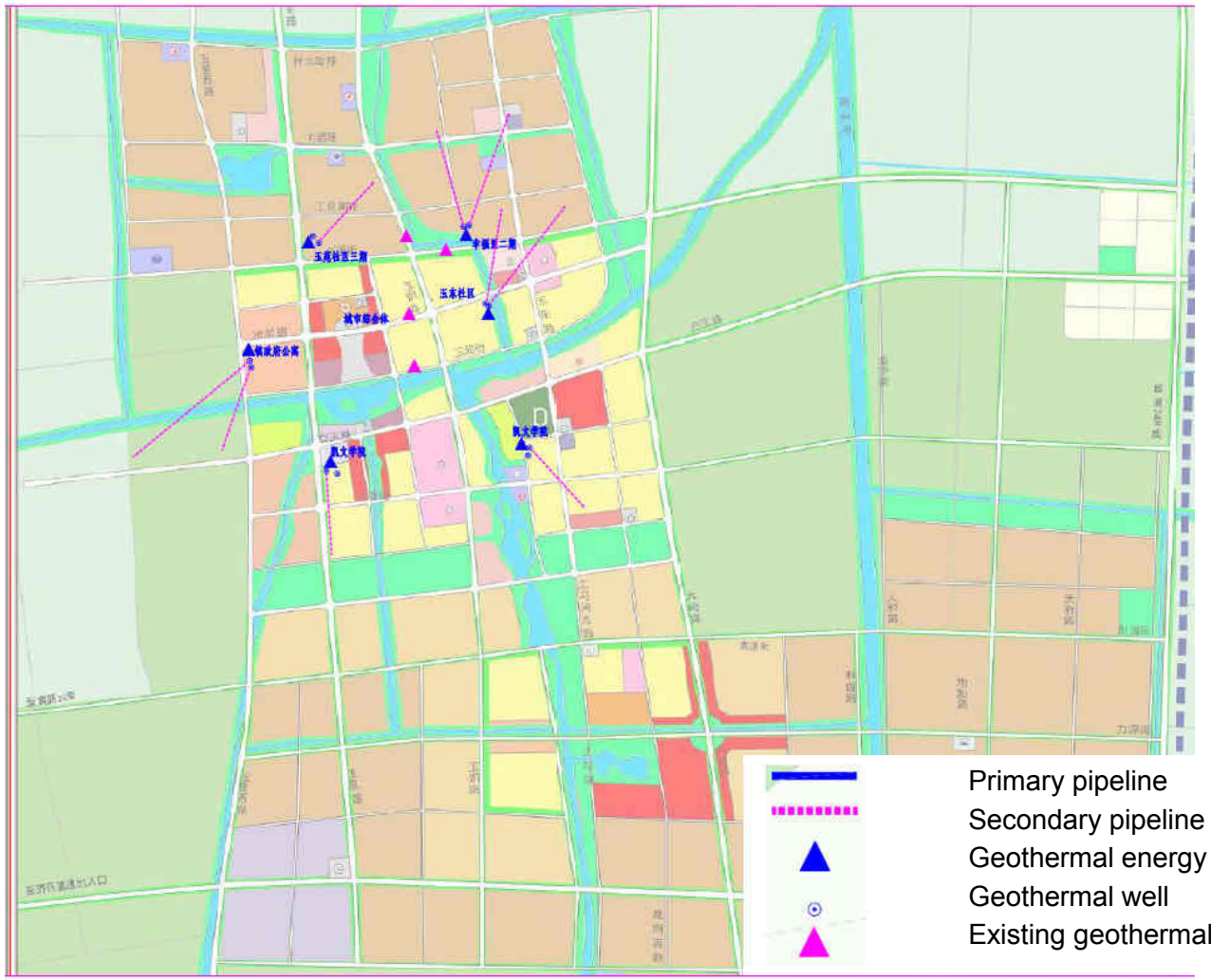


Figure III-19: Location of pipelines and stations in Yinxiang Town

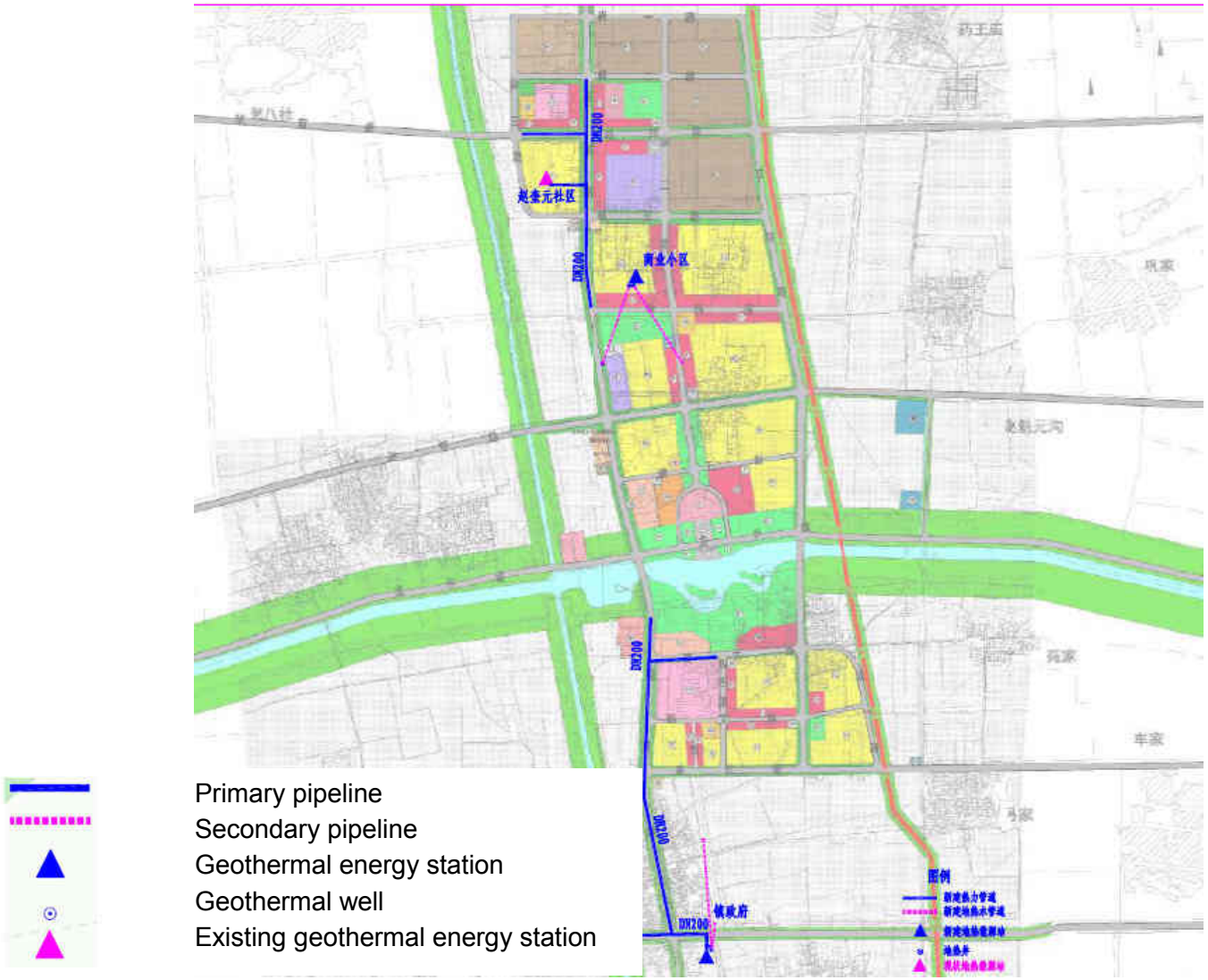


Figure III-20: Location of pipelines and stations in Huairen Town

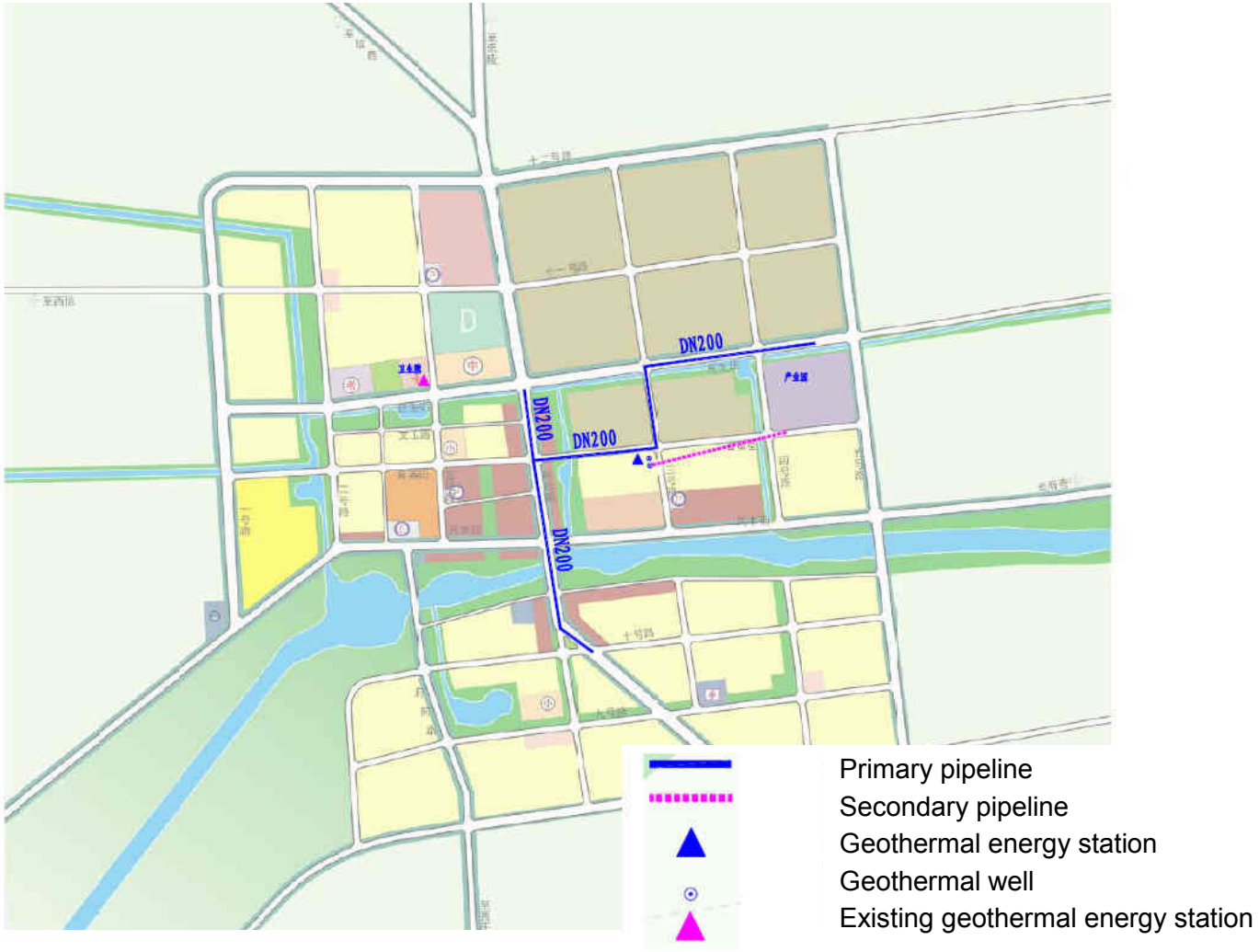


Figure III-21: Location of pipelines and stations in Zhenglu Town

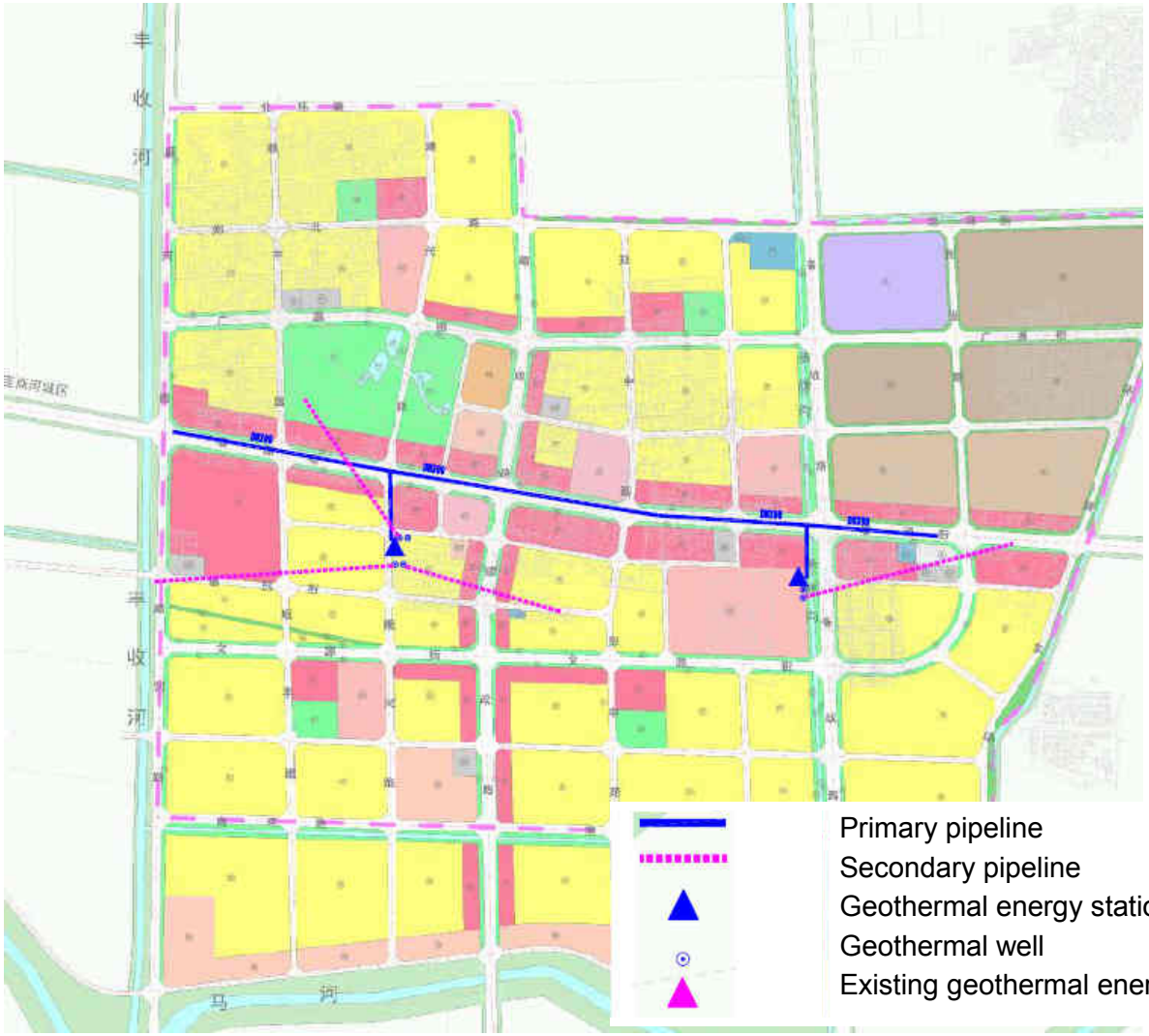


Figure III-22: Location of pipelines and stations in Jiazhuang Town

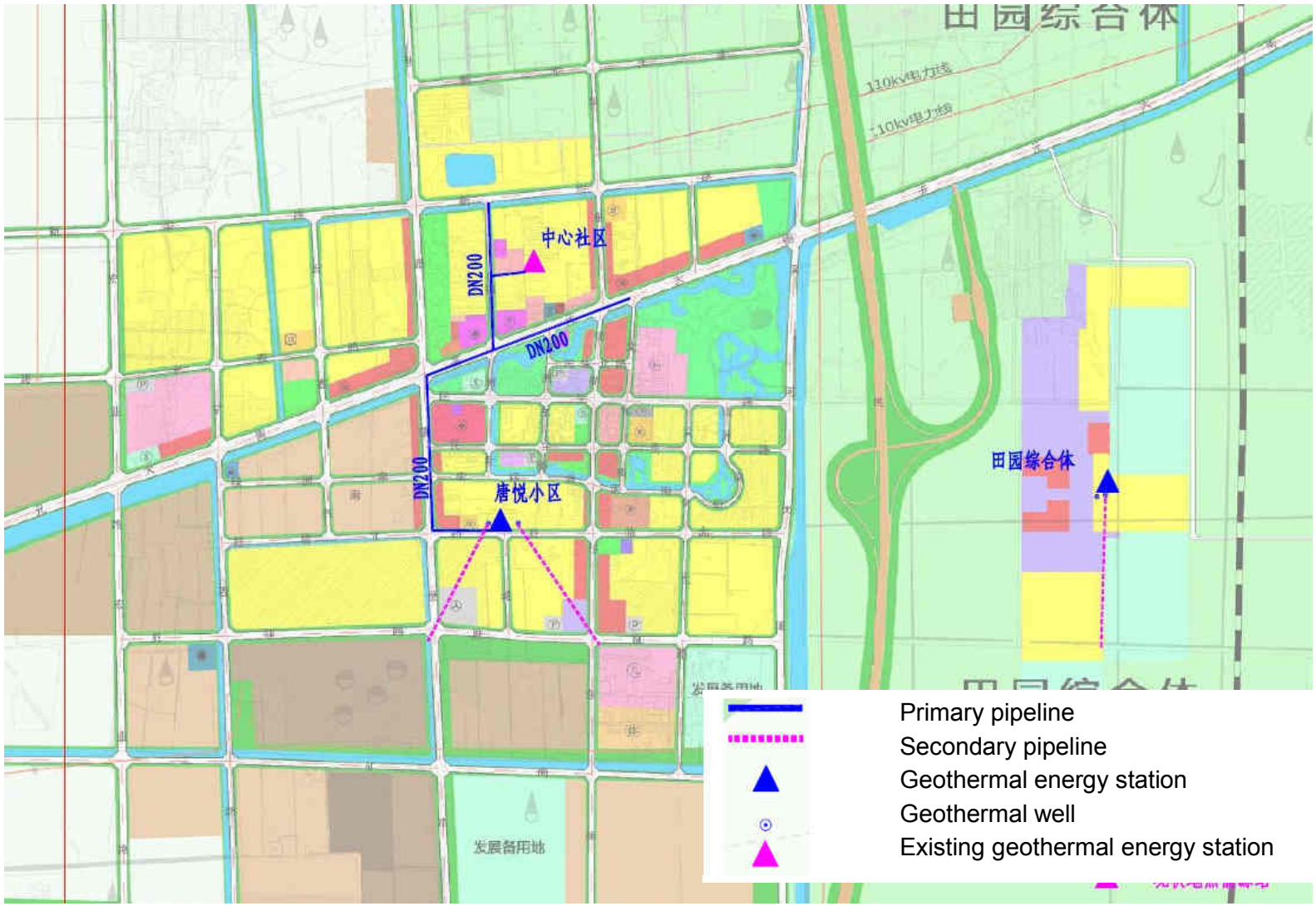


Figure III-23: **Location of pipelines and stations in Baiqiao Town**

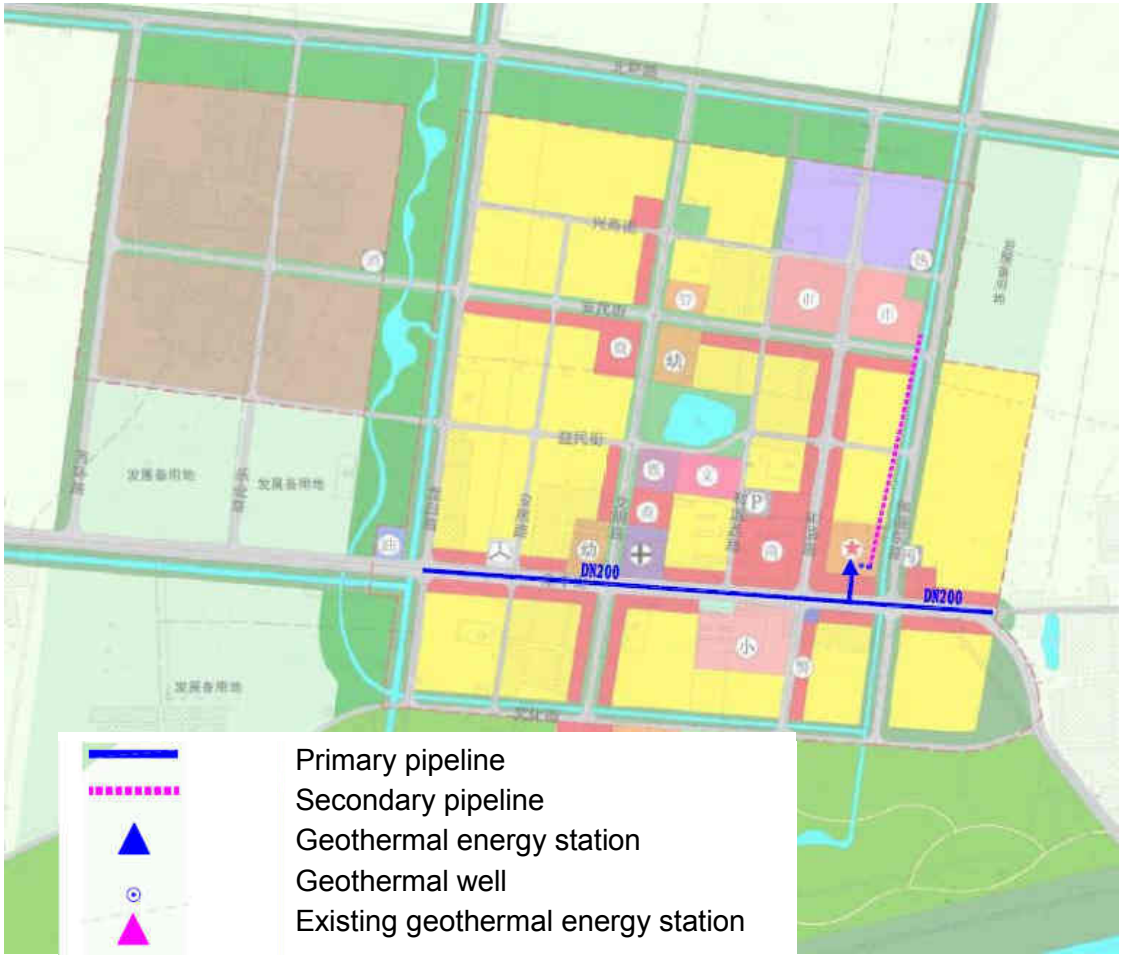


Figure III-24: Location of pipelines and stations in Sunji Town

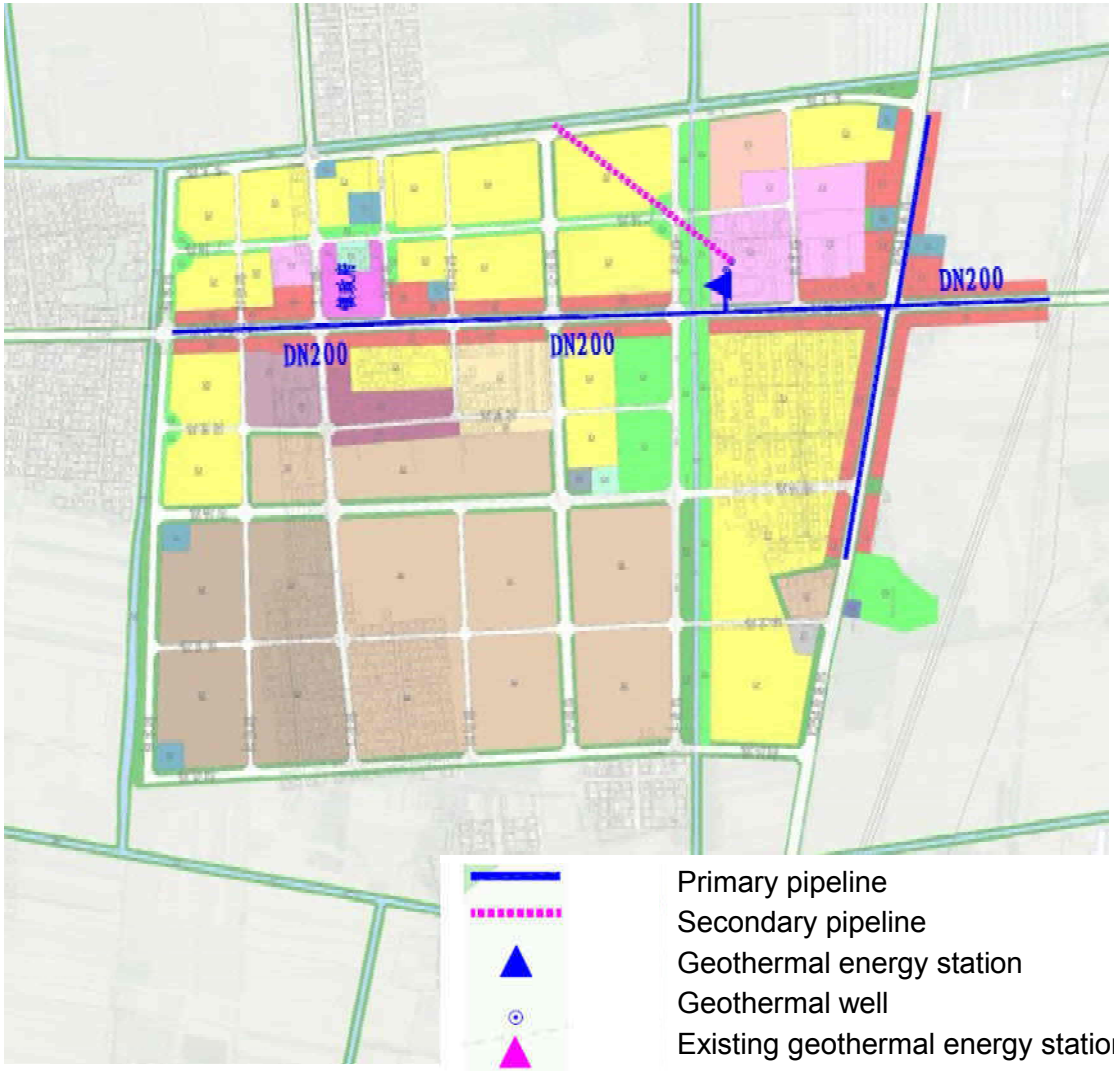


Figure III-25: Location of pipelines and stations in Hanmiao Town

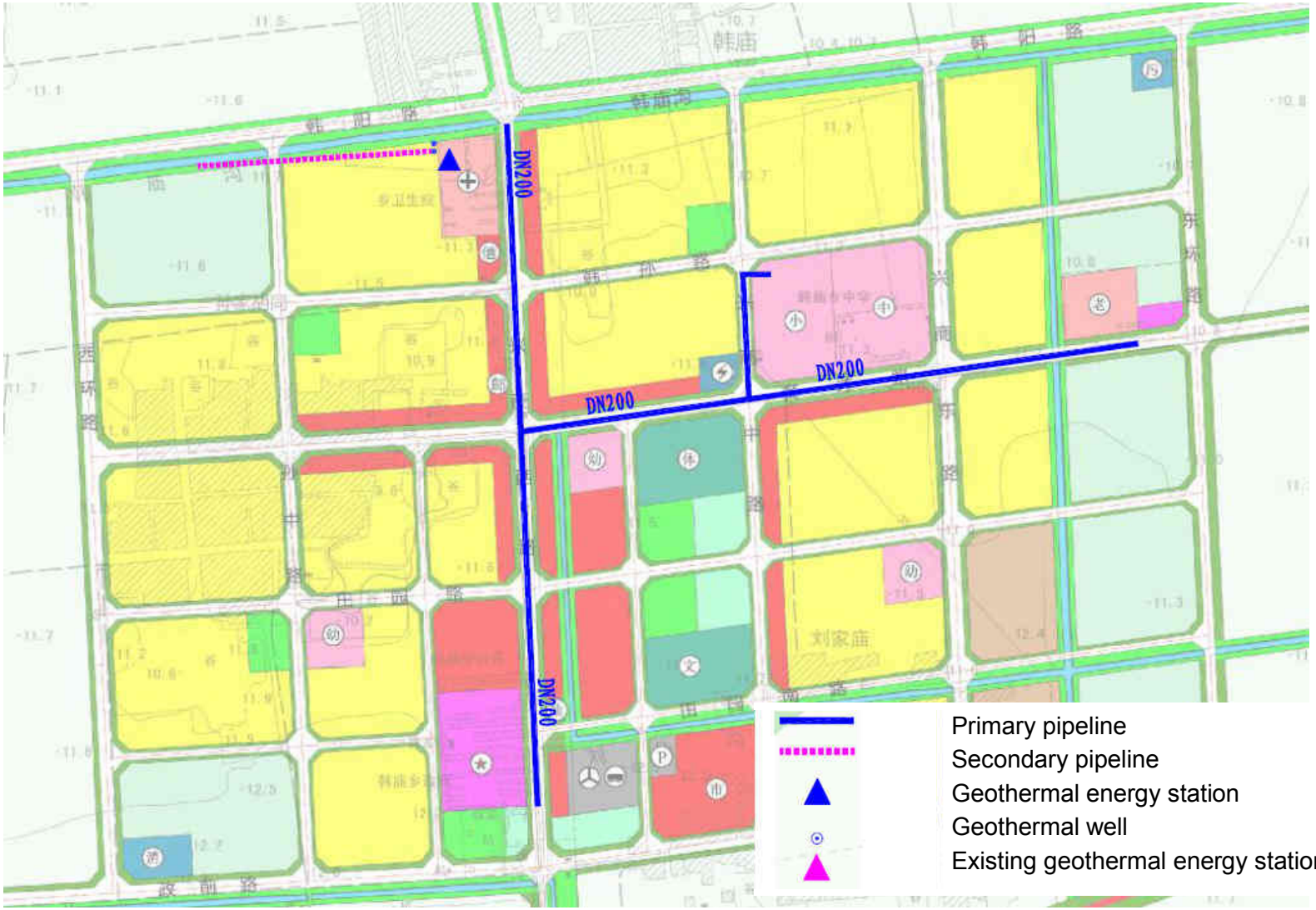


Figure III-26: Location of pipelines and stations in Shahe Town

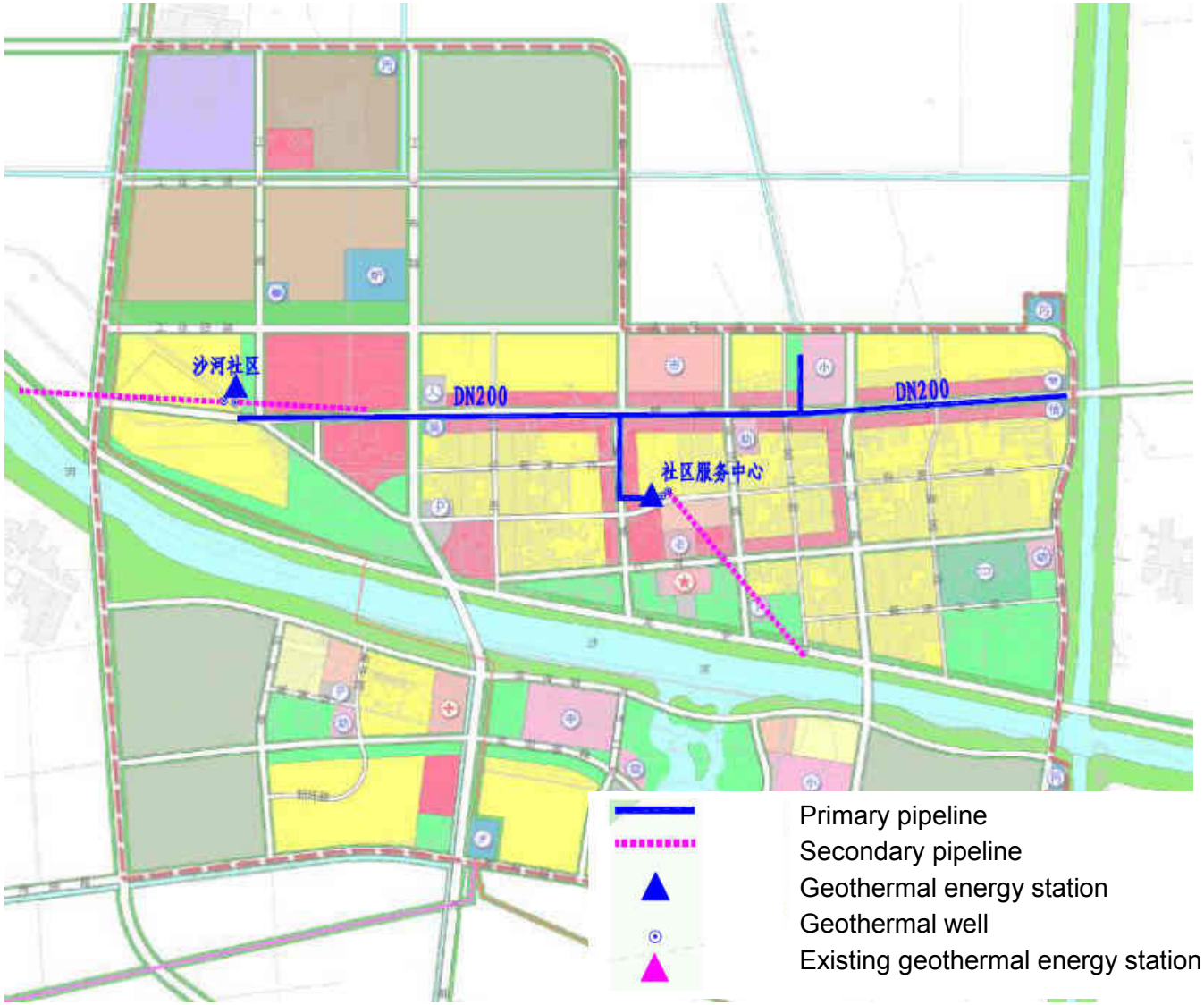
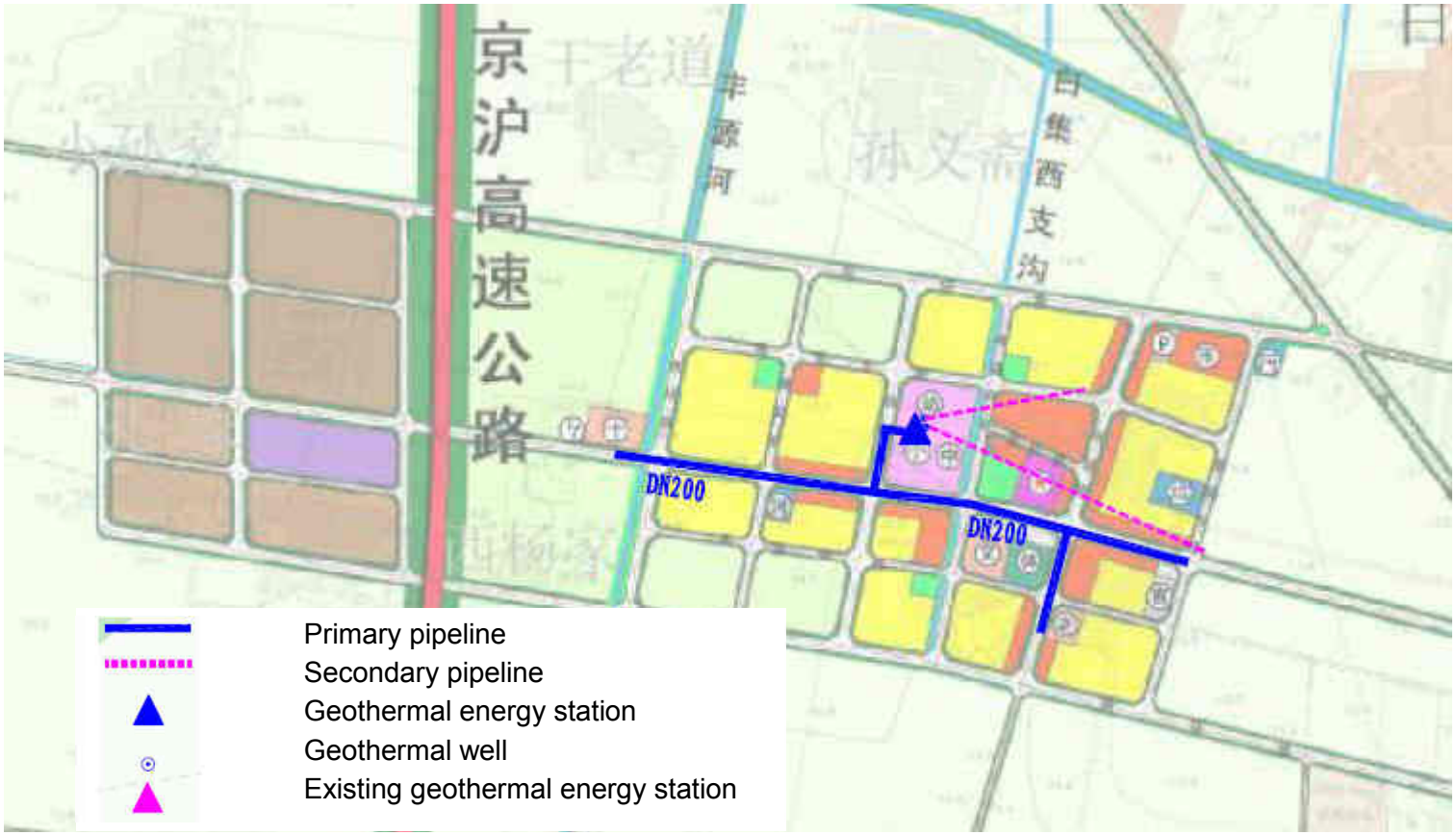


Figure III-27: Location of pipelines and stations in Zhangfang Town



3. Heating in rural area

118. The detailed district heating information in five kindergartens of Shanghe is presented in **Table III-12**. Detailed heating information in rural area of Shanghe is presented in **Table III-13**.

Table III-12: District heating information in five kindergartens of Shanghe

No.	Name	Heating area (1,000 m^2)	Numbers of air source heat pump units
1	Huangdun Kindergarten	2.2	2
2	Zhenbang Kindergarten	2.2	2
3	Houwaai Kindergarten	2.2	2
4	Zhanbei Kindergarten	1.2	1
5	Laodong Kindergarten	1.5	1
	Total	9.3	8

Table III-13: District heating information in rural area of Shanghe

No.	Name	Heating area (1,000 m^2)	Numbers of households (1,000 m^2)
1	Air-to-air heat pumps	3,000	60
2	Air-water heat pumps	500	10
3	Gas heater	50	1
4	Carbon crystal plate radiators	150	3
5	Heat-storage radiators	300	6
6	Energy saving transformation	1,500	30 (included in the 80,000 households)
	Total	4,000	80

4. Wastewater generation and discharge

119. Gas fired boilers of the component will be installed with soften water equipment to produce make up water. The technology will be iron exchange resin and the water is municipal water. Water storage tank will be installed in case of emergency situation for gas fired boilers.

120. The geothermal well system will not discharge any wastewater during operation because the extracted groundwater will be 100% recharged to the same level aquifer. An emergency water tank will be prepared for temporary storage of geothermal groundwater in case the injection well is blocked or leak happens due to flocculation or corrosion.

121. The wastewater generated during operation includes domestic wastewater (30 staff for operation, maintenance and regular check of the HES), resin regeneration wastewater, blow down

of boilers, wastewater from district heating system and re-generation wastewater of soften water system. Based on operation data from similar projects, parameters of wastewater are presented in **Table III-14**.

Table III-14: Wastewater analysis data in heating season[14]

No.	Item	Flow (m^3/d)	COD (mg/L)	Ammonia nitrogen (mg/L)	Petroleum (mg/L)
1	Boiler blow down	78	30	15	0
2	Resin regeneration wastewater	4	150	15	0
3	Heating system blow down	288	135	13	0
4	Domestic wastewater	1.2	200	25	20
	Total	371.2	77.4	43.8	1.1
	Standard	NA	NA	≤500	≤20

Source: PPTA consultant, 2018.

122. Domestic wastewater and production wastewater will be discharged to the municipal sewerage system and treated at the nearby WWTPs. For gas boilers in urban area, wastewater will be treated at Shanghe WWTP with a capacity of 20,000 m^3/d. For gas modular boilers in Yuhuangmiao Town, wastewater will be treated at Shanghe Fangyuan WWTP with a capacity of 10,000 m^3/d. These two WWTPs have adequate capacity to accept the wastewater from the component. All discharge concentration of SS, COD, BOD_5 and ammonia nitrogen will be in compliance with of *Wastewater Quality Standards for Discharge to Municipal Sewers* (GB/T 31962-2015) for wastewater discharged to a municipal sewerage system.

5. Solid waste generation

123. The component will have 30 staff during operation period. Estimated domestic waste generated by the component is 0.9 tons per year.[15]

124. The component will generate waste resin from the ion exchange system during operation period. The component will change all the resin every four years and 2.5 tons waste resin will be generated. The waste resin is considered as hazardous waste based on PRC laws and regulations which will be collected and stored at existing waste resin storage room in Hengtai HSP following the PRC laws and regulations, then transported and treated by a certificated hazardous waste treatment company in a engineered hazardous waste disposal facility following the PRC laws and regulations.

6. Environmental protection measures

125. Environmental protection measures of the component are summarized in **Table III-15**.

[14] The parameters are for all the boilers.
[15] Based on a waste production factor of 0.2 kg/worker/day and 150 working days.

Table III-15: Environmental protection measures

Category	Item	Measures
Wastewater	Heating system blow down	To sewage
	Boiler blow down	To sewage
	Resin regeneration wastewater	To sewage
	Domestic wastewater	To sewage
Category	**Item**	**Measures**
Solid waste	Waste resin	Disposed by a certificated company in a engineered hazardous waste disposal facility
	Domestic waste	Collected and treated by local sanitary department
Exhaust gas	Low NOx burner	To ambient air

Source: PPTA consultant, 2018.

7. Fire protection

126. Gas regulation stations and boilers pose a fire and explosion hazard due to the potential for gas leaks. All gas works will be in compliance with relevant PRC building code requirements, including Code for Design of City Gas Engineering (GB 50028-2006) and Regulation on Electric Apparatus Design for Explosion and Fire Risk Environment (GB50058-92). Independent gas regulation station will be constructed 12 meters away from the boilers, gas modular boilers and the residential buildings in the communities, to minimize the risk of explosion damaging other Project facilities or the public. The boilers and gas-modular boilers will be at least 13m from the buildings with a height no more than 24m, and 15m from the buildings with a height no more than 50m following the PRC requirement. Quantitative risk assessment of gas explosion will be conducted during detailed design. Alarm system will be installed for gas leakage to prevent explosion. The Jinan Jihua Gas Company will construct and operate the gas regulation stations.

127. The gas regulation stations will be specially designed to withstand and contain explosions, and the stations and the connection to the boilers and gas modular boilers will be equipped with flammable gas detection and alarm systems. In case of a gas leak, automatic shutdown valves will shut down the gas supply, the system will generate audible and visual alarms, and the emergency ventilation system will exhaust gas from the stations so as to protect the buildings, residents and operators.

128. All other at risk areas will have flammable gas detection and alarm systems with audible and visual alarms, and automatic fire suppression systems. All gas related devices will be brightly colored and equipped with warning signs.

129. During detailed design construction and operation phase emergency risk and response plans for each heating zone will be established in accordance with the “National Environmental Emergency Plan” (24 January 2006) and other relevant PRC laws, regulations and standards and will include measures in the World Bank EHS guidelines with respect to occupational and community health and safety. Liaison with community will be implemented during the public

consultation before the component construction. Construction and operation phase Environment, Health and Safety (EHS) plans will also be developed by occupational and gas boilers specialists to ensure worker and community safety.

8. Temporary Worker's Camps

130. Workers camps will only will be needed for the 42 MW natural gas boiler which will be located in the existing Hengtai HSP. Maximum staff for boiler installation will be around 150. The workers camp will utilize existing municipal water system. Adequate temporary sanitary facilities will be provided for construction workers. Toilets will be equipped with septic tanks in accordance with the PRC standards. Domestic wastewater will be treated in the septic tanks to meet relevant national standards and discharged to the existing municipal sewer system.

131. Domestic waste bins will be provided and domestic waste will be routinely collected by the local sanitation department for recycling, if possible, or final disposal at an approved waste disposal site.

132. No workers' camp is needed for pipeline construction as it is done in phases and a very limited number of workers will be needed for each phase of pipe installation.

IV. DESCRIPTION OF THE ENVIRONMENT

A. Location

133. The component will be implemented at Shanghe County, Jinan City of Shandong Province. Jinan is located in the north-western part of Shandong province at 36°40′ northern latitude and 116°57′ east of Greenwich, about 400 kilometers south of the national capital of Beijing. It borders Liaocheng to the southwest, Dezhou to the northwest, Binzhou to the northeast, Zibo to the east, Laiwu to the southeast, and Tai'an to the south. In the relief of the region, the city occupies a transition zone between the northern foothills of the Taishan Massif to the south of the city and the valley of the Yellow River to the north. Karst aquifers in limestone formations sloping down from the south to the north give rise to many artesian springs in the city center as well as in surrounding areas.

Figure IV-1: Component site location

Source: https://en.wikipedia.org/wiki/China

B. Shandong Province Overview

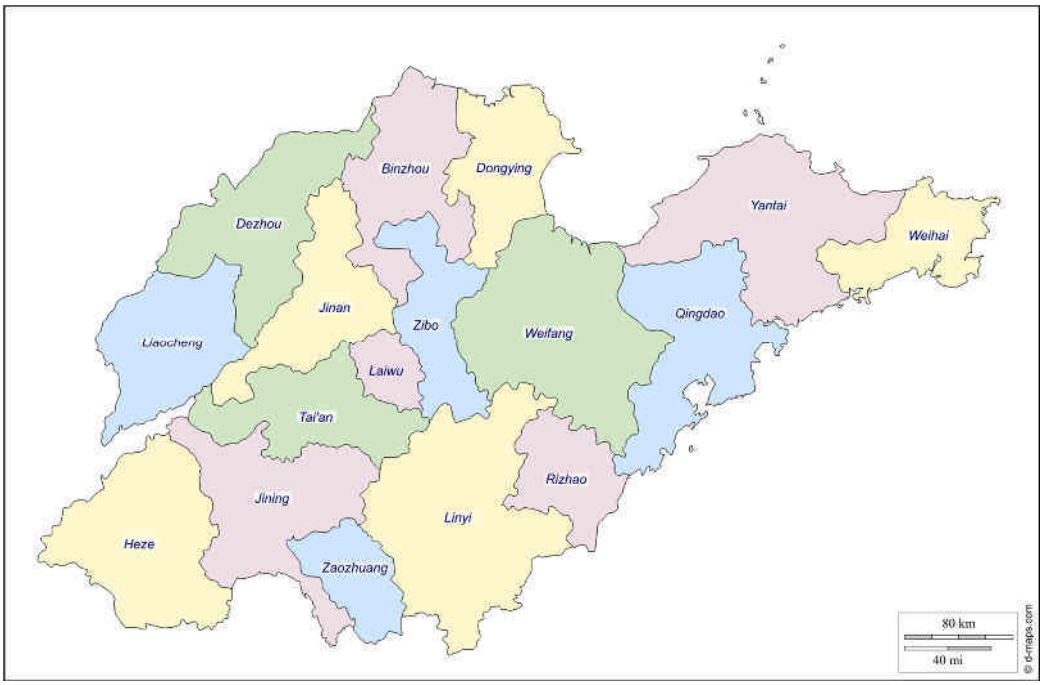
134. Shandong is a coastal province of the PRC and is part of the East China region (**Figure IV-2**). Neighboring provinces are Anhui, Hebei, Henan and Jiangsu.

Figure IV-2: Shandong Province in China

Source: https://en.wikipedia.org/wiki/Shandong

135. Shandong is divided into seventeen prefecture-level divisions including two sub-provincial cities. The seventeen prefecture-level divisions of Shandong are subdivided into 137 county-level divisions (51 districts, 28 county-level cities, and 58 counties). Those are in turn divided into 1941 township-level divisions (1223 towns, 293 townships, two ethnic townships, and 423 sub-districts).

Figure IV-3: Map of Shandong Province administrative divisions



Source: http://d-maps.com

136. In 2016, the population of the province was 99.47 million. The land area is 157,100 km^2 and the length of coastline is 3,100 km. The province has 17 municipalities and 140 counties (including county level cities and districts). Shandong has a temperate climate, with hot, rainy summers and dry, cold winters. Mean annual temperature is 10.5-13.5°C; the average temperature in July is 24-27°C, while the temperature in January is -4-1°C. Mean annual precipitation is 550-950 mm, increasing from northwest to southeast. The province is divided into four topographical zones: (i) Northwestern Shandong Plain, formed by deposits of the Yellow River; (ii) Jiaolai Plain, between central-south Shandong and Jiaodong hilly regions, bounded by bays in the north and south and traversed by the Jiaolai, Weihe and Dagu rivers; (iii) Central-South Shandong hilly area, with elevations >1,000 m above sea level (ASL); and (iv) Jiaodong Hilly Area, the main part of the Shandong Peninsula.

137. Shandong ranks first among PRC provinces in the agriculture production of a variety of products, including cotton and wheat. Other important crops include tobacco, sorghum and maize, as well as peanuts, for which the province is especially well-known, producing nearly a quarter of the country's total. Shandong is also a significant producer of fruits. The province also has extensive deposits of natural gas, iron, diamonds, gold, and bauxite deposits. In 2017, Shandong ranked the third largest provincial economy, contributing 8.79% of the country's total GDP. In 2017, the total GDP of the province was CNY 7.2678.18 trillion and per capita GDP was CNY 72,851.

138. Shandong is one of the leading provinces driving the economic development in the PRC. However, it is facing increasing pressure to reduce its energy consumption and emissions in light of PRC's objective for achieving 40%–45% carbon intensity reduction by 2020 compared to 2005 levels. Shandong was included in the first three provinces to implement province-wide circular economy.

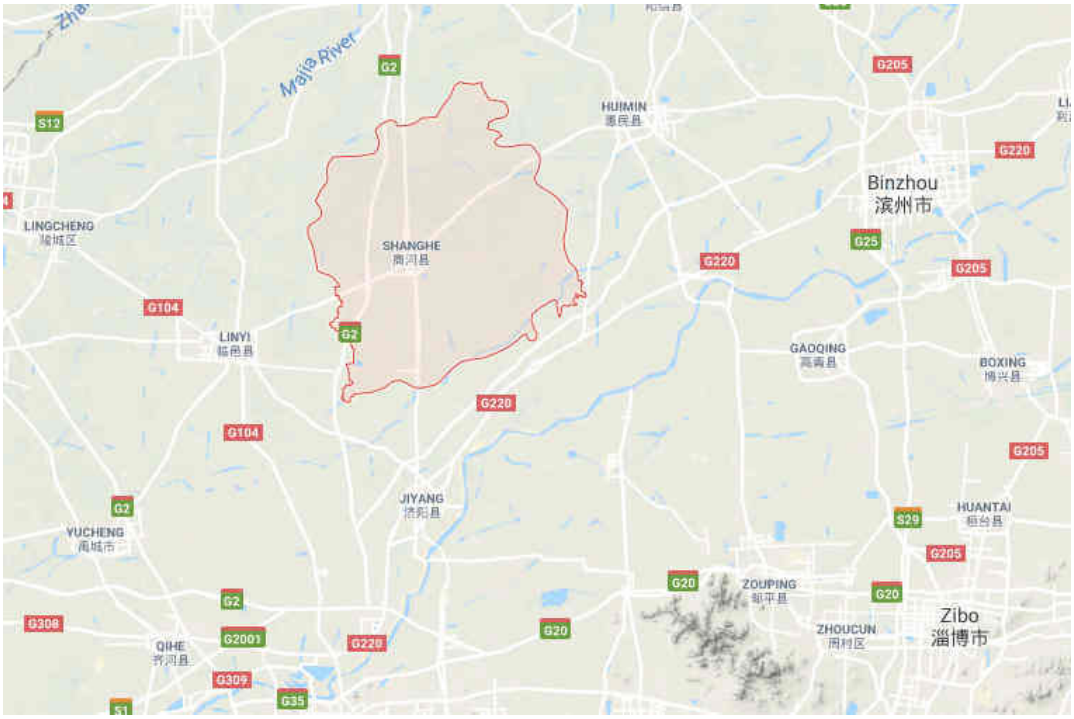
139. The Yellow River passes through Shandong's western areas, entering the sea along Shandong's northern coast; in its traversal of Shandong it flows on a levee, higher than the surrounding land, and dividing western Shandong into the Hai River watershed in the north and the Huai River watershed in the south. The Grand Canal of China enters Shandong from the northwest and leaves on the southwest. Weishan Lake is the largest lake in the province. Shandong Peninsula has a rocky coastline with cliffs, bays, and islands; the large Laizhou Bay, the southernmost of the three bays of Bohai Sea, is located to the north, between Dongying and Penglai; Jiaozhou Bay, which is much smaller, is to the south, next to Qingdao. The Miaodao Islands extend northwards from the northern coast of the peninsula.

140. The province has 30.58 billion m^3 of water resources and 307.4 m^3 per capita in 2016. Based on the standard of water quantity for the residential use in Shandong, daily average water consumption per capita is 85-120 l/d. Water resources in Shandong can just meet the requirements. The groundwater resources of Shandong are large, but are being exploited at an unsustainable rate. The demand for groundwater resources will continue to increase in the future with rising population and higher temperatures predicted in climate change scenarios.

C. Site Physical Resources

141. **Topography**. Jinan City occupies a transition zone between the northern foothills of the Taishan Massif to the south-southeast of the city and the Yellow River Valley to the north and northwest. Karst aquifers in limestone formations sloping down from the south to the north give rise to many artesian springs in the city center as well as in surrounding areas. Shanghe County is part of alluvial plain in north China. There is no any mountain or hill in Shanghe. Within the Shanghe County, the topography is generally flat, sloping slightly downwards from the east to the west. The highest elevation above sea level is in Xiaoshi Village with a height of 17.10 while the lowest elevation is in Hongmiao Village with a height of 8.94 m (**Figure IV-4**).

Figure IV-4: Shanghe topography



Source: Google map, 2018

142. **Geology and seismicity**. According to China Seismic Ground Motion Parameters Zoning Map (GB18306-2015), the stratigraphic structure of the component area is simple and stable, without unfavorable geological processes, and is therefore suitable for the component construction.

143. The PRC classifies seismic intensity into 12 grades under the China Seismic Intensity Table (GB/T 17742-2008), based on the severity of "shaking" of the earth surface and the extent of potential impact. According to the China Seismic Ground Motion Parameters Zoning Map (GB18306-2015, Amendment 1), the seismic intensity in the component area is Grade 6, with a design peak ground acceleration of 0.05 g, a 10% probability of exceedance in 50 years, and a return period of 475 years.

144. According to the domestic FSR, the component site is class II under the Code for Seismic Design of Buildings (GB50011-2010), applicable to medium dense and loose gravel, dense and medium dense coarse and sands, and clays with a bearing capacity >250 kPa. The component site is thus considered as suitable for construction activities, and there is no significant risk of potential disasters like landslides, mud flows, land subsidence or geological faults.

145. **Land use.** The boilers, geothermal and heat pumps stations will be installed at developed urbanized residential areas, and the pipeline will be predominantly in existing road right-of-ways.

146. **Hydrogeology.** The depth of groundwater in Shanghe is 2.3-2.6 m. The groundwater flows from southwest to northeast in Shanghe. Groundwater in Shanghe is pore phreatic water in loose rock mass. The groundwater at the depth from 0-2,000 m can be divided into shallow freshwater (10-60 m), middle level saltwater (60 – 200 m) and deep freshwater (below 200 m). Groundwater is not used in Shanghe for drinking water.

147. **Geothermal energy.** Shanghe's geothermal resource is generally located at the depth of 1,000–1,500 meters with water temperature of 48°C–60°C. The heating yield of a single well is about 500–2,000 m^3 per day based on the richness of underground water. The total exploitable geothermal resource is about 29.871×10^{17}J, equivalent to 101.89 million tce, theoretically this is sufficient to supply the heating demand for the entire Shanghe.

148. **Meteorology and Climate.** Shanghe has a temperate continental climate with four distinct seasons. It is dry in the spring, hot and rainy in the summer, cool in the autumn, and dry and cold in the winter. The average annual temperature in Shanghe is 12.6°C, the average summer average temperature is 25.6°C and the maximum recorded summer temperature was 40.5 °C. The average temperature in the 4 coldest months of winter is below 0°C, and the lowest maximum recorded temperature is -22.6°C (**Table IV-1**).

149. The average annual precipitation is 570.6 mm, with a recorded maximum of 823.6 mm (2010) and a minimum of 383.5 mm (2015). In winter months, precipitation is low (average 20 mm–25 mm/month), and majority of precipitation occurs during the summer months. Average annual average humidity is 67%. The dominate wind direction is from the southwest and annual average wind speed is 2.1m/s.

150. **Sunshine and humidity.** Annual average sunshine hours of Shanghe were 2,734.4 hours, or 62.4% of the annual daytime hours.

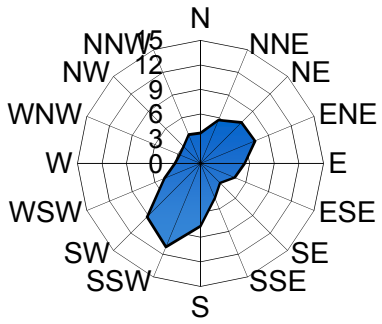
151. **Frost-free Days.** There is an average of 173 frost free days per year. The first frost typically occurs in the first 10 days of October, and the last frost day is typically in the first 10 days of March.

Table IV-1: Shanghe Climate data (1997–2016)

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Wind speed(m/s)	1.8	2.3	2.8	2.9	2.5	2.3	1.9	1.6	1.6	1.9	2.0	1.9	2.1
Temperature (°C)	-2.8	1.0	6.9	14.2	20.0	25.1	26.8	25.2	20.5	14.1	5.8	-0.7	13.0
Relative humidity (%)	61	57	55	57	72	62	77	82	76	68	67	66	67
Precipitation (mm)	3.0	8.4	9.7	22.7	50.4	90.8	170.6	137.1	40.4	34.6	13.3	3.9	584.8
Sunshine hours (h)	177.5	160.2	201.3	250.6	267.6	255.5	227.5	216.3	212.3	208.6	193.5	156.7	2527.6

Source: domestic EIA

Figure IV-5: Shanghe Wind Rose (1997–2016)



Clam wind is 13.3%

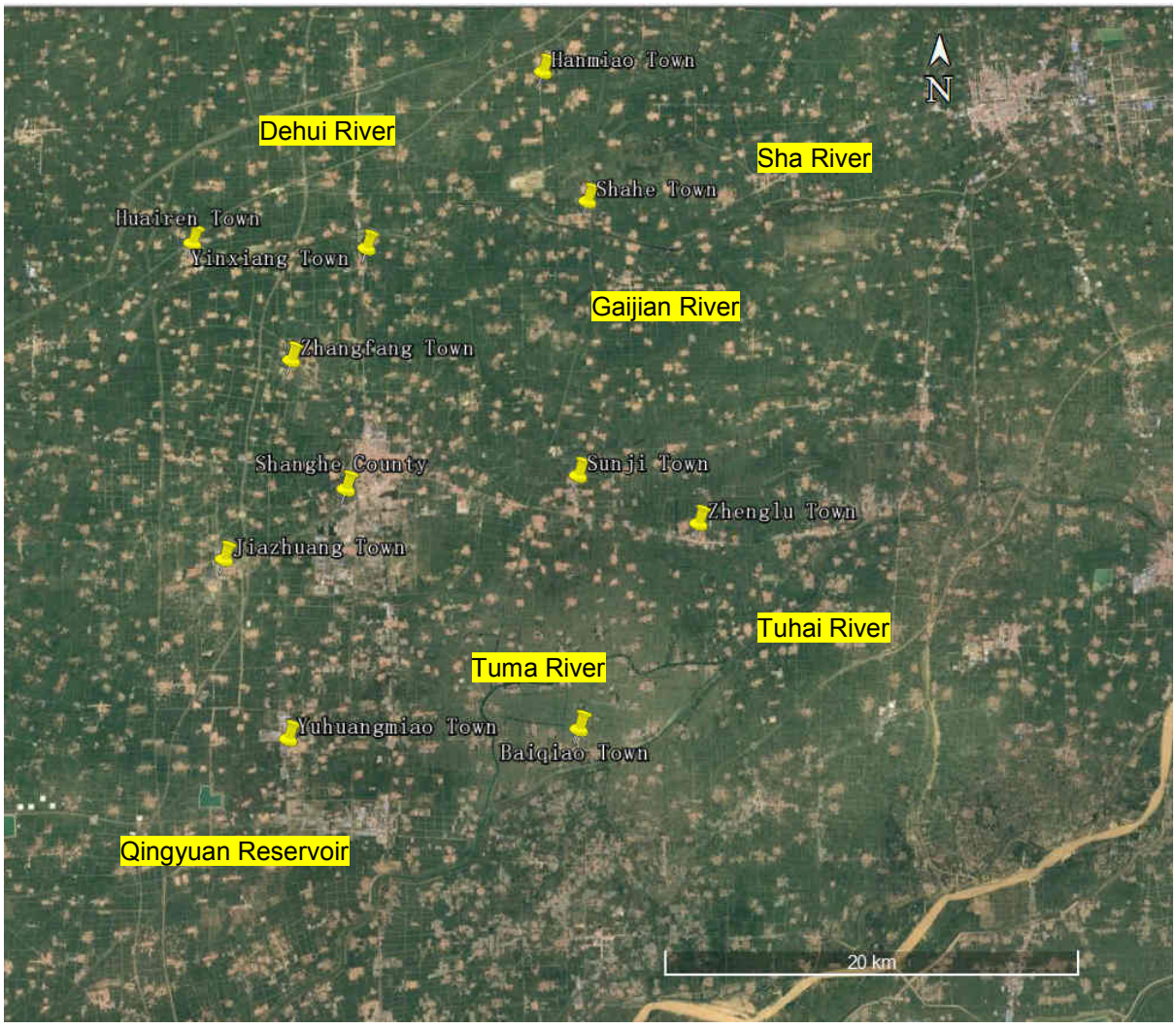
Source: domestic EIA

152. **Surface water - rivers and reservoirs**. **Hydrology.** Shanghe lies on the north shore of the Yellow River. Tuhai River and Dehui River are the main rivers in Shanghe. Tuhai River originates in Puyang City of Henan Province, and then it flows through 14 cities then enters into the Bohai Sea near Zhanhau County, Binzhou City. Tuhai River enters into Shanghe near Yangzhuangpu Village and leaves Shanghe in Zhanjia Village. It has a length of 31.7 km and watershed area of 347.06 km^2 in Shanghe. Dehui River is an artificial river built in 1970. It connects to Dezhou City and Huimin City. Dehui River enters into Shanghe in Huairen Town and leaves in Hanmiao Town. It has a length of 21 km and watershed area of 813.43 km^2 in Shanghe. Both the two rivers have many branches in Shanghe. Tuma River, Gangou River and Shahe River are branches of Tuhai River in Shanghe while Shangxi River, Shangzhong River, Shangdong River and Gaijian River are branches of Dehui River.

153. Shanghe sources drinking water from Yellow River and Qingyuan Reservoir and Qingyuan Reservoir extracts water from Yellow River. Qingyuan reservoir provides drinking water to urban area, Yuhuangmiao Town and Jiazhuang Town. Qingyuan reservoir is about 3.7 km away from Yuhuangmiao in northeast direction.

154. Surface water resource in the component area is presented in **Figure IV-6**.

Figure IV-6: Water resources in the component area



Source: Google earth, 2018.

155. **Groundwater and springs.** Jinan is well known for its artesian karst springs and lakes and is referred to as the Spring City. Because of its rich geothermal source, Shanghe has the biggest spring group in Jinan with a water flow of 80 m^3/h and a temperature from 58-62°C. These springs are not hydrogeologically linked to the locations of boreholes.

156. There are no reservoirs or springs in the component site and the nearest spring is Shanghe Spring which is about 6 km away from Jiazhuang Town in east direction and 3km away from urban area of Shanghe in south direction.

157. Annual average surface water resource of Shanghe is 250.06 million m^3 and underground freshwater resource is 117.63 million m^3. The total water resource is 367.69 million m^3. The population of Shanghe was 579,500 in 2017 and the per capita water resource in 2017 is only 635 m^3. To provide adequate water to people in Shanghe, Shanghe sources drinking water from Yellow River.

D. Ambient environment baseline and environmental monitoring

158. **Baseline data.** According to Shanghe's Environmental Quality Bulletin (2017), urban air quality in Shanghe has improved compared with 2016, but pollution levels remain high. The quality of drinking water sources is good and surface water quality has slightly improved. The acoustic environmental quality is relatively good and biological environment is good.

1. Air Quality Monitoring

159. **Air quality index.** MEE monitors air pollution in cities throughout the PRC and presents the results in an Air Quality Index (AQI) based on the level of 6 pollutants (**Figure IV-7**).

160. The AQI was introduced in 2012 and replaces the old Air Pollution Index (API). The MEE measures airborne pollution using AQI. The AQI is based on the concentration levels of six major atmospheric pollutants: SO_2, NO_2, PM_{10}, carbon monoxide (CO), ozone (O_3), and $PM_{2.5}$. The AQI is employed at monitoring stations in 367 cities across the nation.

161. The MEE measures and assigns an individual air quality score (IAQI) to each of the six pollutants over a period of one, eight, or 24 hours. A city's final AQI is the highest of those six scores with that particular pollutant being the city's major pollutant. When the index is lower than 50, the ministry does not name the major pollutant. The AQI ranges from zero to over 300.

Figure IV-7: The PRC's Air Quality Index (AQI) System

AQI	Air Pollution Level	Health Implications
0–50	Excellent	No health implications.
51–100	Good	Few hypersensitive individuals should reduce outdoor exercise.
101–150	Lightly Polluted	Slight irritations may occur, individuals with breathing or heart problems should reduce outdoor exercise.
151–200	Moderately Polluted	Slight irritations may occur, individuals with breathing or heart problems should reduce outdoor exercise.
201–300	Heavily Polluted	Healthy people will be noticeably affected. People with breathing or heart problems will experience reduced endurance in activities. These individuals and elders should remain indoors and restrict activities.
300+	Severely Polluted	Healthy people will experience reduced endurance in activities. There may be strong irritations and symptoms and may trigger other illnesses. Elders and the sick should remain indoors and avoid exercise. Healthy individuals should avoid out door activities.

Source: Li and Dong-Jun Liu (2014) and http://multimedia.scmp.com/china-air-pollution-in-2014/

162. **Air quality in Shanghe**. There are 2 automatic air quality monitoring stations in Shanghe. Both of them are in the urban area while one in the north and one in the south (**Figure IV-8**). Pollutants monitored in the stations include PM_{10}, $PM_{2.5}$, SO_2, NO_2, CO, and O_3. Summary data on stations and monitoring results for 2017 are presented in **Table IV-2**.

Figure IV-8: Location of Jinan EPB Automated Continuous Air Quality Monitoring Stations

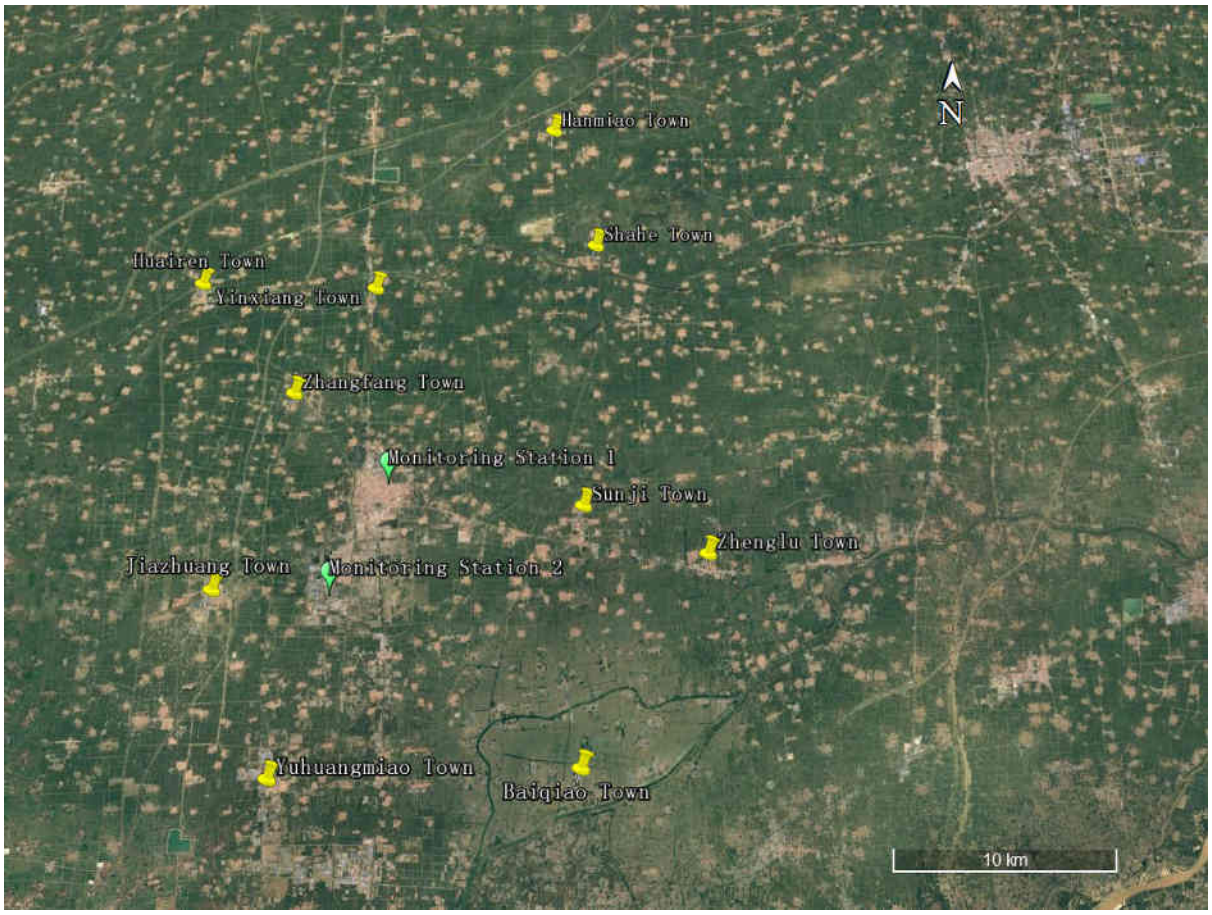


Table IV-2: Annual average Ambient Air Quality in Shanghe, 2017. Unit: mg/m^3

Item	PM_{10}	$PM_{2.5}$	SO_2	NO_2	CO (mg/m^3)	O_3 (8 hours)
Annual average concentration	0.117	0.063	0.029	0.038	2.1	0.205
PRC annual average standard	0.07	0.035	0.06	0.04	4	0.16
WHO guidelines	0.020	0.010	NA	0.04	NA	0.1

Note: Shading denotes exceedance of relevant standard (Class II of Ambient Air Quality Standard GB3095-2012).

Source: Jinan Environmental Quality Bulletin (2017).

163. In 2017, annual average concentrations of PM_{10}, $PM_{2.5}$, SO_2, NO_2, CO, and O_3 in Shanghe were 117 μg/m^3, 63 μg/m^3, 29 μg/m^3, 38 μg/m^3, 2.1 mg/m^3 and 205 μg/m^3, respectively (**Table IV-2**). Of these, the concentrations of PM_{10}, $PM_{2.5}$, and O_3 exceeded the National Ambient Air Quality Standard (GB3095-2012) by 0.67, 0.80, 0.15 and 0.28 times, while the concentrations of SO_2, NO_2 and CO met the PRC standard.

164. Air quality monitoring data from January 25 to 31, 2018 was collected from two existing air quality monitoring stations and is presented in **Table IV-3** and **Table IV-4**. The 24-hour average concentrations of $PM_{2.5}$ exceeded the national standard on 29 and 30 January 2018 in the two monitoring locations and PM_{10} in Shanghe EPB failed to meet the standard on 29 and 30 January 2018. The 1-hour concentrations of SO_2 and NO_x met the national standards.

Table IV-3: Daily Average Monitoring Results (Unit: mg/m^3)

Station	Data	PM_{10}	$PM_{2.5}$	SO_2	NOx
Shanghe EPB	2018-1-25	0.078	0.044	0.046	0.04
	2018-1-26	0.078	0.047	0.044	0.033
	2018-1-27	0.1	0.068	0.036	0.032
	2018-1-28	0.096	0.062	0.033	0.031
	2018-1-29	0.168	0.106	0.051	0.042
	2018-1-30	0.157	0.087	0.062	0.058
	2018-1-31	0.126	0.067	0.072	0.053
Shanghe Development Zone	2018-1-25	0.066	0.04	0.028	0.036
	2018-1-26	0.064	0.042	0.023	0.026
	2018-1-27	0.086	0.062	0.021	0.027
	2018-1-28	0.089	0.061	0.02	0.024
	2018-1-29	0.146	0.097	0.032	0.039
	2018-1-30	0.141	0.083	0.037	0.049
	2018-1-31	0.111	0.065	0.043	0.048
National Standards		0.15	0.075	0.15	0.10

Note: Shading denotes exceedance of relevant standard (Class II of Ambient Air Quality Standard GB3095-2012).

Table IV-4: 1-hour Average Monitoring Results (Unit: mg/m^3)

Time	Shanghe EPB		Shanghe Development Zone	
	SO_2	NOx	SO_2	NOx
2018-1-25 0:00	0.052	0.044	0.023	0.045
2018-1-25 1:00	0.058	0.047	0.023	0.051
2018-1-25 2:00	0.047	0.054	0.014	0.055
2018-1-25 3:00	0.045	0.055	0.013	0.054
2018-1-25 4:00	0.041	0.052	0.021	0.048
2018-1-25 5:00	0.058	0.057	0.017	0.047
2018-1-25 6:00	0.06	0.056	0.022	0.047
2018-1-25 7:00	0.046	0.054	0.026	0.052
2018-1-25 8:00	0.06	0.051	0.036	0.049
2018-1-25 9:00	0.062	0.044	0.051	0.035
2018-1-25 10:00	0.06	0.035	0.069	0.022
2018-1-25 11:00	0.068	0.031	0.049	0.02
2018-1-25 12:00	0.048	0.03	0.045	0.023
2018-1-25 13:00	0.049	0.03	0.041	0.021
2018-1-25 14:00	0.037	0.037	0.033	0.024

2018-1-25 15:00	0.041	0.059	0.03	0.051
2018-1-25 16:00	0.031	0.039	0.027	0.038
2018-1-25 17:00	0.027	0.025	0.022	0.023
2018-1-25 18:00	0.027	0.028	0.021	0.022
2018-1-25 19:00	0.036	0.026	0.021	0.025
2018-1-25 20:00	0.047	0.024	0.022	0.025
2018-1-25 21:00	0.05	0.027	0.022	0.033
2018-1-25 22:00	0.028	0.033	0.015	0.033
2018-1-25 23:00	0.019	0.029	0.01	0.029
2018-1-26 0:00	0.018	0.033	0.009	0.035
2018-1-26 1:00	0.018	0.039	0.01	0.038
2018-1-26 2:00	0.017	0.045	0.004	0.034
2018-1-26 3:00	0.017	0.047	0.004	0.029
2018-1-26 4:00	0.021	0.038	0.01	0.026
2018-1-26 5:00	0.024	0.035	0.005	0.029
2018-1-26 6:00	0.024	0.036	0.011	0.031
2018-1-26 7:00	0.027	0.038	0.011	0.035
2018-1-26 8:00	0.039	0.037	0.014	0.03
2018-1-26 9:00	0.06	0.036	0.022	0.022
2018-1-26 10:00	0.055	0.026	0.031	0.015
2018-1-26 11:00	0.053	0.02	0.032	0.013
2018-1-26 12:00	0.041	0.017	0.029	0.011
2018-1-26 13:00	0.039	0.016	0.027	0.01
2018-1-26 14:00	0.041	0.017	0.028	0.011
2018-1-26 15:00	0.044	0.02	0.03	0.014
2018-1-26 16:00	0.062	0.024	0.031	0.018
2018-1-26 17:00	0.082	0.032	0.032	0.023
2018-1-26 18:00	0.087	0.039	0.029	0.024
2018-1-26 19:00	0.086	0.047	0.038	0.028
2018-1-26 20:00	0.077	0.042	0.044	0.03
2018-1-26 21:00	0.045	0.037	0.043	0.033
2018-1-26 22:00	0.04	0.038	0.03	0.038
2018-1-26 23:00	0.043	0.04	0.031	0.042
2018-1-27 0:00	0.054	0.041	0.032	0.037
2018-1-27 1:00	0.049	0.042	0.032	0.031
2018-1-27 2:00	0.044	0.041	0.019	0.029
2018-1-27 3:00	0.034	0.036	0.014	0.033
2018-1-27 4:00	0.029	0.034	0.018	0.029
2018-1-27 5:00	0.027	0.04	0.01	0.034
2018-1-27 6:00	0.027	0.037	0.015	0.033
2018-1-27 7:00	0.024	0.041	0.015	0.032
2018-1-27 8:00	0.033	0.038	0.017	0.029
2018-1-27 9:00	0.061	0.033	0.025	0.024
2018-1-27 10:00	0.061	0.03	0.031	0.02
2018-1-27 11:00	0.041	0.024	0.025	0.017
2018-1-27 12:00	0.039	0.025	0.024	0.017
2018-1-27 13:00	0.037	0.025	0.024	0.018
2018-1-27 14:00	0.039	0.026	0.028	0.018
2018-1-27 15:00	0.04	0.026	0.044	0.02
2018-1-27 16:00	0.039	0.026	0.035	0.022
2018-1-27 17:00	0.034	0.027	0.024	0.022
2018-1-27 18:00	0.022	0.029	0.015	0.025
2018-1-27 19:00	0.022	0.03	0.013	0.029

2018-1-27 20:00	0.023	0.03	0.013	0.031
2018-1-27 21:00	0.025	0.029	0.013	0.031
2018-1-27 22:00	0.025	0.028	0.013	0.029
2018-1-27 23:00	0.028	0.028	0.014	0.031
2018-1-28 0:00	0.028	0.031	0.013	0.031
2018-1-28 1:00	0.028	0.033	0.014	0.028
2018-1-28 2:00	0.026	0.036	0.008	0.026
2018-1-28 3:00	0.027	0.038	0.008	0.03
2018-1-28 4:00	0.024	0.028	0.014	0.024
2018-1-28 5:00	0.021	0.028	0.007	0.023
2018-1-28 6:00	0.022	0.027	0.013	0.02
2018-1-28 7:00	0.022	0.03	0.013	0.028
2018-1-28 8:00	0.024	0.032	0.016	0.028
2018-1-28 9:00	0.028	0.026	0.035	0.02
2018-1-28 10:00	0.025	0.018	0.026	0.011
2018-1-28 11:00	0.022	0.015	0.029	0.01
2018-1-28 12:00	0.024	0.014	0.023	0.009
2018-1-28 13:00	0.025	0.016	0.022	0.01
2018-1-28 14:00	0.025	0.017	0.022	0.012
2018-1-28 15:00	0.025	0.019	0.022	0.015
2018-1-28 16:00	0.026	0.024	0.022	0.018
2018-1-28 17:00	0.037	0.032	0.022	0.027
2018-1-28 18:00	0.072	0.045	0.027	0.033
2018-1-28 19:00	0.061	0.044	0.026	0.029
2018-1-28 20:00	0.057	0.049	0.025	0.027
2018-1-28 21:00	0.049	0.045	0.023	0.033
2018-1-28 22:00	0.046	0.043	0.021	0.036
2018-1-28 23:00	0.042	0.047	0.019	0.047
2018-1-29 0:00	0.034	0.051	0.017	0.054
2018-1-29 1:00	0.026	0.047	0.015	0.056
2018-1-29 2:00	0.028	0.049	0.005	0.05
2018-1-29 3:00	0.033	0.049	0.004	0.044
2018-1-29 4:00	0.027	0.047	0.01	0.045
2018-1-29 5:00	0.022	0.051	0.004	0.048
2018-1-29 6:00	0.022	0.048	0.014	0.047
2018-1-29 7:00	0.025	0.048	0.016	0.045
2018-1-29 8:00	0.038	0.046	0.023	0.041
2018-1-29 9:00	0.045	0.042	0.035	0.038
2018-1-29 10:00	0.049	0.037	0.042	0.027
2018-1-29 11:00	0.032	0.027	0.026	0.014
2018-1-29 12:00	0.025	0.019	0.017	0.01
2018-1-29 13:00	0.023	0.016	0.017	0.009
2018-1-29 14:00	0.023	0.017	0.017	0.01
2018-1-29 15:00	0.024	0.018	0.016	0.011
2018-1-29 16:00	0.027	0.025	0.011	0.016
2018-1-29 17:00	0.044	0.034	0.033	0.029
2018-1-29 18:00	0.088	0.048	0.052	0.047
2018-1-29 19:00	0.119	0.053	0.072	0.062
2018-1-29 20:00	0.125	0.052	0.089	0.066
2018-1-29 21:00	0.142	0.058	0.09	0.058
2018-1-29 22:00	0.109	0.065	0.074	0.054
2018-1-29 23:00	0.1	0.065	0.063	0.056
2018-1-30 0:00	0.088	0.064	0.06	0.059

2018-1-30 1:00	0.064	0.062	0.051	0.059
2018-1-30 2:00	0.058	0.067	0.03	0.06
2018-1-30 3:00	0.055	0.069	0.024	0.063
2018-1-30 4:00	0.042	0.062	0.026	0.058
2018-1-30 5:00	0.039	0.068	0.017	0.061
2018-1-30 6:00	0.04	0.062	0.029	0.059
2018-1-30 7:00	0.048	0.061	0.029	0.056
2018-1-30 8:00	0.066	0.059	0.035	0.05
2018-1-30 9:00	0.078	0.057	0.044	0.045
2018-1-30 10:00	0.079	0.053	0.058	0.038
2018-1-30 11:00	0.066	0.046	0.048	0.03
2018-1-30 12:00	0.063	0.041	0.043	0.026
2018-1-30 13:00	0.052	0.038	0.038	0.027
2018-1-30 14:00	0.046	0.036	0.031	0.023
2018-1-30 15:00	0.044	0.036	0.03	0.024
2018-1-30 16:00	0.052	0.045	0.032	0.033
2018-1-30 17:00	0.069	0.059	0.032	0.04
2018-1-30 18:00	0.086	0.065	0.036	0.045
2018-1-30 19:00	0.073	0.064	0.034	0.053
2018-1-30 20:00	0.071	0.069	0.037	0.064
2018-1-30 21:00	0.074	0.071	0.044	0.068
2018-1-30 22:00	0.073	0.07	0.045	0.068
2018-1-30 23:00	0.076	0.071	0.04	0.069
2018-1-31 0:00	0.066	0.07	0.039	0.069
2018-1-31 1:00	0.063	0.069	0.041	0.069
2018-1-31 2:00	0.052	0.077	0.038	0.071
2018-1-31 3:00	0.048	0.075	0.028	0.07
2018-1-31 4:00	0.05	0.066	0.032	0.065
2018-1-31 5:00	0.049	0.071	0.028	0.064
2018-1-31 6:00	0.053	0.061	0.04	0.054
2018-1-31 7:00	0.049	0.057	0.036	0.057
2018-1-31 8:00	0.051	0.062	0.044	0.057
2018-1-31 9:00	0.063	0.058	0.057	0.056
2018-1-31 10:00	0.053	0.042	0.062	0.04
2018-1-31 11:00	0.035	0.03	0.032	0.021
2018-1-31 12:00	0.03	0.023	0.026	0.015
2018-1-31 13:00	0.03	0.02	0.023	0.014
2018-1-31 14:00	0.029	0.021	0.022	0.014
2018-1-31 15:00	0.026	0.021	0.02	0.013
2018-1-31 16:00	0.025	0.024	0.019	0.016
2018-1-31 17:00	0.062	0.042	0.023	0.028
2018-1-31 18:00	0.159	0.066	0.03	0.044
2018-1-31 19:00	0.181	0.068	0.05	0.055
2018-1-31 20:00	0.152	0.066	0.064	0.052
2018-1-31 21:00	0.177	0.064	0.078	0.062
2018-1-31 22:00	0.119	0.061	0.098	0.068
2018-1-31 23:00	0.096	0.05	0.114	0.069
Limit	0.5	0.25	0.5	0.25

Note: Shading denotes exceedance of relevant standard (Class II of Ambient Air Quality Standard GB3095-2012).

2. Surface water quality

165. Qingyuan reservoir is the drinking water source in Shanghe, which extracts water from the

Yellow River.

166. In 2017, 29 parameters were monitored at the Qingyuan reservoir which utilizes Yellow River water as a source of drinking water. The monitoring results are presented in **Table IV-5**.

167. In 2016 and 2017, only total nitrogen exceeded Class II standards of the Surface Water Environmental Quality Standards (GB3838－2002).

Table IV-5: Monitoring Results of Qingyuan Reservoir (Unit: mg/L)

Year	pH	NH_3-N	Permanganate index	Fluoride	Total phosphorus	Total nitrogen	Fecal coliform
2017	8.05	0.102	1.5	0.57	0.023	2.74	719
2016	80.2	0.0898	1.4	0.63	0.014	2.22	217
Limit	6-9	0.5	4	1.0	0.025	0.5	2000

Note: Shading denotes exceedance of relevant standard (Class II of Ambient Air Quality Standard GB3095-2012).

Source: Domestic EIA

168. In 2017, 10 sections of the rivers in Shanghe listed in **Table IV-6** were monitored by Shanghe EPB. For Shangzhong River, Shangxi River and Gaimao River, 14 parameters were monitored. For Shangdong River, Tuhai River and Dehui River, COD, fluoride, NH_3-N and total phosphorus were monitored. **Table IV-6**. presents a summary of water quality of the 10 sections compliance with Surface Water Environmental Quality Standards (GB3838－2002) of Shanghe in 2017.

Table IV-6: Summary of Water Quality in Compliance with Functional Zoning for Surface Waters, Shanghe, 2017

Water Body	Section	Applicable Standards	Compliance Status	Actual Water Quality Category	Exceedance parameter
Shangzhong River	Daling Bridge	Agricultural irrigation (Class IV)	No	Class IV	Total phosphorus
	Hejia Bridge	Agricultural irrigation (Class IV)	Yes	Class IV	NA
	Cuiwa Bridge	Landscape (Class V)	Yes	Class V	NA
Gaimao River	Sujia Bridge	Agricultural irrigation (Class IV)	Yes	Class IV	NA
	Lvjia Bridge	Agricultural irrigation (Class IV)	Yes	Class IV	NA
	Ganzixing	Agricultural irrigation (Class IV)	Yes	Class IV	NA
Shangxi River	Wangermao	Agricultural irrigation (Class IV)	Yes	Class IV	NA
Dehui River	Zhanbei	Agricultural irrigation (Class IV)	Yes	Class IV	COD, NH_3

Shangdong River	Beimao	Agricultural irrigation (Class IV)	Yes	Class IV	NH_3
Tuhai River	Xiaozhangjia	Landscape (Class V)	Yes	Class V	NA

Source: Jinan Environmental Quality Bulletin (2017).

3. Groundwater quality

169. Ground water monitoring is implemented in Shanghe Xinyuan Water Supply Plant in urban area of Shanghe. 24 parameters were monitored. Based on domestic EIA, all the parameters in 2017 met the Groundwater Quality Standards (GB/T 14848-2017).

4. Noise

170. In May 2017, Shanghe EPB implemented nighttime and daytime noise monitoring at 106 points in urban area of Shanghe. The results are presented in **Table IV-7**.

Table IV-7: Noise monitoring results (May 2017)

Item	Numbers of monitoring points	Range	Average	Limit
Daytime noise	106	49.8-58.5	53.6	55
Nighttime noise	106	41.5-47.4	43.6	45

Source: Domestic EIA.

171. The average nighttime and daytime noise level in May 2017 complied with the Class II standard of Environmental Quality Standard for Noise (GB3096－2008).

E. Ecology and Sensitive Resources

172. **Ecology.** Jinan City (the full extent of the administrative boundary, including 6 districts and 4 counties or county level cities) is home to a reported 1,175 plant species in 149 families. This includes 12 families and 18 species of fern; 7 families and 21 species of gymnosperm; 106 families and 870 species of dicotyledon; and 24 families and 266 species of monocotyledon. There are 382 known species of wild plants, accounting for 33% of the total number of plant species; and 793 species of cultivated plants, accounting for 67% of the total. The fauna resources of Jinan include wild terrestrial and aquatic species typically associated with Yellow River watershed.

173. Natural vegetation is sparse and concentrated in the southern and eastern mountain area. In the vast loess hilly area, the forest coverage rate is lower. Shrub and grass coverage are poor. Dominant flora within the component area is natural and artificial secondary vegetation being repeatedly destruction. Also, there are some artificial afforestation such as Pinus tabulaeformis, Platycladus orientalis, Robinia pseudoacacia, elm, poplar, and walnut, apple, hawthorn, persimmon and other economic forest.

174. The component is located in developed residential and commercial area, and there are no known ecological and/or sensitive resources in or near the component site. The primary pipeline of the component will be installed along existing roads with little or no vegetation cover.

Figure IV-9: Surroundings of component

(i) Yinhe Road

(ii)Xinyuan Road

(iii) Shangxi Road

(iv) Binhe Road

(v) Shangdong Road

(vi) Baoyuan Street

(vii) Huayuan Street

175. Based on the domestic EIA, site surveys and records review, there are no known rare or endangered flora or fauna, species with international, national or provincial protection status,

areas of natural or critical habitat,[16] parks, nature reserves, or areas with special national, regional or local ecological significance within or adjacent to any of the component site. There are also no known drinking water sources (Qingyuan Reservoir is the only drinking water source and is 3.7 km away from Yuhuangmiao, the nearest component site in northeast direction), scenic sites based on sites surveys, a review of relevant literature, sites with Physical Cultural Resources (PCRs).[17]

176. **Sensitive receptors.** The domestic EIA report identifies sensitive receptors in urban area. (**Table IV-8**).

Table IV-8: Sensitive receptors in urban area of Shanghe

No.	Community	Nearby sensitive receptors	Direction	Distance (m)
1	Rainbow Community	Shanghe No.2 school	SW	390
		Rainbow Community	--	15
		Qingxin Garden	N	60
		Linuo Community	W	220
2	Xicheng Middle School	Mengyu Community	NE	140
		Xicheng Middle School	--	15
		Supang Community	W	72
		Suncun Community	SW	140
		Zhangzhao Community	SW	300
3	Lvdi Baihe Community	Hejia Community	W	150
		Shanghe Middle School	ESE	200
		Lvdi Baihe Community	--	15
4	37 ° N No. 1 Plot	37 ° N No. 1 Plot	--	15

[16] Natural habitat is land and water areas where the biological communities are formed largely by native plant and animal species, and where human activity has not essentially modified the area's primary ecological functions. Critical habitat are areas with high biodiversity value, including habitat required for the survival of critically endangered or endangered species; areas having special significance for endemic or restricted-range species; sites that are critical for the survival of migratory species; areas supporting globally significant concentrations or numbers of individuals of congregatory species; areas with unique assemblages of species or that are associated with key evolutionary processes or provide key ecosystem services; and areas having biodiversity of significant social, economic, or cultural importance to local communities (Environment Safeguards: A Good Practice Sourcebook, ADB, 2012).

[17] PCRs are broadly defined as covering all types of tangible cultural heritage, including movable or immovable objects, sites, structures, groups of structures, and natural features and landscapes that have archaeological, paleontological, historical, architectural, religious, aesthetic or other cultural significance. PCR are human-made objects, natural features, or a mix of the two. They may be located in urban or rural areas and may be above or below ground or underwater. They may be known and listed on official inventories, but often they are undiscovered (Environment Safeguards: A Good Practice Sourcebook, ADB, 2012).

		37 ° N School	SE	500
		Dongbali Village	SW	470
5	37 ° N No. 2 Plot	37 ° N No. 2 Plot	--	15
		37 ° N No. 4 Plot	SW	400
6	37 ° N School and residential buildings	Dongbali Village	W	600
7	37 ° N No. 3 Plot	Dongbali Village	NW	450
8	37 ° N No. 4 Plot	37 ° N No. 4 Plot	--	15
9	37 ° N No. 5 Plot	37 ° N No. 5 Plot	--	15
10	Shanghe activity center	Shimu Primary School	SW	400
		Minghui Community	E	240
		Dongsheng Community	N	80
		Jiurun Community	ENE	240
		Yujing Community	WNW	120
11	Minghui Community	Dongsheng Community	WNW	180
		Zhuangyuan Fudi	NE	140
12	Banjia Community	Banjia Community	--	15
		Qingxin Community	S	120
		Jiarun Community	E	80
13	Xisanli West Plot	Xisanli	--	15
		Haomen Community	W	50
		Shanghe Community	S	200
		Yinqiao Community	N	300
14	Xisanli East Plot	Xisanli	--	15
		Dong Sanli	E	70
		No.2 Shanghe Middle School	SE	330
		Doufu Village	NE	200
15	Dongsanli West Plot	Shuimuqinghua Community	S	300
		Hongde Middle School	SW	400

		Doufu Village	N	200
16	Dongsanli East Plot	Wenchang School	S	500
		Youfang Community	SE	420
17	Youfang West Plot	Youfang Community	--	15
		Shuimuqinghua Community	W	400
		Wenchang School	SW	500
18	Youfang East Plot	Youfang Community	--	15
		Zhuangyuan Fudi	S	520
		Shuian Garden	S	460
19	Zhuangyuan Fudi	Zhuangyuan Fudi	--	15
		Xunrun Community	W	250
		Minghui Community	SW	300
20	Shuian Garden	Shuian Garden	--	15
		Zhuangyuan Fudi	W	220
21	Xiyanghong Community	Xiyanghong Community	--	15
		Jiarun Community	N	70
22	Yinqiao South Plot	Yinqiao	--	15
		Huafu Community	NW	350
		Dijing Community	ENE	550
23	Yinqiao North Plot	Dijing Community	E	350
		Changqing Community	N	50
24	Jixiechang South Plot	Dongguan Village	E	200
		Shiyan primary school	W	300
25	Jixiechang North Plot	Yongxin Garden	N	50
		Xinzhuang	W	370
26	Shanghe detention house	Yangjia Village	SE	240
		Tianjia Village	NE	120
27	Douhe Community	Doujia Community	NW	110

		Wujia Village	SW	240
		Kaocheng Jiajia	W	350
28	Mengyu Community	Mengjia Village	NNE	160
		Kaocheng Pangjia	W	500
29	Supang Community	Xicheng School	E	50
		Kaocheng Sujia	S	50
		Zhangzhao Community	S	290
30	Zhangzhao Community	Xicheng School	E	80
		Phoenix City	SE	260
31	Yiyang West Plot	Meiguiyuan Community	S	320
		Tandu Community	E	570
32	East Phoenix City	Jiayuan Community	NE	350
		Taihe Community	S	170
33	Wenquan Guoji	Tangjia Village	S	981
34	Shanghe No.6 kindergarten	Linuo Community	N	240
		Jiayuan Community	NW	380
35	Yiyang East Plot	Shanghe Community	E	50
		Tandu Community	S	300

177. Sensitive receptors of this component are shown **Table IV-8** and **Table IV-9**.

Table IV-9: Sensitive receptors in semi-urban and rural area of Shanghe

Name of town	Location	Sensitive receptors	Direction	Distance (m)
Yuhuangmiao Town	Yuyuan Community	Yuyuan Community	--	15
	Yudong South Plot	Baoqing Community	NW	220
		Yuhuangmiao Primary School	E	280
	Yudong North Plot	Yudong Community	S	80
		Baoqing Community	W	70
		Dongzhen Village	E	600

	Kaiwen professional school East Plot	Yudu Garden	NW	420
	Kaiwen professional school West Plot	Yuhuangmiao middle School	W	500
	Apartment for government	Yuyuan Community	NE	600
Yinxiang Town	Zhaokuiyuan Community and surroundings	Zhaokuiyuan Primary School	N	170
	Urban area	Yinxiang Village	NW	150
		Zhangsihu	SE	420
	Shangye Community and surroundings	Shanghe Hospital	W	45
		Yinxiang School	S	25
		Shangjia Village	E	45
Huairen Town	East urban area	Huairen Village	W	390
Zhenglu Town	Linhai Huayuan and surroundings	Mingde Primary School	NE	260
	Urban area	Zhenglu Nursing home	W	230
		Zhenglu Middle School	S	15
		Zhenglu Kindergarten	NW	110
		Shenghe Hospital Zhenglu Branch	NE	75
		Zhenglu Hospital	NE	150
		Xiren Village	E	250
Jiazhuang Town		Mingshang Jiayuan	E	120
		Kaiyuan Mingjun	E	220
	Jiazhuang Baize Community	Jiazhuang Hospital	NE	45
		Jintaiyang Kindergarten	NE	150
		Hou Jiazhuang	N	130
	Urban area	Tianshuijing Village	NE	650
		Zhongxin Community	N	25
Baiqiao Town	Urban area	Baiqiao Primary School	S	20
		Baiqiao Hospital	N	20

		Dahou Village	S	25
		Tiancai Kindergarten	N	25
		Doujia Village	N	25
	Yueqiao Community and surroundings	Yueqiao Primary School	E	25
		Panpan Kindergarten	S	25
		Yueqiao Village	S	25
		Xiaozhuang Village	S	25
Sunji Town	Sunji Community and surroundings	Sunji Primary School	S	130
		Wangpi Village	W	75
		Sunji Village	N	50
	Niupu Community and surroundings	Niupu Village	SE	100
		Niupu Middle School	E	25
Hanmiao Town	Urban area	Hanmiao Hospital	--	15
		Hanmiao Village	N	50
		Sunhutong Village	S	320
		Hanmiao Middle School	E	25
		Hanmiao nursing home	N	25
		Shahe Village	E	55
Shahe Town	Shahe Community and surroundings	Shahexu	W	200
		Shahe Primary School	--	15
Zhangfang Town	Urban area	Rongde Middle School	--	15
		Zhangfang Kindergarten	W	110
		Zhangfang Nursing home	SW	50
		Zhangfang Hospital	N	25
Huangtun Kindergarten		Huangtun Village	--	15
Zhenbang Kindergarten		Zhenbang Village	--	15
Houaiwa Kindergarten		Houaiwa Village	--	15
Zhanbei Kindergarten		Zhanbei Village	--	15

Laodong Kindergarten	Laodong Village	--	15

178. Sensitive receptors are given special attention in the assessment of impacts (Section V) and the EMP (Appendix I).

F. Socio-economic and Cultural Resources

179. **Shanghe County**. Shanghe County is comprised of eleven towns and one street (urban area) with a total area of 1,162 km^2 (**Error! Reference source not found.0**). Total population of Shanghe was 579,500 by the end of 2017

180. There are 13 ethnicities in Shanghe including Hui, Mongolian and Manchu. However, the ethnic minorities only account for 1.38% of the total population while the rest is Han ethnicity. None of the ethnic groups will be affected by the component implementation since there are no ethnic groups in Shanghe.

Figure IV-10: Map of Shanghe County administrative divisions

Table IV-10: Data on Shanghe administrative divisions

Subdivision	Land Area (km²)	Population (1,000 2017)	Population Density (persons/km²)
Xushang Street	114.54	103	899
Sunji Town	106.04	53	500
Longsangshi Town	92.50	43	465
Shahe Town	86.87	29	334
Hanmiao Town	68.11	30	440
Yinxiang Town	122.98	61	496
Huairen Town	59.56	35	588
Zhangfang Town	37.56	28	745
Jiazhuang Town	108.89	52	478
Yuhuangmiao Town	153.55	38	247
Baiqiao Town	83.31	46	552
Subdivision	**Land Area (km²)**	**Population (1,000 2017)**	**Population Density (persons/km²)**
Zhenglu Town	128.71	61.5	478
Total	1162.62	579.5	498

Source: Shanghe Statistical Bureau, 2018.

181. **Economy.** In 2017, Shanghe's GDP was CNY 20.39 billion, of which the primary sector accounted for 24.0% or CNY 4.89 billion; the secondary sector accounted for 39.6% or CNY 8.08 billion; and the tertiary sector accounted for 36.4% or CNY 7.42 billion. GDP per capita is 35,188 CNY. Disposable personal income of Shanghe in 2017 was 16,988 CNY, in urban area was 25,870 CNY and in rural area of was 13,738 CNY.

182. **Public transit and traffic conditions.** The number of vehicles on the roads of Shanghe is increasing dramatically. In 2017 total vehicle ownership reached 112,544 vehicles, of which car ownership was 80,065, an increase of 15.1%.

183. Shanghe is the north gate of Jinan. Provincial Road S248 runs through Shanghe from north to south while S316 runs from west to east. Shanghe has 1,170 km roads. Shanghe is about 50 km away from Jinan Xiaoqiang Airport.

184. **Wastewater treatment and solid waste management**. In 2017, all wastewater and domestic waste in Shanghe urban area were 100% treated following PRC regulations.

185. Jinan has a rich history, but Shanghe is not famous for its history. In the past, Shanghe is known as it agriculture due to is flat terrain and fertile soil. However, the component activities are all on long developed sites within highly developed and modified environment. There are no known PCRs in component site or in a radius of 500 m from the component site and within the airshed that could be affected by the component.

V. ANTICIPATED IMPACTS AND MITIGATION MEASURES

186. Anticipated positive and negative environmental impacts of the proposed component were assessed based on the domestic FSR, domestic EIA, a technical due diligence review of the FSR undertaken by ADB PPTA specialists, public consultations led by the IA and assisted by ADB PPTA consultants and site visits, surveys and consultations undertaken by ADB PPTA consultants.

187. Pre-construction, construction and operation phases were considered separately. The results of the assessment indicate that during the pre-construction phase environmental issues are very limited and are mostly associated with ensuring appropriate incorporation of mitigation measures into the component design.

188. Potential negative environmental impacts during the construction phase are short-term and localized, and are associated with construction noise, fugitive dust, solid waste, wastewater, disruption of traffic and community services, and risks to worker health and safety. Potential negative operation phase impacts are associated with boiler emissions, waste and wastewater, noise, and health and safety risks to workers and community.

189. Potential positive operation phase impacts are significant and long-term and are associated with emissions reductions compared to equivalent heat production from coal-fired boilers.

A. Pre-Construction Phase Measures to be Implemented During Detailed Design

1. Siting and Land Acquisition

190. The component will not entail any permanent or temporary physical displacement or economic displacement. This is because:

(i) Based on PPTA social specialist's due diligence report, the land for energy stations, geothermal wells will be provided by the local communities, the component will not result in any land acquisition,
(ii) The pipeline will be installed along the right-of-ways of the existing roads.

191. Overall, the component will not result in any involuntary land acquisition, resettlement or physical displacement. There will be no loss of personal property, structures, crops, trees or other assets. There are also no potential adverse impacts on disadvantaged or vulnerable groups, including the poor, women and children, and Indigenous Peoples.

2. Mitigation Measures and Monitoring during Detailed Design

192. Mitigation measures to be adopted during detailed design to minimize the impacts are as follows:

(i) **Detailed Design.** Environmental mitigation and pollution control measures indicated in this IEE, the EMP and the domestic EIA will be incorporated into the detailed design.

(ii) **Organization.** A PMO will be established and an external Loan Implementation Environmental Consultant (LIEC) will be hired by the IA.

(iii) **Institutional strengthening**: Prior to the start of construction, the institutional strengthening and training program will be delivered by the LIEC. The training will focus on ADB's and PRC's relevant environmental, health and safety laws, regulations and policies; implementation of the EMP, environmental monitoring, chance find procedures for PCRs, and the GRM. Training will be provided to the IA, relevant PMO staff, and contractors.

(iv) **Bidding Documents and Contracts.** Environmental mitigation measures indicated in this IEE, the EMP and the domestic EIA will be included in contracts for civil works and equipment installations. All contractors will be required to strictly comply with the EMP.

(v) **Environmental monitoring.** The environmental monitoring program (EMoP, see **Table 3** in **Appendix I**) will be incorporated into the design to ensure that environmental impacts are closely monitored and activities of the component construction and operation are closely supervised against the PRC environmental laws, regulations and standards, ADB SPS, EMP and the approved domestic EIA.

3. Grievance Redress Mechanism

193. In accordance with the GRM presented in Chapter VIII of the IEE, a staff member from IA will be assigned to be overall responsible for the GRM; GRM training will be provided for PMO, IA and GRM access points; and the GRM access point phone numbers, fax numbers, addresses and emails will be disclosed to the public at the construction site and Energy Centers and HESs.

4. Training and Capacity Building

194. An institutional strengthening and training program will be delivered by LIEC (see **Table 4** in **Appendix I**). The training will focus on ADB's and PRC's environmental, health and safety laws, regulations and policies; implementation of the EMP, EMoP, the GRM and international good EHS practices. Training will be provided to the IA, relevant staff and contractors and the construction supervision company.

5. Permitting

195. All necessary permits have been obtained from the relevant authorities.

B. Anticipated Environmental Impacts and Mitigation Measures during Construction Phase

196. Potential impacts during the construction phase could include air pollution, noise, water pollution, solid waste, poor occupational health and safety practices, and community health and safety. Potential air quality impacts could occur due to fugitive dust generated at construction sites from stockpiles of uncovered earth materials, and vehicles hauling materials. The use of powered mechanical equipment (PME) during construction activities will generate noise. Construction activities will generate process wastewater and construction workers will produce wastewater. Wastewater generation is expected to be limited considering the nature and scale of construction. Construction works will produce construction waste. Workers will face occupational health and safety issues working on construction sites. Potential impacts are assessed and addressed below. Identified impacts can be readily addressed through the application of good construction site practices.

1. Impacts on Flora and Fauna

197. Typical construction impacts on flora and fauna include removal of vegetation and disruption of the ecosystem during construction. If present, rare or endangered flora or fauna may also be impacted. However, the component construction site is located in residential environments or existing roads with little or no vegetation cover other than recently established grasses and shrubs. It is therefore unlikely that there will be direct impacts on natural lands or ecological values from component.

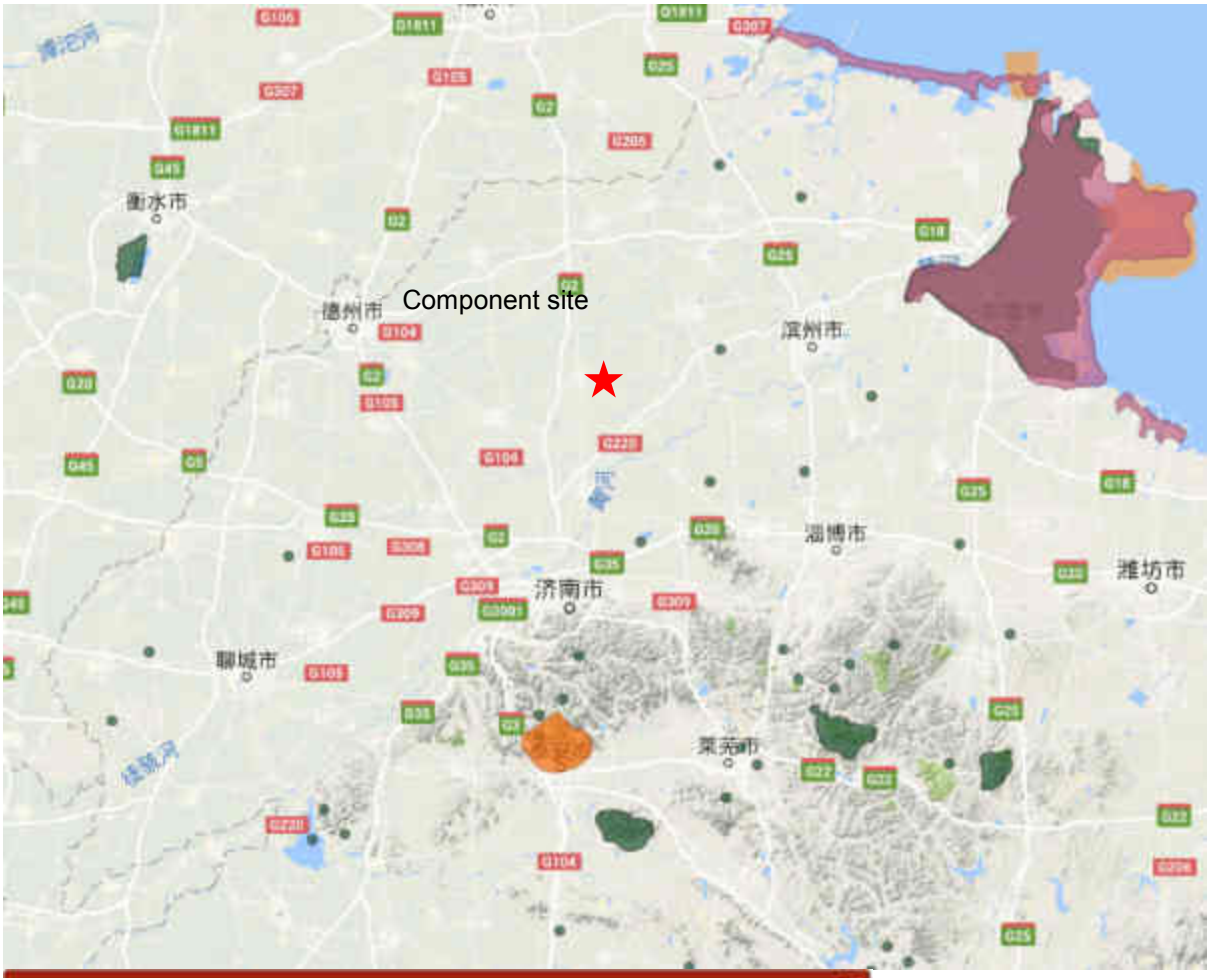
198. The locations of component site have been reviewed against provincial records provided by the IBAT[18] maps of Shandong protected areas and Important Bird and Biodiversity Areas (IBBAs). No component encroaches on any legally protected natural area or other critical habitats.

199. Based on site visits, there is no known rare or endangered flora or fauna, parks, nature reserves or areas with special ecological significance which will be impacted by the component. Impacts on flora or fauna are thus expected to be minimal and short-term. Nonetheless, to address potential impacts, a greening plan will be implemented. Site vegetation plans will be developed at component site using appropriate local native species. Any existing greening areas impacted by the component will be restored post-construction using appropriate native species.

200. During construction, construction working areas will be demarcated to prevent encroachment and damage to adjacent areas.

[18] International Biodiversity Assessment Tool. https://www.ibat-alliance.org/ibat-conservation/

Figure V-1: IBAT Habitat Areas and Component location



2. Erosion and Spoil

201. Construction activities such as land leveling, excavation and filling activities may lead to surface erosion. The most vulnerable soil erosion areas in the construction site include drilling sites, excavation sites, leveling sites, spoil sites, temporary construction sites, and other areas where surface soil is disturbed. Soil erosion can also be more serious on slopes or near water bodies, though based on site visits all construction sites are generally flat and there are no rivers, streams, ditches or lakes that are likely to be affected. Soil erosion can also occur after the completion of construction if site restoration is inadequate. Pipeline excavation and burial may also cause localized erosion and mudding of adjacent road. Finally, construction activities may generate surplus spoil.

202. These impacts can be mitigated through typical good construction practice as set out in EHS Guidelines on Construction and Decommissioning (C&D), erosion controls and site maintenance:

(i) At construction site, the potential for storm water runoff will be assessed and appropriate storm water drainage systems to minimize soil erosion will be implemented, including perimeter bunds and establishment of temporary detention and settling ponds to control topsoil runoff.

(ii) Land excavation and filling will be balanced so as minimize the requirement for fill material transportation.

(iii) During earthworks, the area of soil exposed to potential erosion at any time will be minimized through good project and construction management practices.

(iv) Temporary spoil storage sites will be identified, designed, and operated to minimize impacts. Spoil sites will be restored at the conclusion of storage activities.

(v) Spoil will be reused on-site to the maximum extent feasible as fill. Excess spoil that cannot be used on-site will be transported to an approved spoil disposal site.

(vi) Spoil and aggregate piles will be covered with landscape material and/or regularly watered.

(vii) Waste construction material such as residual concrete, asphalt, etc., will be properly handled for reuse or disposal.

(viii) Construction and material handling activities will be limited or halted during periods of rains and high winds.

(ix) Pipelines will be installed and backfilled in a sequenced section-by-section approach. Open excavation areas during trenching activities will be minimized, and appropriate construction compaction techniques utilized.

(x) Any planned paving or vegetating of areas will be done as soon as practical after the materials are removed to protect and stabilize the soil.

(xi) Once construction is complete disturbed surfaces will be properly sloped and revegetated with native trees and grass (see greening plan).

3. Wastewater

203. Inappropriate disposal of domestic wastewater (from construction workers) or construction wastewater (from drainage of washing construction equipment and vehicles, and oil-containing

wastewater from machinery repairs) may cause soil or groundwater resources contamination. Drilling water will be reused as much as possible during drilling. Wastewater generated during drilling activities will be collected and toxicity assessment will be conducted. If toxicity is found, wastewater will be transported for treatment by a certified company.

204. Construction wastewater will be produced from the maintenance and cleaning of mechanical equipment and vehicles, wastewater from pipeline cleaning and equipment cleaning. Hydrotest water and cleaning water will be discharged to sewer system. It is unlikely that runoff from site will reach distant water bodies, however to guard against runoff and infiltration impacting the immediately surrounding areas, the contractors shall ensure that runoff from site will not reach distant water bodies.

205. Inappropriate disposal of construction wastewater (from construction site runoff, washing construction equipment and vehicles, and oil-containing wastewater from machinery repairs) could potentially pollute nearby water bodies and clog local drains. Workers will generate but limited amount of domestic wastewater.

206. To prevent pollution of water resources, the following mitigation measures and construction good practice as set out in EHS Guidelines on C&D, will be implemented:

(i) Existing toilets at the component site will be provided for the workers.

(ii) Construction wastewater generated during construction phase will be discharged to the municipal sewer system. All discharged construction wastewater will meet the appropriate PRC standard GB/T 31962-2015 prior to discharge. Discharged water will then be treated in the nearby WWTP.

(iii) All necessary measures will be undertaken to prevent construction materials and waste from entering drainage system.

(iv) Maintenance of construction equipment and vehicles will not be allowed on sites to reduce wastewater generation.

(v) All construction machinery is repaired and washed at special repairing shops. No on-site machine repair, maintenance and washing shall be allowed so as to reduce wastewater generation.

(vi) Oil traps are provided for service areas and parking areas, and oil-water separators are installed for oil-containing wastewater.

(vii) Storage facilities for fuels, oil, and other hazardous materials are within secured areas on impermeable surfaces with 110% volume of the materials stored, and provided with bunds and cleanup kits;

(viii) The contractors' fuel suppliers are properly licensed, follow proper protocol for transferring fuel, and are in compliance with Transportation, Loading and Unloading of Dangerous or Harmful Goods (JT 3145-88).

(ix) Drilling equipment will be cleaned up before drilling to prevent ground water pollution.

(x) Drilling water will be reused as much as possible during drilling. Waste water generated during drilling activities will be collected and toxicity assessment will be conducted. Cuttings will be reused if they are non-toxic (e.g. as construction fill) or disposed of in a landfill facility and wastewater will be discharged to municipal sewer system. If toxicity is found, cutting and wastewater will be transported for

treatment by a certified company.

4. Air Pollution

207. Fugitive emission of dust (measured as TSP) during earthworks and fumes from asphalting and concrete batching off-site are expected to be the main air pollutants during the construction stage. The PRC Shandong Province's integrated particulate matter emission standard for stationary sources in Shandong Province (DB 37/1996-2011) establishes standards for the emission of air pollutants from these activities.

208. Fugitive dust will be generated on construction sites during earthworks from construction activities, uncovered earth material stockpiles on construction sites and temporary spoil storage and disposal areas (and containers), and from vehicles hauling loads, especially if loads are uncovered. Impacts will be short-term and localized, and in line with typical construction works that occur daily in cities throughout the PRC and the world.

209. Anticipated sources of air pollution from construction activities include: (i) dust generated from loading, hauling and unloading; (ii) dust generated from disturbed and uncovered construction areas, especially on windy days; (iii) dust generated by the movement of vehicles and heavy machinery on unpaved access and haul roads; (vi) emissions from construction vehicles (gaseous CO and NO_2) and heavy diesel machinery and equipment.

210. Without appropriate mitigations, construction phase activities may generate significant localized total suspended particulate (TSP)[19] levels, with worst case conditions occurring in clear weather without watering.

211. To reduce air quality impacts during the construction period, the following air quality management measure and construction good practice as set out in EHS Guidelines on C&D will be implemented:

(i) Water will be sprayed on active construction sites including where fugitive dust is being generated on a daily basis, and more frequently during windy days.

(ii) Transport vehicles will be limited to low speeds in construction sites.

(iii) Loads will be covered during truck transportation to avoid spillage or fugitive dust generation. Fine materials will be transported in fully contained trucks.

(iv) Construction site roads will be well maintained and watered and swept on an as-needed basis. Construction site road entry points will be equipped with truck drive through wash ponds.

(v) Transport routes and delivery schedules will be planned to avoid densely populated and sensitive areas, and high traffic times.

(vi) Store petroleum or other harmful materials in appropriate places and cover to minimize fugitive dust and emission.

(vii) Provide regular maintenance to vehicles in order to limit gaseous emissions (to be done off-site).

(viii) Temporary fencing will be erected around pipeline installation activities.

19 Airborne particles or aerosols that are less than 100 micrometers are collectively referred to as total suspended particulate matter (TSP).

(ix) Construction spoil and other construction materials will be temporary stored using containers, but they may the potential to generate dust. Thus, containers will be covered and/or watered if necessary.

(x) Muddy or dusty materials on public roads outside the exits of works areas will be cleaned immediately.

(xi) On-site asphalting and concrete batching is prohibited.

(xii) Drilling sites will be fenced during drilling.

(xiii) Disturbed site will be revegetated as soon as possible after the completion of pipeline installation.

212. Overall, air quality impacts from construction activities will be short-term (because of the phased construction approach), localized and low in magnitude, and are in line with typical construction or road works undertaken daily in cities throughout the PRC and around the world.

5. Noise Impacts

213. During the construction phase noise and vibration will be generated by on site construction activities using heavy equipment and by the transport of construction materials and equipment. Noise source during construction phase is considered a point noise source, and the predictive model is as follows:

$$L_i = L_0 - 20 \lg \frac{R_i}{R_0} - \Delta L$$

Where, L_i and L_0 are equipment noise sound levels at R_i and $R_{0,}$ respectively, ΔL is additional decrement produced by barriers, vegetation and air.

214. For the impact of multiple construction machines on a location, sound level superposition uses the following formula:

$$L = 10 \lg \Sigma 10^{0.1 \times L_i}$$

215. The component will install fence at the construction site boundaries and pipeline sites which can reduce the noise by 10 dB. A significant increase in localized noise is expected during construction. Noise will be from construction activities including equipment unload and installation and other heavy machinery, as well as noise from goods and material transportation. The major anticipated noise sources at each construction stage are presented in **Table V-1**. Though noise levels may be high, the impacts will be temporary and localized, and can be further mitigated.

Table V-1: Primary noise sources at each construction phase

Construction Phase	Name	Sound Level dB(A)	Distance from the source (m)	Noise level at the 100m away without/with fence	Directivity
Earthwork	Excavator	80-85	5	40-45/30-35	No
	Loader	85-90	5	45-50/30-40	No
	Bulldozer	85-90	3	45-50/35-40	No
	Dump truck	85-90	3	45-50/35-40	No
Equipment installation	Electrical drill	85-95	5	45-55/35-45	No
	Electrical hammer	90-95	5	50-55/40-45	No
	Electrical saw	90-95	5	50-55/40-45	No
Transport Vehicle	Trailer	70-75	5	30-35/20-24	No
	Flat car	70-75	5	30-35/20-24	No
	Truck	70-75	5	30-35/20-24	No
Drilling	Driller	80-95	5	45-55/35-45	No

Source: Domestic EIA.

216. To ensure construction activities meet PRC noise standards and to protect workers and adjacent residents, the following mitigation measures and construction good practice as set out in EHS Guidelines on C&D will be implemented:

(i) Construction activities will be planned in consultation with local authorities and communities so that activities with the greatest potential to generate noise and vibration are planned during periods of the day that will result in the least disturbance.

(ii) Construction activities, and particularly noisy ones, are to be limited to reasonable hours during the day and early evening. Construction activities will be strictly prohibited during the nighttime (22:00 h to 07:00 h). Exceptions will only be allowed in special cases, and only after getting approval of the surrounding residents, local EPB and other relevant departments. And nearby residents should be notified of such night time activities well in advance.

(iii) When undertaking construction planning, simultaneous high-noise activities will be avoided, and high noise activities will be scheduled during the day rather than evening hours. Similarly, construction site will be planned to avoid multiple high noise activities or equipment from operating at the same location.

(iv) Low-noise equipment will be selected as much as possible. Equipment and machinery will be equipped with mufflers and will be properly maintained to minimize noise.

(v) Noise PPE will be provided to workers to meet the requirements in occupational exposure limits for hazardous agents in work place Part 2: physical agents (GBZ 2.2-2007) and EHS Guidelines.

(vi) Transportation routes and delivery schedules will be planned during detailed design to avoid densely populated and sensitive areas and high traffic times.

(vii) Vehicles transporting construction materials or waste will slow down and not use their horn when passing through or nearby sensitive locations, such as residential communities, schools and hospitals.

(viii) Special attention will be paid to protect sensitive sites near the component site: high noise construction activities will be positioned as far away from sensitive sites as possible.

(ix) Noise from cleaning of heating pipelines will be minimized by utilization of low noise valves, mufflers after the valves and sound insulation on the external walls of pipelines.

(x) Drilling site will be enclosed by fence to reduce noise if there are sensitive receptors within 100 meters.

6. Solid Waste

217. Solid waste generated in the construction phase will include construction and domestic waste. Construction wastes include various waste packing materials and waste generated during equipment and pipeline installation and cleaning. An estimated of 0.5 kg/day per worker of domestic waste will be generated from construction workers with an estimated 750 kg domestic waste per day in total. Inappropriate waste storage and disposal could affect soil, groundwater and surface water resources, and hence, public health and sanitation.

218. The following solid waste management measure and construction good practice as set out in EHS Guidelines on C&D will be implemented:

(i) Wastes will be reused or recycled to the extent possible.

(ii) Littering by workers will be prohibited.

(iii) Excavated soil will be backfilled onsite to the extent possible. Excess spoil that cannot be used on-site will be transported to an approved spoil disposal site.

(iv) Existing domestic waste containers will be used for domestic waste collection at component sites. Domestic waste will be collected on a regular basis by the local sanitation departments and transported for recycling, reuse, or disposal at a licensed landfill, in accordance with relevant PRC regulations and requirements.

(v) Construction waste dumpsters will be provided at all construction sites. Construction waste will be collected on a regular basis by a licensed waste collection company and transported for recycling, reuse, or disposal at a licensed landfill, in accordance with relevant PRC regulations and requirements.

(vi) There should be no final waste disposal on site. Waste incineration at or near the site is strictly prohibited.

(vii) Cuttings are typically reused if they are non-toxic (e.g. as construction fill) or disposed of in a certified and engineered landfill facility.

(viii) Contractors will be held responsible for proper removal and disposal of any significant residual materials, wastes, spoil, waste from drilling and contaminated soils that remain on the site after construction.

7. Hazardous and Polluting Materials

219. Inappropriate transportation, storage, use and spills of petroleum products and hazardous materials such as oily waste can cause soil, surface and groundwater contamination. To prevent this, the following mitigation measures and construction good practice as set out in EHS Guidelines on C&D will be implemented:

(i) A hazardous material handling and disposal protocol that includes spill emergency response will be prepared and implemented by contractors.

(ii) Storage facilities for fuels, oil, chemicals and other hazardous materials will be within secured areas on impermeable surfaces provided with dikes with a 110% volume, and at least 300 m from drainage structures and important water bodies. A standalone site within the storage facility will be designated for hazardous wastes.

(iii) Signs will be placed at chemicals and hazardous materials storage sites to provide information on type and name of chemicals and hazardous materials.

(iv) Suppliers of chemicals and hazardous materials must hold proper licenses and follow all relevant protocols and PRC regulations and requirements.

(v) A licensed company will be hired to collect, transport, and dispose of hazardous materials in accordance with relevant PRC regulations and requirements.

8. Impacts on Community Health and Safety

220. Construction activities have the potential to cause community disturbance such as traffic congestion or delays, and public safety risks from heavy vehicles and machinery traffic and risk to kids trying to get onto construction site. Mitigations and construction good practice as set out in EHS Guidelines on C&D and EHS general guidelines will be implemented to address traffic and other community disturbance issues.

(i) Each contractor will undertake H&S risk assessment of construction works and implement relevant construction phase EHS plan in line with construction good practice as set out in EHS Guidelines on C&D and EHS General Guidelines.

(ii) Transportation routes and delivery schedules will be planned during detailed design to avoid densely populated and sensitive areas and high traffic times.

(iii) Vehicles transporting construction materials or wastes will slow down and not use their horn when passing through or nearby sensitive locations, such as residential communities, schools and hospitals.

(iv) Emergency response system and health and safety protocols will be developed by the IA before construction of geothermal wells. If the concentration of H_2S is high, the geothermal well will be shut down.

(v) Signs will be placed at construction sites in clear view of the public, warning people of potential dangers. All sites will be made secure , discouraging access by members of the public through appropriate fencing with security guards if the construction sites are in residential areas.

9. Workers Occupational Health and Safety

221. Construction may cause physical hazards to workers from noise and vibration, dust,

handling heavy materials and equipment, falling objects, work on slippery surfaces, fire hazards, chemical hazards such as toxic fumes and vapors, and others.

222. Contractors will implement adequate precautions to protect the health and safety of their workers:

(i) Each contractor will undertake H&S risk assessment of construction works and implement relevant construction phase EHS plan in line with construction good practice as set out in EHS Guidelines on C&D and Occupational H&S guidelines.

(ii) Identify and minimize the causes of potential hazards to workers. Implement appropriate safety measures.

(iii) Provide training to workers on occupational health and safety, emergency response, especially with respect to using potentially dangerous equipment and storage, handling and disposal of hazardous waste. Induction will be conducted before construction and no worker is allowed on site without induction.

(iv) Ensure that all equipment is maintained in a safe operating condition.

(v) Provide appropriate PPE to workers.

(vi) Provide procedures for limiting exposure to high noise or high temperature working environments in compliance with PRC occupational exposure limits for hazardous agents in work place Part 2: physical agents (GBZ 2.2-2007) and World Bank EHS Guidelines.

(vii) Ensure regular safety meetings with staff.

(viii) H_2S monitoring and warning systems will be installed. If the H_2S level is over 5 ppm, the well shall be sealed and shut-down.

(ix) Electrical safety risks especially related to existing power transmission line following World Bank EHS Guidelines for Electric Power Transmission and Distribution and drilling activities will be assessed and safety protocols will be developed following EHS Guidelines for Geothermal Power Generation.

10. Physical Culture Resources

223. Based on site visits there are no known cultural heritage or archaeological sites at or near the component sites. However, construction activities have the potential to disturb as yet unknown underground cultural relics. To address this issue, a construction phase chance find procedure will be established and activated if any chance finds of PCRs are encountered:

(i) construction activities will be immediately suspended if any PCRs are encountered;

(ii) destroying, damaging, defacing, or concealing PCRs will be strictly prohibited in accordance with PRC regulations;

(iii) local Cultural Heritage Bureau will be promptly informed and consulted; and,

(iv) construction activities will resume only after thorough investigation and with the permission of the local Cultural Heritage Bureau.

(v) In case of any PCR is found, ADB SPS 2009 requirements as well as PRC laws and regulations will be followed.

C. Anticipated Operation Phase Impacts and Mitigation Measures

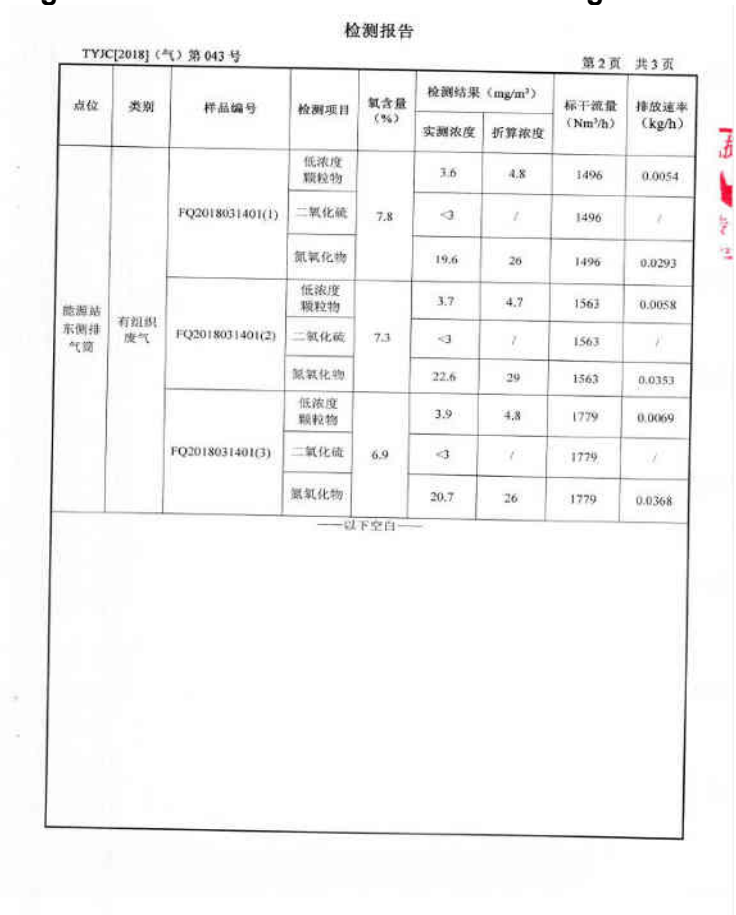
224. The component may cause some adverse impacts during operation including use of water, production of wastewater and solid wastes, fire and safety hazards, and community and workers health and safety.

1. Air pollution

225. The primary emissions to air from the combustion of natural gas are sulfur dioxide (SO_2), nitrogen oxides (NO_X), particulate matter (PM), carbon monoxide (CO), and greenhouse gases such as carbon dioxide (CO_2).

226. Monitoring results of the gas modular boilers is presented in **Figure V-2** and **Table V-2**.

Figure V-2: Gas modular boiler monitoring results



检测报告

TYJC[2018]（气）第043号　　第2页　共3页

点位	类别	样品编号	检测项目	氧含量（%）	检测结果（mg/m³）		标干流量（Nm³/h）	排放速率（kg/h）
					实测浓度	折算浓度		
能源站东侧排气筒	有组织废气	FQ2018031401(1)	低浓度颗粒物	7.8	3.6	4.8	1496	0.0054
			二氧化硫		<3	/	1496	/
			氮氧化物		19.6	26	1496	0.0293
		FQ2018031401(2)	低浓度颗粒物	7.3	3.7	4.7	1563	0.0058
			二氧化硫		<3	/	1563	/
			氮氧化物		22.6	29	1563	0.0353
		FQ2018031401(3)	低浓度颗粒物	6.9	3.9	4.8	1779	0.0069
			二氧化硫		<3	/	1779	/
			氮氧化物		20.7	26	1779	0.0368

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Table V-2: Gas modular boiler monitoring results

Location	Sample No.	Pollutants	Oxygen content	Monitoring Results	Concentration in normal conditions (11% oxygen content)	Flow (m^3/h)	Emission rate (kg/h)
Stack in east side	1	PM	7.8	3.6	4.8	1496	0.0054
		SO_2		<3	/	1496	/
		NOx		19.6	26	1496	0.0293
	2	PM	7.3	3.7	4.7	1563	0.0058
		SO_2		<3	/	1563	/
		NOx		22.6	29	1563	0.0353
	3	PM	6.9	3.9	4.8	1779	0.0069
		SO_2		<3	/	1779	/
		NOx		20.7	26	1779	0.0368

227. Emission levels of the gas modular boilers **shown** in **Figure V-2 and Table V-2** (SO_2: <3 mg/m^3; NOx: 29 mg/m^3; PM: 4.8 mg/m^3) comply with most stringent of provincial standards (see **Table II-6**).

228. The main pollutants of concern of emissions from gas modular boilers are SO_2 and NOx. Atmospheric dispersion modeling for SO_2 and NOx using SCREEN3, a US EPA approved screening model. The screening assessment will be conducted in the locations where more than one modular boiler will be installed. The emission parameters utilized in the modeling are presented in **Table V-3.**

Table V-3: Exhaust Gas Emission Parameters of gas modular boilers

No.	Community Name.	Boilers No.	Stack height (m)	Inner diameter (m)	Maximum natural gas consumption (m^3/h)	Exhaust air flow (m^3/h)	Emission rate (g/s) [20]	
							SO_2	NO_x
1	37° N No. 5 Plots	3	15	0.4	300	3642	3.04E-03	2.93E-02
2	37° N No. 4 Plots	1	15	0.4	100	1214	1.01E-03	9.78E-03
3	37° N No. 2 Plots	2	15	0.4	200	2428	2.02E-03	1.96E-02
4	37° N No.1 Plots	2	15	0.4	200	2428	2.02E-03	1.96E-02

[20] Burning 1m³ natural gas produces 12.14m³ waste gas. Based on **Table V-1**, emission concentrations of gas modular boilers are SO_2: 3 mg/m^3; NOx: 29 mg/m^3.

No.	Community Name.	Boilers No.	Stack height (m)	Inner diameter (m)	Maximum natural gas consumption (m^3/h)	Exhaust air flow (m^3/h)	Emission rate (g/s) [20]	
							SO_2	NO_x
5	37° N School and residential buildings	3	15	0.4	300	3642	3.04E-03	2.93E-02
6	Yuyuan Community	2	15	0.4	200	2428	2.02E-03	1.96E-02
7	Yudong South Plot	2	15	0.4	200	2428	2.02E-03	1.96E-02
8	Kaiwen professional school East Plot	1	15	0.4	100	1214	1.01E-03	9.78E-03
9	Kaiwen professional school West Plot	1	15	0.4	100	1214	1.01E-03	9.78E-03
10	Apartment for government	2	15	0.4	200	2428	2.02E-03	1.96E-02

229. SCREEN3 can only calculate the 1-hour GLCs of SO_2 and NO_2. To make a better understanding of the impacts of the gas modular boilers, 24-hour and annual GLCs of SO_2 and NO_2 are calculated assuming that 24-hour GLCs is 1/3 of 1-hour GLCs and annual GLCs is 1/6 of 1-hour GLCs.[21]

230. Based on **Table V-3**, community 2, 8 and 9 have the same screening modeling results, community 1 and 5 have the same screening modeling results, and community 3, 4, 6, 7 and 10 have the same screening modeling results.

231. The modeling results are presented from to Error! Reference source not found.**V-4** to **Error! Reference source not found. V-12** and to **Figure V-8.**

232. The modeling results indicates that for No.2, No.8 and No.9 community, the worst case 1-hour ground level concentration (GLC) of SO_2 is 0.06% of the PRC standard and the worst case 1-hour GLC of NO_2 is 1.34% of the PRC and WHO standard; the worst case 24-hour GLC of SO_2 is 0.06% of the PRC standard or 0.46% of WHO standard and the worst case 24-hour GLC of NO_2 is 1.11% of the PRC standard; the worst case annual GLC of SO_2 is 0.08% of the PRC standard and the worst case annual GLC of NO_2 is 1.11% of the PRC and WHO standard. The location with the maximum concentration is 222 m downwind of the pollution source.

233. The modeling results indicates that for NO.3, No.4, No.6, No.7 and No.10 community, the worst case 1-hour GLC of SO_2 from the three boilers is 0.08% of the PRC standard and the worst case 1-hour GLC of NO_2 is 1.87% of the PRC and WHO standard; the worst case 24-hour GLC of SO2 is 0.09% of the PRC standard or 0.64% of WHO standard and the worst case 24-hour GLC of NO_2 is 1.56% of the PRC; the worst case annual GLC of SO_2 is 0.11% of the PRC standard and the worst case annual GLC of NO_2 is 1.56% of the PRC and WHO standard. The location with the maximum concentration is 268 m downwind of the pollution source.

234. The modeling results indicates that for No.1 and NO.5 community, the worst case 1-hour GLC of SO_2 from the two boilers is 0.09% of the PRC standard and the worst case 1-hour GLC

[21] Technical Guidelines for Environmental Impact Assessment – Atmospheric Environment (HJ2.2-2018).

of NO_2 is 2.11% of the PRC and WHO standard; the worst case 24-hour GLC of SO_2 is 0.10% of the PRC standard or 0.73% of WHO standard and the worst case 24-hour GLC of NO_2 is 1.76% of the PRC; the worst case annual GLC of SO_2 is 0.12% of the PRC standard and the worst case annual GLC of NO_2 is 1.76% of the PRC and WHO standard. The location with the maximum concentration is 311 m downwind of the pollution source.

235. The modeling results indicate that the emissions from the modular boilers are in compliance with both PRC and WHO standards. The short-term (1-h and 24-h) GLCs of SO_2 and NO_2 are less than 10% of the PRC and WHO standards, which means that the component will have negligible impacts on air quality. The annual GLC of SO_2 is less than 1% of the PRC standard which the annual GLC of NO_2 is over 1%. Offsets will be taken by replacing 80,000 household coal stoves to mitigate the residual impacts. Once the component is in operation, the loan implementation environment consultant will support the IA in monitoring the offsets and include the information in the environmental monitoring reports submitted to ADB.

Table V-4: Predicted downwind direction pollutant 1-hour GLCs of No.2, No.8 and No.9 community

No.	Distance from point pollution source (m)	SO_2			NO_2		
		Predicted downwind GLC (ug/m^3)	Ratio of GLC to PRC Standard (%)	Ratio of GLC to WHO Standard (%)	Predicted downwind GLC (ug/m^3)	Ratio of GLC to PRC Standard (%)	Ratio of GLC to WHO Standard (%)
1	10	0	0	NA	0	0	0
2	100	2.37E-04	0.05%	NA	2.30E-03	1.15%	1.15%
3	200	2.71E-04	0.05%	NA	2.62E-03	1.31%	1.31%
4	222	2.76E-04	0.06%	NA	2.68E-03	1.34%	1.34%
5	300	2.44E-04	0.05%	NA	2.37E-03	1.18%	1.18%
6	400	2.40E-04	0.05%	NA	2.32E-03	1.16%	1.16%
7	500	2.22E-04	0.04%	NA	2.15E-03	1.08%	1.08%
8	600	1.95E-04	0.04%	NA	1.89E-03	0.94%	0.94%
9	700	1.68E-04	0.03%	NA	1.63E-03	0.81%	0.81%
10	800	1.45E-04	0.03%	NA	1.40E-03	0.70%	0.70%
11	900	1.25E-04	0.03%	NA	1.21E-03	0.61%	0.61%
12	1000	1.09E-04	0.02%	NA	1.06E-03	0.53%	0.53%
13	1100	9.68E-05	0.02%	NA	9.37E-04	0.47%	0.47%
14	1200	8.64E-05	0.02%	NA	8.37E-04	0.42%	0.42%
15	1300	7.88E-05	0.02%	NA	7.63E-04	0.38%	0.38%
16	1400	8.00E-05	0.02%	NA	7.75E-04	0.39%	0.39%
17	1500	8.04E-05	0.02%	NA	7.79E-04	0.39%	0.39%
18	1600	8.02E-05	0.02%	NA	7.76E-04	0.39%	0.39%
19	1700	7.94E-05	0.02%	NA	7.69E-04	0.38%	0.38%
20	1800	7.83E-05	0.02%	NA	7.58E-04	0.38%	0.38%
21	1900	7.70E-05	0.02%	NA	7.45E-04	0.37%	0.37%
22	2000	7.54E-05	0.02%	NA	7.30E-04	0.37%	0.37%
23	2100	7.35E-05	0.01%	NA	7.12E-04	0.36%	0.36%
24	2200	7.16E-05	0.01%	NA	6.94E-04	0.35%	0.35%
25	2300	6.97E-05	0.01%	NA	6.75E-04	0.34%	0.34%
26	2400	6.79E-05	0.01%	NA	6.57E-04	0.33%	0.33%
27	2500	6.60E-05	0.01%	NA	6.39E-04	0.32%	0.32%
Worst case GLC	**222**	**2.76E-04**	**0.06%**	**NA**	**2.68E-03**	**1.34%**	**1.34%**

Table V-5: Predicted downwind direction pollutant 24-hour GLCs of No.2, No.8 and No.9 community

No.	Distance from point pollution source (m)	SO_2			NO_2		
		Predicted downwind GLC (ug/m^3)	Ratio of GLC to PRC Standard (%)	Ratio of GLC to WHO Standard (%)	Predicted downwind GLC (ug/m^3)	Ratio of GLC to PRC Standard (%)	Ratio of GLC to WHO Standard (%)
1	10	0	0	0	0	0	NA
2	100	7.90E-05	0.05%	0.40%	7.65E-04	0.96%	NA
3	200	9.03E-05	0.06%	0.45%	8.74E-04	1.09%	NA
4	222	9.21E-05	0.06%	0.46%	8.92E-04	1.11%	NA
5	300	8.14E-05	0.05%	0.41%	7.89E-04	0.99%	NA
6	400	7.99E-05	0.05%	0.40%	7.73E-04	0.97%	NA
7	500	7.40E-05	0.05%	0.37%	7.17E-04	0.90%	NA
8	600	6.49E-05	0.04%	0.32%	6.28E-04	0.79%	NA
9	700	5.60E-05	0.04%	0.28%	5.42E-04	0.68%	NA
10	800	4.83E-05	0.03%	0.24%	4.67E-04	0.58%	NA
11	900	4.18E-05	0.03%	0.21%	4.04E-04	0.51%	NA
12	1000	3.64E-05	0.02%	0.18%	3.52E-04	0.44%	NA
13	1100	3.23E-05	0.02%	0.16%	3.12E-04	0.39%	NA
14	1200	2.88E-05	0.02%	0.14%	2.79E-04	0.35%	NA
15	1300	2.63E-05	0.02%	0.13%	2.54E-04	0.32%	NA
16	1400	2.67E-05	0.02%	0.13%	2.58E-04	0.32%	NA
17	1500	2.68E-05	0.02%	0.13%	2.60E-04	0.32%	NA
18	1600	2.67E-05	0.02%	0.13%	2.59E-04	0.32%	NA
19	1700	2.65E-05	0.02%	0.13%	2.56E-04	0.32%	NA
20	1800	2.61E-05	0.02%	0.13%	2.53E-04	0.32%	NA
21	1900	2.57E-05	0.02%	0.13%	2.48E-04	0.31%	NA
22	2000	2.51E-05	0.02%	0.13%	2.43E-04	0.30%	NA
23	2100	2.45E-05	0.02%	0.12%	2.37E-04	0.30%	NA
24	2200	2.39E-05	0.02%	0.12%	2.31E-04	0.29%	NA
25	2300	2.32E-05	0.02%	0.12%	2.25E-04	0.28%	NA
26	2400	2.26E-05	0.02%	0.11%	2.19E-04	0.27%	NA
27	2500	2.20E-05	0.01%	0.11%	2.13E-04	0.27%	NA
Worst case GLC	**222**	**9.21E-05**	**0.06%**	**0.46%**	**8.92E-04**	**1.11%**	**NA**

Table V-6: Predicted downwind direction pollutant annual GLCs of No.2, No.8 and No.9 community

No.	Distance from point pollution source (m)	SO_2			NO_2		
		Predicted downwind GLC (ug/m^3)	Ratio of GLC to PRC Standard (%)	Ratio of GLC to WHO Standard (%)	Predicted downwind GLC (ug/m^3)	Ratio of GLC to PRC Standard (%)	Ratio of GLC to WHO Standard (%)
1	10	0	0	0	0	0	0
2	100	3.95E-05	0.07%	NA	3.83E-04	0.96%	0.96%
3	200	4.52E-05	0.08%	NA	4.37E-04	1.09%	1.09%
4	222	4.60E-05	0.08%	NA	4.46E-04	1.11%	1.11%
5	300	4.07E-05	0.07%	NA	3.94E-04	0.99%	0.99%
6	400	3.99E-05	0.07%	NA	3.87E-04	0.97%	0.97%
7	500	3.70E-05	0.06%	NA	3.58E-04	0.90%	0.90%
8	600	3.25E-05	0.05%	NA	3.14E-04	0.79%	0.79%
9	700	2.80E-05	0.05%	NA	2.71E-04	0.68%	0.68%
10	800	2.41E-05	0.04%	NA	2.34E-04	0.58%	0.58%
11	900	2.09E-05	0.03%	NA	2.02E-04	0.51%	0.51%
12	1000	1.82E-05	0.03%	NA	1.76E-04	0.44%	0.44%
13	1100	1.61E-05	0.03%	NA	1.56E-04	0.39%	0.39%
14	1200	1.44E-05	0.02%	NA	1.39E-04	0.35%	0.35%
15	1300	1.31E-05	0.02%	NA	1.27E-04	0.32%	0.32%
16	1400	1.33E-05	0.02%	NA	1.29E-04	0.32%	0.32%
17	1500	1.34E-05	0.02%	NA	1.30E-04	0.32%	0.32%
18	1600	1.34E-05	0.02%	NA	1.29E-04	0.32%	0.32%
19	1700	1.32E-05	0.02%	NA	1.28E-04	0.32%	0.32%
20	1800	1.31E-05	0.02%	NA	1.26E-04	0.32%	0.32%
21	1900	1.28E-05	0.02%	NA	1.24E-04	0.31%	0.31%
22	2000	1.26E-05	0.02%	NA	1.22E-04	0.30%	0.30%
23	2100	1.23E-05	0.02%	NA	1.19E-04	0.30%	0.30%
24	2200	1.19E-05	0.02%	NA	1.16E-04	0.29%	0.29%
25	2300	1.16E-05	0.02%	NA	1.13E-04	0.28%	0.28%
26	2400	1.13E-05	0.02%	NA	1.10E-04	0.27%	0.27%
27	2500	1.10E-05	0.02%	NA	1.07E-04	0.27%	0.27%
Worst case GLC	**222**	**4.60E-05**	**0.08%**	**NA**	**4.46E-04**	**1.11%**	**1.11%**

Table V-7: Predicted downwind direction pollutant 1-hour GLCs of No.3, No.4, No.6, No.7 and No.10 community

No.	Distance from point pollution source (m)	SO_2			NO_2		
		Predicted downwind GLC (ug/m^3)	Ratio of GLC to PRC Standard (%)	Ratio of GLC to WHO Standard (%)	Predicted downwind GLC (ug/m^3)	Ratio of GLC to PRC Standard (%)	Ratio of GLC to WHO Standard (%)
1	10	0	0	0	0	0	0
2	100	2.98E-04	0.06%	NA	2.89E-03	1.44%	1.44%
3	200	3.60E-04	0.07%	NA	3.49E-03	1.74%	1.74%
4	268	3.86E-04	0.08%	NA	3.74E-03	1.87%	1.87%
5	300	3.79E-04	0.08%	NA	3.67E-03	1.84%	1.84%
6	400	3.16E-04	0.06%	NA	3.06E-03	1.53%	1.53%
7	500	3.29E-04	0.07%	NA	3.19E-03	1.59%	1.59%
8	600	3.10E-04	0.06%	NA	3.01E-03	1.50%	1.50%
9	700	2.81E-04	0.06%	NA	2.72E-03	1.36%	1.36%
10	800	2.50E-04	0.05%	NA	2.43E-03	1.21%	1.21%
11	900	2.22E-04	0.04%	NA	2.15E-03	1.08%	1.08%
12	1000	1.97E-04	0.04%	NA	1.91E-03	0.96%	0.96%
13	1100	1.77E-04	0.04%	NA	1.71E-03	0.86%	0.86%
14	1200	1.59E-04	0.03%	NA	1.54E-03	0.77%	0.77%
15	1300	1.44E-04	0.03%	NA	1.40E-03	0.70%	0.70%
16	1400	1.32E-04	0.03%	NA	1.27E-03	0.64%	0.64%
17	1500	1.21E-04	0.02%	NA	1.17E-03	0.59%	0.59%
18	1600	1.23E-04	0.02%	NA	1.19E-03	0.60%	0.60%
19	1700	1.24E-04	0.02%	NA	1.20E-03	0.60%	0.60%
20	1800	1.24E-04	0.02%	NA	1.20E-03	0.60%	0.60%
21	1900	1.24E-04	0.02%	NA	1.20E-03	0.60%	0.60%
22	2000	1.23E-04	0.02%	NA	1.19E-03	0.59%	0.59%
23	2100	1.21E-04	0.02%	NA	1.17E-03	0.58%	0.58%
24	2200	1.19E-04	0.02%	NA	1.15E-03	0.57%	0.57%
25	2300	1.16E-04	0.02%	NA	1.13E-03	0.56%	0.56%
26	2400	1.14E-04	0.02%	NA	1.11E-03	0.55%	0.55%
27	2500	1.12E-04	0.02%	NA	1.08E-03	0.54%	0.54%
Worst case GLC	**268**	**3.86E-04**	**0.08%**	**NA**	**3.74E-03**	**1.87%**	**1.87%**

Table V-8: Predicted downwind direction pollutant 24-hour GLCs of No.3, No.4, No.6, No.7 and No.10 community

No.	Distance from point pollution source (m)	SO_2			NO_2		
		Predicted downwind GLC (ug/m^3)	Ratio of GLC to PRC Standard (%)	Ratio of GLC to WHO Standard (%)	Predicted downwind GLC (ug/m^3)	Ratio of GLC to PRC Standard (%)	Ratio of GLC to WHO Standard (%)
1	10	0	0	0	0	0	0
2	100	9.93E-05	0.07%	0.50%	9.62E-04	1.20%	NA
3	200	1.20E-04	0.08%	0.60%	1.16E-03	1.45%	NA
4	268	1.29E-04	0.09%	0.64%	1.25E-03	1.56%	NA
5	300	1.26E-04	0.08%	0.63%	1.22E-03	1.53%	NA
6	400	1.05E-04	0.07%	0.53%	1.02E-03	1.28%	NA
7	500	1.10E-04	0.07%	0.55%	1.06E-03	1.33%	NA
8	600	1.03E-04	0.07%	0.52%	1.00E-03	1.25%	NA
9	700	9.37E-05	0.06%	0.47%	9.07E-04	1.13%	NA
10	800	8.35E-05	0.06%	0.42%	8.08E-04	1.01%	NA
11	900	7.41E-05	0.05%	0.37%	7.17E-04	0.90%	NA
12	1000	6.57E-05	0.04%	0.33%	6.37E-04	0.80%	NA
13	1100	5.89E-05	0.04%	0.29%	5.71E-04	0.71%	NA
14	1200	5.31E-05	0.04%	0.27%	5.14E-04	0.64%	NA
15	1300	4.81E-05	0.03%	0.24%	4.66E-04	0.58%	NA
16	1400	4.39E-05	0.03%	0.22%	4.25E-04	0.53%	NA
17	1500	4.04E-05	0.03%	0.20%	3.91E-04	0.49%	NA
18	1600	4.10E-05	0.03%	0.21%	3.97E-04	0.50%	NA
19	1700	4.13E-05	0.03%	0.21%	4.00E-04	0.50%	NA
20	1800	4.14E-05	0.03%	0.21%	4.01E-04	0.50%	NA
21	1900	4.12E-05	0.03%	0.21%	3.99E-04	0.50%	NA
22	2000	4.09E-05	0.03%	0.20%	3.96E-04	0.49%	NA
23	2100	4.02E-05	0.03%	0.20%	3.89E-04	0.49%	NA
24	2200	3.95E-05	0.03%	0.20%	3.83E-04	0.48%	NA
25	2300	3.88E-05	0.03%	0.19%	3.76E-04	0.47%	NA
26	2400	3.80E-05	0.03%	0.19%	3.68E-04	0.46%	NA
27	2500	3.72E-05	0.02%	0.19%	3.61E-04	0.45%	NA
Worst case GLC	**268**	**1.29E-04**	**0.09%**	**0.64%**	**1.25E-03**	**1.56%**	**NA**

Table V-9: Predicted downwind direction pollutant annual GLCs of No.3, No.4, No.6, No.7 and No.10 community

No.	Distance from point pollution source (m)	SO_2			NO_2		
		Predicted downwind GLC (ug/m^3)	Ratio of GLC to PRC Standard (%)	Ratio of GLC to WHO Standard (%)	Predicted downwind GLC (ug/m^3)	Ratio of GLC to PRC Standard (%)	Ratio of GLC to WHO Standard (%)
1	10	0	0	0	0	0	0
2	100	4.97E-05	0.08%	NA	4.81E-04	1.20%	1.20%
3	200	6.00E-05	0.10%	NA	5.81E-04	1.45%	1.45%
4	268	6.44E-05	0.11%	NA	6.24E-04	1.56%	1.56%
5	300	6.32E-05	0.11%	NA	6.12E-04	1.53%	1.53%
6	400	5.27E-05	0.09%	NA	5.10E-04	1.28%	1.28%
7	500	5.49E-05	0.09%	NA	5.32E-04	1.33%	1.33%
8	600	5.17E-05	0.09%	NA	5.01E-04	1.25%	1.25%
9	700	4.68E-05	0.08%	NA	4.54E-04	1.13%	1.13%
10	800	4.17E-05	0.07%	NA	4.04E-04	1.01%	1.01%
11	900	3.70E-05	0.06%	NA	3.59E-04	0.90%	0.90%
12	1000	3.29E-05	0.05%	NA	3.18E-04	0.80%	0.80%
13	1100	2.95E-05	0.05%	NA	2.85E-04	0.71%	0.71%
14	1200	2.66E-05	0.04%	NA	2.57E-04	0.64%	0.64%
15	1300	2.41E-05	0.04%	NA	2.33E-04	0.58%	0.58%
16	1400	2.19E-05	0.04%	NA	2.12E-04	0.53%	0.53%
17	1500	2.02E-05	0.03%	NA	1.96E-04	0.49%	0.49%
18	1600	2.05E-05	0.03%	NA	1.99E-04	0.50%	0.50%
19	1700	2.07E-05	0.03%	NA	2.00E-04	0.50%	0.50%
20	1800	2.07E-05	0.03%	NA	2.00E-04	0.50%	0.50%
21	1900	2.06E-05	0.03%	NA	2.00E-04	0.50%	0.50%
22	2000	2.04E-05	0.03%	NA	1.98E-04	0.49%	0.49%
23	2100	2.01E-05	0.03%	NA	1.95E-04	0.49%	0.49%
24	2200	1.98E-05	0.03%	NA	1.91E-04	0.48%	0.48%
25	2300	1.94E-05	0.03%	NA	1.88E-04	0.47%	0.47%
26	2400	1.90E-05	0.03%	NA	1.84E-04	0.46%	0.46%
27	2500	1.86E-05	0.03%	NA	1.80E-04	0.45%	0.45%
Worst case GLC	**268**	**6.44E-05**	**0.11%**	**NA**	**6.24E-04**	**1.56%**	**1.56%**

Table V-10: Predicted downwind direction pollutant 1-hour GLCs of No.1 and No.5 community

No.	Distance from point pollution source (m)	SO_2			NO_2		
		Predicted downwind GLC (ug/m^3)	Ratio of GLC to PRC Standard (%)	Ratio of GLC to WHO Standard (%)	Predicted downwind GLC (ug/m^3)	Ratio of GLC to PRC Standard (%)	Ratio of GLC to WHO Standard (%)
1	10	0	0	NA	0.00E+00	0	0
2	100	3.32E-04	0.07%	NA	3.20E-03	1.60%	1.60%
3	200	4.12E-04	0.08%	NA	3.98E-03	1.99%	1.99%
4	300	4.37E-04	0.09%	NA	4.22E-03	2.11%	2.11%
5	311	4.38E-04	0.09%	NA	4.23E-03	2.11%	2.11%
6	400	4.02E-04	0.08%	NA	3.88E-03	1.94%	1.94%
7	500	3.63E-04	0.07%	NA	3.50E-03	1.75%	1.75%
8	600	3.67E-04	0.07%	NA	3.55E-03	1.77%	1.77%
9	700	3.49E-04	0.07%	NA	3.37E-03	1.69%	1.69%
10	800	3.22E-04	0.06%	NA	3.11E-03	1.56%	1.56%
11	900	2.94E-04	0.06%	NA	2.83E-03	1.42%	1.42%
12	1000	2.66E-04	0.05%	NA	2.56E-03	1.28%	1.28%
13	1100	2.41E-04	0.05%	NA	2.33E-03	1.16%	1.16%
14	1200	2.20E-04	0.04%	NA	2.12E-03	1.06%	1.06%
15	1300	2.01E-04	0.04%	NA	1.94E-03	0.97%	0.97%
16	1400	1.84E-04	0.04%	NA	1.78E-03	0.89%	0.89%
17	1500	1.70E-04	0.03%	NA	1.64E-03	0.82%	0.82%
18	1600	1.57E-04	0.03%	NA	1.51E-03	0.76%	0.76%
19	1700	1.53E-04	0.03%	NA	1.48E-03	0.74%	0.74%
20	1800	1.55E-04	0.03%	NA	1.50E-03	0.75%	0.75%
21	1900	1.56E-04	0.03%	NA	1.51E-03	0.75%	0.75%
22	2000	1.56E-04	0.03%	NA	1.51E-03	0.75%	0.75%
23	2100	1.55E-04	0.03%	NA	1.50E-03	0.75%	0.75%
24	2200	1.53E-04	0.03%	NA	1.48E-03	0.74%	0.74%
25	2300	1.51E-04	0.03%	NA	1.46E-03	0.73%	0.73%
26	2400	1.49E-04	0.03%	NA	1.44E-03	0.72%	0.72%
27	2500	1.47E-04	0.03%	NA	1.42E-03	0.71%	0.71%
Worst case GLC	**311**	**4.38E-04**	**0.09%**	**NA**	**4.23E-03**	**2.11%**	**2.11%**

Table V-11: Predicted downwind direction pollutant 24-hour GLCs of No.1 and No.5 community

No.	Distance from point pollution source (m)	SO_2			NO_2		
		Predicted downwind GLC (ug/m^3)	Ratio of GLC to PRC Standard (%)	Ratio of GLC to WHO Standard (%)	Predicted downwind GLC (ug/m^3)	Ratio of GLC to PRC Standard (%)	Ratio of GLC to WHO Standard (%)
1	10	0	0	0	0	0	NA
2	100	1.11E-04	0.07%	0.55%	1.07E-03	1.33%	NA
3	200	1.37E-04	0.09%	0.69%	1.33E-03	1.66%	NA
4	300	1.46E-04	0.10%	0.73%	1.41E-03	1.76%	NA
5	311	1.46E-04	0.10%	0.73%	1.41E-03	1.76%	NA
6	400	1.34E-04	0.09%	0.67%	1.29E-03	1.62%	NA
7	500	1.21E-04	0.08%	0.60%	1.17E-03	1.46%	NA
8	600	1.22E-04	0.08%	0.61%	1.18E-03	1.48%	NA
9	700	1.16E-04	0.08%	0.58%	1.12E-03	1.40%	NA
10	800	1.07E-04	0.07%	0.54%	1.04E-03	1.30%	NA
11	900	9.78E-05	0.07%	0.49%	9.44E-04	1.18%	NA
12	1000	8.86E-05	0.06%	0.44%	8.55E-04	1.07%	NA
13	1100	8.04E-05	0.05%	0.40%	7.76E-04	0.97%	NA
14	1200	7.32E-05	0.05%	0.37%	7.06E-04	0.88%	NA
15	1300	6.69E-05	0.04%	0.33%	6.46E-04	0.81%	NA
16	1400	6.14E-05	0.04%	0.31%	5.92E-04	0.74%	NA
17	1500	5.65E-05	0.04%	0.28%	5.45E-04	0.68%	NA
18	1600	5.22E-05	0.03%	0.26%	5.04E-04	0.63%	NA
19	1700	5.11E-05	0.03%	0.26%	4.94E-04	0.62%	NA
20	1800	5.18E-05	0.03%	0.26%	5.00E-04	0.62%	NA
21	1900	5.21E-05	0.03%	0.26%	5.03E-04	0.63%	NA
22	2000	5.21E-05	0.03%	0.26%	5.03E-04	0.63%	NA
23	2100	5.17E-05	0.03%	0.26%	4.99E-04	0.62%	NA
24	2200	5.11E-05	0.03%	0.26%	4.93E-04	0.62%	NA
25	2300	5.05E-05	0.03%	0.25%	4.87E-04	0.61%	NA
26	2400	4.98E-05	0.03%	0.25%	4.80E-04	0.60%	NA
27	2500	4.90E-05	0.03%	0.25%	4.73E-04	0.59%	NA
Worst case GLC	**311**	**1.46E-04**	**0.10%**	**0.73%**	**1.41E-03**	**1.76%**	**NA**

Table V-12: Predicted downwind direction pollutant annual GLCs of No.1 and No.5 community

No.	Distance from point pollution source (m)	SO_2			NO_2		
		Predicted downwind GLC (ug/m^3)	Ratio of GLC to PRC Standard (%)	Ratio of GLC to WHO Standard (%)	Predicted downwind GLC (ug/m^3)	Ratio of GLC to PRC Standard (%)	Ratio of GLC to WHO Standard (%)
1	10	0	0	0	0	0	0
2	100	5.53E-05	0.09%	NA	5.33E-04	1.33%	1.33%
3	200	6.87E-05	0.11%	NA	6.63E-04	1.66%	1.66%
4	300	7.28E-05	0.12%	NA	7.03E-04	1.76%	1.76%
5	311	7.30E-05	0.12%	NA	7.04E-04	1.76%	1.76%
6	400	6.70E-05	0.11%	NA	6.47E-04	1.62%	1.62%
7	500	6.04E-05	0.10%	NA	5.83E-04	1.46%	1.46%
8	600	6.12E-05	0.10%	NA	5.91E-04	1.48%	1.48%
9	700	5.82E-05	0.10%	NA	5.62E-04	1.40%	1.40%
10	800	5.37E-05	0.09%	NA	5.19E-04	1.30%	1.30%
11	900	4.89E-05	0.08%	NA	4.72E-04	1.18%	1.18%
12	1000	4.43E-05	0.07%	NA	4.27E-04	1.07%	1.07%
13	1100	4.02E-05	0.07%	NA	3.88E-04	0.97%	0.97%
14	1200	3.66E-05	0.06%	NA	3.53E-04	0.88%	0.88%
15	1300	3.35E-05	0.06%	NA	3.23E-04	0.81%	0.81%
16	1400	3.07E-05	0.05%	NA	2.96E-04	0.74%	0.74%
17	1500	2.83E-05	0.05%	NA	2.73E-04	0.68%	0.68%
18	1600	2.61E-05	0.04%	NA	2.52E-04	0.63%	0.63%
19	1700	2.56E-05	0.04%	NA	2.47E-04	0.62%	0.62%
20	1800	2.59E-05	0.04%	NA	2.50E-04	0.62%	0.62%
21	1900	2.60E-05	0.04%	NA	2.51E-04	0.63%	0.63%
22	2000	2.61E-05	0.04%	NA	2.52E-04	0.63%	0.63%
23	2100	2.58E-05	0.04%	NA	2.49E-04	0.62%	0.62%
24	2200	2.56E-05	0.04%	NA	2.47E-04	0.62%	0.62%
25	2300	2.52E-05	0.04%	NA	2.44E-04	0.61%	0.61%
26	2400	2.49E-05	0.04%	NA	2.40E-04	0.60%	0.60%
27	2500	2.45E-05	0.04%	NA	2.37E-04	0.59%	0.59%
Worst case GLC	**311**	**7.30E-05**	**0.12%**	**NA**	**7.04E-04**	**1.76%**	**1.76%**

Figure V-3: Predicted Downwind Direction 1-h SO_2 GLC of No.2, No.8 and No.9 community.

Ratio of GLC to Standard (%)

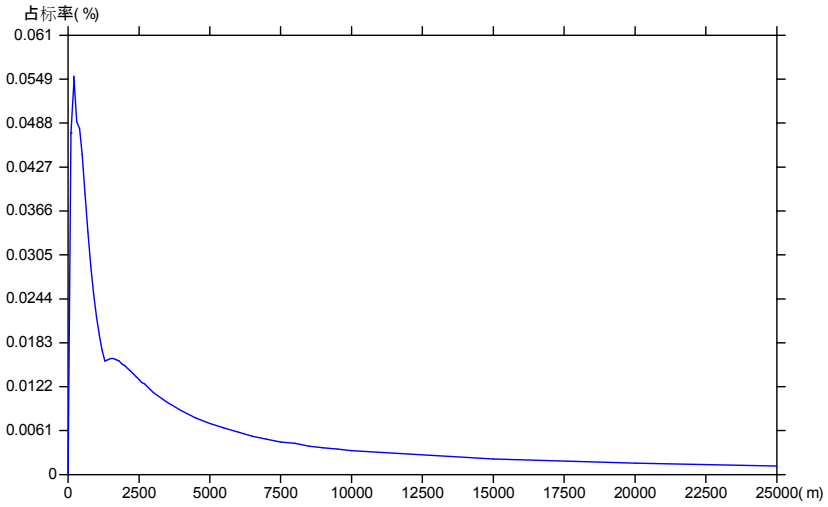


Figure V-4: Predicted Downwind Direction 1-h NO_2 GLC of No.2, No.8 and No.9 community.

Ratio of GLC to Standard (%)

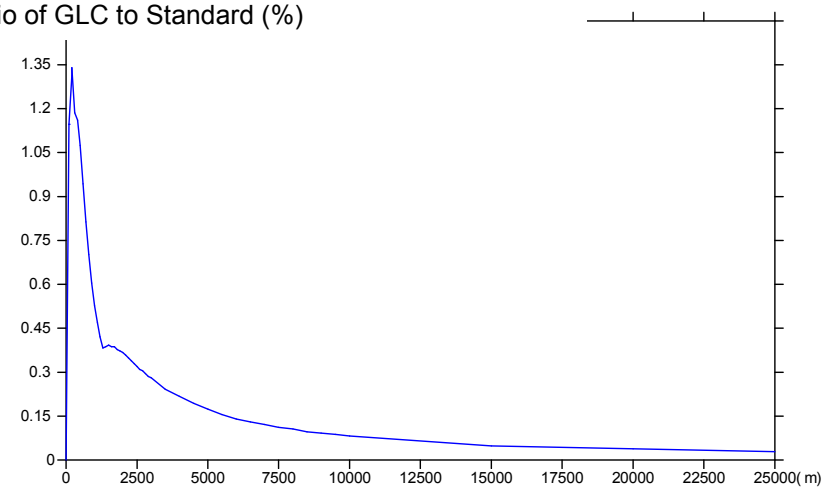


Figure V-5: Predicted Downwind Direction 1-h SO_2 GLC of No.3, No.4, No.6, No.7 and No.10 community.

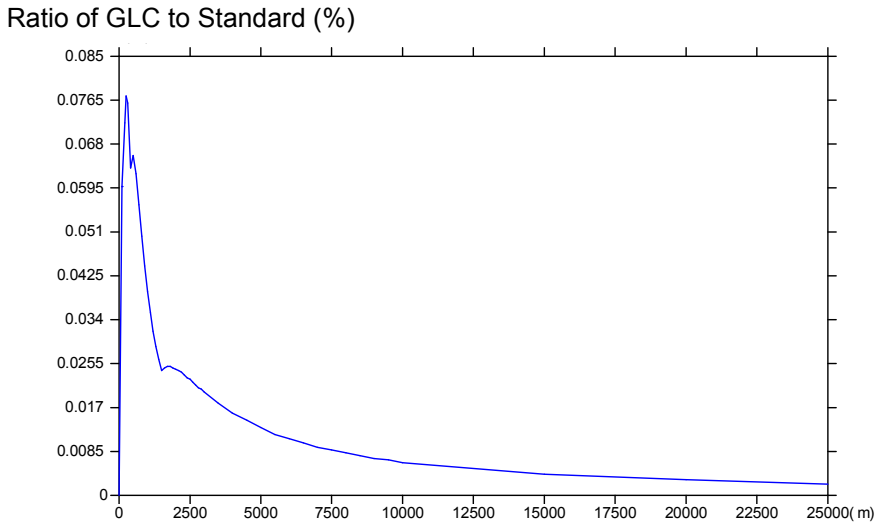


Figure V-6: Predicted Downwind Direction 1-h NO_2 GLC of No.3, No.4, No.6, No.7 and No.10 community

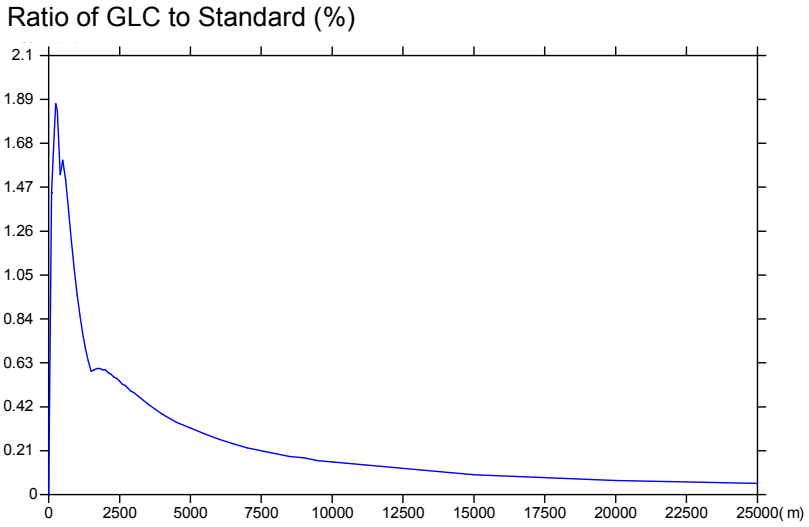


Figure V-7: Predicted Downwind Direction 1-h SO_2 GLC of No.1 and No.5 community.

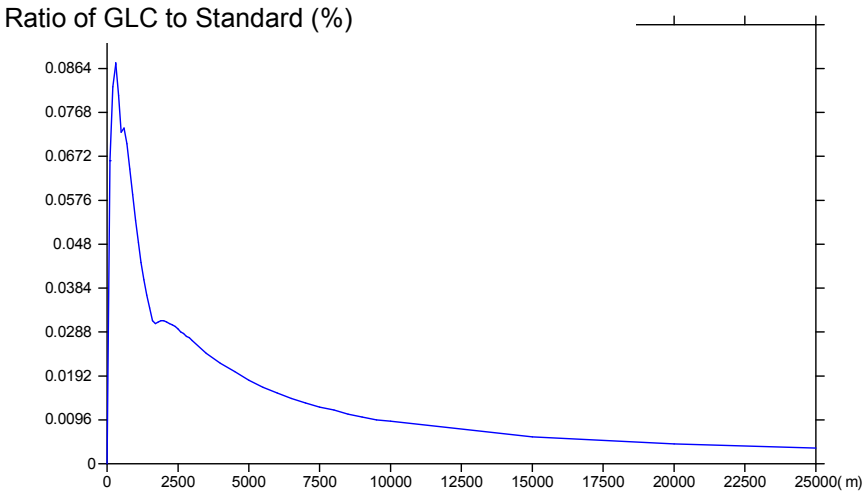
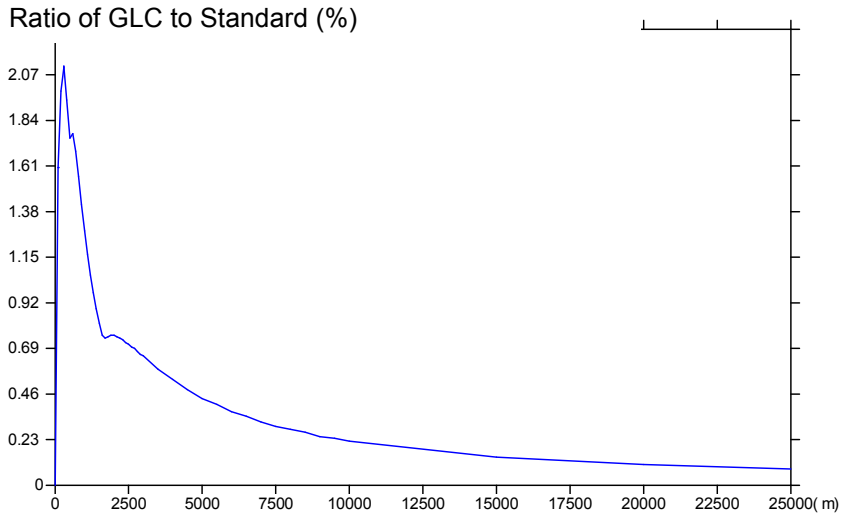


Figure V-8: Predicted Downwind Direction 1-h NO_2 GLC of No.1 and No.5 community.



236. The 42 MW gas fired boiler will be designed to comply with the most stringent of provincial standards (see **Table II-6**). According to a 2007 survey of industrial natural gas boilers in the PRC, natural gas boilers typically have a NOx emission of 137.31 mg/m^3. This emission level is in compliance with the 2007 EHS Guidelines of 240 mg/m^3 for boilers but not comply with Integrated Emission Standard of Air Pollutants for Shandong Province (Table 2 of dB 37/2376-2013) of 100 mg/m^3. However, to in order to maximize environmental benefits, low NOx natural gas boilers with

less than 100 mg/m^3 NOx emissions will be used.

237. A low NOx boiler is designed to optimize flame shape. Staged combustion technology is used, resulting in a cooler flame which suppresses thermal NOx formation. The swirl-stabilized primary area is responsible for producing a very stable flame. Combustion chambers are designed to match the low NOx burners. In addition, smart fuel-air compound control generates the optimum conditions for the combustion air through a joint fan with a frequency converter. The combination of low NOx combustion, large combustion chambers, smart control systems and efficient combustion technology benefits the environment as well as the operator, and ensures that NOx emissions are less than 100 mg/m^3. The designed stack height is 30m.

a. Atmospheric Dispersion Modelling

238. Atmospheric dispersion modelling was undertaken by EIA Institute utilizing AERMOD, a US EPA and PRC approved steady-state short range (up to 50 km) plume model that incorporates air dispersion based on planetary boundary layer turbulence structure and scaling concepts, including treatment of all point, surface and body sources.[22] AERMOD can simulate the concentration distribution in both the short term (1-hour and daily average concentrations) and the long term (annual average concentrations). AERMOD is applicable for rural or urban districts and simple or complicated terrain. The impact of bottom flow of buildings (e.g. plume downwash) is also taken into account. AERMOD uses meteorological data for 1-hour continuous pre-treatment to simulate average concentration distribution in periods down to 1 hour. AERMOD includes two preprocessors: AERMET, which accepts surface meteorological data and upper air soundings, and then calculates atmospheric parameters needed by the dispersion model; and AERMAP, a terrain preprocessor which provide a physical relationship between terrain features and the behavior of air pollution plumes. It generates location and height data for each receptor location. It also provides information that allows the dispersion model to simulate the effects of air flowing over hills or splitting to flow around hills.

239. Ground characteristic parameters required by AERMOD (surface albedo at high noon, Bowen at daytime and ground roughness) were set according to recommended parameters in the reference model suitable for the component area. Atmospheric diffusion parameters mainly use ground meteorological data and sounding meteorological data to generate the predicted meteorological input document.

b. Meteorological Data

240. Climate data from 1997-2016 and daily and hourly conventional meteorological data for 2016 was obtained from the Shanghe meteorological station to provide meteorological data for the atmospheric dispersion modeling. The Shanghe meteorological station is located at 37°20′N and 117°10′E and is about 3.2 km away from the existing Hengtai HSP, where the 42 MW natural gas boiler will be installed.

241. The modeling utilized one year of 8,784 hourly and 366 daily meteorological data for 2016, including hourly wind directions and wind speed for each day, dry-bulb temperature, ground data like cloud cover (total cloud cover and low cloud cover), etc. Daily high altitude data was extrapolated in AERMET from two times per day every 100 m from 0-3000 m. The AERMET estimate method was used for mixed layer height. The default of 200 calculated layers was utilized

[22] AERMOD is recommended model in Appendix A of Guidelines for Environmental Impact Assessment of Atmospheric Environment (HJ2.2-2008).

with a maximum altitude of 5000 m.

242. From 1997 to 2016, maximum wind speed of Shanghe is 15.2 (2009) m/s, extreme high temperature is 40.6°C (2005) and extreme low temperature is -19.3°C (2001), maximum annual precipitation is 826.3 mm in 2009. **Table V-13** presents summary data obtained for the period 1996-2016 from the Shanghe meteorological station.

Table V-13: Summary of Shanghe meteorological data, 1997–2016

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Wind speed(m/s)	1.8	2.3	2.8	2.9	2.5	2.3	1.9	1.6	1.6	1.9	2.0	1.9	2.1
Temperature (°C)	-2.8	1.0	6.9	14.2	20.0	25.1	26.8	25.2	20.5	14.1	5.8	-0.7	13.0
Relative humidity (%)	61	57	55	57	72	62	77	82	76	68	67	66	67
Precipitation (mm)	3.0	8.4	9.7	22.7	50.4	90.8	170.6	137.1	40.4	34.6	13.3	3.9	584.8
Sunshine hours (h)	177.5	160.2	201.3	250.6	267.6	255.5	227.5	216.3	212.3	208.6	193.5	156.7	2527.6

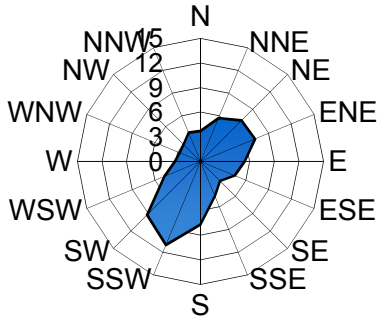
243. Wind direction frequency of Shanghe meteorological station from 1997 to 2016 is presented in **Table V-14**.

Table V-14: Summary Shanghe wind direction frequency data, 1997–2016

Wind direction	N	NNE	NE	ENE	E	ESE
Frequency	3.7	5.7	7.1	7.2	5.4	4.5
Wind direction	SE	SSE	S	SSW	SW	WSW
Frequency	3.4	4.5	7.7	11.0	9.2	4.8
Wind direction	W	WNW	NW	NNW	Calm wind	
Frequency	3.1	2.7	3.0	3.8	13.3	

244. Wind rose of Shanghe from 1997 to 2016 is presented in **Figure V-9**.

Figure V-9: Shanghe wind roses, based on data from 1997-2016



245. Conventional meteorological data the Shanghe meteorological station for 2016 was obtained. Monthly average temperature and wind speed of Shanghe are presented in **Table V-15**. Monthly average wind speeds in four seasons are presented in **Table V-16**

Table V-15: Monthly average temperature of Shanghe 2016

Item	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Wind speed (m/s)	1.96	2.33	3.03	2.8	2.48	2.38	1.77	1.48	1.49	1.57	1.95	1.73	2.08
Temperature (°C)	-5.49	-0.19	7.37	13.53	19.13	25.94	27.2	24.82	18.53	14.3	7.22	-1.44	12.6

Table V-16: Monthly average wind speeds in four seasons of Shanghe, 2016 Unit: m/s

Time	0	1	2	3	4	5	6	7
Spring	2.15	2.19	2.11	2.11	2.19	2.13	2.09	2.31
Summer	1.45	1.44	1.51	1.37	1.33	1.37	1.44	1.67
Autumn	1.3	1.27	1.21	1.16	1.25	1.31	1.39	1.42
Winter	1.76	1.71	1.74	1.68	1.61	1.67	1.58	1.58
Time	8	9	10	11	12	13	14	15
Spring	2.86	3.54	3.93	4.02	2.15	2.19	2.11	2.11
Summer	1.99	2.15	2.33	2.38	1.45	1.44	1.51	1.37
Autumn	1.61	1.9	2.27	2.53	1.3	1.27	1.21	1.16
Winter	1.57	1.92	2.43	2.73	1.76	1.71	1.74	1.68
Time	16	17	18	19	20	21	22	23
Spring	2.19	2.13	2.09	2.31	2.86	3.54	3.93	4.02
Summer	1.33	1.37	1.44	1.67	1.99	2.15	2.33	2.38
Autumn	1.25	1.31	1.39	1.42	1.61	1.9	2.27	2.53
Winter	1.61	1.67	1.58	1.58	1.57	1.92	2.43	2.73

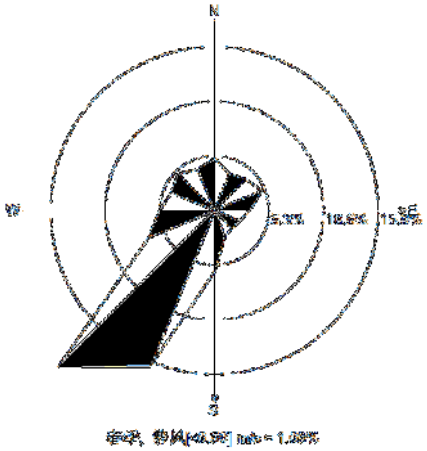
246. Wind direction frequency of Shanghe in 2016 is presented in **Table V-17**.

Table V-17: Wind direction frequency of Shanghe, 2016

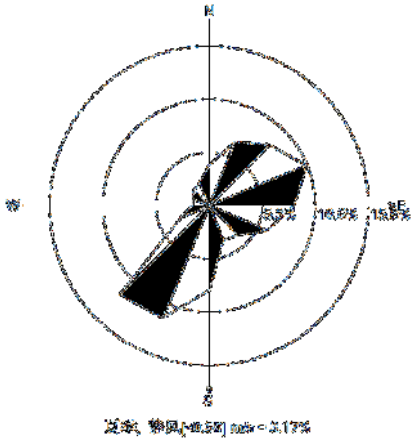
Wind direction	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Calm
Jan	9.01	9.27	5.78	9.01	5.78	2.96	3.36	3.36	5.51	6.85	9.27	7.93	5.51	3.49	4.03	5.91	2.96
Feb	4.89	5.75	9.48	10.06	12.93	5.89	5.6	3.3	6.75	9.63	7.18	3.3	3.59	3.02	3.02	3.3	2.3
Mar	6.32	4.03	2.82	5.91	2.82	1.48	2.15	2.69	6.72	18.95	16.8	7.39	6.45	3.76	4.57	6.72	0.4
Apr	5.97	3.75	5.42	3.75	2.08	2.64	3.19	3.75	6.81	13.06	20.83	6.81	5.28	5.83	5.97	3.61	1.25
May	2.82	3.76	4.57	5.38	5.38	3.76	1.88	1.75	4.3	16.8	26.61	6.32	4.17	3.9	4.44	2.55	1.61
Jun	3.19	6.53	4.72	8.06	8.33	6.39	4.03	3.47	11.39	16.11	17.5	2.64	0.56	2.08	1.25	2.92	0.83
Jul	3.9	3.36	6.99	8.33	6.45	4.3	5.11	4.97	10.22	14.52	15.59	4.17	2.96	1.75	2.82	2.28	2.28
Aug	5.11	10.62	13.84	15.05	10.62	8.33	3.23	2.69	3.76	5.78	4.7	2.28	1.61	1.48	2.42	2.15	6.32
Sep	7.22	9.58	12.92	9.44	6.53	3.33	2.08	1.67	3.61	9.17	8.06	4.58	2.5	2.22	3.75	4.31	9.03
Oct	3.09	5.11	4.7	4.3	6.72	5.11	2.55	3.76	13.04	18.55	10.75	6.05	1.88	2.42	1.75	1.34	8.87
Nov	7.5	9.72	13.33	17.08	6.25	4.44	3.33	2.22	3.33	5.97	7.5	1.94	3.75	1.81	2.64	3.89	5.28
Dec	7.66	7.8	5.38	8.33	4.97	5.24	4.17	3.36	5.91	6.59	12.1	4.17	6.85	3.09	3.63	3.76	6.99
Annual	5.56	6.6	7.47	8.71	6.55	4.49	3.38	3.09	6.79	11.85	13.1	4.82	3.77	2.9	3.36	3.56	4.02
Spring	5.03	3.85	4.26	5.03	3.44	2.63	2.4	2.72	5.93	16.3	21.42	6.84	5.3	4.48	4.98	4.3	1.09
Summer	4.08	6.84	8.56	10.51	8.47	6.34	4.12	3.71	8.42	12.09	12.55	3.03	1.72	1.77	2.17	2.45	3.17
Autumn	5.91	8.1	10.26	10.21	6.5	4.3	2.66	2.56	6.73	11.31	8.79	4.21	2.7	2.15	2.7	3.16	7.74
Winter	7.23	7.65	6.82	9.11	7.78	4.67	4.35	3.34	6.04	7.65	9.57	5.17	5.36	3.21	3.57	4.35	4.12

247. Wind roses of Shanghe in 2016 are presented in **Figure V-10**.

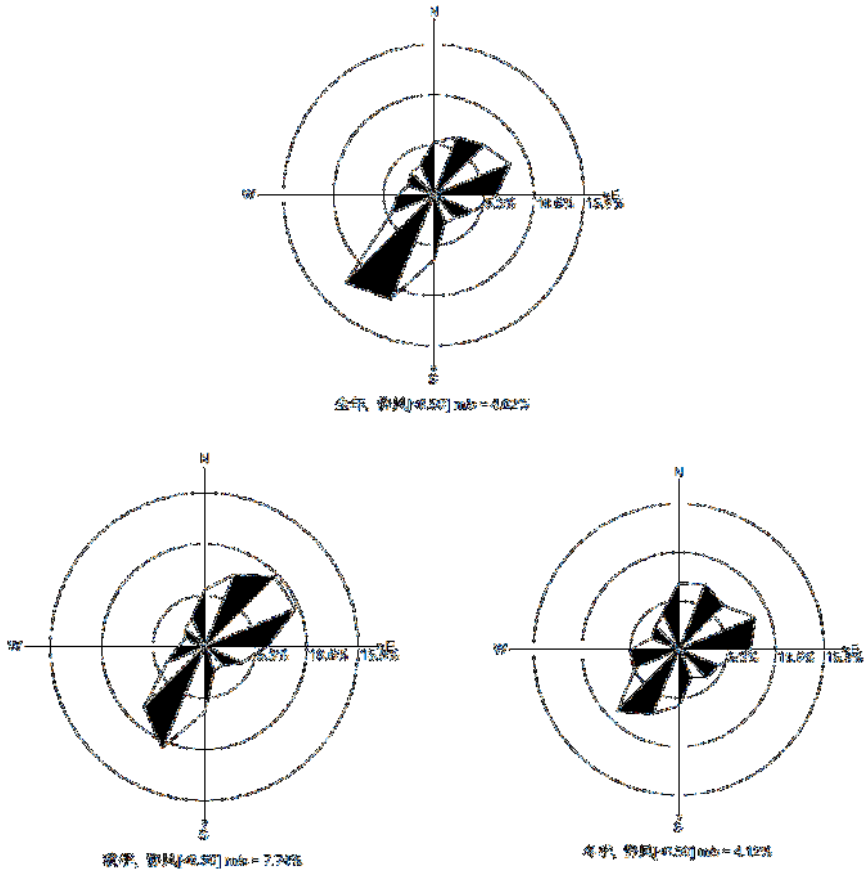
Figure V-10: Shanghe wind roses in 2016.



Spring, 1.09% calm wind



Summer, 3.17% calm wind



c. Atmospheric Dispersion Model Scenarios

248. This component will build one 42 MW gas fired boiler to replace the existing 58 MW coal fired boiler in the existing Hengtai HSP. Based on the information provided by JHG, two more 42 MW gas fired boilers will be installed to meet the increasing heat demand in Shanghe County in the future with no timeframe yet, which will not be financed by ADB and are not part of the Project. The replaced 58 MW coal fired boiler will not be demolished but kept as a backup during extreme weather conditions.

249. Atmospheric Dispersion Modelling Scenarios of the component are presented below:

(i) Scenario 1: Worst case SO_2, PM_{10} and NO_2 ground level concentrations (GLCs) over the entire 2016 modelling period (8640h) with the 42 MW gas boiler+58 MW coal fired boiler running simultaneously, including:

(a) Worst case predicted 1-hour averaging period SO_2 and NO_2 GLCs;

(b) Worst case predicted 24-hour averaging period SO_2, $PM_{2.5}$, PM_{10} and NO_2 GLCs;

(c) Worst case predicted annual averaging period SO_2, $PM_{2.5}$, PM_{10} and NO_2 GLCs.

(ii) Scenario 2: Worst case SO_2, PM_{10} and NO_2 ground level concentrations (GLCs) over the entire 2016 modelling period (8640h) with three boilers (3x42 MW) + 58 MW coal fired boiler running simultaneously, including:

(a) Worst case predicted 1-hour averaging period SO2 and NO2 GLCs;

(b) Worst case predicted 24-hour averaging period SO2, PM2.5, PM10 and NO2 GLCs;

(c) Worst case predicted annual averaging period SO2, PM2.5, PM10 and NO2 GLCs.

(iii) Scenario 3: Worst case SO_2, PM_{10} and NO_2 ground level concentrations (GLCs) over the entire 2016 modelling period (8640h) with the 42 MW boiler running, superimposed over worst case background ambient air quality monitoring data (deducting the emissions from the 58 MW coal fired boiler) from Shanghe ambient air quality monitoring stations from January 25, 2018 to January 31, 2018 (**Table IV-3 and IV-4**) including:

(a) Worst case predicted 1-hour averaging period SO2, PM10 and NO2 GLCs + worst case ambient concentration at sensitive receptors.

(b) Worst case predicted 24-hour averaging period SO2, PM10 and NO2 GLCs + worst case ambient concentration at sensitive receptors.

(c) Worst case predicted annual averaging period SO2, PM10 and NO2 GLCs + worst case ambient concentration at sensitive receptors.

(iv) Scenario 4: Worst case SO_2, PM_{10} and NO_2 ground level concentrations (GLCs) over the entire 2016 modelling period (8640h) with three boilers running simultaneously, superimposed over worst case background ambient air quality monitoring data (deducting the emissions from the 58 MW coal fired boiler), including:

(a) Worst case predicted 1-hour averaging period SO2, PM10 and NO2 GLCs + worst case ambient concentration at sensitive receptors.

(b) Worst case predicted 24-hour averaging period SO2, PM10 and NO2 GLCs + worst case ambient concentration at sensitive receptors.

(c) Worst case predicted annual averaging period SO2, PM10 and NO2 GLCs + worst case ambient concentration at sensitive receptors.

d. Atmospheric Dispersion Model Input

250. The emission parameters of the component are presented in **Table V-18**.

Table V-18: Parameter of boilers for dispersion modelling

Boiler No.	Period	Stack parameter			Exhaust gas flow (Nm^3/h)	Emission rate (kg/h)			
		Height(m)	Inner diameter (m)	Exhaust gas temperature (K)		SO_2	PM_{10}	$PM_{2.5}$	NOx
No. 1 42 MW gas fired boiler	Nov 15, 2016 – Mar 14, 2017	30	1.2	353.15	53,500	1.53	0.53	0.27	4.29
No. 2 42 MW gas fired boiler		30	1.2	353.15	53,500	1.53	0.53	0.27	4.29
No. 3 42 MW gas fired boiler		30	1.2	353.15	53,500	1.53	0.53	0.27	4.29
58 MW coal fired boiler		100	4.1	376.95	19.73	3.97	0.94	0.47	13.29

Note: Emission rate of 58 MW coal fired boiler is based on CEMS data.

Source: Domestic EIA.

e. Receptor Grid System

251. Predictions of concentration were made for a 7,000 × 7,000 m grid. The grid consists of 100 m x 100 m cells with a total of 4,900 receptors. The grid origin coordinates (0,0) is 117° 7'57.56"E and 37°17'35.00"N. Map projection is UTM and geodetic datum is WGS84. Terrain was assumed to be flat.

252. Sensitive receptors within the influence area are listed in **Table V-19**.

Table V-19: Model Input Data for Sensitive receptors

No.	Location	Direction	Distance (m)	X (m)	Y (m)
1	Shanghe EPB	NE	3760.1	2794.22	2516.14
2	Shanghe High-Tech Zone	SE	3344.5	558.27	-3297.62
3	Jinqidian Kindergarten	SE	148.8	131.56	-69.52
4	Mengjia Community	NE	765.0	71.59	761.63
5	Shanghe Community	SE	740.4	539.81	-506.7
6	Qilu Community	SW	1159.9	-704.51	-921.48
7	Zhanggongliang Community	NW	1779.7	-1777.62	87.04
8	Shanghe No.2 School	SE	1931.3	1931.18	-23.91
9	Shanghe No.1 School	NW	1946.8	984.45	1679.58

No.	Location	Direction	Distance (m)	X (m)	Y (m)
10	Xinlong Community	NW	2270.9	1953.79	1157.39

Source: Domestic EIA (2018).

f. Meteorological Data

253. Climate data from 1996-2016 and daily and hourly conventional meteorological data in 2016 was obtained from the Shanghe meteorological station to provide meteorological data for atmospheric dispersion modeling. The Shanghe meteorological station is located at 37°20′N and 117°10′E and is 3.2 km from the Hengtai HSP.

254. The modeling utilized one year of hourly and daily meteorological data for the year 2016, including hourly wind directions and wind speed for each day in 2016, dry-bulb temperature, ground data like cloud cover (total cloud cover and low cloud cover), etc. Daily high altitude data was extrapolated in AERMET from two times per day every 100 m from 0 -3000 m. The missed layer heights were calculated using AERMET's default method. The default of 200 calculated layers was utilized with a maximum altitude of 5000 m.

255. Ground characteristic parameters required by AERMOD (surface albedo at high noon, Bowen at daytime and ground roughness) were set according to recommended parameters in the reference model suitable for the component. Atmospheric diffusion parameters mainly use ground meteorological data and sounding meteorological data to generate the predicted meteorological input document.

g. Scenario 1 Result

256. The Scenario 1 five worst case SO_2 GLCs and corresponding date and position are presented in **Table V-20**, **Figure V-11**, **Figure V-12** and **Figure V-13**.

257. The modelling shows that, under the meteorological conditions of 2016, the worst case 1-hour average GLC of SO_2 from the component is 4.82 μg/m³, equivalent to 0.96% of the PRC standard. The location is (700, 0) and the time is 10 am of February 14, 2016. The worst case 24-hour average GLC of SO_2 from the component is 1.07 μg/m³ equivalent to 0.71% of the PRC standard and 5.35% of WHO guideline value (20 μg/m³). The location is (200, 300) and the time is March 11, 2016. The worst case annual average GLC of SO_2 from the component is 0.00434 μg/m³ equivalent to 0.07% of the PRC standard. The location is (300,300).

258. Based on the modeling results, these worst case GLCs are only predicted to occur one time in the modeling year (2016).

Table V-20: Scenario 1 five worst case SO_2 GLCs and corresponding date and positions. Unit: mg/m^3

No.	1-hour average concentration			24-hour average concentration			Annual average concentration	
	X, Y	Time	Value	X, Y	Time	Value	X, Y	Value
1	700,0	16021410	0.00482	200,300	20160311	0.00107	300,300	4.34 E-05
2	800,0	16021410	0.00477	300,400	20160311	0.00103	200,200	4.31 E-05
3	900,0	16021410	0.00472	300,300	20160311	0.00101	200,300	4.16 E-05
4	600,0	16021410	0.00462	200,200	20160311	0.00098	300,400	3.88 E-05
5	1000,0	16021410	0.00459	-100,-300	20161122	0.00082	300,200	3.61 E-05

Note: For 1-hour average, time is Year/Month/Day/Hour. For 24-hour average, time is Year/Month/Day.
Source: Domestic EIA (2018).

Figure V-11: SO_2 contour map of worst case 1-hour average concentration

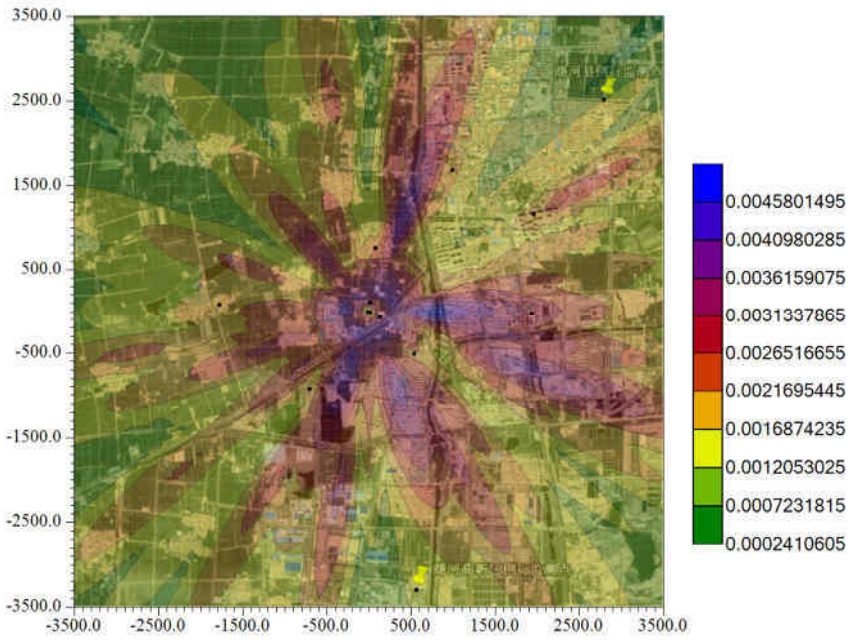


Figure V-12: SO_2 contour map of worst case 24-hour average concentration

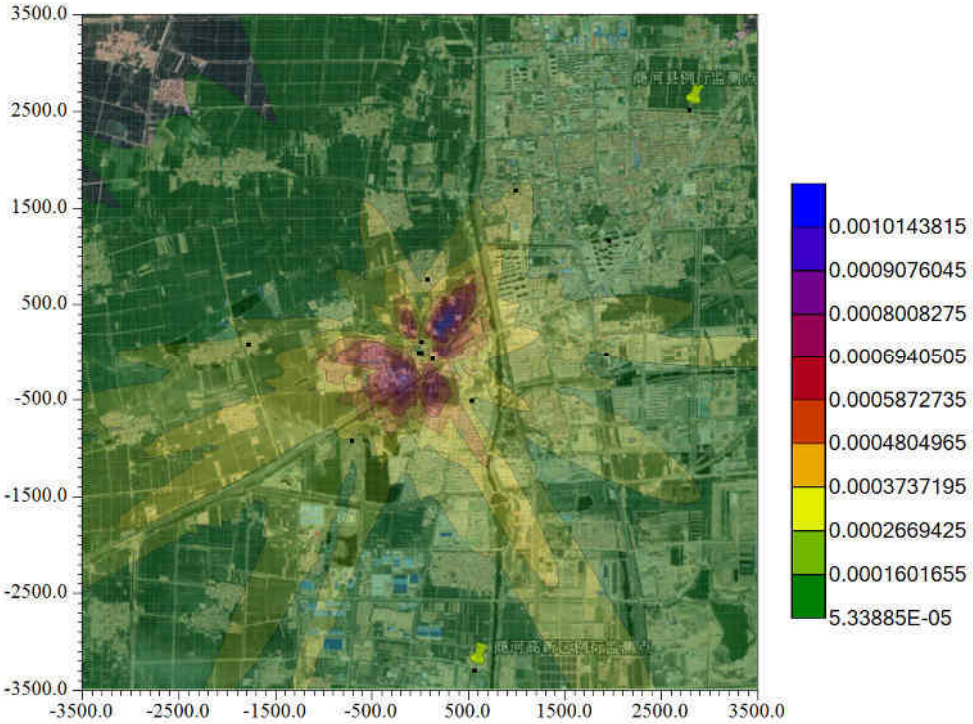
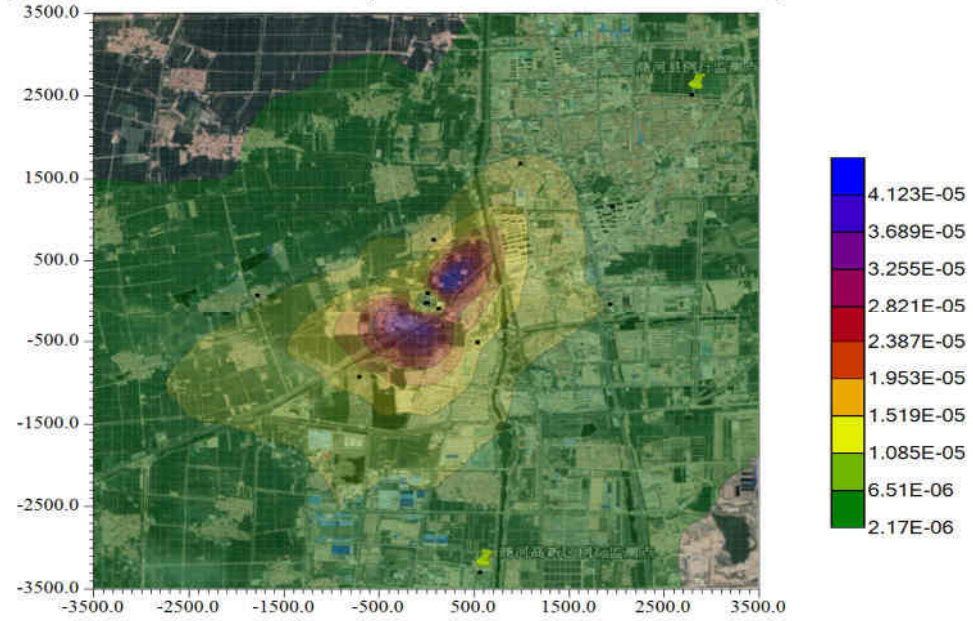


Figure V-13: SO_2 contour map of worst case annual average concentration



259. The Scenario 1 five worst case NO_2 GLCs and corresponding date and position are presented in **Table V-21**, **Figure V-14, Figure V-15** and **Figure V-16**.

260. The modelling shows that, under the meteorological conditions of 2016, the worst case 1-hour average GLC of NO_2 from the component is 16.3 μg/m³ equivalent to 8.16% of the PRC

standard and WHO Guideline value. The location is (700, 0) and the time is 10 am of February 14, 2016. The worst case 24-hour average GLC of NO_2 from the component is 3.51 μg/m³ equivalents to 4.38% of the PRC standard. The location is (200, 300) and the time is March 11. The worst case annual average GLC of NO_2 from the component is 0.14 μg/m³ equivalent to 0.36% of the PRC standard and WHO Guideline value. The location is (300,300).

261. Based on the modeling results, all these worst case GLCs are only predicted to occur one time in the modeling year (2016).

Table V-21: Scenario 1 five worst case NO_2 GLCs and corresponding date and positions. Unit: mg/m³

No.	1-hour average concentration			24-hour average concentration			Annual average concentration	
	X, Y	Time	Value	X, Y	Time	Value	X, Y	Value
1	700,0	16021410	0.01631	200,300	20160311	0.00351	300,300	1.43 E-04
2	800,0	16021410	0.01623	300,400	20160311	0.00337	200,200	1.42 E-04
3	900,0	16021410	0.01614	300,300	20160311	0.00333	200,300	1.37 E-04
4	1000,0	16021410	0.01574	200,200	20160311	0.0032	300,400	1.28 E-04
5	600,0	16021410	0.01557	-100,-300	20161122	0.00269	300,200	1.19 E-04

Note: T For 1-hour average, time is Year/Month/Day/Hour. For 24-hour average, time is Year/Month/Day.
Source: Domestic EIA (2018).

Figure V-14: NO_2 contour map of worst case 1-hour average concentration

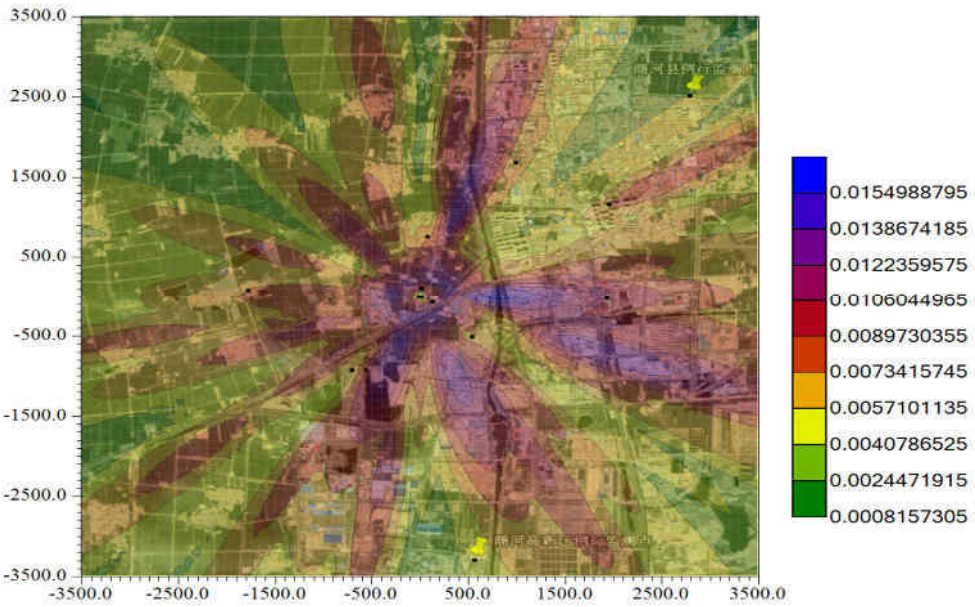


Figure V-15: NO_2 contour map of worst case 24-hour average concentration

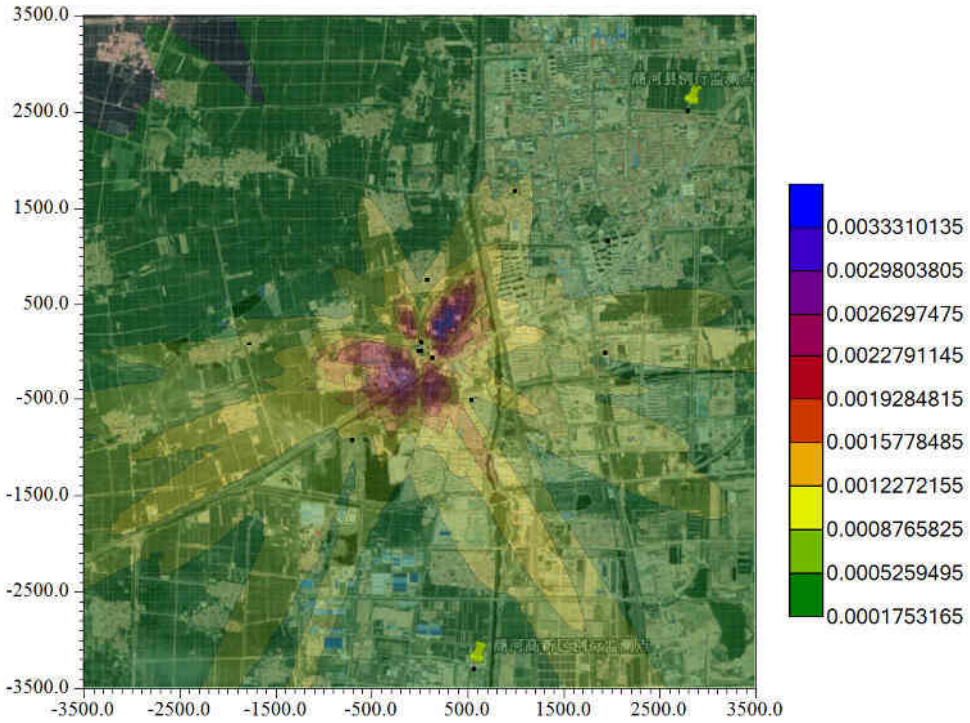
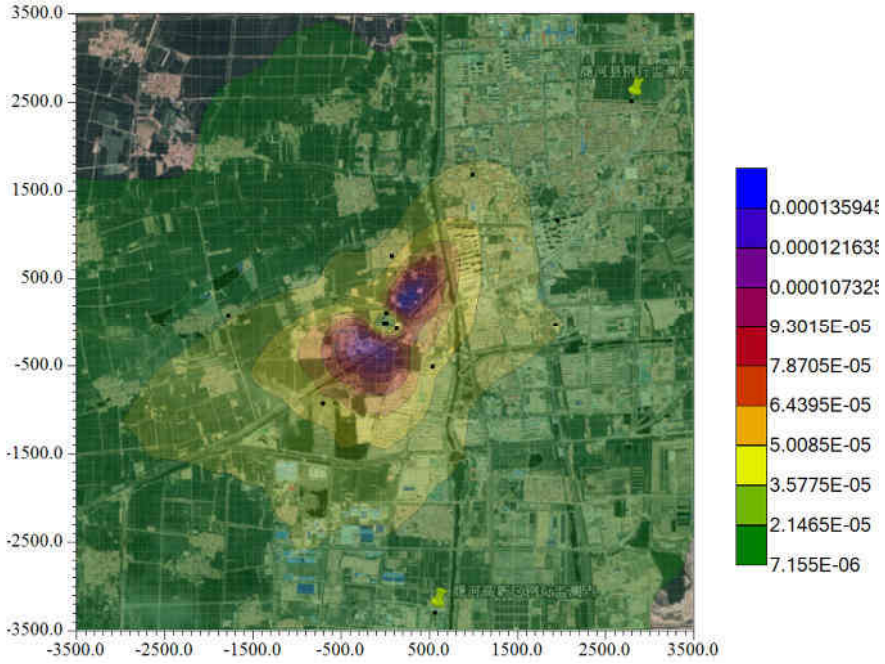


Figure V-16: NO_2 contour map of worst case annual average concentration



262. The Scenario 1 five worst case PM_{10} GLCs and corresponding date and position are presented in **Table V-22**, **Figure V-17** and **Figure V-18**.

263. The modelling results show that, under the meteorological conditions of 2016, the worst

case 24-hour average GLC of PM_{10} from the component is 0.32 µg/m³ equivalents to 0.21% of the PRC standard and 0.64% of WHO Guideline value (50 µg/m³). The location is at coordinate (200, 300) and the time is 11 March 2016. The worst case annual average GLC of PM_{10} from the component is 0.013 µg/m³ equivalents to 0.02% of the PRC standard and 0.07% of WHO Guideline value (20 µg/m³). The location is at (300, 300).

264. Based on the modeling results, all these worst case GLCs are only predicted to occur one time in the modeling year (2016).

Table V-22: Scenario 1 five worst case PM_{10} GLCs and corresponding date and positions. Unit: mg/m³

No.	1-hour average concentration			24-hour average concentration			Annual average concentration	
	X, Y	Time	Value	X, Y	Time	Value	X, Y	Value
1		NA		200,300	20160311	0.00032	300,300	1.31 E-05
2		NA		300,400	20160311	0.00031	200,200	1.30 E-05
3		NA		300,300	20160311	0.00031	200,300	1.26 E-05
4		NA		200,200	20160311	0.00029	300,400	1.17 E-05
5		NA		-100,-300	20161122	0.00025	300,200	1.09 E-05

Note: For 1-hour average, time is Year/Month/Day/Hour. For 24-hour average, time is Year/Month/Day.
Source: Domestic EIA (2018).

Figure V-17: PM_{10} contour map of worst case 24-hour average concentration

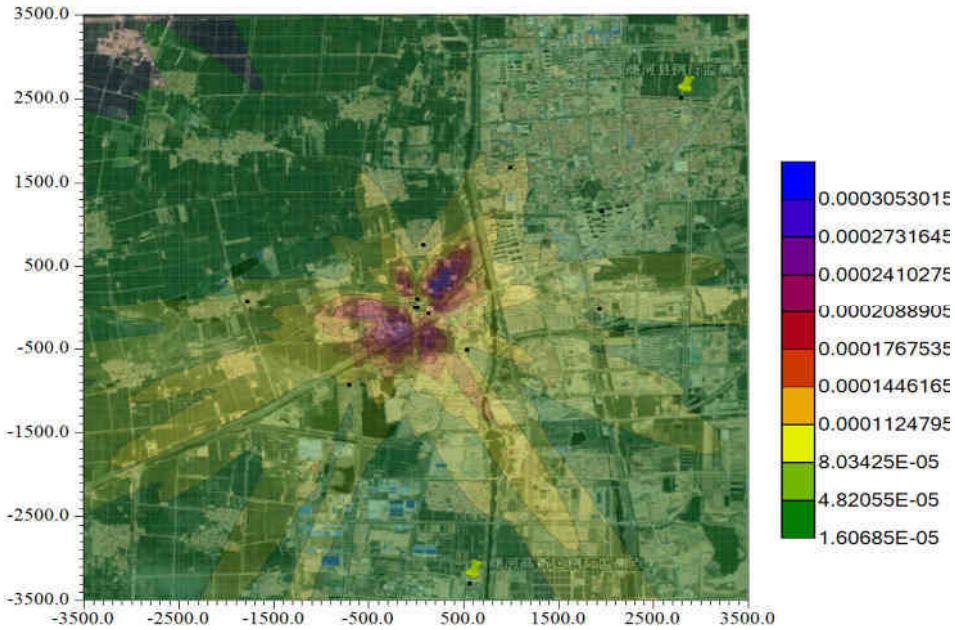
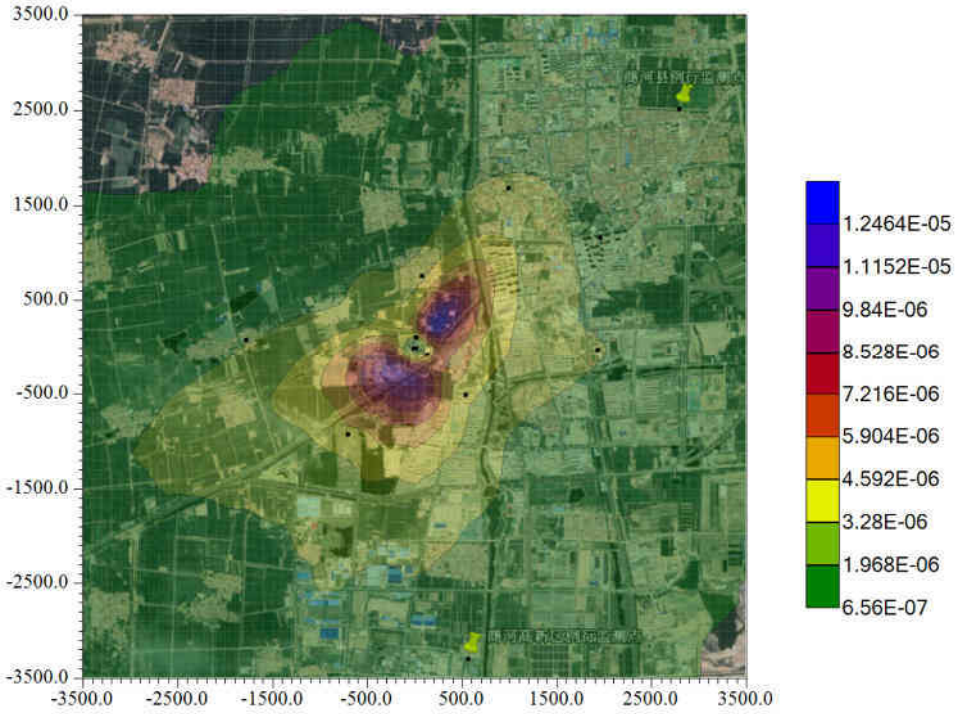


Figure V-18: PM_{10} contour map of worst case annual average concentration



265. The Scenario 1 five worst cases $PM_{2.5}$ GLCs and corresponding date and position are presented in **Table V-23**, **Figure V-19** and **Figure V-20**.

266. The modelling shows that, under the meteorological conditions of 2016, the worst case 24-hour average GLC of $PM_{2.5}$ from the component is 0.16 μg/m³ equivalent to 0.21% of the PRC standard for $PM_{2.5}$ and 0.64% of WHO Guideline value (25 μg/m³). The location is (200, 300) and the time is 11 March 2016. The worst case annual average GLC of $PM_{2.5}$ from the component is 6.56 E-03 μg/m³ equivalent to 0.19% of the PRC standard and 0.66% of WHO Guideline value (10 μg/m³). The location is (300,300).

267. These worst case GLCs are predicted to occur one time in the modeling year (2016).

Table V-23: Scenario 1 five worst case $PM_{2.5}$ GLCs and corresponding date and positions
Unit: mg/m³

No.	1-hour average concentration			24-hour average concentration			Annual average concentration	
	X, Y	Time	Value	X, Y	Time	Value	X, Y	Value
1		NA		200,300	20160311	0.00016	300,300	6.56 E-06
2		NA		300,400	20160311	0.00015	200,200	6.51 E-06

No.	1-hour average concentration			24-hour average concentration		Annual average concentration	
	X, Y	Time	Value	X, Y	Time	Value	
3	NA	300,300	20160311	0.00015	200,300	6.29 E-06	
4	NA	200,200	20160311	0.00015	300,400	5.87 E-06	
5	NA	-100,-300	20161122	0.00012	300,200	5.45 E-06	

Note: Time is Year/Month/Day/Hour.
Source: Domestic EIA (2018).

Figure V-19: $PM_{2.5}$ contour map of worst case 24-hour average concentration

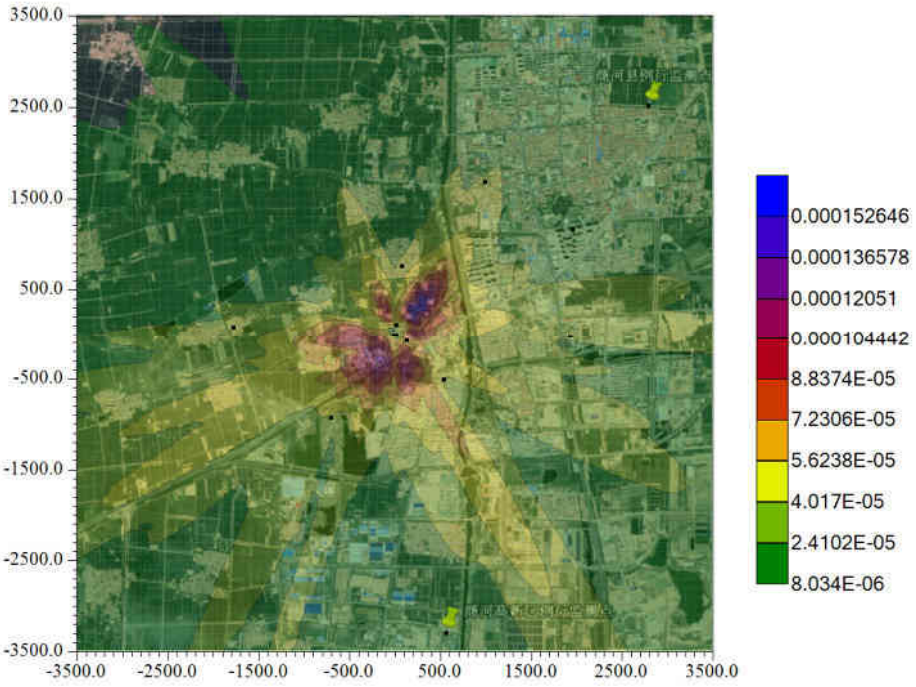
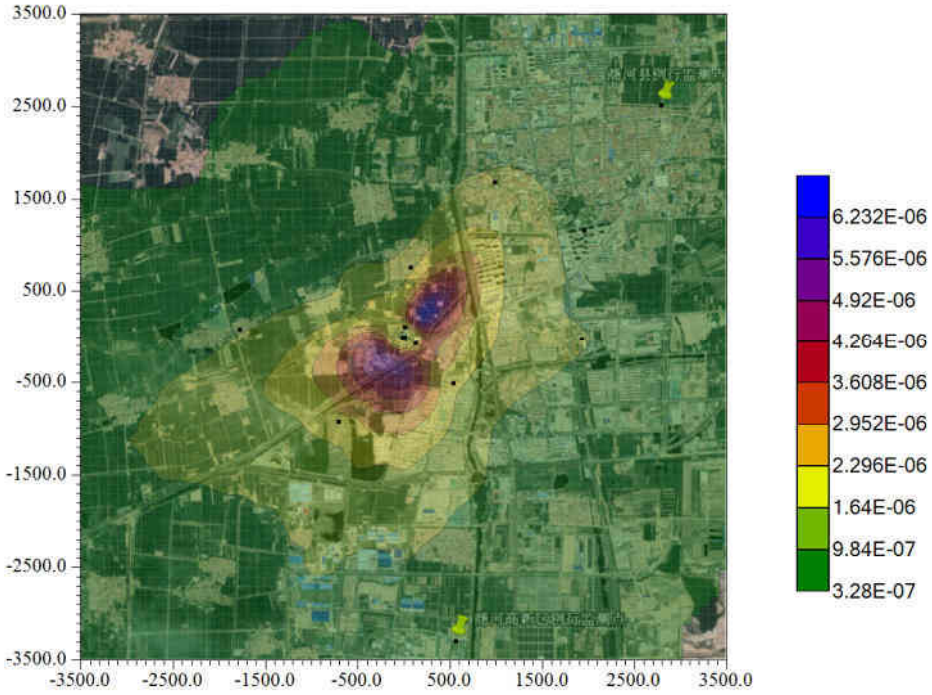


Figure V-20: $PM_{2.5}$ contour map of worst case annual average concentration



268. The worst case GLCs of Scenario 1 are summarized in **Table V-24**.

Table V-24: Scenario 1 worst case GLCs. Unit: mg/m3

Emission factor (Max. GLC)		Predicted GLCs			GB3095-2012 / WHO Guidelines
		Concentration	Ratio to national standard (%)	Ratio to WHO Guidelines (%)	
SO_2	1-hour	4.82E-03	0.964	NA	0.5/NA
	24-hour	1.07E-03	0.713	5.35	0.15/0.020
	Annual	4.34E-05	0.072	NA	0.06/NA
NO_2	1-hour	1.63E-02	8.155	8.16	0.2/0.2
	24-hour	3.51E-03	4.382	NA	0.08/NA
	Annual	1.43E-04	0.358	0.358	0.04/0.04
PM_{10}	1-hour	NA	NA	NA	NA/NA
	24-hour	1.60E-04	0.213	0.64	0.075/0.025
	Annual	6.56E-05	0.187	0.66	0.035/0.010
$PM_{2.5}$	1-hour	NA	NA	NA	NA/NA
	24-hour	3.20E-04	0.213	0.64	0.15/0.050
	Annual	1.30E-05	0.019	0.07	0.07/0.02

269. The worst case GLCs of Scenario 1 at sensitive receptors are summarized in **Table V-25**.

270. After the boiler is under operation, worst case 1-hour average GLCs of SO_2 and NO_2 at sensitive receptors are equivalent to 0.61% and 5.47% of the PRC standards respectively; worst case 24-hour average GLCs of SO_2, NO_2, PM_{10} and $PM_{2.5}$ at sensitive receptors are equivalent to 0.27%, 1.05%, 0.082% and 0.082% of the PRC standards respectively; and worst case annual average GLCs of SO_2, NO_2, PM_{10} and $PM_{2.5}$ at sensitive receptors are equivalent to 0.025%, 0.13%, 0.0066% and 0.0066% of the PRC standards respectively.

Table V-25: worst case GLCs at sensitive receptors. Unit: mg/m^3

Points		No.1	No.2	No.3	No.4	No.5	No.6	No.7	No.8	No.9	No.10
SO_2	1-hour	0.00122	0.00139	0.00258	0.00194	0.00206	0.00159	0.00198	0.00305	0.00179	0.00212
	24-hour	0.00008	0.00008	0.00041	0.00019	0.00025	0.00026	0.00019	0.00016	0.00017	0.00011
	Annual	0.000003	0.000004	0.000015	0.000009	0.000012	0.000014	0.000006	0.000006	0.000007	0.000005
NO_2	1-hour	0.00425	0.00485	0.00848	0.00641	0.0068	0.00557	0.00741	0.01093	0.00639	0.00744
	24-hour	0.00028	0.00031	0.00135	0.00062	0.00082	0.00084	0.00062	0.00056	0.00058	0.00039
	Annual	0.00001	0.00001	0.00005	0.00003	0.00004	0.00005	0.00002	0.00002	0.00002	0.00002
PM_{10}	24-hour	0.00003	0.00003	0.00012	0.00006	0.00008	0.00008	0.00006	0.00005	0.00005	0.00004
	Annual	0.000001	0.000001	0.000005	0.000003	0.000004	0.000004	0.000002	0.000002	0.000002	0.000002
$PM_{2.5}$	24-hour	0.000013	0.000014	0.000062	0.000029	0.000038	0.000039	0.000029	0.000026	0.000027	0.000018
	Annual	0.000001	0.000001	0.000002	0.000001	0.000002	0.000002	0.000001	0.000001	0.000001	0.000001

h. Scenario 2 Results

271. The Scenario 2 five worst case SO_2 GLCs and corresponding date and position are presented in **Table V-26**, **Figure V-21**, **Figure V-22 a**nd **Figure V-23**.

272. The modelling shows that, under the meteorological conditions of 2016, the worst case 1-hour average GLC of SO_2 from the three boilers is 13.3 μg/m³, equivalent to 2.66% of the PRC standard. The location is (700, 0) and the time is 10 am of February 14, 2016. The worst case 24-hour average GLC of SO_2 from the three boilers is 2.95 μg/m³ equivalent to 2.0% of the PRC standard and 14.8% of WHO guideline value (20 μg/m³). The location is (200, 300) and the time is March 11, 2016. The worst case annual average GLC of SO_2 from the three boilers is 0.0123 μg/m³ equivalent to 0.21% of the PRC standard. The location is (200,200).

273. Based on the modeling results, these worst case GLCs are only predicted to occur one time in the modeling year (2016).

Table V-26: Scenario 2 five worst case SO_2 GLCs and corresponding date and positions. Unit: mg/m³

No.	1-hour average concentration			24-hour average concentration			Annual average concentration	
	X, Y	Time	Value	X, Y	Time	Value	X, Y	Value
1	700,0	16021410	0.01332	200,300	20160311	0.00295	200,200	0.00012
2	800,0	16021410	0.01305	300,400	20160311	0.00279	300,300	0.00012
3	600,0	16021410	0.0129	300,300	20160311	0.00277	200,300	0.00012
4	900,0	16021410	0.01286	200,200	20160311	0.00271	300,400	0.00011
5	-300,0	16112412	0.01247	-100,-300	20161122	0.00231	300,200	0.0001

Note: For 1-hour average, time is Year/Month/Day/Hour. For 24-hour average, time is Year/Month/Day.
Source: Domestic EIA (2018).

Figure V-21: SO_2 contour map of worst case 1-hour average concentration

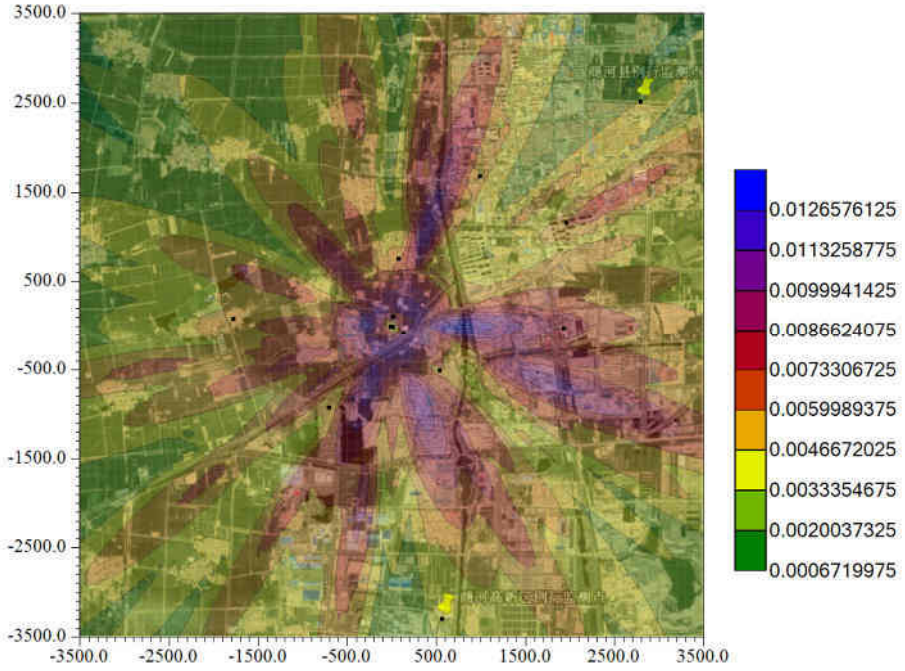


Figure V-22: SO_2 contour map of worst case 24-hour average concentration

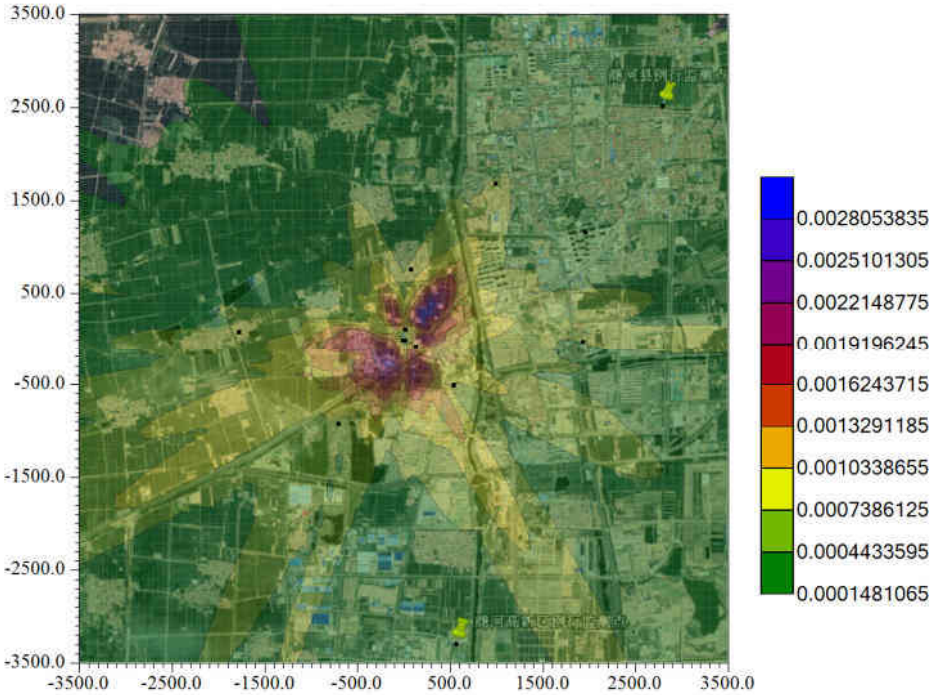
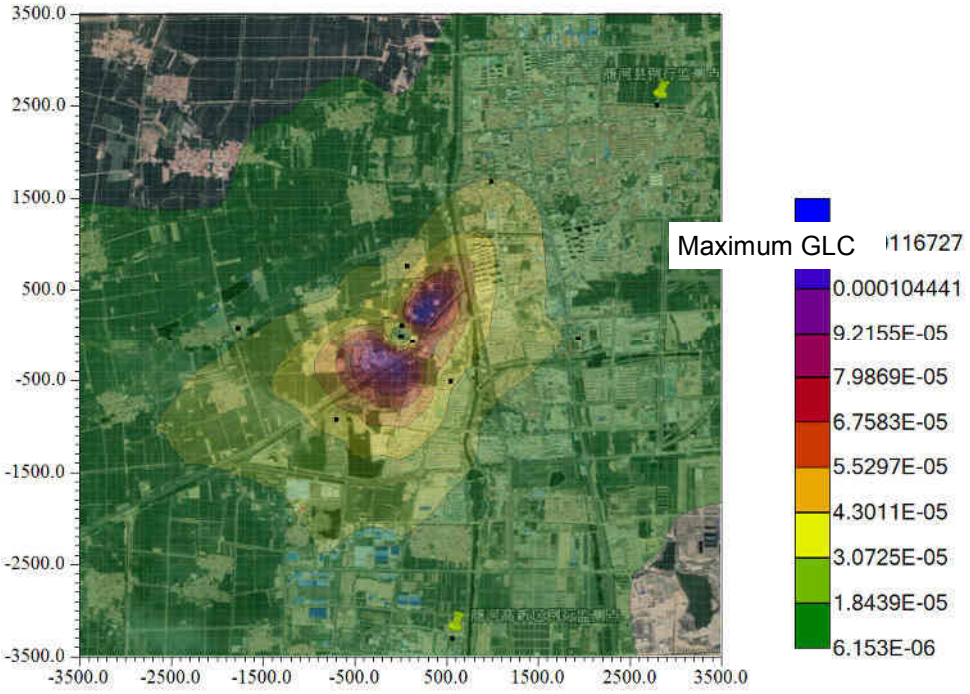


Figure V-23: SO_2 contour map of worst case annual average concentration



274. The Scenario 2 five worst case NO_2 GLCs and corresponding date and position are presented in **Table V-27**, **Figure V-24**, **Figure V-25** and **Figure V-26**.

275. The modelling shows that, under the meteorological conditions of 2016, the worst case 1-hour average GLC of NO_2 from the three boilers is 41.0 μg/m³ equivalent to 20.5% of the PRC standard and WHO Guideline value. The location is (700, 0) and the time is 10 am of February 14, 2016. The worst case 24-hour average GLC of NO_2 from the three boilers is 3.51 μg/m³ equivalents to 4.38% of the PRC standard. The location is (200, 300) and the time is March 11. The worst case annual average GLC of NO_2 from the three boilers is 0.37 μg/m³ equivalent to 0.92% of the PRC standard and WHO Guideline value. The location is (200,200).

276. Based on the modeling results, all these worst case GLCs are only predicted to occur one time in the modeling year (2016).

Table V-27: Scenario 2 five worst case NO_2 GLCs and corresponding date and positions. Unit: mg/m³

No.	1-hour average concentration			24-hour average concentration			Annual average concentration	
	X, Y	Time	Value	X, Y	Time	Value	X, Y	Value
1	700,0	16021410	0.01631	200,300	20160311	0.00351	200,200	0.00037
2	800,0	16021410	0.01623	300,400	20160311	0.00337	300,300	0.00036
3	900,0	16021410	0.01614	300,300	20160311	0.00333	200,300	0.00035

No.	1-hour average concentration			24-hour average concentration			Annual average concentration	
	X, Y	Time	Value	X, Y	Time	Value	X, Y	Value
4	1000,0	16021410	0.01574	200,200	20160311	0.0032	300,400	0.00032
5	600,0	16021410	0.01557	-100,-300	20161122	0.00269	300,200	0.00031

Note: T For 1-hour average, time is Year/Month/Day/Hour. For 24-hour average, time is Year/Month/Day.
Source: Domestic EIA (2018).

Figure V-24: NO_2 contour map of worst case 1-hour average concentration

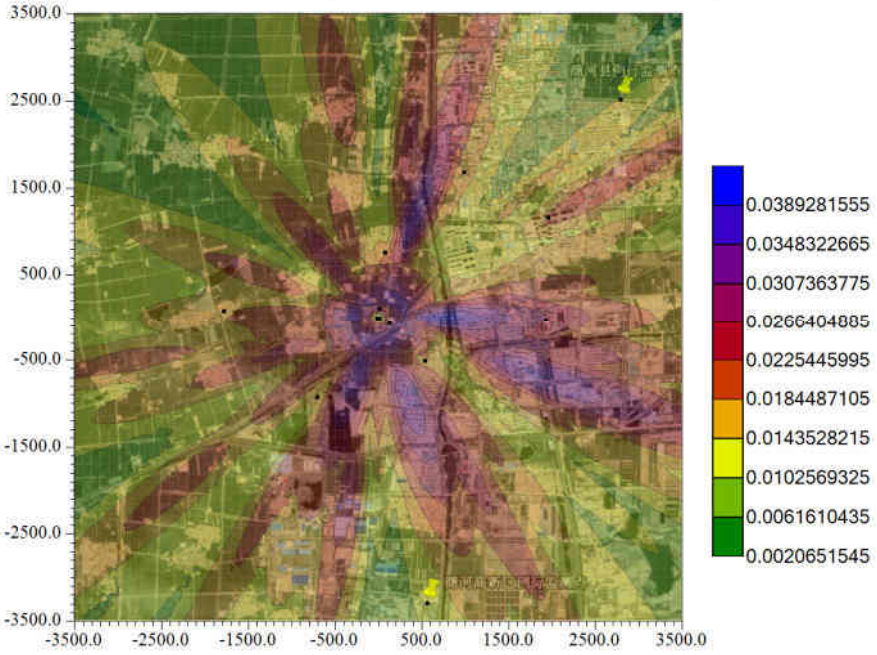


Figure V-25: NO_2 contour map of worst case 24-hour average concentration

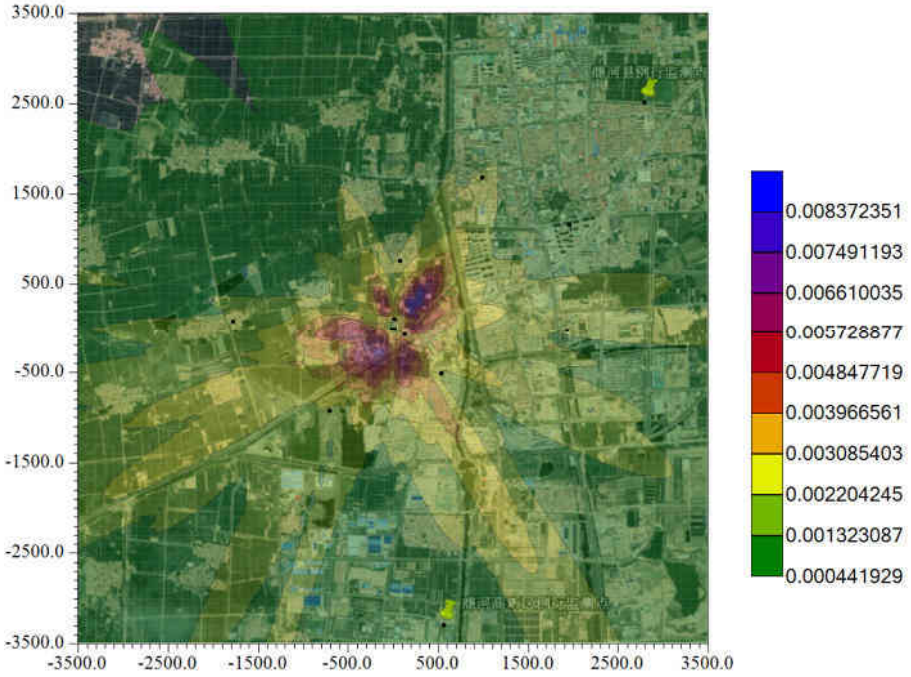
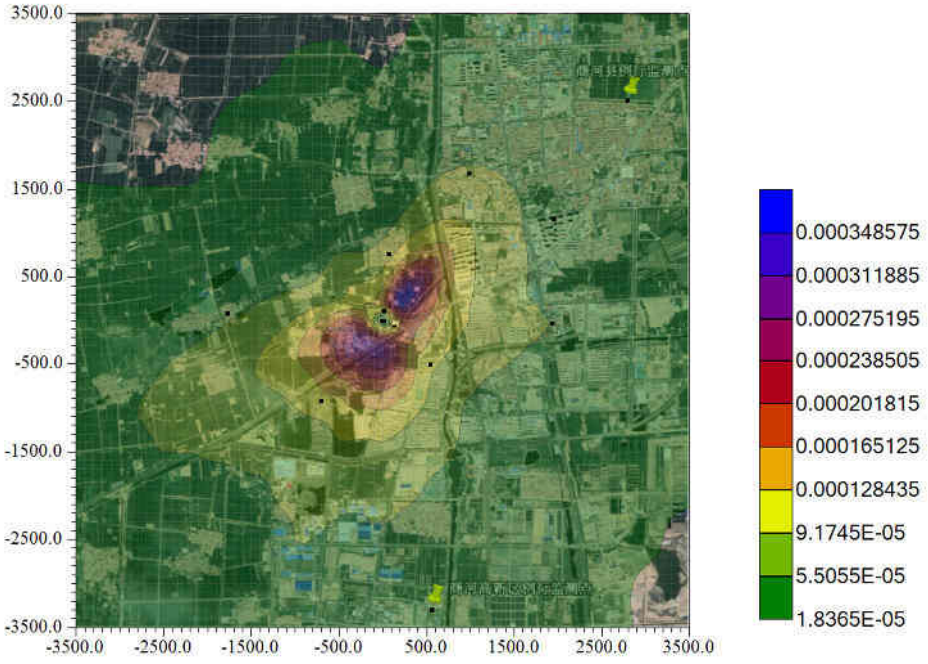


Figure V-26: NO_2 contour map of worst case annual average concentration



277. The Scenario 2 five worst case PM_{10} GLCs and corresponding date and position are presented in **Table V-28**, **Figure V-27** and **Figure V-28**.

278. The modelling results show that, under the meteorological conditions of 2016, the worst case 24-hour average GLC of PM_{10} from the three boilers is 0.32 μg/m³ equivalents to 0.21% of

the PRC standard and 0.64% of WHO Guideline value (50 μg/m³). The location is at coordinate (200, 300) and the time is 11 March 2016. The worst case annual average GLC of PM_{10} from the three boilers is 0.041 μg/m³ equivalents to 0.06% of the PRC standard and 0.21% of WHO Guideline value (20 μg/m³). The location is at (200, 200).

279. Based on the modeling results, all these worst case GLCs are only predicted to occur one time in the modeling year (2016).

Table V-28: Scenario 2 five worst case PM_{10} GLCs and corresponding date and positions. Unit: mg/m³

No.	1-hour average concentration			24-hour average concentration			Annual average concentration	
	X, Y	Time	Value	X, Y	Time	Value	X, Y	Value
1		NA		200,300	20160311	0.00032	200,200	0.00004
2		NA		300,400	20160311	0.00031	300,300	0.00004
3		NA		300,300	20160311	0.00031	200,300	0.00004
4		NA		200,200	20160311	0.00029	300,400	0.00004
5		NA		-100,-300	20161122	0.00025	300,200	0.00003

Note: For 1-hour average, time is Year/Month/Day/Hour. For 24-hour average, time is Year/Month/Day.
Source: Domestic EIA (2018).

Figure V-27: PM_{10} contour map of worst case 24-hour average concentration

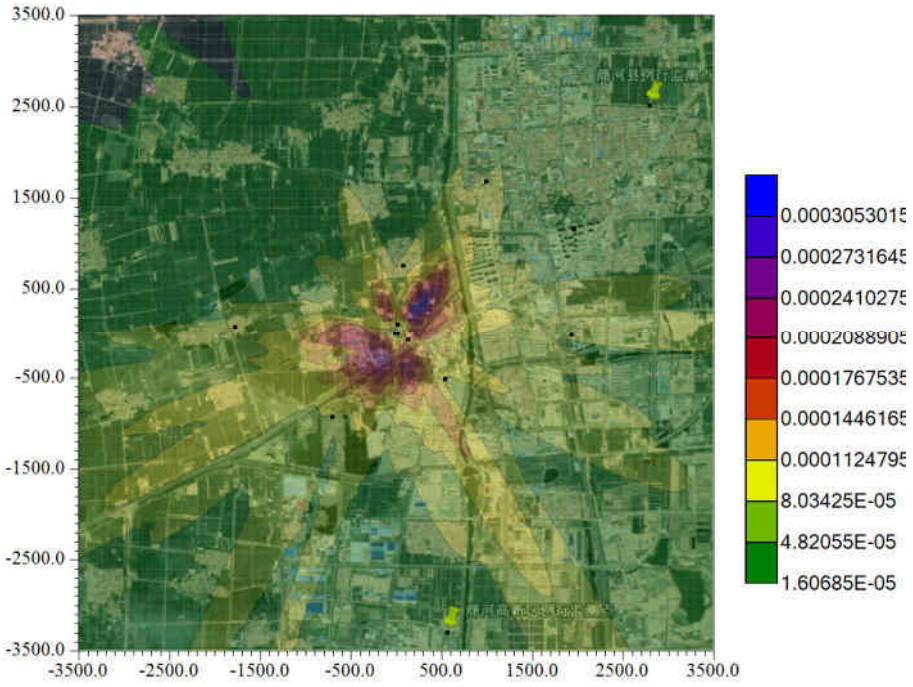
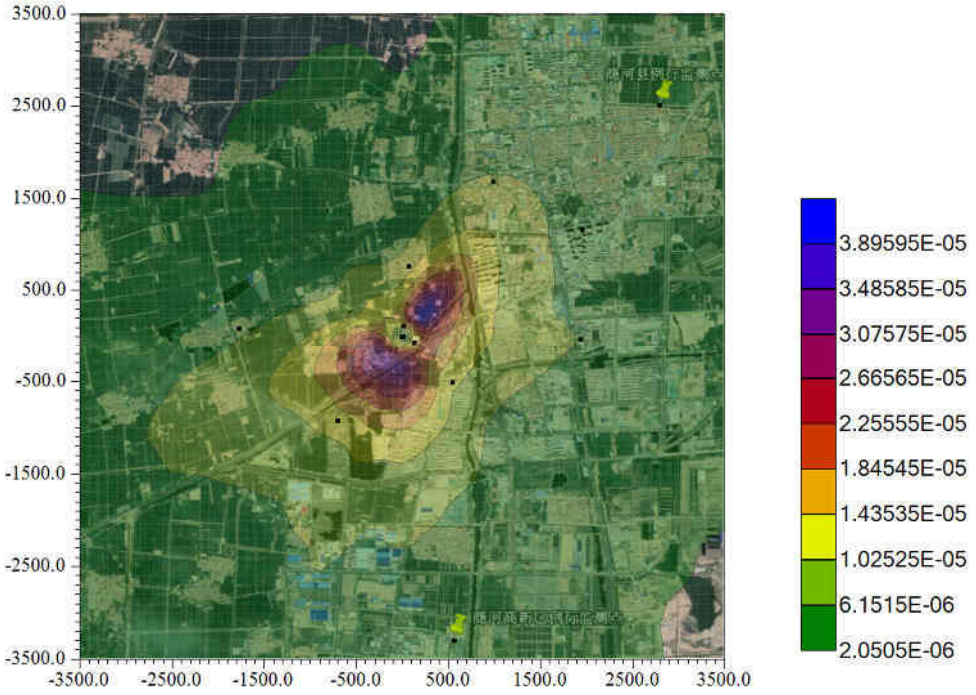


Figure V-28: PM_{10} contour map of worst case annual average concentration



280. The Scenario 2 five worst cases $PM_{2.5}$ GLCs and corresponding date and position are presented in **Table V-29**, **Figure V-29** and **Figure V-30**.

281. The modelling shows that, under the meteorological conditions of 2016, the worst case 24-hour average GLC of $PM_{2.5}$ from the three boilers is 0.16 μg/m³ equivalent to 0.21% of the PRC standard for $PM_{2.5}$ and 0.64% of WHO Guideline value (25 μg/m³). The location is (200, 300) and the time is 11 March 2016. The worst case annual average GLC of $PM_{2.5}$ from the three boilers is 0.02 μg/m³ equivalent to 0.06% of the PRC standard and 0.21% of WHO Guideline value (10 μg/m³). The location is (300,300).

282. These worst case GLCs are predicted to occur one time in the modeling year (2016).

Table V-29: Scenario 2 five worst case $PM_{2.5}$ GLCs and corresponding date and positions
Unit: mg/m³

No.	1-hour average concentration			24-hour average concentration			Annual average concentration	
	X, Y	Time	Value	X, Y	Time	Value	X, Y	Value
1		NA		200,300	20160311	0.00016	200,200	0.00002
2		NA		300,400	20160311	0.00015	300,300	0.00002
3		NA		300,300	20160311	0.00015	200,300	0.00002

No.	1-hour average concentration			24-hour average concentration			Annual average concentration	
	X, Y	Time	Value	X, Y	Time	Value	X, Y	Value
4		NA		200,200	20160311	0.00015	300,400	0.00002
5		NA		-100,-300	20161122	0.00012	300,200	0.00002

Note: Time is Year/Month/Day/Hour.
Source: Domestic EIA (2018).

Figure V-29: $PM_{2.5}$ contour map of worst case 24-hour average concentration

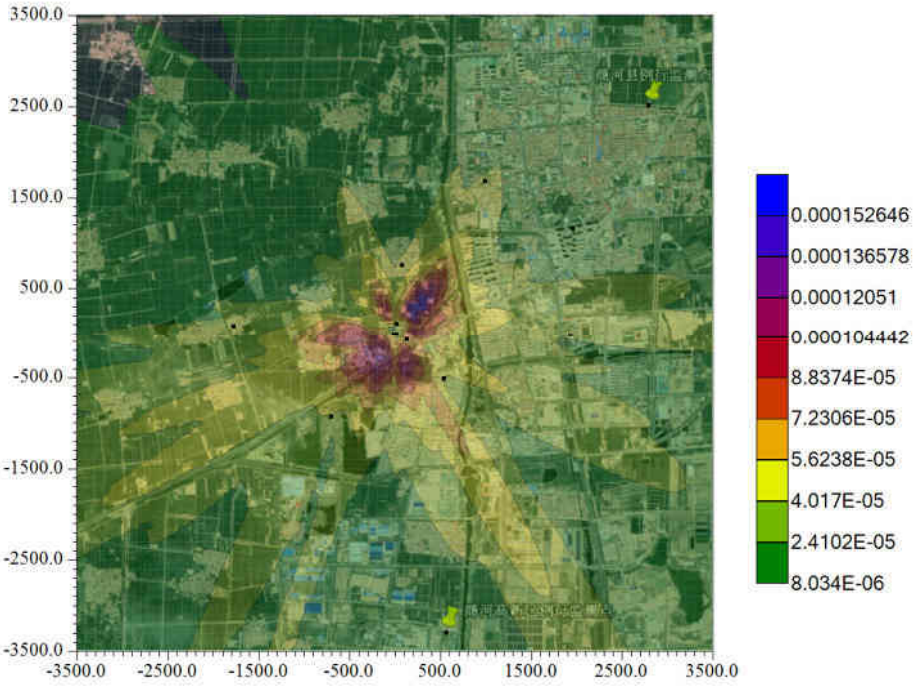
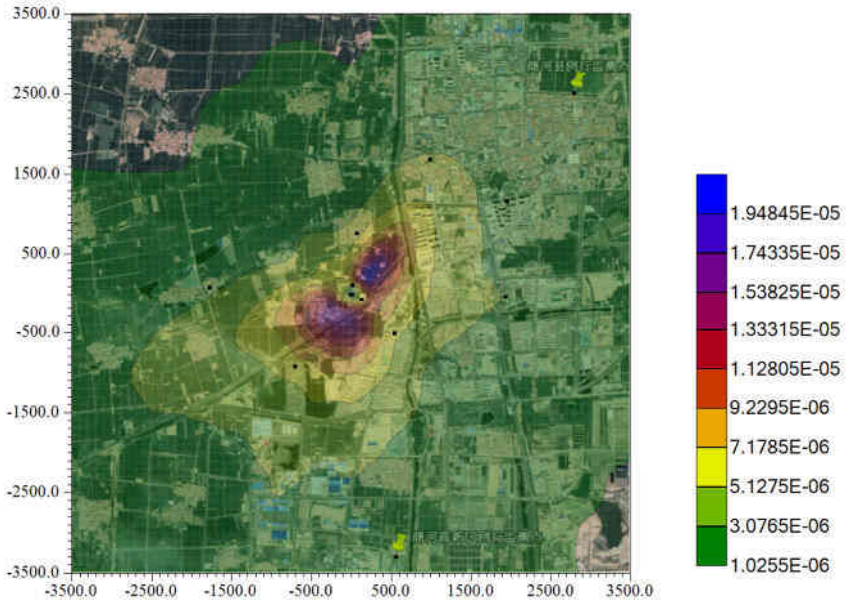


Figure V-30: $PM_{2.5}$ contour map of worst case annual average concentration



283. The worst case GLCs of Scenario 2 are summarized in **Table V-30**.

Table V-30: Scenario 2 worst case GLCs. Unit: mg/m^3

Emission factor (Max. GLC)		Predicted GLCs			GB3095-2012 / WHO Guidelines
		Concentration	Ratio to national standard (%)	Ratio to WHO Guidelines (%)	
SO_2	1-hour	1.33E-02	2.664	NA	0.5/NA
	24-hour	2.95E-03	1.967	14.75	0.15/0.020
	Annual	1.23E-04	0.205	NA	0.06/NA
NO_2	1-hour	4.10E-02	20.490	20.49	0.2/0.2
	24-hour	8.81E-03	11.013	NA	0.08/NA
	Annual	3.67E-04	0.917	0.92	0.04/0.04
PM_{10}	1-hour	NA	NA	NA	NA/NA
	24-hour	4.90E-04	0.653	1.96	0.075/0.025
	Annual	2.05E-05	0.059	0.21	0.035/0.010
$PM_{2.5}$	1-hour	NA	NA	NA	NA/NA
	24-hour	9.80E-04	0.653	1.96	0.15/0.050
	Annual	4.10E-05	0.059	0.21	0.07/0.02

284. The worst case GLCs of Scenario 2 at sensitive receptors are summarized in **Table V-31**.

285. After the three boilers are under operation, worst case 1-hour average GLCs of SO_2 and NO_2 at sensitive receptors are equivalent to 1.65% and 13.42% of the PRC standards respectively; worst case 24-hour average GLCs of SO_2, NO_2, PM_{10} and $PM_{2.5}$ at sensitive receptors are equivalent to 0.76%, 4.3%, 0.256% and 0.256% of the PRC standards respectively; and worst case annual average GLCs of SO_2, NO_2, PM_{10} and $PM_{2.5}$ at sensitive receptors are equivalent to 0.073%, 0.33%, 0.021% and 0.021% of the PRC standards respectively.

Table V-31: Worst case GLCs at sensitive receptors. Unit: mg/m^3

Points		No.1	No.2	No.3	No.4	No.5	No.6	No.7	No.8	No.9	No.10
SO_2	1-hour	0.003418	0.003967	0.007409	0.005273	0.005664	0.004398	0.005255	0.008225	0.005294	0.006101
	24-hour	0.000225	0.000214	0.001147	0.000514	0.000673	0.000688	0.000528	0.00046	0.000481	0.000316
	Annual	0.000009	0.000011	0.000044	0.000026	0.000033	0.000037	0.000016	0.000017	0.000019	0.000015
NO_2	1-hour	0.010797	0.012529	0.022064	0.015843	0.017009	0.01349	0.017946	0.026846	0.016119	0.019452
	24-hour	0.000706	0.000748	0.003436	0.001552	0.002022	0.002065	0.001591	0.001452	0.001458	0.001006
	Annual	0.00003	0.000036	0.000132	0.000078	0.000101	0.000113	0.000051	0.000055	0.000059	0.000046
PM_{10}	24-hour	0.000079	0.000083	0.000384	0.000173	0.000225	0.000229	0.000178	0.000162	0.000162	0.000112
	Annual	0.000003	0.000004	0.000015	0.000009	0.000011	0.000013	0.000006	0.000006	0.000007	0.000005
$PM_{2.5}$	24-hour	0.000039	0.000042	0.000192	0.000086	0.000112	0.000115	0.000089	0.000081	0.000081	0.000056
	Annual	0.000002	0.000002	0.000007	0.000004	0.000006	0.000006	0.000003	0.000003	0.000003	0.000003

i. Scenario 3 Results

286. Worst case SO_2, NO_2, PM_{10} and $PM_{2.5}$ cumulative (worst case predicted + worst case background)[23] GLCs at monitoring sites (sensitive receptors) are presented in **Table V-32** and **Table V-33**. The airshed is degraded in terms of $PM_{2.5}$ and PM_{10}.

287. The modelling shows that, under the meteorological conditions of 2016, the worst case cumulative 1-hour average GLC of SO_2 at sensitive receptors is 0.18 mg/m^3, equivalent to 36% of PRC standard and occurs in Shanghe EPB. The worst case cumulative 24-hour average GLC of SO_2 at sensitive receptors is 0.072 mg/m^3, equivalent to 48% of standard and occurs in Shanghe EPB.

288. The modelling shows that, under the meteorological conditions of 2016, the worst case cumulative 1-hour average GLC of NO_2 at sensitive receptors is 0.101 mg/m^3, equivalent to 50.4% of PRC standard and occurs in Shanghe EPB. The worst case cumulative 24-hour average GLC of NO_2 at sensitive receptors is 0.059 mg/m^3, equivalent to 73.3% of standard and occurs in Shanghe No.2 Middle School.

289. The modelling shows that, under the meteorological conditions of 2016, the worst case cumulative 24-hour average GLC of PM_{10} at sensitive receptors is 0.168 mg/m^3, equivalent to 112% of PRC standard and occurs in Shanghe EPB.

[23] Background data from Shanghe ambient air quality monitoring stations from January 25, 2018 to January 31, 2018 (Table IV-3 and IV-4).

290. The modelling shows that, under the meteorological conditions of 2016, the worst case cumulative 24-hour average GLC of $PM_{2.5}$ at sensitive receptors is 0.106 mg/m^3, equivalent to 141% of PRC standard and occurs in Shanghe EPB.

291. The main reason for exceedance of $PM_{2.5}$ and PM_{10} is that the environmental background data exceed relevant standards.

292. It can be noted that these worst case cumulative GLC exceedances are a result of high worst case ambient levels of $PM_{2.5}$ and PM_{10}, and not as a result of the emissions from the component; in fact, the component will reduce emissions after the coal fired boilers is replaced. Nonetheless, during the operation phase gas emissions will be sampled on a regular basis and also be monitored by CEMS system installed at the stack to confirm compliance with relevant PRC emission standards, and ambient monitoring will be undertaken through the Jinan EPB Continuous Ambient Air Quality Monitoring Stations and 3rd party environmental monitoring companies. Calibration of the CEMS system will be quarterly implemented by Jinan EPB.

Table V-32: Worst case 1-hour average cumulative (worst case predicted + worst case background) GLCs at monitoring sites. Unit: mg/m^3

	Sensitive receptors	No.1	No.2	No.3	No.4	No.5	No.6	No.7	No.8	No.9	No.10
SO_2	One 42 MW gas boiler the	-1.22E-03	-1.39E-03	-2.58E-03	-1.65E-03	-1.91E-03	-1.53E-03	-1.65E-03	-3.05E-03	-1.75E-03	-2.12E-03
	Background	1.81E-01	1.14E-01	1.48E-01	1.48E-01	1.48E-01	1.48E-01	1.48E-01	1.48E-01	1.48E-01	1.48E-01
	Worst case cumulative GLC	1.80E-01	1.13E-01	1.45E-01	1.46E-01	1.46E-01	1.46E-01	1.46E-01	1.45E-01	1.46E-01	1.46E-01
	Ratio of GLC to PRC standard (%)	36.0%	22.5%	29.1%	29.3%	29.2%	29.3%	29.3%	29.0%	29.3%	29.2%
NO_2	One 42 MW gas boiler	-4.25E-03	-4.85E-03	-8.46E-03	-5.43E-03	-6.30E-03	-5.05E-03	-5.48E-03	-1.09E-02	-5.88E-03	-7.44E-03
	Background	7.70E-02	7.10E-02	7.40E-02	7.40E-02	7.40E-02	7.40E-02	7.40E-02	7.40E-02	7.40E-02	7.40E-02
	Worst case cumulative GLC	7.28E-02	6.62E-02	6.55E-02	6.86E-02	6.77E-02	6.90E-02	6.85E-02	6.31E-02	6.81E-02	6.66E-02
	Ratio of GLC to PRC standard (%)	36.4%	33.1%	32.8%	34.3%	33.9%	34.5%	34.3%	31.5%	34.1%	33.3%

Table V-33: Worst case 24-hour average cumulative (worst case predicted + worst case background) GLCs at monitoring sites. Unit: mg/m³

Sensitive receptors		No.1	No.2	No.3	No.4	No.5	No.6	No.7	No.8	No.9	No.10
SO_2	One 42 MW gas boiler	-5.00E-05	-5.00E-05	-2.70E-04	-1.30E-04	-2.00E-04	-1.40E-04	-6.00E-05	-1.60E-04	-8.00E-05	-1.10E-04
	Background	7.20E-02	4.30E-02	5.80E-02	5.80E-02	5.80E-02	5.80E-02	5.80E-02	5.80E-02	5.80E-02	5.80E-02
	Worst case cumulative GLC	7.20E-02	4.30E-02	5.77E-02	5.79E-02	5.78E-02	5.79E-02	5.79E-02	5.78E-02	5.79E-02	5.79E-02
	Ratio of GLC to PRC standard (%)	48.0%	28.6%	38.5%	38.6%	38.5%	38.6%	38.6%	38.6%	38.6%	38.6%
NO_2	One 42 MW gas boiler	-1.80E-04	-1.70E-04	-8.80E-04	-4.30E-04	-6.50E-04	-4.70E-04	-2.00E-04	-5.50E-04	-2.70E-04	-3.80E-04
	Background	5.80E-02	4.90E-02	5.40E-02	5.40E-02	5.40E-02	5.40E-02	5.40E-02	5.40E-02	5.40E-02	5.40E-02
	Worst case cumulative GLC	5.78E-02	4.88E-02	5.31E-02	5.36E-02	5.34E-02	5.35E-02	5.38E-02	5.35E-02	5.37E-02	5.36E-02
	Ratio of GLC to PRC standard (%)	72.3%	61.0%	66.4%	67.0%	66.7%	66.9%	67.3%	66.8%	67.2%	67.0%
PM_{10}	One 42 MW gas boiler	-2.00E-05	-2.00E-05	-9.00E-05	-4.00E-05	-6.00E-05	-5.00E-05	-3.00E-05	-5.00E-05	-3.00E-05	-4.00E-05
	Background	1.68E-01	1.46E-01	1.57E-01	1.57E-01	1.57E-01	1.57E-01	1.57E-01	1.57E-01	1.57E-01	1.57E-01
	Worst case cumulative GLC	1.68E-01	1.46E-01	1.57E-01	1.57E-01	1.57E-01	1.57E-01	1.57E-01	1.57E-01	1.57E-01	1.57E-01
	Ratio of GLC to PRC standard (%)	112.0%	97.3%	104.6%	104.6%	104.6%	104.6%	104.6%	104.6%	104.6%	104.6%
$PM_{2.5}$	One 42 MW gas boiler	-1.00E-05	-1.00E-05	-4.00E-05	-2.00E-05	-3.00E-05	-3.00E-05	-1.00E-05	-3.00E-05	-1.00E-05	-2.00E-05
	Background	1.06E-01	9.70E-02	1.02E-01	1.02E-01	1.02E-01	1.02E-01	1.02E-01	1.02E-01	1.02E-01	1.02E-01
	Worst case cumulative GLC	1.06E-01	9.70E-02	1.02E-01	1.02E-01	1.02E-01	1.02E-01	1.02E-01	1.02E-01	1.02E-01	1.02E-01
	Ratio of GLC to PRC standard (%)	141.3%	129.3%	135.9%	136.0%	136.0%	136.0%	136.0%	136.0%	136.0%	136.0%

j. Scenario 4 Results

293. Worst case SO_2, NO_2, PM_{10} and $PM_{2.5}$ cumulative (worst case predicted + worst case background)[24] GLCs at monitoring sites (sensitive receptors) are presented in **Table V-34** and **Table V-35**.

294. The modelling shows that, under the meteorological conditions of 2016, the worst case cumulative 1-hour average GLC of SO_2 at sensitive receptors is 0.184 mg/m^3, equivalent to 36.9% of PRC standard and occurs in Shanghe EPB. The worst case cumulative 24-hour average GLC of SO_2 at sensitive receptors is 0.072 mg/m^3, equivalent to 48.1% of standard and occurs in Shanghe EPB.

295. The modelling shows that, under the meteorological conditions of 2016, the worst case cumulative 1-hour average GLC of NO_2 at sensitive receptors is 0.073 mg/m^3, equivalent to 36.4% of PRC standard and occurs in Shanghe EPB. The worst case cumulative 24-hour average GLC of NO_2 at sensitive receptors is 0.058 mg/m^3, equivalent to 72.8% of standard and occurs in Shanghe EPB.

296. The modelling shows that, under the meteorological conditions of 2016, the worst case cumulative 24-hour average GLC of PM_{10} at sensitive receptors is 0.209 mg/m^3, equivalent to 139% of PRC standard and occurs in Shanghe EPB.

297. The modelling shows that, under the meteorological conditions of 2016, the worst case cumulative 24-hour average GLC of $PM_{2.5}$ at sensitive receptors is 0.125 mg/m^3, equivalent to 167% of PRC standard and occurs in Shanghe EPB.

298. The main reason for exceedance of $PM_{2.5}$ and PM_{10} is that the environmental background data exceed relevant standards.

299. It should be noted that these worst case cumulative GLC exceedances are a result of high worst case ambient levels of $PM_{2.5}$ and PM_{10}, and not as a result of the emissions from the component; in fact, emissions from the three boilers accounts for only a small percentage of ambient levels. Nonetheless, during the operation phase gas emissions will be sampled on a regular basis and also be monitored by CEMS system installed at the stack to confirm compliance with relevant PRC emission standards, and ambient monitoring will be undertaken through the Jinan EPB CEMS and 3rd party environmental monitoring companies. Calibration of the CEMS system will be quarterly implemented by Jinan EPB.

Table V-34: Worst case 1-hour average cumulative (worst case predicted + worst case background) GLCs at monitoring sites. Unit: mg/m^3

	Sensitive receptors	No.1	No.2	No.3	No.4	No.5	No.6	No.7	No.8	No.9	No.10
SO_2	3x42 MW gas boilers	3.42E-03	3.97E-03	7.40E-03	4.98E-03	5.52E-03	4.40E-03	4.55E-03	8.23E-03	5.29E-03	6.10E-03
	Background	1.81E-01	1.14E-01	1.48E-01	1.48E-01	1.48E-01	1.48E-01	1.48E-01	1.48E-01	1.48E-01	1.48E-01

[24] Background data from Shanghe ambient air quality monitoring stations from January 25, 2018 to January 31, 2018 (Table IV-3 and IV-4).

	Worst case cumulative GLC	1.84E-01	1.18E-01	1.55E-01	1.53E-01	1.54E-01	1.52E-01	1.53E-01	1.56E-01	1.53E-01	1.54E-01
	Ratio of GLC to PRC standard (%)	36.9%	23.6%	31.1%	30.6%	30.7%	30.5%	30.5%	31.2%	30.7%	30.8%
NO_2	3x 42 MW gas boilers	1.08E-02	1.25E-02	2.21E-02	1.49E-02	1.65E-02	1.32E-02	1.38E-02	2.69E-02	1.61E-02	1.95E-02
	Background	7.70E-02	7.10E-02	7.40E-02	7.40E-02	7.40E-02	7.40E-02	7.40E-02	7.40E-02	7.40E-02	7.40E-02
	Worst case cumulative GLC	8.78E-02	8.35E-02	9.61E-02	8.89E-02	9.05E-02	8.72E-02	8.78E-02	1.01E-01	9.01E-02	9.35E-02
	Ratio of GLC to PRC standard (%)	43.90%	41.77%	48.03%	44.43%	45.26%	43.59%	43.88%	50.43%	45.06%	46.73%

Table V-35: Worst case 24-hour average cumulative (worst case predicted + worst case background) GLCs at monitoring sites. Unit: mg/m^3

Sensitive receptors		No.1	No.2	No.3	No.4	No.5	No.6	No.7	No.8	No.9	No.10
SO_2	3x 42 MW gas boilers	1.90E-04	1.80E-04	1.01E-03	4.60E-04	5.70E-04	5.70E-04	4.00E-04	4.60E-04	3.30E-04	3.10E-04
	Background	7.20E-02	4.30E-02	5.80E-02	5.80E-02	5.80E-02	5.80E-02	5.80E-02	5.80E-02	5.80E-02	5.80E-02
	Worst case cumulative GLC	7.22E-02	4.32E-02	5.90E-02	5.85E-02	5.86E-02	5.86E-02	5.84E-02	5.85E-02	5.83E-02	5.83E-02
	Ratio of GLC to PRC standard (%)	48.1%	28.8%	39.3%	39.0%	39.0%	39.0%	38.9%	39.0%	38.9%	38.9%
NO_2	3x 42 MW gas boilers	6.00E-04	6.10E-04	2.96E-03	1.36E-03	1.72E-03	1.68E-03	1.15E-03	1.44E-03	9.60E-04	1.00E-03
	Background	5.80E-02	4.90E-02	5.40E-02	5.40E-02	5.40E-02	5.40E-02	5.40E-02	5.40E-02	5.40E-02	5.40E-02
Sensitive receptors	No.1	No.2	No.3	No.4	No.5	No.6	No.7	No.8	No.9	No.10	Sensitive receptors
	Worst case cumulative GLC	5.86E-02	4.96E-02	5.70E-02	5.54E-02	5.57E-02	5.57E-02	5.52E-02	5.54E-02	5.50E-02	5.50E-02
	Ratio of GLC to PRC standard (%)	73.3%	62.0%	71.2%	69.2%	69.7%	69.6%	68.9%	69.3%	68.7%	68.8%
PM_{10}	3x42 MW gas boilers	7.00E-05	7.00E-05	3.50E-04	1.60E-04	2.00E-04	2.00E-04	1.50E-04	1.60E-04	1.30E-04	1.10E-04

	Background	1.68E-01	1.46E-01	1.57E-01	1.57E-01	1.57E-01	1.57E-01	1.57E-01	1.57E-01	1.57E-01	1.57E-01
	Worst case cumulative GLC	1.68E-01	1.46E-01	1.57E-01	1.57E-01	1.57E-01	1.57E-01	1.57E-01	1.57E-01	1.57E-01	1.57E-01
	Ratio of GLC to PRC standard (%)	112.0%	97.4%	104.9%	104.8%	104.8%	104.8%	104.8%	104.8%	104.8%	104.7%
$PM_{2.5}$	3x42 MW gas boilers	4.00E-05	4.00E-05	1.70E-04	8.00E-05	1.00E-04	1.00E-04	7.00E-05	8.00E-05	6.00E-05	6.00E-05
	Background	1.06E-01	9.70E-02	1.02E-01	1.02E-01	1.02E-01	1.02E-01	1.02E-01	1.02E-01	1.02E-01	1.02E-01
	Worst case cumulative GLC	1.06E-01	9.70E-02	1.02E-01	1.02E-01	1.02E-01	1.02E-01	1.02E-01	1.02E-01	1.02E-01	1.02E-01
	Ratio of GLC to PRC standard (%)	141.4%	129.4%	136.2%	136.1%	136.1%	136.1%	136.1%	136.1%	136.1%	136.1%

300. To address air pollution issues, good practice air pollution management measures per the thermal power EHS Guidelines and the following measures will be implemented:

(i) Low NOx burner will be installed to treat the exhaust gas before final emission.

(ii) CEMS system will be installed at the stack to monitor the exhaust gas as well as stack emission test by a licensed company semi-annually.

(iii) Offsets will be taken by replacing 80,000 household coal stoves.

(iv) Geothermal-wells will be sealed and shut down if H_2S level is over 5 ppm.

2. Water supply and wastewater pollution

301. The component will have 30 staff and daily domestic water consumption is 12 kg and annual is 5.4 tons (150 working days). The total water supply plant in Shanghe urban is 77,000 tons per day. The total municipal water consumption is very limited compared to Shanghe's water supply capacity. This is not expected to result in any significant negative impact on Jinan's water supply. Water supply agreement will be signed before the operation of the component before construction starts.

302. The component will use municipal water as domestic water and production water. Domestic wastewater will be produced from and toilet facilities. Production wastewater will include wastewater from boilers, soften water treatment workshop and heating system.

303. Once operational, annual wastewater discharged by the component will be 55,680 m^3 and pollutants concentration in the wastewater is presented in **Table V-36** which can meet Class B maximum acceptable concentrations (MACs) in *Wastewater Quality Standards for Discharge to Municipal Sewers* (GB/T 31962-2015). The wastewater will be treated in nearby WWTPs.

Estimated COD and ammonia nitrogen discharged by the component are 71.24 and 7.59 tons respectively.

Table V-36: Wastewater quantity and quality

Item	Annual flow (m^3)	Unit	COD	Ammonia nitrogen
Wastewater generated in heating season	55,680	mg/L	113.3	13.5
		tons	6.31	0.75

304. To address production and domestic wastewater, good practice water management measures per the general EHS Guidelines and the following measures will be implemented:

(i) Wastewater from soften water treatment process and regeneration processes will be discharged to the municipal sewerage system.

(ii) Boiler blow down, heating system blow down will be discharged to the municipal sewerage system.

(iii) No metal (chromium or zinc) permitted to use as scaling and corrosion additive.

(iv) Because wastewater generated by equipment and pump contains oil, the wastewater will be treated in oil separator and will be discharged to the municipal sewerage system.

(v) Domestic wastewater will be produced from worker sanitation facilities. Domestic wastewater will be treated in digestion tank and will be discharged to the municipal sewerage system.

(vi) An emergency water tank will be prepared for temporary storage of geothermal groundwater in case the injection well is blocked or leak happens due to flocculation or corrosion.

(vii) For deep geothermal wells, extracted water and recharged water are in a closed system which mean no wastewater water will be generated during operation. Because there is a filter process installed in the closed system for groundwater filter, wastewater generated during operation will be from filter back wash and will be discharged to the municipal sewerage system.

3. Solid Waste

305. The component will generate a domestic waste and production waste. Production waste will be generated from equipment maintenance and waste thermal insulation materials. If not properly managed this waste can cause visual and environmental impacts. To mitigate this risk, the following measures and good practice waste management measures per the EHS General Guidelines, EHS Guidelines for Environmental Waste Management, EHS Guidelines for Thermal Power Plants and national regulations will be implemented:

(i) Domestic waste bins will be provided and domestic waste will be routinely collected by the local sanitation department for recycling, if possible, or final disposal at an approved waste disposal site.

(ii) No permanent on-site solid waste disposal will be permitted at the component site.

(iii) No burning of wastes will be permitted at the component site.

(iv) Oily waste from equipment maintenance will be collected, transported and treated by a certified 3rd party hazardous waste treatment company.

4. Chemicals and Hazardous Materials

306. Toxic, hazardous, and harmful materials present in the operation of the component include solvents, scale and corrosion inhibitors and chemicals used for water analysis and purification for gas fired boilers (which are Ethylene Diamine Tetraacetic Acid, Silver nitrate standard solution, Dilute sulphuric acid standard solution, Potassium chromate indicator, Erio-chrome black T indicator, Methyl orange indicator, Ammonia - ammonium chloride buffer solution, Sodium hydroxide solution and Phenolphthalein indicator), waste lubrication oil and waste oil-contained fabric, and waste ion exchange resin. Toxic chemicals and hazardous wastes can have negative impacts on human health and the environment if not appropriately managed. Special care and good practice hazardous materials measures per the EHS General Guidelines and will be taken to mitigate these risks, including:

(i) A registry of all activities that involve the handling of potentially hazardous substances will be developed, including protocols for the storage, handling and spill response. This will include all fuels, oils, grease, lubricants, and other chemicals.

(ii) All chemicals, toxic, hazardous, and harmful materials will be transported in spill proof tanks with filling hoses and nozzles in working order.

(iii) All chemicals, toxic, hazardous, and harmful materials will be stored in secure areas with impermeable surfaces and protective dikes such that spillage or leakage will be contained from affecting soil, surface water or groundwater systems. The area should be 110% volume of storage capacity. Their usage will be strictly monitored and recorded.

(iv) Material safety data sheets (MSDSs) will be posted for all hazardous materials.

(v) Oil absorbents will be readily accessible in marked containers.

(vi) Good housekeeping procedures will be established to avoid the risk of spills.

(vii) Spills will be dealt with immediately, and personnel will be trained and tasked with this responsibility.

(viii) Workers will be properly trained before handling hazardous wastes and have the requisite PPE.

(ix) Hazardous waste will be temporarily stored in closed containers away from direct sunlight, wind, water and rain in secure designated areas with impermeable surfaces and protective dikes such that spillage or leakage will be contained.

(x) Hazardous wastes including oily waste, waste chemicals and waste ion exchange resin will be collected and disposed by licensed contractors.

(xi) Engineering and administrative control measures will be implemented to avoid or minimize the release of hazardous substances into the work environment keeping the level of exposure below internationally established or recognized limits.

(xii) Keep the number of employees exposed, or likely to become exposed, to a minimum to hazardous substances.

(xiii) Communicating chemical hazards to workers through labeling and marking according to national and internationally recognized requirements and standards, including the International Chemical Safety Cards (ICSC), Materials Safety Data Sheets (MSDS), or equivalent. Any means of written communication should be in an easily understood language and be readily available to exposed workers and first-aid personnel.

(xiv) Training workers in the use of the available information (such as MSDSs), safe work practices, and appropriate use of PPE.

5. Noise

307. Noise sources during operation will mainly be from noise from pumps, boiler, etc. To mitigate noise impacts the component will:

(i) Low-noise equipment will be used as far as possible, and noise reduction measures such as noise elimination, shock absorption, insulated enclosures and sound dampening materials on exterior walls will be implemented.

(ii) All equipment will be properly maintained in order to minimize noise.

(iii) Appropriate noise PPE will be provided to the workers who are likely to be exposed to high noise level environments to meet the requirements in occupational exposure limits for hazardous agents in work place Part 2: physical agents (GBZ 2.2-2007) and EHG Guidelines on Occupational H&S.

(iv) Layout for component site will be reasonable planned to reduce noise.

6. Community and Occupational Health and Safety

308. Plant operation poses potential risks to workers and community, including well blowout, H_2S exposure, seismic risk and fire, natural gas leaks and noise. Natural gas also presents fire, burn and explosive hazards.

309. To minimize risks associated with leaks of natural gas, the following measures and good practice measures per the EHS Guidelines for occupational H&S, EHS Guidelines for Geothermal Power Generation, and EHS Guidelines for Thermal Power Generation will be taken:

(i) All natural gas works will be in compliance with relevant PRC building code requirements, including the *Code for Design of City Gas Engineering* (GB 50028-2006) and *Regulation on Electric Apparatus Design for Explosion and Fire Risk Environment* (GB50058-92).

(ii) The nearby communities will be informed of the potential risks of well blowout, H_2S exposure, seismic risk, fire and explosion, and the emergency response plan.

(iii) Independent gas regulation stations will be constructed at least 12 meters away from other buildings and 30 m from the site boundary, to minimize the risk of explosion damaging other project facilities or the public.[25]

[25] Gas regulation stations are defined as Class II explosion risks. Space within 4.5 meter away from a regulation station is included in the explosion risk region, as regulated in *Regulation on Electric Apparatus Design for Explosion and Fire Risk Environment* (GB50058-92). In the *Code for Design of City Gas* Engineering (GB 50028-2006) the recommended distance from a gas regulation station with no more than 1.6 MPa inlet pressure to other buildings is 9 m.

(iv) The gas regulation stations will be specially designed to withstand and contain explosions following PRC regulations.

(v) Gas regulation stations and the connection to the boilers will be equipped with flammable gas detection, alarm and fire suppression systems. Electrical devices within the explosion risk area will be safety equipped.

(vi) Gas pipelines will be grounded and equipped with anti-lightning devices where applicable.

(vii) All other at risk areas will have flammable gas detection and alarm systems able generate audible and visual alarms, and automatic fire suppression systems.

(viii) All gas related devices will be brightly colored and equipped with warning signs.

(ix) Nearby community will be involved in the emergency plan. In case of a leakage, the nearby community will be informed.

(x) Quantitative risk assessment will be conducted to ensure the risks are avoided during detailed design.

310. To mitigate potential health and safety risks to the community and workers, the following measures and good practice measures per EHS General Guidelines, EHS Guidelines for Geothermal Power Generation, EHS Guidelines for Thermal Power Generation and EHS Guidelines on occupational H&S will be taken:

(i) Operation phase EHS plan and traffic management plan will be developed and implemented and workers will be trained regularly on their implementation.

(ii) PPE including goggles, gloves, safety shoes, hard hats, high vis vest, etc. will be provided to workers. Noise protection equipment will be provided to workers in high-noise area. Noise areas with more than 85 dB(A) shall be marked and hearing protections shall be provided to workers.

(iii) Noise level inside control room should be no more than 60 dBA.

(iv) Provide training to workers on occupational health and safety, and emergency response.

(v) Pipelines will be grounded and equipped with anti-lightning devices where applicable.

(vi) Vehicles transporting materials or wastes will slow down and not use their horn when passing through or nearby sensitive locations, such as residential communities, schools and hospitals.

(vii) Natural gas systems will be designed in strict compliance with relevant PRC fire, health and safety standards. Fire compartments will be established based on the fire risk, and fire-resistant buildings/structures will include fire-proof doors and windows.

(viii) Fire-alarm and suppression systems will be installed and tested regularly to ensure it functions properly.

(ix) Safe traffic control measures, including road signs and flag persons to warn of dangerous conditions will be taken as needed. Regular maintenance of vehicles to minimize potential accidents caused by equipment malfunction.

(x) Regular inspection and maintenance of pressure vessels and piping will be conducted. Adequate ventilation in work areas to reduce heat and humidity will be installed. Surfaces where workers come in close contact with hot equipment will be shielded. Warning sign will be placed in high temperature areas.

(xi) Managing closure of well heads including sealing well with cement, removing the well head, and backfilling depression around the well head, as necessary.

7. Emergency Response Plan

311. An emergency risk and response plan will be established in accordance with the "National Environmental Emergency Plan" (24 January 2006) and other relevant PRC laws, regulations and standards and will include measures in the World Bank EHS guidelines with respect to occupational and community health and safety. The nearby communities will be informed of the potential risks and emergency response plan. The main risks include potential fire, well blowout, and explosion hazards. Major elements of the emergency response plan are presented in **Table 2** of Appendix I.

D. Anticipated Positive Operation Phase Impacts

312. The component will deliver significant positive social impacts to beneficiaries through the delivery of heating by clean energy. The coal and emission reduction calculations of the component are presented in **Table V-37** and **Table V-38**. Offsets will be implemented by replacing coal stoves of 80,000 households.

313. Instead of coal, the component will use a mix of cleaner heat sources such as geothermal and natural gas. When compared to the equivalent production of heat generation through traditional coal-fired sources, once operational, the component will: (i) result in annual energy savings equivalent to 111,748 tce, thereby providing a global public good by avoiding the annual emission of 391,526.6 tons of CO_2; (ii) improve local air quality through the estimated annual reduction of emissions of SO_2 by 598.6 tons, NOx by 258.3 tons, and PM by 881.2 tons; and (iii) eliminate the negative impacts of coal transportation through urban areas by truck or train.

Table V-37: Coal reduction calculations

Component				Baseline		
Project Technology	Heating area (1,000m³)	Energy sources	Energy consumption	Baseline technology	Energy sources	Energy consumption
Deep-well Geothermal	2,285.7 (Urban area)	Electricity	59.34GWh[a]	Coal-fired boiler district heating service	Coal Electricity	13,0692ce[b] 23.7GWh[c]
Air source heat pump	15	Electricity	0.44GWh[d]			
Shallow-ground source	10	Electricity				
Shallow-ground source heat pump	10	Electricity	0.21GWh[e]			
Gas-fired boiler	2,748.3	Natural gas[f]	37.9 million m³ [g]			
Gas modular boiler	442.5	Natural gas	5.9 million m³[h]			
Deep-well Geothermal	1,694.9(Semi-urban area)	Electricity	42.37GWh[i]	Distributed coal-fired boiler	Coal and electricity	42,744tce[j] 8.7GWh[k]
Gas modular boiler	318.5	Natural gas	4.3 million[l] m³			
Component				Baseline		
Project Technology	Heating area (1,000m³)	Energy sources	Energy consumption	Baseline technology	Energy sources	Energy consumption
Air source heat pump	9.3 (Kindergartens in rural area of Shanghe County)	Electricity	0.14GWh[m]	Small coal stoves	Low-quality coal	85,879tce[n]
Air-to-air heat pumps	3,000	Electricity	130.32GWh[o]			
Air-water heat pumps	500	Electricity	40.80GWh[p]			
Gas heater	50	Electricity Natural gas	0.13GWh 0.5 million m³ [q]			
Carbon crystal plate radiators	150	Electricity	2.95GWh[r]			
Heat-storage radiators	300	Electricity	23.54GWh[s]			

[a] Based on the operating experience, the electricity consumption intensity of deep-well geothermal heating is estimated at 25kWh/ m^2/a.

[b] Statistically, Shanghe County has district heating area of 1,800,000 m^2, consuming 42,800 tce. Coal consumption intensity is 0.024tce/ m^2/a. The heating area of component is 5.5015 million m^2, so the baseline coal consumption: (42,760.39/1,800,000) *5,501.50*1,000=130,692 tce.

[c] Statistically, in Jinan city, the total power consumption of 6,220,000 m^2 of coal-fired heating area is 26.87GWh. The total power consumption of 55.5015 million m^2 of coal-fired heating area is about 23.7GWh.

[d] There are 3 air source heat pumps in Shanghe Detention House, with total installed capacity of 123kW. The three air source heat pumps run 24hrs a day, 120 days per year. The Shanghe No.6 Kindergarten in Shanghe has 5 air source heat pumps with a total installed capacity of 98.37kW. The 5 air source heat pumps run 10hrs a day, 90 days per year (winter holiday is 30 days).

[e] Wenquan Guoji has one ground source heat pump, with a total installed 126.24kW. The ground source heat pump runs 14hrs a day, 120 days per year.

[f] 1 Nm^3 of NG is 9.89 kWh as may be slight variations in NG heat value based on source.

[g] Heat indicator is 45W/m^2. The burning efficiency is 95%. Heat is supplied 24hrs a day, 120 days per year.

[h] Heat indicator is 45W/m^2. The burning efficiency is 98.2%. Heat is supplied 24hrs a day, 120 days per year.[i] Same as footnote a.
[j] Heat indicator is 45W/m^2. The burning efficiency is 75%. Heat is supplied 24hrs a day, 120 days per year. The heat value of standard coal is about 7000kcal/kg. After calculating, the coal consumption of Semi-urban area is 42744tce.
[k] Statistically, in Jinan city, the total power consumption of 6220(1000 ㎡) coal-burning heating area is 26.87GWh. After calculating, the total power consumption of 201.32(1000 ㎡) coal-burning heating area is 8.7GWh.
[l] Same as footnote h.
[m] There are 8 air source heat pumps in the 5 kindergartens, with a total installed capacity 156.85kW. The air source heat pumps run 10hrs a day, 90 days per year (winter holiday is 90 days).
[n] Heat indicator is 80W/m^2. The air source heat pumps run 10hrs a day, 90 days per year (winter holiday is 90 days). The burning efficiency of coal boilers is 50%. Statistically, one household in Shanghe consumes 1.5t per heating season. The heat value of coal is 5000kcal/kg.
[o] One air-to-air heater consumes 1.81kWh per hour. There are 60,000 heaters. Heat is supplied 10hrs a day, 120 days per year.
[p] One air-to-water heater consumes 3.4kWh per hour. There are 10,000 heaters. Heat is supplied 10hrs a day, 120 days per year.
[q] One wall-hanged gas heater consumes 0.11kWh of electricity and 0.427m³of natural gas per hour. There are 1000 heaters. Heat is supplied 10hrs a day, 120 days per year.
[r] One carbon crystal plate consumes 0.8kWh per hour. There are 3,000 plates. Heat is supplied 10hrs a day, 120 days per year.
[s] One heat storage electrical radiator consumes 3.2kWh per hour. There are 6,000 heaters. Heat is supplied 10hrs a day, 120 days per year.

314. This component will consume 298 GWh of power, 48.6 million m³ of natural gas, which is equivalent to a total of 158,420 tce.[26] The total energy consumption can replace 259,315 tce of coal-fired heating and 32.5GW of power, which is equivalent to a total of 270,168 tce. Thus, this component will save 111,748 tce of energy.

Table V-38: Emission reduction calculations

Item	Energy consumption	Energy consumption	Pollutants emission(tons)			
			CO_2	SO_2	NOx	PM
Baseline	Coal	173,436tce[a]	454,403.3	90.1	180.2	18.0
	Low-quality coal	85,879[b]	225,003.0	635.5	223.3	889.7
	Electricity	32.5GWh[c]	23,547.7	12.7	11.7	2.6
Component	Electricity	298GWh[d]	216,240.6	116.3	107.3	23.9
	Gas modular boilers	10.7millionm^{3}naturalgas[e]	20,883.9	0.4	3.5	0.6
	Gas-fired boilers	37.9millionm^{3}naturalgas[f]	74,302.8	23.0	46.0	4.6
Savings			391,526.6	598.6	258.3	881.2

[a] According to Air Pollutants Emission Standards for Boilers (GB13271-2014), the PM, SO_2, and NOx emission standard is 10mg/m³, 50 mg/m³, and 100 mg/m³respectively. Burning 1kg standard coal produces 10.39Nm³ waste gas and burning 1t standard coal produces 2.62t CO_2.
[b] According to Technique Guidance for Emission Inventory of coal briquettes：SO_2, NOx and PM emission factor of poor quality coal was 7.4kg/t, 2.6kg/t and 10.36kg/t.

[26] According to the China Power Sector Annual Development Report 2017 issued by CEC (China Electricity Council), coal-fired power plant above 6000Kw consumes 312gce to produce per kWh of electricity. Take 6.66% as the loss of transmission. Based on the heat value, per cubic meter of NG is converted to 1.21kgce.

[c] Based on the China Power Sector Annual Development Report 2017 issued by CEC (China Electricity Council), the PM, SO_2, and NOx emission factor of thermal power generation was 0.08, 0.39, and 0.36gce/kWh respectively in 2016. NDRC (National Development and Reform Commission) issues CO_2 emission per kWh every year for CDM project development. The carbon emission factor of North China Grid was 0.7253 t-CO_2/MWh in 2016. The loss of transmission is 6.66%.

[d] Wang Ya Nan, 2012. Public Participation in EIA, SEA and Environmental Planning in China. Environmental Impact Assessment Research Centre.

[e] According to Environment Protect Practical Data Handbook, CO_2 emission is 1.96kg per m³of natural gas. Burning 1m³ natural gas produces 12.14m³ waste gas. And the emission calculation of gas modular boiler is based on the monitoring data SO_2: 3 mg/m^3; NOx: 27 mg/m^3; PM: 4.8mg/m^3);

[f] According to Environment Protect Practical Data Handbook, CO_2 emission is 1.96kg per m³of natural gas. Burning 1m³ natural gas produces 12.14m³ waste gas. Based on Integrated Emission Standard of Air Pollutants for Shandong Province, emission concentrations of gas fired boiler are SO_2: 50 mg/m^3; NOx: 100 mg/m^3; PM: 10 mg/m^3).

VI. ANALYSIS OF ALTERNATIVES

315. An analysis of component alternatives was undertaken during the feasibility stage to determine the most financially, environmentally and technically feasible way of achieving the project objectives while minimizing environmental and social impacts.

A. No Project Alternative

316. Shanghe is situated in the northeastern part of PRC. The winter temperature drops to as low as –22.6°C, and sub-zero temperatures typically last for 4 months a year; under this climate heating service is an essential requirement for sustaining people's livelihoods. Heat demand in urban area Shanghe is increasing substantially due to rapid ongoing urban expansion but in rural area and semi-urban area, individual coal fired boilers and small coal stoves are wildly used for heating.

317. The existing system in urban area of Shanghe is a large scale district heating system driven by coal-fired heat source plants or CHP plants. However, the expansion of the existing coal-based district heating system to meet the increasing demand is not an option as Shanghe has been experiencing significant pollution problems in the winter heating seasons including hazy skies and high levels of particulates.

318. Coal-based heating is the major cause of rising level of outdoor and indoor air pollution during the winter. According to PM source analysis result in Jinan in 2017 by Jinan EPB, 24.6% of $PM_{2.5}$ and 17.4% of PM_{10} are from coal combustion.

319. The component's implementation will: (i) fulfil rapidly increasing heat demand in urban area of Shanghe and provide clean heating to semi-urban and rural areas of Shanghe; (ii) significantly reduce coal consumption; (iii) improve air quality; and (iv) reduce GHG emissions. It will also provide valuable hands on experience and help to explore various uses of different energy sources like geothermal energy, natural gas, air source heat pumps, etc., which will support the development of sustainable energy system solutions. For these reasons the "no project" alternative is considered unacceptable.

B. Energy Sources

320. There are several heat sources options for district heating, including CHP plants, large coal, natural gas or biomass-fired heat source plants (HSPs), solar energy, wind energy, industrial or residential waste heat, geothermal energy, and heat pumps.

321. CHPs and HSPs are considered the most proven, economically viable, energy efficient and environmentally friendly heat source options for northern China.

322. Based on No Project Alternative analysis, coal based CHPs and HSPs are not acceptable.

323. Shanghe is rich in biomass. There are 821,000 Mu[27] wheat, 793,000 Mu corn, 32,300 Mu cotton and 5,253 Mu bean in Shanghe. 0.33 ton biomass can be obtained from 1 Mu wheat, 1 ton

[27] 1 Mu=667 m^2.

from corn, 0.37 ton from cotton and 0.24 ton from bean. Around 1.05 million tons biomass can be obtained in Shenghe annually.

324. There is one biomass power plant in Yuhuangmiao Town. This plant has two 30 MW power generation units and annual biomass consumption of the plant is around 0.7 million tons. Therefore, biomass is not a good choice because 66.7% of available biomass will be consumed by this biomass power plant.

325. Annual average sunshine hours near the component site from 1997-2016 were 2,734.4 hours and is classified as middle level solar energy area. Considering the 7,514.9 million m^2 heating area in urban and semi-urban area of Shanghe. Given solar panel has a big size (for 300W solar power panel, the size is around 2mx1m), solar power is not a good choice for providing district heating to a large area. Besides, the component will use more energy in the nighttime for heating, therefore, solar power is not a good choice.

326. Average wind speed near the component site from 1997-2016 were 2.1 m/s and is classified as middle level wind power area. Therefore, wind power is not a good choice.

327. Natural gas is the recommended fuel source in the World Bank Group's *Environmental Health and Safety (EHS) Guidelines*. Natural gas generally produces negligible quantities of particulate matter and sulfur oxides, and levels of nitrogen oxides are about 60% of those from plants using coal (without emission reduction measures). Natural gas-fired plants also release lower quantities of carbon dioxide, a greenhouse gas. Natural gas is the only fossil fuel applied in the project and will contribute to emissions reduction in Jinan. In addition, gas-fired facilities do not require large coal storage sheds or ash storage silos, and do not need water and electricity for coal, fly and bottom ash and slag treatment. Thus, the use of natural gas-fired to replace coal-fired boilers will require less land and will consume less water and electricity. Furthermore, the transmission of natural gas by pipeline will eliminate the negative impacts of coal transportation through urban areas by truck or train. The component will install high efficiency gas boiler. The 42 MW gas fired boiler has an efficiency of 95% and the gas modular boilers have an efficiency of around 97%.

328. Geothermal energy is a clean and renewable energy source deriving from the exploitation of the heat flux reaching the surface from the deeper part of the Earth's crust. The heat can be utilized in district heating. The total exploitable geothermal resource is about 29.871×10^{17}J, equivalent to 101.89 million tce, theoretically this is sufficient to supply the heating demand for the entire Shanghe.

329. Overall, the component has selected the most appropriate fuel type and heat sources.

C. Deep geothermal energy

322. Geothermal energy is a clean and renewable energy source deriving from the exploitation of the heat flux reaching the surface from the deeper part of the Earth's crust. The heat can be utilized in district heating. There are two technical options for geothermal heating. One is shallow geothermal utilization and the other is deep-well geothermal utilization.

323. Shallow-ground source heating involves extracting geothermal energy from ground water at around 16°C, via heat exchange tubes buried at a depth of 80 – 120 meters, then using a heat pump to increase the temperature to around 50°C. The advantages of this technology are: (i) deep drilling technology is not necessary, and there is minimal impact on groundwater resources;

(ii) the COP of shallow-ground source heat pump is above 4, which is higher than those of air source heat pump or electric boiler, etc. (iii) detailed geothermal resource survey data is not necessary. However, this technology also has disadvantages, mainly is that multiple shallow wells may be needed to draw enough heat energy. Generally, the proportion of areas for buried tube against heating area is 1:3. Hence, it could not be used for large areas. Secondly, a large amount of electricity will still be consumed by the heat pump during the heating period. The power consumption is 39 kWh for heating per square meter per heating period (assuming 15 hours per day and 120 days per year). Thirdly, heating and cooling imbalance will lead to the decay of geothermal energy after long time of operation.

324. The other option, deep-well geothermal energy involves extracting ground water around 50 – 60°C at the depth of 1,000-2,000 meters, and heat exchanging via indirect counter current heat exchangers for heat supply. The water extracted from ground will then be filtered and recharged back underground. The whole system consists of geothermal well, pump room and pipe networks, among those the water pump is the only energy-consuming equipment. Compared to shallow-ground source heat pump, deep-well geothermal energy has the tri-fold advantages of less land acquisition, stable heating and low maintenance cost. To make full use of the heat from ground water, heat pumps can be used to make the water to a higher temperature. However, the environmental risk of deep-well geothermal energy is the potential impact to underground water quantity and quality, so it is important to make sure that the extracted water is filtered and 100% recharged back. The component will ensure 100% recharge of the groundwater. The ground water will be extracted and recharged in a closed system and no wastewater will be generated. Therefore the component will not have impact to groundwater quantity and quality.

325. Weighing between the two technologies explained above, the deep well geothermal energy can be used for direct district heating which is more cost benefit compared to shallow-ground geothermal energy, thus the component is to adopt deep well geothermal energy technology for district heating.

326. There are two technical options for geothermal heating. One is shallow geothermal utilization and the other is deep-well geothermal utilization. Shanghe's geothermal resources are generally located at the depth of 1,000–1,500 meters with water temperature of 48°C–60°C. The heating yield of a single well is about 500–2,000 m^3 per day based on the richness of underground water. Thus, deep-well geothermal is utilized in this component.

D. Building energy efficiency improvement

327. A survey shows that the rural residents consume about 1.5-ton raw coal per household per winter. Factors to be consider when design clean heating systems for rural residents are: (i) low investment and operational cost, and (ii) easy to operate and maintain. People prefer a heating system with the following functions: (i) generating heat very fast that can increase indoor temperature rapidly and allowing frequent switches, (ii) separate controlling by rooms can be installed when heating is needed in a specific room.

328. Building energy efficiency improvement is necessary, because it can reduce the heating price while the persons live in the rural area are very sensitive at the heating price. It is not necessary to implement energy efficiency in all rooms of the houses, because it costs around 30,000 CNY for a 100 m^2 house which is a very high price for the villagers. Disposable personal income of persons in rural area of Shanghe is 13,738 CNY in 2017.

329. The component will add an insulation curtain to windows and adding roof insulation layer

with a cost around 3,000 CNY (the villagers can get a subsidy of 2,000 CNY for energy efficiency improvement) and the heat of the heating room will be reduced by 40% which means the heating cost will be reduced by 40% correspondingly.

330. Overall, the component has selected the most appropriate cost performance building energy efficiency improvement measures.

E. Pipeline Network

331. The component will utilize direct-buried pre-insulated bonded pipeline, which is by far the most commonly used technology for both new district heating systems and for rehabilitation of existing systems. Steel pipes and insulation materials made of polyurethane foam and high density polyethylene are bonded into one piece in a sandwich-like structure. Compared to onsite insulated pipe buried in a tunnel, direct-buried pre-insulation bonded pipe has many advantages including lower capital costs, reduced heat losses and improved energy efficiency, better anti-corrosive and insulation performance, longer service life, limited land acquisition requirement and shorter installation cycles. Although pre-insulated bonded pipe is designed for open-cutting installation in trenches, some sections of pipeline may need to run overhead, depending on local site conditions.

332. The component will also install low temperature heat supply secondary networks. Pre-insulated plastic pipes will be directly buried, and twin-pipe can be utilized where both supply and return pipe can be inserted into one insulation jacket. Construction of secondary networks is easier when bendable plastic pipes are used.

F. Overall Alternative Analysis

333. Based on the analysis of alternatives, the component has selected the most appropriate and sustainable heat source, most appropriate cost performance building energy efficiency improvement measures, pipeline type and clean heating methods.

VII. INFORMATION DISCLOSURE AND PUBLIC CONSULTATION

A. PRC and ADB Requirements for Disclosure and Public Consultation

1. PRC Requirements

334. Relevant provisions in the PRC *Environmental Impact Assessment Law* (revised in 2016) and the *Regulations on the Administration of Construction Project Environmental Protection* (No. 253 Order of the State Council, 1998, revised in 2017) require that an EIA study for a construction project shall solicit opinions from affected residents, as well as other organizations and concerned stakeholders. However, the requirements for public consultation are different for various sectors and projects. For an environmental Category A project a full EIA report is required including two rounds of public consultations, while for a Category B project only a simplified tabular EIA is required without the need for public consultation.

335. The "Provisional Regulations on Public Participation in Environmental Impact Assessment" (2006) promulgated by State Environmental Protection Administration further improved the legislation of public participation in EIA in China. It provides detailed requirements for the public participation process, including information disclosure standards, consultation methods, and public enquiry process. It is significant since it was the first document clearly regulating public participation in EIA in China.[28]

336. In 2014, former MEE released "Guiding Opinions on Promoting Public Participation in Environmental Protection" (2014, No. 48) which defines public participation as 'citizens, legal persons and other organizations' voluntary participation in environmental legislation, enforcement, judicature and law obedience, and the development, utilization, protection and transformation activities related to environment.

337. The public disclosure and consultation process undertaken during the preparation of the domestic EIA was undertaken in compliance with the relevant PRC requirements, including the "Provisional Regulations on Public Participation in Environmental Impact Assessment" (2006) and the "Guiding Opinions on Promoting Public Participation in Environmental Protection" (2014, No. 48).

2. ADB Requirements

338. ADB's SPS (2009) has specific requirements for information disclosure and public consultation. Information disclosure involves delivering information about a proposed project to the general public and to affected communities and other stakeholders, beginning early in the project cycle and continuing throughout the life of the project. Information disclosure is intended to facilitate constructive engagement with affected communities and stakeholders over the life of the project.

339. The SPS requires that borrowers take a proactive disclosure approach and provide relevant information from environmental assessment documentation directly to affected peoples and stakeholders. In addition, in order to make key documents widely available to the general public, the SPS requires submission to ADB for posting on the ADB website as follows:

28 Wang Ya Nan, 2012. Public Participation in EIA, SEA and Environmental Planning in China. Environmental Impact Assessment Research Centre.

(i) a draft full EIA (including the draft EMP) at least 120 days prior to ADB Board consideration for Category A projects, and/or environmental assessment and review frameworks before project appraisal, where applicable;
(ii) the final EIA/IEE;
(iii) a new or updated EIA/IEE, EMP and corrective action plan prepared during project implementation, if any; and
(iv) environmental monitoring reports.

340. The SPS also requires that the borrower carry out meaningful consultation with affected people and other concerned stakeholders, including civil society, and facilitate their informed participation. Consultations should include presentations on environmental impacts, benefits and mitigation measures, the project GRM, and ADB's Accountability Mechanism. For category A projects, such consultations should include consultations both at an early stage of EIA field work and when the draft EIA report is available.

B. Project Information Disclosure

341. Domestic EIA Institute has undertaken two rounds of information disclosure in accordance with the Interim Guidelines on Public Consultation for EIA (2006) during domestic EIA process of the component.

1. Information Disclosure by EIA Institute

342. IA disclosed the information of the component in two steps. The first public information notice was posted on the Jinan EPB's website in June 20, 2018, after the domestic EIA registered by Jinan EPB. The information in the first public notification (The link is http://jnepb.jinan.gov.cn/art/2018/6/20/art_24998_2029858.html) is listed below:

(i) Name and summary of the component.
(ii) Name and contact information of the construction company.
(iii) Name and contact information of the institute responsible for preparing the EIA of the component.
(iv) EIA procedures and content.
(v) Type of EIA notification notice.
(vi) Request for questions, suggestions and feedback from the public.

343. A second public information notice was also posted on the Jinan EPB's website from August 16 to August 24, 2018, prior to the approval of the draft EIA report by the Jinan EPB (http://jnepb.jinan.gov.cn/art/2018/8/16/art_10495_2465500.html). The notice included Project name and information below:

(i) Name and summary of the component.
(ii) Name and contact information of the institute responsible for preparing the EIA report.
(iii) Name and contact information of the institute responsible for approval of the EIA report.
(iv) Name and contact information of the construction company.

(v) Potential project environmental impacts and mitigation measures during construction phase and operation phase.

(vi) Key conclusions of the EIA report.

(vii) A link to get the full version of the EIA report.

Figure VII-1: Information disclosure on Jinan EPB's website

索引号:	11370100004189250W/2018-00823	公开方式:	主动公开
发布机构:	市环保局	组配分类:	环评报告、批复
文件编号:		发文日期:	2018-06-20

济南市环保局关于受理《济南热力集团有限公司利用亚洲开发银行贷款建设商河冬季清洁取暖无煤化示范县项目环境影响报告表》的公示

发布日期：2018-06-20 00:00　浏览次数：5次　字体：[大 中 小]

济南热力集团有限公司委托山东省环境保护科学研究设计院有限公司编制了《济南热力集团有限公司利用亚洲开发银行贷款建设商河冬季清洁取暖无煤化示范县项目环境影响报告表》并报我局，该项目建设地点为商河县。根据建设项目环境影响评价审批程序的有关规定，我局于2018年6月20日受理了该项目环境影响评价文件。现将受理情况予以公示，公示期为2018年6月20日 - 2018年6月22日。

联系电话(传真)：0531-68967417
通讯地址：济南市市中区站前街9号
邮　编：250000

济南市环境保护局

济南热力集团商河冬季清洁取暖无煤化示范项目.pdf

(i) First information disclosure

济南市环境保护局关于作出《济南热力集团有限公司利用亚洲开发银行贷款建设商河冬季清洁取暖无煤化示范县项目环境影响报告表》审批决定的公告

发布日期：2018-08-16 10:58　浏览次数：4次　字体：[大 中 小]

根据《建设项目环境影响评价政府信息公开指南（试行）》及建设项目环境影响评价审批程序的有关规定，经审查，2018年8月16日，我局对济南热力集团有限公司利用亚洲开发银行贷款建设商河冬季清洁取暖无煤化示范县项目环境影响评价文件作出审批决定（审批文号：济环报告表〔2018〕34号）。现将作出的审批决定予以公告，公告期为2018年8月16日—2018年8月24日（7日）。

行政复议与行政诉讼权利告知：依据《中华人民共和国行政复议法》和《中华人民共和国行政诉讼法》，公民、法人或者其他组织认为公告的建设项目环境影响评价文件审批决定侵犯其合法权益的，可以自公告期限届满之日起六十日内提起行政复议，也可以自公告期限届满之日起六个月内提起行政诉讼。

电话（传真）：0531—68967417
通讯地址：济南市市中区站前街9号
邮编：250000

作出的建设项目环境影响评价文件审批决定

序号	文件名称	文号	批复时间	环境影响报告文件（最终版）
1	关于济南热力集团有限公司利用亚洲开发银行贷款建设商河冬季清洁取暖无煤化示范县项目环境影响报告表的批复	济环报告表〔2018〕34号.pdf	2018-8-16	利用亚洲开发银行贷款建设商河冬季清洁取暖无煤化示范县项目报告表.zip

(ii) Second information disclosure

344. No public feedback was received during two rounds of public information disclosure. When separate EIAs is beings prepared, all the EIAs will follow the same public information disclosure process.

345. This IEE prepared will be disclosed on the JHG's website and ADB website. Two rounds of information disclosure have been implemented by the JHG.

2. Public Consultation

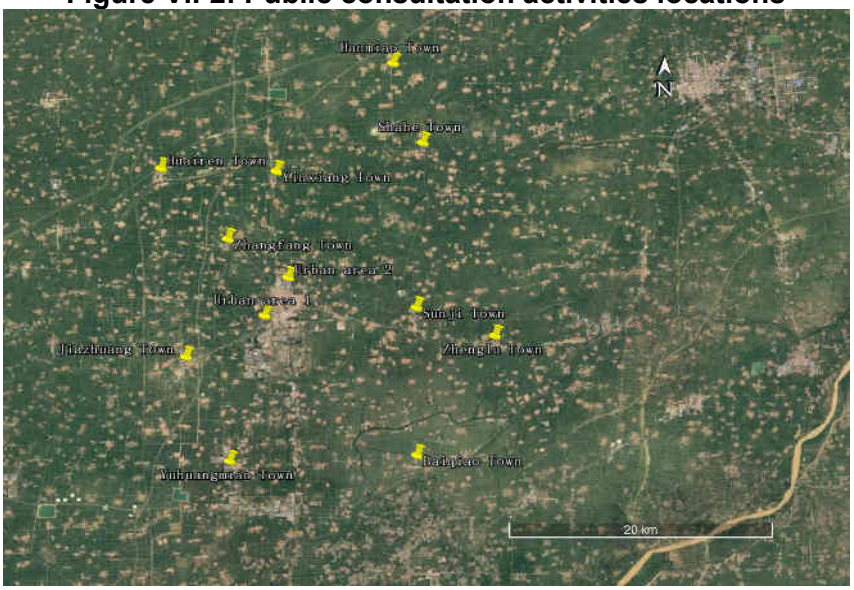
346. As part of the social safeguards due diligence undertaken for the component by ADB PPTA team, a social analysis was undertaken to (i) assess social patterns influenced by the component including the identification of any adverse effects; (ii) assess the current status of poverty within the heating areas and analyzed the poverty reduction impact resulting from the Project; and (iii) analyze and proposes activities which would complement the Project by enhancing the livelihood of the vulnerable people within the heating area of the component.

347. The methodology for the social analysis included socioeconomic surveys (carried out from March – April 2018) and local consultations. The consultants visited all heating areas and held meetings with the IA and local people and various district government agencies including the development and reform committees, land administration bureaus, civil affairs bureaus, urban construction bureaus and women's federations, etc.

348. The social analysis results are presented in the social analysis report prepared by PPTA social specialist.

349. The JHG held 12 separate public consultation meetings from March – April 2018 during the preparation of the IEE. 12 public consultation meetings were held in urban area of Shanghe (two meetings, one meeting was held in Hengtai HSP), Yuhuangmiao Town, Yinxiang Town, Huairen Town, Zhenglu Town, Jiazhuang Town, Baiqiao Town, Sunji Town, Hanmiao Town, Shahe Town and Zhangfang Town. The locations of the public consultation meetings are presented in **Figure VII-2**.

Figure VII-2: Public consultation activities locations



350. A public project information notice was posted in the nearby communities for one weeks prior to the meetings. Nearby residents were invited to the meetings. During the meetings, information on the component construction content and status was presented by JHG while information on potential environmental impacts and proposed mitigation measures, GRM requirements of ADB and component benefits was presented by social consultant and environmental consultant. Then questions and subsequent discussions focused on environmental issues of the component and benefits of the component especially clean district heating and employment promotion. During the meetings, most of the participants believed that the component can provide a clean district heating service and can improve your living quality of them provide more job opportunities to the nearby communities and 90.6% of participants supported the component.

351. During the public consultant meetings, a total of 267 questionnaires (**Table VII-1**) were distributed and 267 completed questionnaires were received. The main contents of the questionnaire are potential impacts and mitigation measures. Photos of the consultation meeting and survey are shown in **Figure VII-3**.

352. **Table VII-2** presents summary data on the questionnaire respondents, while **Table VII-3** presents a summary of the questionnaire results.

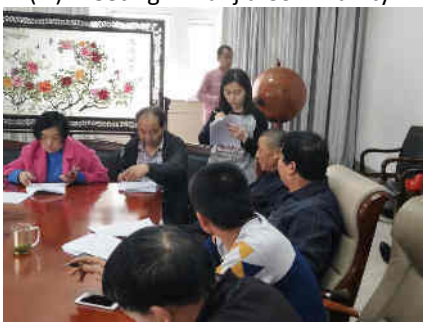
Figure VII-3: Public consultation activities

(i) Meeting in Hengtai HSP.

(ii) Meeting in Shanghe Nursing Home.

(iii) Meeting in Banjia Community.

(iv) Meeting in Yuhuangmiao Town



(v) Meeting in YinxiangTown

(vi) Meeting in Huairen Town

(vii) Meeting in ZhengluTown

(viii) Meeting in JiazhuangTown

(ix) Meeting in BaiqiaoTown

(x) Meeting in Sunji Town

(xi) Meeting in Hanmiao Town

(xii) Meeting in Shahe Town

(xiii) Meeting in Zhangfang Town

353. 92.1% of the respondents work within a 5 km radius of the component while 89.9% live within a 5 km; 48.7% of respondents knew about the component either from other persons, newspapers or information signs, and 80.1% of respondents indicated that they were already familiar with the project benefits after the introduction of the component. 58.1% of the participants were female. The top three environment issues respondents identified in their neighborhoods are air quality (58.1%), noise (28.1%) and surface water (25.5%). Dust (29.6%) and noise (24.3%) were identified as the top two issues during the construction period. Air pollution and noise were identified as the top two issues during the operation phase. However, most participants also indicated that potential environmental impacts during construction period and operation period can be appropriately mitigated.

354. Overall support for the project is very strong; 76.8% of the respondents indicated that the component will improve local economic development; 88.0% indicated that the component will improve quality of life; and 90.6% of respondents indicated that they support the proposed component.

Table VII-1: Project public consultation questionnaire (2018)

Name		Sex		Age	
Education level		Occupation		Nationality	
Contact information					
Question		**Choices**		**Yes**	**Comments**
1. In your opinion, what are the major environment pollution issues in your areas?		Ambient air			
		Noise			
		Surface water			
		Ground water			
		Soil			
		Solid waste			
		Odor			
		Risks associated with chemicals and hazardous chemicals			
		Other concern			
2. Distance between your working place and project site		<1 km			
		1-3 km			
		3-5 km			
		> 5km			
3. Distance between your house and project site		<1 km			
		1-3 km			
		3-5 km			
		> 5km			
4. Do you know this project before this public consultation?		Yes			
		No			
5. Do you understand environment impacts of this project before this public consultation?		Yes			
		No			
		Not clear			
6. After knowing about the EIA findings, are all the potential positive and adverse impacts of the proposed project components clear to you?		Clearly understand			
		Somewhat understand			
		Barely understand			
		Do not understand			
7. Do you understand the potential adverse impacts during the construction of the proposed project components?		Clearly understand			
		Somewhat understand			
		Barely understand			
		Do not understand			
8. What would be the major impacts during project construction?		Noise			
		Dust			
		Solid waste			
		Traffic congestion			
		Others			
		No major impacts			
9. Without mitigation measures, do you accept anticipated construction phase impacts?		Accept			
		Barely accept			
		Do not accept			
		Have no idea			
10. After learning about mitigation measures during the construction, do you accept anticipated construction phase impacts?		Accept			
		Barely accept			
		Do not accept			
		Have no idea			
		Clearly understand			

11. Do you understand all the anticipated environmental adverse impacts of the project during operation?	Somewhat understand		
	Barely understand		
	Do not understand		
12. Do you understand all the anticipated health and safety adverse impacts of the project during operation?	Clearly understand		
	Somewhat understand		
	Barely understand		
	Do not understand		
13. Do you understand the proposed mitigation measures during the project operation?	Clearly understand		
	Somewhat understand		
	Barely understand		
	Do not understand		
14. Do you accept the impacts to ambient air quality by this project?	Accept		
	Barely accept		
	Do not accept		
	Have no idea		
15. Do you accept the impacts to surface water quality by this project?	Accept		
	Barely accept		
	Do not accept		
	Have no idea		
16. Do you accept the impacts to ground water quality by this project?	Accept		
	Barely accept		
	Do not accept		
	Have no idea		
17. Do you accept the impacts to acoustic environment quality by this project?	Accept		
	Barely accept		
	Do not accept		
	Have no idea		
18. Do you accept the solid waste pollution by this project?	Accept		
	Barely accept		
	Do not accept		
	Have no idea		
19. Do you accept the impacts to ecological environment by this project?	Accept		
	Barely accept		
	Do not accept		
	Have no idea		
20. Do you accept environment, health, and safety risks caused by this project?	Accept		
	Barely accept		
	Do not accept		
	Have no idea		
21. What are the major concerns of this project	Ambient air		
	Noise		
	Surface water		
	Ground water		
	Soil		
	Solid waste		
	Odor		
	Risks associated with chemicals and hazardous chemicals		
	Other concern		
22. Do you think construction of this project can improve local economic development or not?	Yes		
	No		
	I do not know		

23. Do you think whether construction of this project can improve your living quality such as better hear supply service?	Yes		
	No		
	I do not know		
24. Do you support the project?	Yes		
	No		
	I do not know		
Suggestions or requirements for environment protection of the project.			

Table VII-2: Summary data on questionnaire respondents

Parameter	Indicator	No.	%
Sex	Male	112	41.9%
	Female	155	58.1%
Age	Below 30	15	5.6%
	31-40	62	23.2%
	41-50	89	33.3%
	Above 50	101	37.8%
Nationality	Han people	255	95.5%
	Other	12	4.5%
Education Level	Primary School or Below	81	30.3%
	Junior school	115	43.1%
	High school, including technical secondary school	55	20.6%
	Bachelor degree or above, including junior college	16	6.0%
Occupation	Farmer	159	59.6%
	Employee	55	20.6%
	Civil servant	20	7.5%
	Freelancer	33	12.4%

Table VII-3: Public consultation questionnaire results

Question	Item	No.	% (shading denotes highest ranked)
1. In your opinion, what are the major environment pollution issues in your areas?	Ambient air	155	58.1%
	Noise	75	28.1%
	Surface water	68	25.5%
	Ground water	53	19.9%
	Soil	34	12.7%
	Solid waste	49	18.4%

	Odor	22	8.2%
	Risks associated with chemicals and hazardous chemicals	9	3.4%
	Other concern	0	0.0%
2. Distance between your working place and project site	<1 km	57	21.3%
	1-3 km	124	46.4%
	3-5 km	65	24.3%
	> 5km	21	7.9%
3. Distance between your house and project site	<1 km	42	15.7%
	1-3 km	159	59.6%
	3-5 km	39	14.6%
	> 5km	27	10.1%
4. Do you know this project before this public consultation?	Yes	130	48.7%
	No	137	51.3%
5. Do you understand environment impacts of this project before this public consultation?	Yes	55	20.6%
	No	141	52.8%
	Not clear	71	26.6%
6. After this public consultation, are all the potential positive and adverse impacts of the proposed project components clear to you?	Clearly understand	77	28.8%
	Somewhat understand	83	31.1%
	Barely understand	46	17.2%
	Do not understand	61	22.8%
7. Do you understand the potential adverse impacts during the construction of the proposed project?	Clearly understand	82	30.7%
	Somewhat understand	97	36.3%
	Barely understand	35	13.1%
	Do not understand	53	19.9%
8. What would be the major impacts during project construction?	Noise	79	29.6%
	Dust	65	24.3%
	Solid waste	27	10.1%

	Traffic congestion	38	14.2%
	Others	0	0.0%
	No major impacts	58	21.7%
9. Without mitigation measures, do you accept anticipated construction phase impacts?	Accept	74	27.7%
	Barely accept	62	23.2%
	Do not accept	43	16.1%
	Have no idea	88	33.0%
10. After learning about mitigation measures during the construction, do you accept anticipated construction phase impacts?	Accept	93	34.8%
	Barely accept	62	23.2%
	Do not accept	38	14.2%
	Have no idea	74	27.7%
11. Do you understand all the anticipated environmental adverse impacts of the project during operation?	Clearly understand	65	24.3%
	Somewhat understand	72	27.0%
	Barely understand	75	28.1%
	Do not understand	55	20.6%
12. Do you understand all the anticipated health and safety adverse impacts of the project during operation?	Clearly understand	88	33.0%
	Somewhat understand	74	27.7%
	Barely understand	65	24.3%
	Do not understand	40	15.0%
13. Do you understand the proposed mitigation measures during the project operation?	Clearly understand	120	44.9%
	Somewhat understand	84	31.5%
	Barely understand	31	11.6%
	Do not understand	32	12.0%
14. Do you accept the impacts to ambient air quality by this project?	Accept	99	37.1%
	Barely accept	67	25.1%
	Do not accept	33	12.4%
	Have no idea	68	25.5%

15. Do you accept the impacts to surface water quality by this project?	Accept	101	37.8%
	Barely accept	97	36.3%
	Do not accept	26	9.7%
	Have no idea	43	16.1%
16. Do you accept the impacts to ground water quality by this project?	Accept	95	35.6%
	Barely accept	72	27.0%
	Do not accept	44	16.5%
	Have no idea	56	21.0%
17. Do you accept the impacts to acoustic environment quality by this project?	Accept	113	42.3%
	Barely accept	84	31.5%
	Do not accept	32	12.0%
	Have no idea	38	14.2%
18. Do you accept the solid waste pollution by this project?	Accept	128	47.9%
	Barely accept	79	29.6%
	Do not accept	29	10.9%
	Have no idea	31	11.6%
19. Do you accept the impacts to ecological environment by this project?	Accept	132	49.4%
	Barely accept	99	37.1%
	Do not accept	22	8.2%
	Have no idea	14	5.2%
20. Do you accept environment, health, and safety risks caused by this project?	Accept	119	44.6%
	Barely accept	99	37.1%
	Do not accept	17	6.4%
	Have no idea	32	12.0%
21. What are the major concerns of this project	Ambient air	98	36.7%
	Noise	73	27.3%
	Surface water	48	18.0%

	Ground water	30	11.2%
	Soil	42	15.7%
	Solid waste	39	14.6%
	Odor	15	5.6%
	Risks associated with chemicals and hazardous chemicals	9	3.4%
	Other concern	0	0.0%
22. Do you think construction of this project can improve local economic development or not?	Yes	205	76.8%
	No	25	9.4%
	I do not know	37	13.9%
23. Do you think whether construction of this project can improve your living quality such as better hear supply service?	Yes	235	88.0%
	No	12	4.5%
	I do not know	20	7.5%
24. Do you support the project?	Yes	242	90.6%
	No	13	4.9%
	I do not know	12	4.5%

C. Future Consultation Activities

355. This IEE will be disclosed on the ADB website. Any update in the IEE resulting from a change in project scope will be similarly disclosed.

356. The IA will continue to conduct regular community liaison activities during the construction and operations phases, including the implementation of the GRM (see Chapter VIII). Ongoing consultation will ensure that public concerns are understood and dealt with in a timely manner.

VIII. GRIEVANCE REDRESS MECHANISM

A. Introduction

357. A project grievance can be defined as an actual or perceived project related problem that gives ground for complaint by an affected person (AP). As a general policy, a PMO will be established by IA and it will work proactively toward preventing grievances through the implementation of mitigation measures and community liaison activities that anticipate and address potential issues before they become grievances. In addition, as the project has strong public support and will not involve any involuntary land or property acquisition or resettlement, significant grievance are unlikely to happen. Nonetheless, during construction and operation it is possible that unanticipated impacts may occur if the mitigation measures are not properly implemented, or unforeseen issues arise. In order to address complaints if or when they arise, a component-level GRM has been developed in accordance with ADB requirements. A GRM is a systematic process for receiving, recording, evaluating and addressing AP's project-related grievances transparently and in a reasonable timeframe.

B. ADB's GRM Requirements

358. The ADB's SPS 2009 requires a project to establish a GRM to receive and facilitate resolution of AP's concerns and complaints about the project's environmental performance during construction as well as operation phases of the project. The GRM should be scaled to the risks and adverse impacts of the project; should address affected people's concerns and complaints promptly, using an understandable and transparent process; should be readily accessible to the community at no cost and without retribution; and, should not impede access to the PRC's judicial or administrative remedies.

C. Current GRM Practices in the PRC

359. At the national level, a framework to address grievance has been established. State Council Decree No. 431 "Regulations on Letters and Visits" (January 2005) establishes a complaint mechanism at all levels of government, and safeguards the complainants from any retaliation. The former MEP Decree No. 34 "Environmental Letters and Visits System" provides specific guidelines to establish a system and address environmental complaints. When APs are affected by project activities, they may complain to the contractors and the project company by themselves or through their community organizations, or complain directly to local EPBs. If the issue is not resolved they may take legal action, though that is typically considered as a last option.

D. Project Level GRM

360. The objective of the component GRM is to prevent and address community concerns, reduce risks, and assist the project to maximize environmental and social benefits. In addition to serving as a platform to resolve grievances, the sub-project level GRM has been designed to (i) open channels for effective communication, including the identification of new environmental issues of concern arising from the component; (ii) demonstrate concern about community members and their environmental well-being; and (iii) prevent and mitigate any adverse environmental impacts on communities caused by component implementation and operations. The GRM will be accessible to all members of the community through public information disclosure at IA's website, project site and community center, etc.

361. The overall approach of the GRM is to deal with grievances at a local level first in an efficient manner and escalate to higher level of authority if the grievance cannot be resolved. The designated person from the PMO will be responsible for implementation of the GRM. The PMO will be the key contact point for residents, businesses, government departments and other stakeholders who may require information about the component or who have an issue they would like to discuss.

362. The GRM will be implemented through five escalating steps, advancing to the next level only if the grievance was unable to be redressed at the previous level.

(i) **Step 1**: If a concern arises, the AP can try to resolve the issue of concern either directly with the contractor or with the contactor via GRM access points (community leaders, neighborhood organizations, PMO, local EPB) during the construction phase, and/or the operator during the operation phase. If the concern is resolved successfully no further follow-up action is required. Nonetheless, the contractor (during construction) and/or the operator (during operation) shall record any complaint and actions taken to resolve the issues and report the results to the PMO and the AP. If no solution is found within 10 working days or if the AP is not satisfied with the suggested solution under Step 1, proceed to Step 2. The AP may also skip Step 1 and directly file the complaint with the PMO.

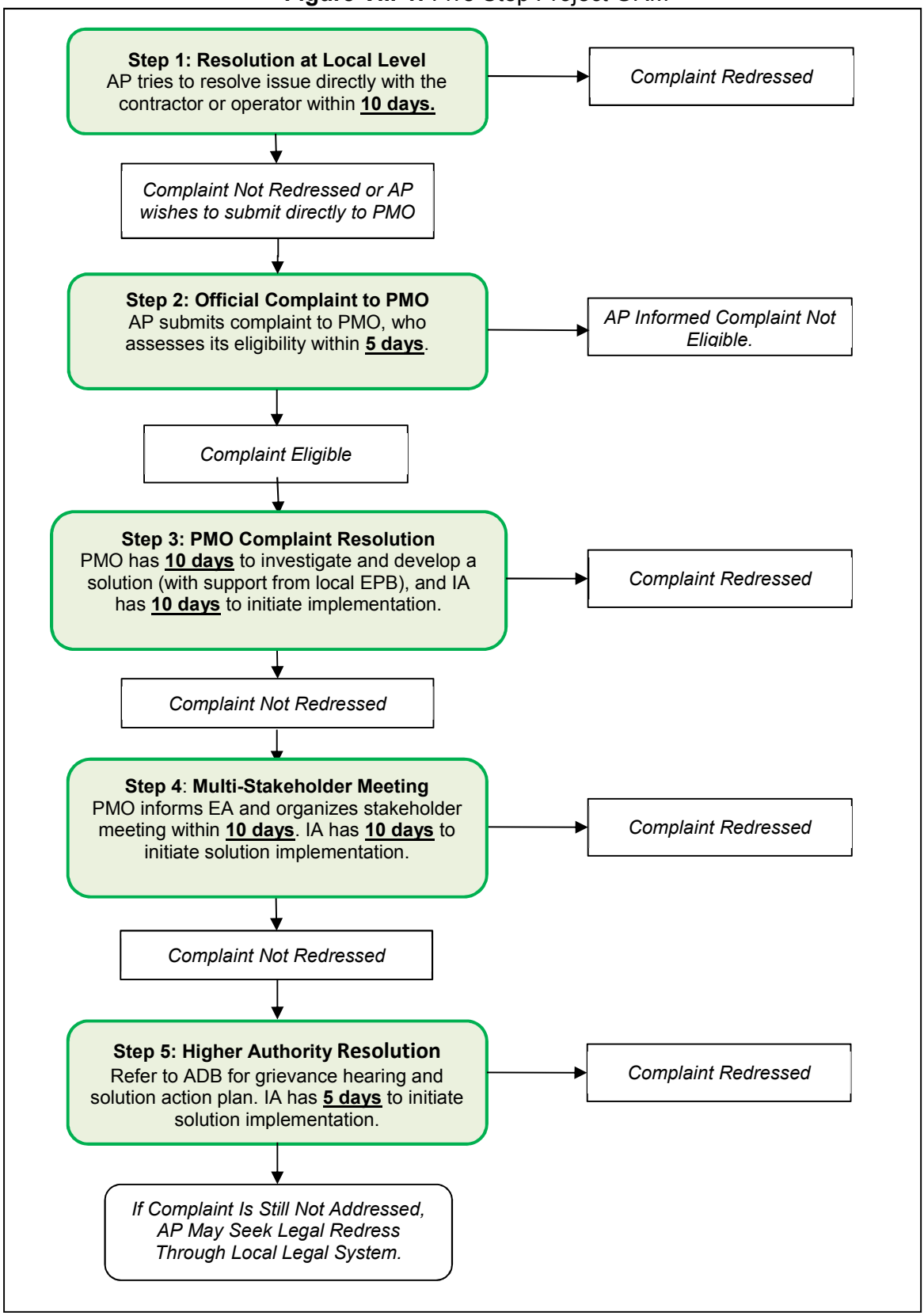
(ii) **Step 2:** The AP will submit the grievance to the PMO, who will record the grievance, assess its eligibility and report back to the AP within 5 working days. If the grievance is eligible, proceed to Step 3.

(iii) **Step 3:** The PMO will investigate the complaint, and consult with the IA, local EPB, and other stakeholders as appropriate to identify a solution. The PMO will give a clear reply to the AP within 10 working days with the suggested solution, and the IA will ensure that implementation of the agreed-upon redress solution begins within 10 working days. If no solution is found or if the complainant is not satisfied with the suggested solution under Step 3, proceed to Step 4.

(iv) **Step 4:** The PMO will inform the EA the grievance and will organize a multi-stakeholder meeting within 10 days, where all relevant stakeholders, including the complainant, EA, IA, and local EPB, can discuss the issue. The multi-stakeholder meeting will aim to find a solution acceptable to all and identify responsibilities and an action plan. The IA will ensure that the implementation of agreed-upon redress solution begins within 10 working days of the completion of the multi-stakeholder meeting.

(v) **Step 5:** If the complainant is still not satisfied with the suggested solution under Step 4, the grievance will be directed to ADB. ADB will direct the EA to organize a hearing process and shall determine a solution acceptable to all. Based on the hearing results, an action plan shall be developed and the IA will ensure that the implementation of the agreed-upon redress solution begins within 5 working days of the completion of the hearing.

Figure VIII-1: Five Step Project GRM



IX. CONCLUSIONS

363. This IEE report has been prepared for the proposed Shanghe Coal-Free Clean Heating Demonstration Component of the Shandong Clean Heating and Cooling Project (the Project) in Shandong Province of the PRC. The proposed Project is the fourth in a multi-year multi-sectoral ADB support for air quality improvement in the greater BTH region.

364. This component aims to build Shanghe as a "coal-free," clean heating pilot county, the first-of-its-kind in Shandong Province. This will be achieved in more densely populated areas by forming a modernized heat supply system in the urban and semi-urban areas. In rural area of Shanghe County, the component will use individual electric clean heating equipment to replace existing small coal stoves. To improve heating efficiency, the component will implement energy saving transformation for buildings and houses in urban and rural areas of Shanghe.

365. This component will be implemented in urban, semi-urban and rural areas of Shanghe County. In urban area of Shanghe, this component will: (i) provide district heating to 5.5015 million m^2 by natural gas, heat pumps and deep-well geothermal energy; (ii) install 6.57 km primary and 204.78 km secondary district heating pipeline network; (iii) install one 42 MW gas fired boiler to replace the existing 58 MW coal fired boiler; and (iv) implement energy saving transformation for existing old residential buildings with an area of 660,400 m^2 through replacing thermal insulation materials for the exterior walls, and replacing single-layer glass wind with double glazing.

366. In semi-urban area of Shanghe, this component will: (i) provide district heating to 2.0134 million m^2 by natural gas and deep-well geothermal energy in ten towns; and (ii) install 25.72 km primary and 75.46 km secondary district heating pipeline network.

367. In rural area of Shanghe, this component will: (i) provide heating to five new kindergartens with a heating area of 9,300 m^2 by air source heat pump; (ii) implement clean heating transformation for 80,000 households with a heating area of 4 million m^2 by replacing coal stoves; and (iii) implement energy saving transformation for 30,000 households by adding an insulation curtain to windows and roof insulation layers.

368. The component will be implemented through four outputs:

i) **Output 1**: Provide clean district heating in urban and semi-urban areas of Shanghe by natural gas, deep-well geothermal energy and heat pumps. Total heating area in urban and semi-urban areas of Shanghe will be 7.5149 million m^2. Provide clean heating to 4,009,300 m^2 in rural area of Shanghe by heat pumps, gas heaters, carbon crystal plate radiators and heat-storage radiators.

ii) **Output 2**: 32.29 km of primary and 280.24 km of secondary district heating pipeline network will be constructed to provide district heating to 7.5147 million m^2 in urban and semi-urban areas of Shanghe. The pipe networks will utilize two-pipe system. One is water supply pipe and another is water return pipe.

iii) **Output 3**: Implement energy saving transformation for existing old residential buildings with an area of 660,400 m^2 in urban area of Shanghe through replacing thermal insulation materials for the exterior walls, and replacing single-layer glass

wind with double glazing and 30,000 households in rural area of Shanghe by adding an insulation curtain to windows and roof insulation layers with an estimated area of 1.5 million m^2; and

(v) **Output 4:** Strengthened capacity to install and maintain clean heating technologies. The component activities will employ women and include awareness raising about the benefits of clean energy targeted toward women who are often responsible for domestic upkeep.

369. The component will bring significant positive environmental benefits. It will reduce the emission of greenhouse gases and other air pollutants in Shanghe. Compared to the equivalent production of heat generation through traditional coal-fired sources, once operational, the component will: (i) result in annual energy savings equivalent to 111,748 tce, thereby providing a global public good by avoiding the annual emission of 391,526.6 tons of CO_2; (ii) improve local air quality through the estimated annual reduction of emissions of SO_2 by 598.6 tons, NOx by 258.3 tons, and PM by 881.2 tons; and (iii) eliminate the negative impacts of coal transportation through urban areas by truck or train.

370. The component has: (i) selected appropriate technologies to reduce the emission of pollutants; (ii) identified potential negative environment impacts and appropriately established mitigation measures; (iii) received public support from the project beneficiaries and affected people; (iv) established effective project GRM procedures; and (v) prepared a comprehensive EMP including environmental management and supervision structure, environmental mitigation and monitoring plans, and capacity building and training.

371. It is concluded that the project will not result in adverse environmental impacts that are irreversible, diverse, or unprecedented. Any minimal adverse environmental impacts associated with the project will be prevented, reduced, or minimized through the implementation of the project EMP.

Appendices

Appendix I: Environmental Management Plan

Appendix II: Existing Facility Due Diligence Environmental Review – Hengtai Heat Source Plant

APPENDIX I: ENVIRONMENTAL MANAGEMENT PLAN

A. Objectives

1. This EMP is for proposed Shanghe Coal-Free Clean Heating Demonstration Component of the proposed Shandong Clean Heating and Cooling Project in Shandong Province of the PRC. The proposed project is the fourth in a multi-year multi-sectoral ADB support for air quality improvement in the greater BTH region.

2. This component aims to build Shanghe as a "coal-free," clean heating pilot county, the first-of-its-kind in Shandong Province. This will be achieved in more densely populated areas by forming a modernized heat supply system in the urban and semi-urban areas. In rural area of Shanghe County, the component will use individual electric heating equipment and natural gas to replace existing small coal stoves. To improve heating efficiency, the component will implement energy saving transformation for buildings in urban and rural areas of Shanghe.

3. This component will be implemented in urban, semi-urban and rural areas of Shanghe County. In urban area of Shanghe, this component will: (i) provide district heating to 5.5015 million m^2 by natural gas, heat pump and geothermal; (ii) install 6.57 km primary and 204.78 km secondary district heating pipeline network; (iii) install one 42 MW gas fired boiler to replace the existing 58 MW coal fired boiler; and (iv) implement energy saving transformation for existing old residential buildings with an area of 660,400 m^2.

4. In semi-urban area of Shanghe, this component will: (i) provide district heating to 2.0134 million m^2 by natural gas and deep-well geothermal energy in ten towns; and (ii) install 25.72 km primary and 75.46 km secondary district heating pipeline network.

5. In rural area of Shanghe, this component will: (i) provide heating to five new kindergartens with a heating area of 9,300 m^2 by air source heat pump; (ii) implement clean heating transformation for 80,000 households with a heating area of 4 million m^2 through replacing coal stoves with clean heating devices and (iii) implement energy saving transformation for 30,000 households with an estimated area of 1.5 million m^2 through by adding an insulation curtain to windows and roof insulation layers.

6. The component will be implemented through four outputs:

(i) **Output 1**: Provide clean district heating in urban and semi-urban areas of Shanghe by natural gas, deep-well geothermal energy and heat pumps. Total heating area in urban and semi-urban areas of Shanghe will be 7.5149 million m^2. Provide clean heating to 4,009,300 m^2 in rural area of Shanghe by heat pumps, gas heaters, carbon crystal plate radiators and heat-storage radiators.

(ii) **Output 2**: 32.29 km of primary and 280.24 km of secondary district heating pipeline network will be constructed to provide district heating to 7.5147 million m^2 in urban and semi-urban areas of Shanghe. The pipe networks will utilize two-pipe system. One is water supply pipe and another is water return pipe.

(iii) **Output 3**: Implement energy saving transformation for existing old residential buildings with an area of 660,400 m^2 in urban area of Shanghe through replacing thermal insulation materials for the exterior walls, and replacing single-layer glass

wind with double glazing, and 30,000 households in rural area of Shanghe with an estimated area of 1.5 million m^2 by adding an insulation curtain to windows and roof insulation layers.

(vi) **Output 4**: Strengthened capacity to install and maintain clean heating. The component activities will employ women and include awareness raising about the benefits of clean energy targeted toward women who are often responsible for domestic upkeep.

7. The component impact will be reduced coal consumption, improved air quality and reduced greenhouse gas emissions in Shanghe County. The outcome will be improved energy efficiency, a cleaner environment in Shanghe County and a reduction in cases of respiratory and heart diseases.

8. The objectives of the EMP are to ensure (i) implementation of the identified mitigation and management measures to avoid, reduce, mitigate, and compensate for anticipated adverse environment impacts; (ii) implementation of monitoring and reporting; and (iii) the component compliance with the PRC's relevant environmental laws, standards and regulations and ADB's SPS 2009. Organizational responsibilities and budgets are clearly identified for implementation, monitoring and reporting.

9. The EMP is to be implemented in all phases of the project cycle, including design, pre-construction, construction, and operation. In the detailed design stage, the EMP will be used by the design institute for incorporating mitigation measures into the detailed designs. The EMP will be updated at the end of the detailed design, as needed.

10. The EMP will be included as a separate annex in all bidding and contract documents. The contractors will be informed of their obligations to implement the EMP, and to provide for EMP implementation costs in their bids for project works.

B. Implementation Arrangements

11. SPG will be the EA and responsible for overall guidance during project preparation and implementation. JHG, a state-owned company will be the IA of the component and responsible for implementing project components and administering and monitoring contractors and suppliers. A PMO led by the Jinan Municipal Bureau of Housing and Urban-rural Development will be responsible for day-to-day management of the project.

12. The IA will implement project components, administer and monitor contractors and suppliers, and be responsible for construction supervision and quality control. The IA will ensure that the EMP is implemented proactively and responds to any adverse impact beyond those foreseen in the IEE. The IA will also attend to requests from relevant agencies and ADB regarding the mitigation measures and monitoring program. It will nominate dedicated, trained, and qualified environment specialists to (i) supervise contractors and ensure compliance with the EMP; (ii) conduct regular site inspections; (iii) conduct periodic environmental quality monitoring in compliance with the approved monitoring plan; (iv) act as local entry point for the project GRM; and (v) submit environmental monitoring reports to the EA and ADB semi-annually during construction and annually during operation. The IA will also appoint a Project Management Office Environment and Safety Officer (PMO ESO) and engage a local EMS for environmental monitoring.

13. Jinan Municipal Bureau of Housing and Urban-rural Development will establish a PMO, which will be responsible for day-to-day management of the project. The PMO will designate a qualified PMO ESO, who will take overall responsibility for supervising the implementation of environmental mitigation measures, coordinating the project level GRM and preparing monitoring reports for submission by the PMO to ADB. The PMO ESO with support of the LIEC will (i) provide overall coordination and support on environmental aspects; (ii) supervise contractors and construction supervision companies (CSCs) and their compliance with the EMP; (iii) conduct regular site compliance inspections; (iv) act as PMO entry point for the project GRM; (v) collect and submit environmental monitoring data provided by (a) contractors and/or CSCs to the PMO, and (b) the EMS to the PMO; and (vi) support PMO with preparation of EMP progress section as a part of semiannual project progress reports and semiannual environmental monitoring reports (EMRs).

14. The PMO will engage a LIEC, a part-time national environmental, health, and safety specialist prior to the engagement of construction contractors and the project construction, who will support the PMO in mitigation implementation, environmental monitoring, reporting, and addressing any environment-related issues that arise including grievances. The LIEC will also support contractors in developing construction site-specific environmental management plans (CEMPs) prior to construction and operation.

15. A local EMS will be engaged by the IA to undertake construction and operation phase ambient environmental monitoring, as per the requirements of the environmental monitoring plan (EMoP) presented in this EMP.

16. Construction contractors will be responsible for implementing the mitigation measures during construction under supervision of the IA and the PMO. In their bids, the contractors will prepare CEMPs which detail how the contractors will comply with the EMP. Each contractor will identify a lead focal point for environmental issues (e.g., Environment, Health and Safety Officer), who will oversee CEMP implementation, take all reasonable measures to minimize the impact of construction activities on the environment, develop and prepare monthly reports for submission to the IA. Contractors are also required to report any spills, accidents, and grievances received, and take appropriate action. The Environment, Health and Safety Officer will also be responsible for developing CEMPs and an Occupational Health and Safety Plan (OHSP). During operation, the existing staff at the HSP will be operating the 42 MW natural gas boiler.

17. CSCs will be responsible for supervising and guiding construction contractors during project construction phase. CSCs will have a qualified Environment, Health and Safety Officer who will be responsible for supervising construction contractors to ensure proper the implementation of EMP and CEMPs; and preparing and submitting consolidated quarterly EMRs to the PMO based on the CEMPs implementation.

18. ADB will conduct due diligence of environment issues during project review missions. ADB will also review the semiannual EMRs submitted by the PMO and will disclose the reports on its website. If the PMO fails to meet safeguards requirements described in the EMP, ADB will seek corrective measures and advise the IA on items in need of follow-up actions. IA will engage loan implementation environment consultant (LIEC).

19. Roles and responsibilities for the EMP implementation are presented in **Table 1**.

Table 1: Project implementation and management organizations

Organization	Role and Responsibility
EA	- -Coordinating and overseeing project preparation and implementation. - -Coordination of strategic issues at regional or national level. - -Providing policy guidance and facilitation during implementation. - -Facilitating interagency coordination with other involved parties at the regional level (and facilitate issues and decision making at the national level, if required).
IA	- Main responsibilities include: - Contracting and administering contractors and suppliers. - Supervising construction and monitoring quality control. - Appointing a PMO ESO. - Engaging a local EMS for environmental monitoring. - Engaging a LIC including a LIEC. - Ensuring compliance with EMP and RP. - Responding to any adverse impact beyond those foreseen in the IEE and ensuring that if there are any changes in scope, the IEE/EMP will be updated as needed. - Responding to requests from relevant agencies and ADB regarding the mitigation measures and environmental monitoring program. - Identifying and implementing O&M arrangements. - Take corrective actions if needed. - Prepare environmental monitoring reports semi-annually during construction and annually during operation.
PMO	- On behalf of the EA, the PMO will be responsible for all project organization and implementation activities, including the following: - Updating IEE/EMP if needed, including EMoP. - -Ensuring that mitigation measures are included in engineering detailed design. - -Ensuring project's compliance with loan and project agreements and safeguards requirements. - Managing the activities of the design institutes, procurement agents, and consultants in accordance with government and ADB regulations. - Coordination with concerned offices, including SPG, and with external contacts. - Taking part in capacity development and training. - Establishing and operating the project complaint center with hotline. - Overseeing the project program and activities of the IA in the implementation of the project outputs. - Monitoring the project's physical and financial progress and compliance with project's reporting requirements, ensuring project progress reports are prepared and submitted to ADB on time. - Preparing progress reports for submission to the IA and/or PMO. - -Coordinating the activities of and meeting the requirements of ADB's review missions.
Loan Implementation Environmental Consultant (LIEC)	The LIEC will: - Review the updated IEE and EMP. - Confirm that mitigation measures have been included in detailed engineering design. - Review bidding documents to ensure that the EMP clauses are incorporated. - Review CEMPs to ensure compliance with the EMP. - Provide technical assistance and support to the PMO and contractors on mitigation measures and EMP implementation. - Deliver the construction and operation phase capacity building programs to the staff of the IA, PMO, and contractors. - Conduct site inspections in compliance with the environmental monitoring plan. - Review reports prepared by contractors and assist the PMO in preparing semiannual environmental monitoring reports.
EMS	- A qualified independent environmental monitoring station will be recruited to implement the ambient monitoring portion of the EMoP.
Contractors	- Ensure sufficient funding and human resources for proper and timely implementation of required mitigation and monitoring measures in the EMP and CEMPs throughout the construction phase. - Responsible for GRM operation during construction phase.
Construction supervision	- Ensure sufficient funding and human resources for supervising and instructing contractors for proper and timely implementation of required mitigation and monitoring measures in the EMP and CEMPs throughout the construction phase.

company(ies) (CSCs)	- Appoint an EHS officer to supervise and instruct contractors and their EHS officers for EMP and CEMPs implementation related to environment, occupational health and safety on construction site. - Prepare and submit quarterly EMP and CEMP monitoring reports to the PMO.
ADB	- Responsible for the following: - Review and clear the IEE and EMP and disclose on ADB website. - Approve updated IEE/EMP if appropriate and disclose on ADB website - Provide guidance to the executing and implementing agencies. - Conducting review missions. - Monitoring status of compliance with loan and project covenants, including safeguards. - Regularly updating the project information documents for public disclosure at ADB website, including the safeguards documents.

ADB = Asian Development Bank, EMP = Environmental Management Plan, O&M = operation and maintenance, PMO = project management office.

C. Potential Impacts and Mitigation Measures

20. The potential impacts of the project during pre-construction, construction and operation have been identified and appropriate mitigation measures developed (see Chapter V of the IEE). Potential impacts and the mitigation measures are presented in **Table 2.**

D. Environment Monitoring Plan

21. An EMoP to monitor the environmental impacts of the project and assess the effectiveness of mitigation measures is presented in **Table 3.** The EMoP includes both compliance inspection undertaken by the PMO Environment Officer, and ambient air, noise, and wastewater monitoring undertaken by the 3rd party environmental monitoring entity. Ambient monitoring will be conducted in compliance with relevant PRC regulations, methods and technical specifications.

22. The data and results of environmental compliance inspection and monitoring activities will be used to assess: (i) the extent and severity of actual environmental impacts against the predicted impacts and baseline data collected before the project implementation; (ii) performance or effectiveness of environmental mitigation measures or compliance with pertinent environmental rules and regulations; (iii) trends in impacts; (iv) overall effectiveness of EMP implementation; and (v) the need for additional mitigation measures and corrective actions if non-compliance is observed.

E. Institutional Strengthening and Capacity Building

23. The institutional strengthening and capacity building focuses on the safeguard requirements of relevant PRC laws and regulations and the ADB SPS 2009. The training will focus on the ADB SPS; PRC safeguard requirements; development and implementation of EHS plans during construction and operation; implementation of the EMP, the EMoP, and the GRM; and worker and community health and safety issues and measures (**Table 4).**

Table 2: Environment Impacts and Mitigation Measures

Category	Potential Impacts and Issues	Mitigation Measures and/or Safeguards	Responsibility		Source of Funds
			Implemented by	Supervised by	
A. Detailed Design Phase					
Health and Safety		Health and safety risk assessment will be conducted prior to detailed design; health and safety management plan will be development prior to the commencement of construction activities.	IA	EA	Detailed Design Budget
Incorporate Mitigation Measures and Monitoring in Detailed Design and Bidding and Contracting	Include mitigation measures and monitoring program in detailed design	Environmental mitigation and pollution control measures identified in the IEE, the EMP and the domestic EIAs will be incorporated into the detailed design. Quantitative risk assessment of gas explosion will be conducted and mitigation measures will be included in the design. Waste management plan will be developed for the retrofitted waste materials following the PRC requirement.	PMO supported by LIEC	IA	Detailed Design Budget
	Include mitigation measures and monitoring program in bidding documents	Environmental mitigation measures identified in the IEE, EMP and the domestic EIA will be incorporated in the bidding documents for the project and will be included in contract documents for civil constructions and equipment installations. All contractors shall be required to strictly comply with the EMP.	PMO supported by LIEC	IA	Detailed Design Budget
	Environmental monitoring incorporated into design.	The environmental monitoring program will be incorporated into the design to ensure that environmental impacts are closely monitored and activities of the project construction and operating are closely supervised against the PRC environmental	PMO supported by LIEC	IA	Detailed Design Budget

Category	Potential Impacts and Issues	Mitigation Measures and/or Safeguards	Responsibility		Source of Funds
			Implemented by	Supervised by	
		laws, regulations and standards, ADB SPS, and the project EMP and approved domestic EIA.			
	Seismic risks	Seismic risks shall be considered in the detailed design.	PMO supported by LIEC	IA	Detailed Design Budget
Grievance Redress Mechanism (GRM)	Impacts on project Affected Persons	In accordance with the GRM presented in Chapter VIII, a staff member within the PMO will be assigned overall responsibility for the GRM; GRM training will be provided for PMO members and GRM access points; and the GRM access point phone numbers, fax numbers, addresses and emails will be disclosed to the public.	PMO supported by LIEC	EA, ADB	PMO Operating Budget
B. Construction Phase					
Flora and Fauna	Removal of vegetation	A greening plan will be implemented: – Site vegetation plans will be developed using appropriate native species. – Any existing vegetated areas impacted by pipeline works or construction of boiler rooms, workshops will be restored post-construction using appropriate native species.	DI (plan design), Contractors (plan implementation)	IA supported by LIEC	Contractor construction budget
Wastewater	Surface and groundwater contamination from construction wastewater, and domestic water	Good wastewater management practices as set out in EHS Guidelines on Construction and Decommissioning and EHS General Guidelines: – Existing toilets at the component site will be provided for the workers.	Contractors	IA supported by LIEC	Contractor construction budget

Category	Potential Impacts and Issues	Mitigation Measures and/or Safeguards	Responsibility		Source of Funds
			Implemented by	Supervised by	
		– Construction wastewater generated during construction phase will be discharged to the municipal sewer system. All discharged construction wastewater will meet the appropriate PRC standard GB/T 31962-2015 prior to discharge. Discharged water will then be treated in the nearby WWTP. – All necessary measures will be undertaken to prevent construction materials and waste from entering drainage system. – Maintenance of construction equipment and vehicles will not be allowed on sites to reduce wastewater generation. – All construction machinery is repaired and washed at special repairing shops. No on-site machine repair, maintenance and washing shall be allowed so as to reduce wastewater generation; – Storage facilities for fuels, oil, and other hazardous materials are within secured areas on impermeable surfaces with 110% volume of the materials stored, and provided with bunds and cleanup kits; – The contractors' fuel suppliers are properly licensed, follow proper protocol for transferring fuel, and are in compliance with Transportation, Loading and Unloading of Dangerous or Harmful Goods (JT 3145-88). – Drilling equipment will be cleaned up before drilling to prevent ground water pollution. – Only water will used during drilling. No chemicals or			

Category	Potential Impacts and Issues	Mitigation Measures and/or Safeguards	Responsibility		Source of Funds
			Implemented by	Supervised by	
		bentonite mud will be used during drilling. – Drilling water will be reused as much as possible during drilling. Waste water generated during drilling activities will be collected and toxicity assessment will be conducted. Cuttings will be reused if they are non-toxic (e.g. as construction fill) or disposed of in a landfill facility and wastewater will be discharged to municipal sewer system. If toxicity is found, cutting and wastewater will be transported for treatment by a certified company			
Erosion and Spoil	Soil erosion, spoil disposal	Good practice construction erosion controls and site maintenance as set out in EHS Guidelines on C&D and EHS General Guidelines: – At construction site, the potential for storm water runoff will be assessed and appropriate storm water drainage systems to minimize soil erosion will be implemented, including perimeter bunds and establishment of temporary detention and settling ponds to control topsoil runoff. – Land excavation and filling will be balanced so as minimize the requirement for fill material transportation. – During earthworks, the area of soil exposed to potential erosion at any time will be minimized through good project and construction management practices. – Temporary spoil storage sites (and storage containers at lane modification and stations construction sites) will be identified, designed, and operated to minimize impacts. Spoil sites will be restored at the conclusion of storage	Contractors	IA supported by LIEC	Contractor construction budget

Category	Potential Impacts and Issues	Mitigation Measures and/or Safeguards	Responsibility		Source of Funds
			Implemented by	Supervised by	
		activities. – Spoil will be reused on-site to the maximum extent feasible as fill. Excess spoil that cannot be used on-site will be transported to an approved spoil disposal site. – Spoil and aggregate piles will be covered with landscape material and/or regularly watered. – Waste construction material such as residual concrete, asphalt, etc., will be properly handled for reuse or disposal. – Construction and material handling activities will be limited or halted during periods of rains and high winds. – Pipelines will be installed and backfilled in a sequenced section-by-section approach. Open excavation areas during trenching activities will be minimized, and appropriate construction compaction techniques utilized. – Storage tank for slurry will be lined to prevent the ingress of any contaminated slurry water into the soil. – Any planned paving or vegetating of areas will be done as soon as practical after the materials are removed to protect and stabilize the soil. – Once construction is complete, disturbed surfaces will be properly sloped and revegetated with native trees and grass.			
Air Pollution	Dust, vehicle emissions	The following air quality management measure and construction good practice as set out in EHS Guidelines	Contractors	IA supported by LIEC	Contractor construction budget

Category	Potential Impacts and Issues	Mitigation Measures and/or Safeguards	Responsibility		Source of Funds
			Implemented by	Supervised by	
		on C&D and EHS General Guidelines will be implemented: – Water will be sprayed on active construction sites including where fugitive dust is being generated on a daily basis, and more frequently during windy days. – Transport vehicles will be limited to low speeds at construction sites. – Loads will be covered during truck transportation to avoid spillage or fugitive dust generation. Fine materials will be transported in fully contained trucks. – Construction site roads will be well maintained and watered and swept on an as-needed basis. Construction site road entry points will be equipped with truck drive through wash ponds. – Transport routes and delivery schedules will be planned to avoid densely populated and sensitive areas, and high traffic times. – Store petroleum or other harmful materials in appropriate places and cover to minimize fugitive dust and emission. – Provide regular maintenance to vehicles in order to limit gaseous emissions (to be done off-site). – Temporary fencing will be erected around pipeline installation activities. – Construction spoil and other construction materials will be temporary stored using containers, but they may the			

Category	Potential Impacts and Issues	Mitigation Measures and/or Safeguards	Responsibility		Source of Funds
			Implemented by	Supervised by	
		potential to generate dust. Thus, containers will be covered and/or watered if necessary. – Muddy or dusty materials on public roads outside the exits of works areas will be cleaned immediately. – On-site asphalting and concrete batching is prohibited. – Disturbed site will be revegetated as soon as possible after the completion of pipeline installation. – Drilling sites will be fenced during drilling.			
Noise	Impacts from construction noise on sensitive resources	To ensure construction activities meet PRC noise standards (Noise Standards for Construction Site Boundary, GB 12523-2011) and to protect workers, the following mitigation measures and construction good practice as set out in EHS Guidelines on C&D and EHS General Guidelines will be implemented: – Construction activities will be planned in consultation with local authorities and communities so that activities with the greatest potential to generate noise and vibration are planned during periods of the day that will result in the least disturbance. – Construction activities, and particularly noisy ones, are to be limited to reasonable hours during the day and early evening. Construction activities will be strictly prohibited during the nighttime (22:00 h to 07:00 h). Exceptions will only be allowed in special cases, and only after getting approval of the surrounding residents, local EPB and other relevant departments. And nearby residents should	Contractors	IA supported by LIEC	Contractor construction budget

Category	Potential Impacts and Issues	Mitigation Measures and/or Safeguards	Responsibility		Source of Funds
			Implemented by	Supervised by	
		be notified of such night time activities well in advance. – When undertaking construction planning, simultaneous high-noise activities will be avoided, and high noise activities will be scheduled during the day rather than evening hours. Similarly, construction site will be planned to avoid multiple high noise activities or equipment from operating at the same location. – Low-noise equipment will be selected as much as possible. Equipment and machinery will be equipped with mufflers and will be properly maintained to minimize noise. – Noise PPE will be provided to workers to meet the requirements in occupational exposure limits for hazardous agents in work place Part 2: physical agents (GBZ 2.2-2007) and EHS Guidelines. – Transportation routes and delivery schedules will be planned during detailed design to avoid densely populated and sensitive areas and high traffic times. – Vehicles transporting construction materials or waste will slow down and not use their horn when passing through or nearby sensitive locations, such as residential communities, schools and hospitals. – Special attention will be paid to protect sensitive sites near the component site: high noise construction activities will be positioned as far away from sensitive sites as possible. – To minimize noise from cleaning of heating pipelines will			

Category	Potential Impacts and Issues	Mitigation Measures and/or Safeguards	Responsibility		Source of Funds
			Implemented by	Supervised by	
		be minimized by utilization of low noise valves, mufflers after the valves and sound insulation on the external walls of pipelines. – Drilling site will be enclosed by fence to reduce noise, if necessary			
Solid Waste	Inappropriate Waste Disposal	The following solid waste management measure and construction good practice as set out in EHS Guidelines on C&D and EHS General Guidelines will be implemented: – Wastes will be reused or recycled to the extent possible. – Littering by workers will be prohibited. – Excavated soil will be backfilled onsite to the extent possible. Excess spoil that cannot be used on-site will be transported to an approved spoil disposal site. – Existing domestic waste containers will be used for domestic waste collection at work sites. Domestic waste will be collected on a regular basis by the local sanitation departments and transported for recycling, reuse, or disposal at a licensed landfill, in accordance with relevant PRC regulations and requirements. – Construction waste dumpsters will be provided at all construction sites. Construction waste will be collected on a regular basis by a licensed waste collection company and transported for recycling, reuse, or disposal at a licensed landfill, in accordance with relevant PRC regulations and requirements.	Contractors, local sanitation departments (domestic waste), licensed waste collection companies (construction waste)	IA supported by LIEC	Contractor construction budget

Category	Potential Impacts and Issues	Mitigation Measures and/or Safeguards	Responsibility		Source of Funds
			Implemented by	Supervised by	
		– There should be no final waste disposal on site. Waste incineration at or near the site is strictly prohibited. – Cuttings are typically reused if they are non-toxic (e.g. as construction fill) or disposed of in a certified and engineered landfill facility. – Contractors will be held responsible for proper removal and disposal of any significant residual materials, wastes, spoil, waste from drilling and contaminated soils that remain on the site after construction.			
Hazardous and Polluting Materials	Inappropriate transportation, storage, use and spills	The following mitigation measures and construction good practice as set out in EHS Guidelines on C&D and EHS General Guidelines will be implemented: – A hazardous material handling and disposal protocol that includes spill emergency response will be prepared and implemented by contractors. – Storage facilities for fuels, oil, chemicals and other hazardous materials will be within secured areas on impermeable surfaces provided with dikes with a 110% volume, and at least 300 m from drainage structures and important water bodies. A standalone site within the storage facility will be designated for hazardous wastes. – Signs will be placed at chemicals and hazardous materials storage sites to provide information on type and name of chemicals and hazardous materials.	Contractors, waste management companies	IA supported by LIEC	Contractor construction budget

Category	Potential Impacts and Issues	Mitigation Measures and/or Safeguards	Responsibility		Source of Funds
			Implemented by	Supervised by	
		– Suppliers of chemicals and hazardous materials must hold proper licenses and follow all relevant protocols and PRC regulations and requirements. – A licensed company will be hired to collect, transport, and dispose of hazardous materials in accordance with relevant PRC regulations and requirements.			
Socioeconomic Resources	**Community Disturbance and Safety**	– Transportation routes and delivery schedules will be planned during detailed design to avoid densely populated and sensitive areas and high traffic times. – Vehicles transporting construction materials or wastes will slow down and not use their horn when passing through or nearby sensitive locations, such as residential communities, schools and hospitals. – Signs will be placed at construction sites in clear view of the public, warning people of potential dangers such as moving. All sites will be made secure, discouraging access by members of the public through appropriate fencing whenever appropriate.	DI (plan design), Contractors (plan implementation)	IA supported by LIEC	Contractor construction budget
	Worker Occupational Health and Safety	Contractors will implement adequate precautions to protect the health and safety of their workers: – Each contractor will undertake H&S risk assessment of construction works and implement relevant construction phase EHS plan in line with construction good practice as set out in EHS Guidelines on C&D and Occupational H&S guidelines.	EHS Plan Developed by LIEC	IA supported by LIEC	LIEC Budget
		– Identify and minimize the causes of potential hazards to	EHS Plan	IA supported	Contractor

Category	Potential Impacts and Issues	Mitigation Measures and/or Safeguards	Responsibility		Source of Funds
			Implemented by	Supervised by	
		workers. Implement appropriate safety measures. – Provide training to workers on occupational health and safety, emergency response, especially with respect to using potentially dangerous equipment and storage, handling and disposal of hazardous waste. Induction will be conducted before construction and no worker is allowed on site without induction. – Ensure that all equipment is maintained in a safe operating condition. – Provide appropriate PPE to workers. – Provide procedures for limiting exposure to high noise or high temperature working environments in compliance with PRC occupational exposure limits for hazardous agents in work place Part 2: physical agents (GBZ 2.2-2007). – Ensure regular safety meetings with staff. – Hydrogen sulfide monitoring and warning systems will be installed during drilling. If the H_2S level is over 5 ppm, the well will be sealed and shut down. – Electrical safety risks especially related drilling activities will be assessed and safety protocols will be developed following EHS Guidelines.	implemented by contractors	by LIEC	construction budget

Category	Potential Impacts and Issues	Mitigation Measures and/or Safeguards	Responsibility		Source of Funds
			Implemented by	Supervised by	
Physical Cultural Resources	As yet unknown PCRs may be damaged if proper precautions are not taken.	A construction phase chance find procedure will be established and activated if any chance finds of PCRs are encountered: – construction activities will be immediately suspended if any PCRs are encountered; – destroying, damaging, defacing, or concealing PCRs will be strictly prohibited in accordance with PRC regulations; – local Cultural Heritage Bureau will be promptly informed and consulted; and, – construction activities will resume only after thorough investigation and with the permission of the local Cultural Heritage Bureau. – In case of any PCR is found, ADB SPS 2009 requirements as well as PRC laws and regulations will be followed.	Contractors	IA supported by LIEC and local Cultural Heritage Bureau	In the event that a PCR is discovered, the direct cost for comp-ensation to contractor will be covered by a special fund to be devel-oped for cultural relic protection.
C. Operation Phase					
Wastewater	Discharge of Production and Domestic Wastewater	– Wastewater from pre-treatment process and concentrated water from chemical water treatment workshop and boiler blow down will be discharged to the municipal sewerage system. – No metal (chromium or zinc) permitted to use as scaling and corrosion additive.	IA	EA supported by LIEC, EPB	IA operation budget

Category	Potential Impacts and Issues	Mitigation Measures and/or Safeguards	Responsibility		Source of Funds
			Implemented by	Supervised by	
		– Because drainage from circulation system is clean, part of the drainage will be recycled for dust control in workshops and the rest will be discharged to the municipal sewerage system. – Because wastewater generated by equipment and pump contains oil, wastewater will be treated in oil separator and will be discharged to the municipal sewerage system. – Wastewater from desulfurization system will be pre-treated by aerated oxidation, then alkali will be used to adjust pH of wastewater to make the metal precipitate. After the pH adjustment, organic sulfur and flocculant agent will be added to make magnesium sulfite precipitate. Treated wastewater will be discharged to the municipal sewerage system. – Because of the high operation temperature of denitration system, no wastewater but steam will be discharged by denitration system. – Domestic wastewater will be produced from worker sanitation facilities. Domestic wastewater will be treated in digestion tank and will be discharged to the municipal sewerage system. – For deep well geothermal wells, extracted water and recharged water are in a closed system which mean no wastewater water will be generated during operation. Because there is a filter process installed in the closed system for groundwater filter, wastewater will be			

Category	Potential Impacts and Issues	Mitigation Measures and/or Safeguards	Responsibility		Source of Funds
			Implemented by	Supervised by	
		generated during operation will be from filter back wash and will be discharged to the municipal sewerage system. – An emergency water tank will be prepared for temporary storage of geothermal groundwater in case the injection well is blocked or leak happens due to flocculation or corrosion.			
Solid Waste	Collection and Disposal	– Domestic waste bins will be provided and domestic waste will be routinely collected by the local sanitation department for recycling, if possible, or final disposal at an approved waste disposal site. – No permanent on-site solid waste disposal will be permitted at project site. – No burning of wastes will be permitted at project site. – Ash and slag will be sold out for utilization and recycling. – Oily waste will be collected, transported and treated by a certificated hazardous waste treatment company.	IA, District Sanitation Departments	EA supported by LIEC, EPB	IA operation budget
Chemical and Hazardous Materials	Inappropriate Management	- A registry of all activities that involve the handling of potentially hazardous substances will be developed, including protocols for the storage, handling and spill response. This will include all fuels, oils, grease, lubricants, and other chemicals. - All chemicals, toxic, hazardous, and harmful materials will be transported in spill proof tanks with filling hoses and nozzles in working order,	IA, Licensed Contactors	EA supported by LIEC, EPB	IA operation budget

Category	Potential Impacts and Issues	Mitigation Measures and/or Safeguards	Responsibility		Source of Funds
			Implemented by	Supervised by	
		- All chemicals, toxic, hazardous, and harmful materials will be stored in secure areas with impermeable surfaces and protective dikes such that spillage or leakage will be contained from affecting soil, surface water or groundwater systems. The area should be 110% volume of storage capacity. Their usage will be strictly monitored and recorded. - Material safety data sheets (MSDSs) will be posted for all hazardous materials. - Oil absorbents will be readily accessible in marked containers. - Good housekeeping procedures will be established to avoid the risk of spills. - Spills will be dealt with immediately, and personnel will be trained and tasked with this responsibility. - Workers will be properly trained before handling hazardous wastes and have the requisite PPE. - Hazardous waste will be temporarily stored in closed containers away from direct sunlight, wind, water and rain in secure designated areas with impermeable surfaces and protective dikes such that spillage or leakage will be contained. - Hazardous wastes including waste urea, oily waste, waste chemicals and waste ion exchange resin will be collected and disposed by licensed contractors on an as needed basis.			

Category	Potential Impacts and Issues	Mitigation Measures and/or Safeguards	Responsibility		Source of Funds
			Implemented by	Supervised by	
		- Engineering and administrative control measures will be implemented to avoid or minimize the release of hazardous substances into the work environment keeping the level of exposure below internationally established or recognized limits. - Keep the number of employees exposed, or likely to become exposed, to a minimum to hazardous substances. - Communicating chemical hazards to workers through labeling and marking according to national and internationally recognized requirements and standards, including the International Chemical Safety Cards (ICSC), Materials Safety Data Sheets (MSDS), or equivalent. Any means of written communication should be in an easily understood language and be readily available to exposed workers and first-aid personnel. - Training workers in the use of the available information (such as MSDSs), safe work practices, and appropriate use of PPE.			
Noise	Impact on Sensitive Receptors	– Low-noise equipment will be used as far as possible, and noise reduction measures such as noise elimination, shock absorption, insulated enclosures and sound dampening materials on exterior walls will be implemented. – All equipment will be properly maintained in order to minimize noise.	IA	EA supported by LIEC, EPB	IA operation budget

Category	Potential Impacts and Issues	Mitigation Measures and/or Safeguards	Responsibility		Source of Funds
			Implemented by	Supervised by	
		– Appropriate noise PPE will be provided to the workers who are likely to be exposed to high noise level environments to meet the requirements in occupational exposure limits for hazardous agents in work place Part 2: physical agents (GBZ 2.2-2007), EHS General Guidelines and EHS Guidelines on Occupational H&S. – Layout for project site will be reasonable planned to reduce noise.			
Community and Occupational Health and Safety	Natural gas leakage	– All natural gas works will be in compliance with relevant PRC building code requirements, including the Code for Design of City Gas Engineering (GB 50028-2006) and Regulation on Electric Apparatus Design for Explosion and Fire Risk Environment (GB50058-92). – Independent gas regulation stations will be constructed at least 14 meters away from other buildings and 30 m from the site boundary, to minimize the risk of explosion damaging other project facilities or the public.[a] – The gas regulation stations will be specially designed to withstand and contain explosions following PRC regulations. – Gas regulation stations and the connection to the boilers will be equipped with flammable gas detection, alarm and fire suppression systems. Electrical devices within the explosion risk area will be safety equipped. – Gas pipelines will be grounded and equipped with anti-lightning devices where applicable.			

Category	Potential Impacts and Issues	Mitigation Measures and/or Safeguards	Responsibility		Source of Funds
			Implemented by	Supervised by	
		– All other at risk areas will have flammable gas detection and alarm systems able generate audible and visual alarms, and automatic fire suppression systems. – All gas related devices will be brightly colored and equipped with warning signs.			
	Risks to Workers and Community	– Operation phase EHS plan and traffic management plan will be developed and implemented and workers will be trained regularly on their implementation. – The nearby communities will be informed of the potential risks of well blowout, H_2S exposure, fire and explosion and the emergency response plan. – PPE including goggles, gloves, safety shoes will be provided to workers. Noise protection equipment will be provided to workers in high-noise area. Noise areas with more than 85 dB(A) shall be marked and hearing protections shall be provided to workers. – Noise level inside control room should be no more than 60 dBA. – Provide training to workers on occupational health and safety, and emergency response. – Pipelines will be grounded and equipped with anti-lightning devices where applicable. – Vehicles transporting materials or wastes will slow down and not use their horn when passing through or nearby sensitive locations, such as residential communities,	Plans developed by LIEC Plans implemented by IA	EA supported by LIEC and authorities	IA operation budget

Category	Potential Impacts and Issues	Mitigation Measures and/or Safeguards	Responsibility		Source of Funds
			Implemented by	Supervised by	
		schools and hospitals. – Safe traffic control measures, including road signs and flag persons to warn of dangerous conditions will be taken as needed. Regular maintenance of vehicles to minimize potential accidents caused by equipment malfunction. – Natural gas systems will be designed in strict compliance with relevant PRC fire, health and safety standards. Fire compartments will be established based on the fire risk, and fire-resistant buildings/structures will include fire-proof doors and windows. – Fire-alarm and suppression systems will be installed and tested regularly to ensure it functions properly. – Potential occupational electric and magnetic fields (EMF) exposure should be prevented/minimized through identifying potential exposure levels in the workplace, training of workers in the dentification of occupational EMF levels and hazards, implementing action plans to address potential or confirmed exposure levels that exceed reference occupational exposure levels developed by international organizations. Personal exposure monitoring equipment should be set to warn of exposure levels that are below occupational exposure reference levels (e.g., 50 percent). – Regular inspection and maintenance of pressure vessels and piping will be conducted. Adequate ventilation in work areas to reduce heat and humidity will be installed. Surfaces where workers come in close contact with hot			

Category	Potential Impacts and Issues	Mitigation Measures and/or Safeguards	Responsibility		Source of Funds
			Implemented by	Supervised by	
		equipment will be shielded. Warning sign will be placed in high temperature areas.			
	Emergency Response	A draft emergency risk and response has been established in accordance with the "National Environmental Emergency Plan" (24 January 2006), other relevant PRC laws, regulations and standards, as well as World Bank EHS Guidelines and ADB's SPS 2009, and will include measures in the World Bank EHS guidelines with respect to occupational and community health and safety. The plan must be established and in place before the component is operational. **Indicative plan requirements are as follows:** – Procedures for responding to different types of emergency situations will be identified in the response plan. – Emergency exercises will be conducted and they should include different emergency scenarios. **Training Requirements** – Appropriate operating and maintenance employees will be trained to ensure that they are knowledgeable of the requirements of emergency response plan. Training will be provided as follows: – Initial training to all employees before the gas-fired facilities are put in operation. – When new equipment, materials, or processes are introduced. – When emergency response procedures have been updated or revised. **Annual Emergency Simulation** – Simulated emergency exercises will be conducted at	Plans developed by PMO with support from LIEC Plans implemented by IA	EA supported by LIEC and local emergency authorities	LIEC budget and IA budget

Category	Potential Impacts and Issues	Mitigation Measures and/or Safeguards	Responsibility		Source of Funds
			Implemented by	Supervised by	

		least annually.
		
		Receiving Notification of a Possible Emergency
		– When a supervisor receives a report of a possible emergency situation, he/she should obtain at minimum the following information from the reporting person:
		  – Name of person reporting emergency;
		  – Nature of emergency - leak, fire, interruption of service if leak, odor present, etc.
		  – Details of emergency: location, amount, how long has the odor been noticed, what actions have been taken, etc.
		  – Leaks or other emergencies require prompt investigation.
		
		Immediate On-site Action
		– The first responder will assess the nature of the report. This assessment should include the status of the emergency, an estimation of how the incident might progress, and an evaluation of the manpower, equipment, and materials needed to adequately cope with the situation.
		– If there is a strong odor or any measurable reading of gas detected inside a structure:
		  – Clear the building of all occupants.
		  – Eliminate potential ignition sources.
		  – Localize or isolate the problem and shut off gas as needed.
		  – Determine the extent of the hazardous area and establish a restricted area.
		– The responding supervisor shall determine the extent of the emergency and inform the dispatcher of the condition at the site.
		– If emergency procedures are put into effect, the			

Category	Potential Impacts and Issues	Mitigation Measures and/or Safeguards	Responsibility		Source of Funds
			Implemented by	Supervised by	
		responding supervisor should select a location and establish an emergency command post. – The responding supervisor will assign one person to remain at the command post to maintain communications until the emergency is over. – When necessary, the command post will be coordinated with the local emergency responders. When local emergency responders are involved, they will be in charge of the incident. – The responding supervisor will make himself known to fire and/or police department officials, or other authority having jurisdiction, and will remain with them during the emergency. – All employees reporting to the scene of the emergency will report to the command post for identification and instructions. – Key personnel will be alerted, and it will be their responsibility to keep the emergency personnel under their supervision informed and available for emergency call out. – When a system failure cannot be made safely by normal procedures, emergency shutdown procedures should be implemented. – Reduce system pressure or segment a section before repair procedures are implemented. – Well trained and qualified personnel will be dispatched to monitor system pressure and repair work. **Communication with Public Officials** – When an emergency resulting in a hazard to the public safety occurs, the local fire department, police, the city medical emergency center and other relevant public officials should be notified. An emergency call list will be prepared and make it available at the plant control			

Category	Potential Impacts and Issues	Mitigation Measures and/or Safeguards	Responsibility		Source of Funds
			Implemented by	Supervised by	
		room.			
Offsets		LIEC will support the IA in the replacement of the coal stoves of 80,000 households, and include the information in the environmental monitoring reports	IA with the support of LIEC	EA	IA operation budget

[a] *Gas regulation stations are defined as Class II explosion risks. Space within 4.5 meter away from a regulation station is included in the explosion risk region, as regulated in* Regulation on Electric Apparatus Design for Explosion and Fire Risk Environment *(GB50058-92). In the* Code for Design of City Gas *Engineering (GB 50028-2006) the recommended distance from a gas regulation station with no more than 1.6 MPa inlet pressure to other buildings is 9 m.*

DI = design institute, EMP = environment monitoring plan, EMS = environment monitoring station, EPB = environment protection bureau, GRM = grievance redress mechanism, IA = implementing agency, LIEC = loan implementation environmental consultant.

Source: Domestic Project EIA Report (2015) and TA consultants.

Table 3: Environmental Monitoring Plan (EMoP)

Subject	Parameter/Methodology	Monitoring Location	Frequency	Implemented by	Supervised by
A. Construction Phase					
Air Pollution	Ambient dust monitoring (TSP, PM_{10}, $PM_{2.5}$) following PRC requirements	Boundaries of the construction site	Quarterly during construction	EMS	EA, EPB
	H_2S monitoring	Geothermal well drilling site		IA	EA, EPB
	Compliance inspection of implementation of air pollution control measures	Construction site	Daily during construction season	IA	EA, EPB
Wastewater	Wastewater sampling - COD, TSS, pH etc. following PRC requirements	After drilling, both shallow-groundwater and deep-well groundwater will be sampled and analyzed. Wastewater discharge point of the construction site	Monthly during construction	IA	EA, EPB
Noise	Ambient noise monitoring (day and night Leq dB(A)) using portable monitoring device following PRC requirement	Boundaries of the construction site and the sensitive receptors in 100 meters	Weekly during construction season	EMS	EA, EPB
Solid Waste	Compliance inspection of implementation of solid waste management measures	Waste collection and disposal sites	Monthly during construction	IA	EA, EPB
Hazardous and Polluting Materials	Compliance inspections of implementation of hazardous materials management measures	Storage facilities for fuels, oil, coal, chemicals and other hazardous materials. Vehicle and equipment maintenance areas.	Monthly during construction	IA	EA, EPB

Subject	Parameter/Methodology	Monitoring Location	Frequency	Implemented by	Supervised by
	Soil contamination at the HSP	HSP component site	Once before construction		
Shallow groundwater	pH, temperature, Hg and other metals, hardness, etc. following the PRC groundwater quality standards	Well sites	Once before construction	IA	EA, EPB
Flora and Fauna	Compliance inspection of land clearing to ensure mitigation measures are being implemented	Construction site	Monthly during construction	IA	EA, EPB
Community Impacts	Compliance inspection of implementation of traffic control measures	Construction site roads. Transportation routes.	Monthly during construction season	IA	EA, EPB
	Compliance inspection of implementation of Occupational and Community Health and Safety measures including records on near miss, minor, major, fatal accidents and an Emergency Response Plan	Construction site	Monthly during construction season	IA	EA, EPB
B. Operation Phase					

Subject	Parameter/Methodology	Monitoring Location	Frequency	Implemented by	Supervised by
Air pollutants generated from operation	Stack Emission calibration monitoring ($PM_{2.5}$, PM_{10}, SO_2, NOx)	Exhaust stack	Quarterly	EMS	EA, EPB
	Continuous emission monitoring ($PM_{2.5}$, PM_{10}, SO_2, NOx)	Exhaust stack	Continuous	IA	EA, EPB
	Ambient air quality at the receptors and at the area maximum predicted deposition ($PM_{2.5}$, PM_{10}, SO_2, NOx)	Nearby receptors	Quarterly	EMS	EA, EPB
	H_2S monitoring	Geothermal wells	Quarterly	IA	EA, EPB
	GHG monitoring (CO_2)	Exhaust stack	Annually	IA	EA, EPB
Wastewater	Wastewater sampling - COD, TSS, pH etc. following PRC requirements	Discharge outlet to municipal sewer of the component site	Quarterly during none heating season and once during heating season	IA	EA, EPB
		Shallow-groundwater and deep-well groundwater and existing wells within 500m will be sampled and analyzed.	Quarterly	EMS	EA, EPB
Solid Waste	Compliance inspection to of operation phase solid waste management measures implementation	Component site	Semi-annually	IA	EA, EPB
Noise	Noise monitoring (day and night Leq dB(A))	Boundaries of the component site and	Quarterly	EMS	EA, EPB

Subject	Parameter/Methodology	Monitoring Location	Frequency	Implemented by	Supervised by
		sensitive receptors in 100 meters			
Earthquake	Seismic monitoring	Geothermal injection well area	Semi-annually	IA	EA, EPA
Hazardous and Polluting Materials	Compliance inspection of operation phase Hazardous Materials Management Plans (HMMPs) implementation	Component site	Semi-annually	IA	EA, EPB
Health and Safety and Emergency Response	Compliance inspection of operation phase occupational and community health and safety management measures including keeping records on near miss, minor, major, fatal accidents and an Emergency Response Plan implementation	Component site	Semi-annually	IA	EA, EPB
Environmental acceptance	Compliance testing for environment acceptance	Component site	Once	IA	EA, EPB

Table 4: Institutional strengthening and training program.

Training Topic	Trainers	Attendees	Contents	Times	Days	# Persons	Budget (USD)
Construction Phase Environment, Health and	LIEC	Contractors, PMO, IA, EA	**ADB and PRC laws, regulations and policies** – ADB's Safeguard Policy Statement – Project applicable PRC environmental, health and safety laws, policies, standards and regulations	3 (once prior to start of construction, and then once during	2	30	**Training Development** Fixed costs:

Safety Training			– International environmental, health and safety management practice in civil irrigation and drainage construction **GRM** – GRM structure, responsibilities, and timeframe – Types of grievances and eligibility assessment **Implementation of Construction Phase EMP** – Impacts and mitigation measures – Monitoring and reporting requirements – Non-compliance and corrective actions	second and third years)			$2000 per course delivery x 3 = $ 6,000
Operation Phase Environment, Health and Safety Plan Training	LIEC	PMO, IA, EA	**ADB and PRC laws, regulations and policies** – ADB's Safeguard Policy Statement – Project applicable PRC environmental, health and safety laws, policies, standards and regulations – International environmental, health and safety management practice in civil irrigation and drainage operation **GRM** – GRM structure, responsibilities, and timeframe – Types of grievances and eligibility assessment **Implementation of Operation Phase EMP** – Impacts and mitigation measures – Monitoring and reporting requirements – Non-compliance and corrective actions	3 (once prior to start of operation, and then once during second and third years)	2	30	**Training Development** Fixed costs: $2000 per course delivery x 3 = $6,000
			Total	**6**		**60**	**$12,000**

F. Reporting Requirements

24. **Environmental reporting.** The CSCs will submit monthly reports to the PMO on implementation and compliance with the EMP and CEMPs, including information on all spills, accidents including near miss, minor, major, fatal accidents, grievance received, and appropriate actions taken.

25. Based on the CSCs' monthly EMP progress reports and the compliance inspection and ambient monitoring results, the PMO will prepare environmental reports semi-annually during construction and annually during operation including EMP implementation and monitoring results for submission to the IA and EA. The PMO ESO with the support from the LIEC will prepare EMRs for onward submission to the IA and the PMO, and then to ADB. The reports should assess the project's compliance with the EMP and PRC environmental standards, identify any environment-related implementation issues and necessary corrective actions, and reflect these in a corrective action plan. The performance of the contractors in respect of environmental compliance will also be reported, as will the operation and performance of the project GRM, environmental institutional strengthening and training, and compliance with all safeguards covenants.

26. **Review by ADB.** ADB will review the EMRs and ADB missions will inspect the project progress and implementation on site twice a year. For environmental issues, inspections will focus mainly on (i) monitoring data; (ii) the implementation status of project performance indicators specified in the loan covenants on the environment, environmental compliance, implementation of the EMP, and environmental institutional strengthening and training; (iii) the environmental performance of contractors, CSCs and the PMO; and (iv) operation and performance of the project GRM.

27. **Environmental acceptance reporting.** Within 3 months after completion, or no later than 1 year with permission of the Jinan EPB, an environmental acceptance report shall be prepared by a licensed institute in accordance with the PRC Regulation on Project Completion Environmental Audit (MEP, 2001), approved by the relevant environmental authority, and reported to ADB. The environmental acceptance report will indicate the timing, extent, effectiveness of completed mitigation and of maintenance, and the need for additional mitigation measures and monitoring (if any) during operation at least until the project completion report is prepared.

28. The environmental reporting requirements are summarized in the **Table 5**.

Table 5: Reporting Requirements

Report	Prepared by	Submitted to	Frequency
A. Construction Phase			
EMP implementation reports	CSC	PMO	Monthly
Compliance monitoring reports	EMS	PMO, IA	Quarterly
Environmental monitoring reports	PMO with the support of LIEC	ADB	Semi-annually
B. Operation Phase			

Report	Prepared by	Submitted to	Frequency
Environmental monitoring report	PMO with the support of LIEC	ADB	Annually

G. Performance Indicators

29. Performance indicators (**Table 6**) have been developed to assess the implementation of the EMP. These indicators will be used to evaluate the effectiveness of environmental management during the component implementation.

Table 6: Performance Indicators

No.	Description	Indicators
1	Staffing	(i) PMO established with appropriately qualified staff including Environmental Officer. (ii) Appropriately qualified environmental expert recruited if needed. (iii) 3rd party environmental monitoring entity engaged.
2	Budgeting	(i) Environment mitigation cost during construction and operation is sufficiently and timely allocated. (ii) Environment monitoring cost is sufficiently and timely allocated. (iii) Budget for capacity building is sufficiently and timely allocated.
3	Monitoring	(i) Compliance monitoring is conducted by IA as per EMoP. (ii) Construction phase and operation phase ambient and effluent monitoring is conducted by EMS.
4	Supervision	(i) IA to review the implementation of EMP. (ii) ADB review missions.
5	Reporting	(i) Semi-annual environmental monitoring reports during construction phase and annual reports operation phase including GHG emission prepared by the IA are submitted to EA and ADB.
6	Capacity Building	(i) Training on ADB safeguard policy, EMP implementation, and GRM is provided during component implementation.
7	Grievance Redress Mechanism	(i) GRM contact persons are designated at all IA and the PMO, and GRM contact information disclosed to the public before construction. (ii) All complains are recorded and processed within the set time framework in the GRM of this IEE.
8	Compliance with PRC standards and EHS Guidelines whichever are more stringent	(i) Project complies with the PRC's environmental laws and regulations and meets all required standards.

H. Estimated Budget for EMP Implementation

30. The estimated budget for EMP implementation of the project is presented in **Table 7**. Costs are presented for mitigation implementation, ambient monitoring, capacity building, implementation support if needed, and GRM implementation. The costs do not include salaries of

PMO staff.

I. Mechanisms for Feedback and Adjustment

31. The effectiveness of mitigation measures and monitoring plans will be evaluated through a feedback reporting system. If, during compliance inspections and monitoring, substantial deviation from the EMP is observed, then the PMO ESO and LIEC will consult with the PMO and Jinan EPB and propose appropriate changes to the EMP monitoring and mitigation plan.

32. Any EMP adjustments will be subject to ADB review and approval and ADB may pursue additional environmental assessment and, if necessary, further public consultation. The revised EMP with ADB confirmation is subject to reposting on the ADB's website as the ADB public communications policy requires. The revised EMP will be passed on to the contractor(s) for incorporation into the CEMPs for implementation

J. Environmental Acceptance

33. After a three months trial operation period the Jinan EPB will conduct an environmental acceptance inspection for the component and issue environmental acceptance approvals. If the component is in compliance with all conditions for approval of the domestic EIA, the component can be put into formal operation.

Table 7: Estimated Budget for Implementing EMP

Construction Phase						**Source of Funds**
1. Ambient Monitoring	**Unit**	**Unit Cost**	**# Times**	**Cost USD**	**Cost RMB**	
Air - TSP	Quarterly	$ 300	12	$ 3,600	¥22,873	Counterpart Financing
Noise	Quarterly	$ 200	12	$ 2,400	¥15,249	
Subtotal				***$ 6,000***	***¥38,122***	
2. Capacity Building	**Unit**	**Course Cost**	**# Times**	**Cost USD**	**Cost RMB**	
Construction Phase HSE Plan Development and Training	EHS Plan Development	$ 2,000	3	$ 6,000	¥38,122	Counterpart Financing
	EHS Course Development	$ 2,000	1	$ 2,000	¥12,707	
	EHS Course Delivery	$ 4,000	1	$ 4,000	¥25,415	
Subtotal				***$ 12,000***	***¥76,244***	
TOTAL Construction Phase				***Cost USD***	***Cost RMB***	
				$ 18,000	***¥114,367***	

Operation Phase (first 2 years)						
	Unit	**Unit Cost**	**# Times**	**Cost USD**	**Cost RMB**	Counterpart
1. Ambient Monitoring	**Unit**	**Unit Cost**	**# Times**	**Cost USD**	**Cost RMB**	
Exhaust gas	Seasonal Sampling	$ 300	14	$ 4,200	¥26,686	
Noise	Seasonal Sampling	$ 200	29	$ 5,800	¥36,851	Counterpart Financing
Wastewater	Seasonal Sampling	$ 150	5	$ 750	¥4,765	
Subtotal				***$ 6,550***	***¥41,617***	
2. Capacity Building	**Unit**	**Course Cost**	**# Times**	**Cost USD**	**Cost RMB**	
Operation Phase HSE Plan Development and Training	EHS Plan Development	$ 2,000	3	$ 6,000	¥38,122	Counterpart Financing
	EHS Course Development	$ 2,000	1	$ 2,000	¥12,707	
	EHS Course Delivery	$ 4,000	1	$ 4,000	¥25,415	
Subtotal				***$ 12,000***	***¥76,244***	
TOTAL Operation Phase				***Cost USD***	***Cost RMB***	
				$ 18,550	***¥117,861***	
GRAND TOTAL Construction + Operation				***Cost USD***	***Cost RMB***	
				$ 36,550	***¥232,228***	

LIEC	**Unit**	**Monthly Cost**	**# Months**	**Cost USD**	**Cost RMB**	ADB Loan
Loan Implementation EHS Consultant	Person Months	$ 6,000	9	***$ 54,000***	***¥343,100***	

APPENDIX II: EXISTING FACILITY DUE DILIGENCE ENVIRONMENTAL REVIEW – HENGTAI HEAT SOURCE PLANT

A. Introduction

1. This is an environmental due diligence report of the Shanghe Hengtai Heat Source Plant (HSP) (hereafter referred to as the Hengtai HSP), being conducted as part of the IEE report for Shanghe Coal-Free Clean Heating Demonstration Component, a component of the proposed Shandong Clean Heating and Cooling Project in Shandong Province of the PRC.

2. This component will build one 42 MW gas fired boiler in Hengtai HSP to replace the existing 58 MW coal fired boiler. The Hengtai HSP is therefore an existing facility for the component, and as per the ADB Safeguard Policy Statement (SPS), an environmental audit is required.

B. Environmental Due Diligence Review Approach

3. Audits are typically used to determine the existence of any areas where the facility has risks associated with Environmental, Health and Safety (EHS) performance. The intent is to identify any deficiencies, and to propose measures for improvement that may be necessary to minimize environmental and safety risks for the proposed ADB investment. The audit provides a baseline in terms of the company's current performance based on the management systems and controls that are in place.

4. This report is based on a site visit, consultations with Hengtai HSP managers and technical staff, and a review of plant environmental and technical documentation. The site visit was undertaken May 9th 2018, and included the following participants:

Environmental Audit Reviewers:
Dai Lei, PPTA National Environmental Specialist
Yun Zhou, ADB Environment Specialist

Jinan Heating Group:
Ms. Han Jiaying, Director of Financial Department
Mr. Sun Dapeng, Technical Engineer
Ms. Zhang Linlin, staff of Financial Department

Hengtai Heat Source Plant:
Mr. Wang Ying, Deputy Manager
Mr. Li Xinwei, Director of Production Department

5. The audit activities included site observations, interviews with site personnel, and review of applicable documents. Time was also devoted to reviewing the environmental monitoring activities for air emissions, water discharges, and noise. The team walked through the following facilities::

i) 2x 58 MW coal fired chain-grate boilers;

ii) 35 sets of gas modular boilers with a total capacity of x58.9 MW;

iii) Cooling towers;

iv) Central control room;

v) Water treatment workshop; and

vi) Closed coal storage rooms.

C. Project Description

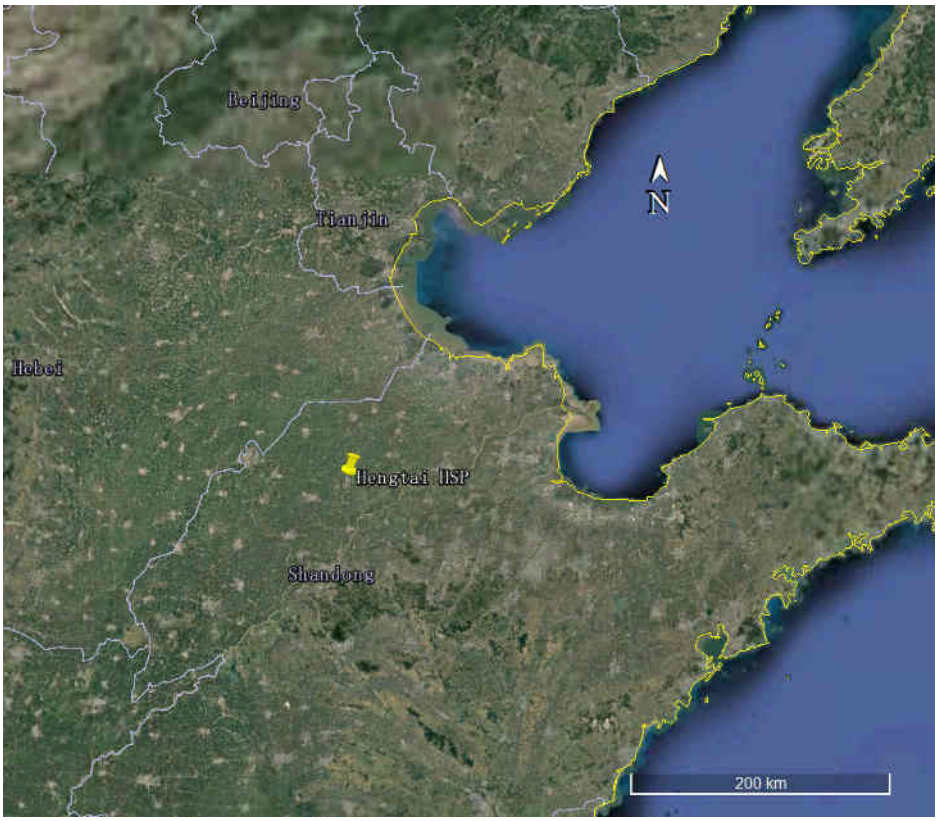
1. Type

6. The Hengtai HSP is an existing coal-fired and natural gas fired HSP for district heating in Shanghe urban area. Hengtai HSP was founded in 2011 with one 58 MW coal fired chain-grate boiler and another 58 MW coal fired chain-grate boiler was put into operation in 2013. Hengtai HSP was merged by JHG in 2017. Hengtai HSP installed 35 sets of gas modular boilers with a total capacity of 58.9 MW to replace one 58 MW coal fired chain-grate boiler in 2017. District heating is Hengtai HSP's most important and core business. In 2017-2018 heating season, heating area of Hengtai HSP was 2 million m^2.

2. Location

7. The Hengtai HSP is located on a 41,333 m^2 site near the S316 Road, Shanghe County, Jinan (**Figure 1**). South of the site area is S316 Road. The Hengtai HSP is surrounded by industrial lands and farm lands (**Figure 2**).

Figure 1: Hengtai HSP's location, Shanghe County, Jinan



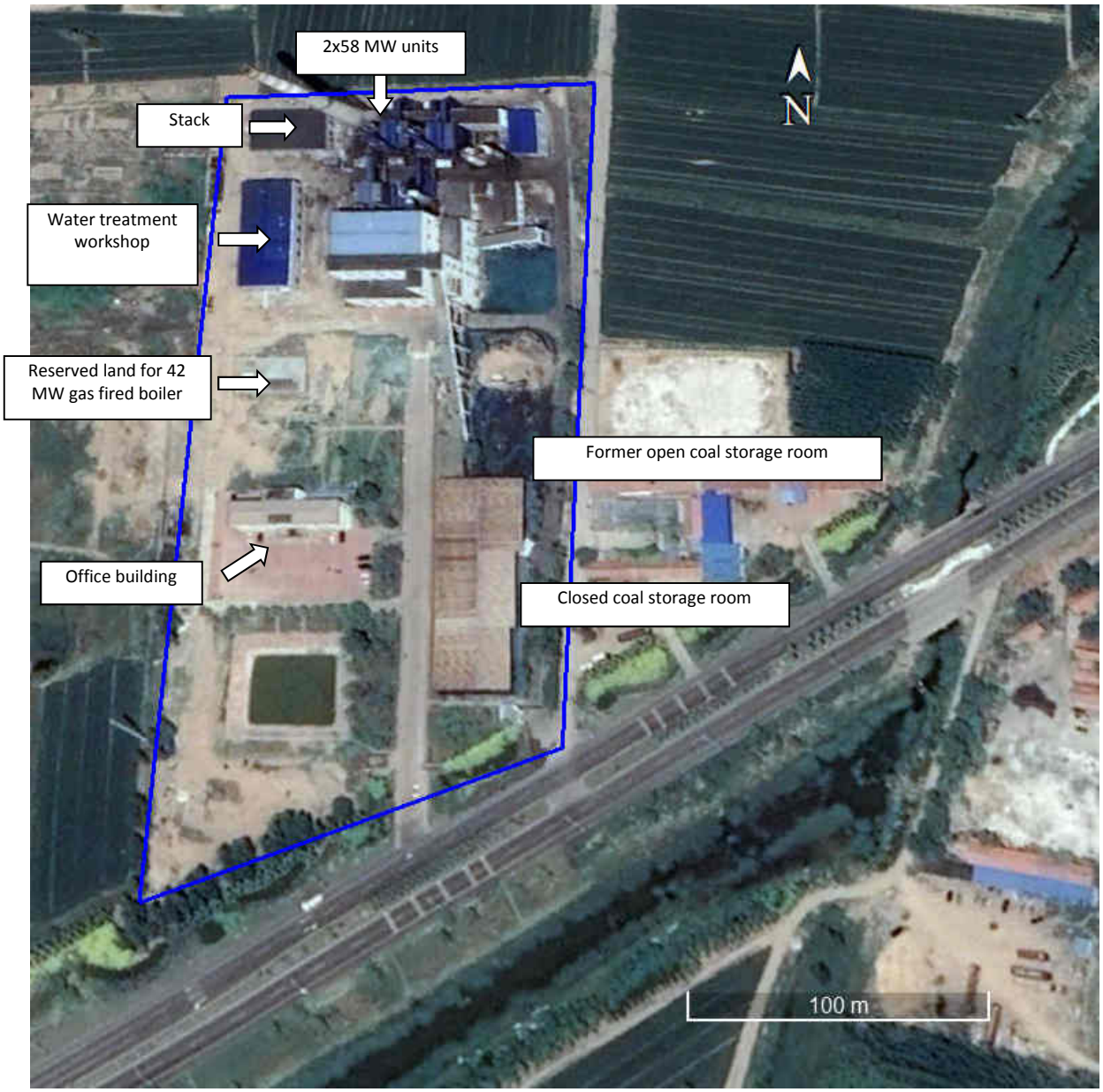
Source: Google Earth, 2018.

Figure 2: Hengtai HSP and surrounding area

Source: Google Earth, 2018.

8. **Figure 3** shows an aerial view of the plant including the boilers, stacks and coal storage place.

Figure 3: Hengtai HSP layout



Source: Google Earth 2018

3. Purpose and Capacity

9. The plant was originally built in 2010 for district heating. The current configuration of the plant is:

(i) 2x 58 MW coal fired chain-grate boilers (one was closed in 2017);

(ii) 35 sets of gas modular boilers with a total capacity of 58.9 MW;

(iii) Dry simultaneous desulfurization and denitration system;

(iv) Central control room;

(v) Dust remove equipment and bag filters;

(vi) Water treatment workshop; and

(vii) Closed coal storage rooms.

10. All gas modular boilers are equipped with low-NOx burners. Flue gases of gas modular boilers are exhausted through three 15m high stack and inner diameter at the outlet of the stack is 1.2 m.

11. Coal fired boilers are equipped with dry simultaneous desulfurization and denitration system, dust remove equipment and bag filters. Flue gases of coal fired boilers are exhausted through one 100 m high stack and inner diameter at the outlet of the stack is 4.1m.

4. Fuel

12. Low sulphur (0.5-0.9%) coal is primarily sourced from Shanxi Province and transported by train and truck. Annual coal consumption of the Hengtai HSP in 2017 is approximately 42,800 tons. The coal was stored in closed coal storage room (**Figure 4**) with a capacity of 15,000 tons. Natural gas is provided by Jinan Ganghua Gas Company. In 2017, natural gas consumption was 17.38 million m^3.

Figure 4: Closed Coal Storage Room

5. Water Supply and Wastewater

13. The Hengtai HSP sources domestic water and production water from municipal water.

14. Daily domestic water consumption of Hengtai HSP is around 20 m^3 per day and production water consumption is around 280 m^3 per day. Water for boilers is treated by ion exchange resin

and then used as boiler make-up water and circulation water.

15. Wastewater from water treatment workshop, which will meet both the PRC standards and EHS Guidelines is recycled as spray water to control dust. Other production wastewater is discharged to municipal sewer.

16. Domestic wastewater system, production wastewater system and storm water system are separated from each other. Domestic wastewater is collected, then treated by septic tank and discharged to municipal sewer. Storm water is collected by storm water system and discharged. Production wastewater is collected and discharged to municipal sewer.

17. To protect groundwater and meet the anti-seepage standard, different anti-seepage are undertaken according to different places and relevant anti-seepage requirements. Based on ground water quality monitoring results of Xinyuan Water Supply Plant (in section D of Chapter IV) which is about 2.5 km away from Hengtai HSP, all the parameters in 2017 met the Groundwater Quality Standards (GB/T 14848-2017).

6. Solid Wastes

18. In 2017, the Hengtai HSP produced approximately 413tons of fly ash, 1,652 tons of coal slag and 325 of desulfurization gypsum. All the desulfurization gypsum, fly ash and coal slag were sold to Shanghe Dayi Construction Material Company for recycling. The agreement is presented in **Figure 5** .Domestic waste is collected, transported and treated by local sanitation department.

Figure 5: Coal Slag Disposal Agreement

煤渣清运协议

甲方：

乙方：

受甲方委托，乙方负责收运，处置甲方生产中产生的煤渣，为明确双方权利义务关系，经甲、乙双方协商一致，签订本协议。

第一条 协议履行期限 2017 年 11 月 15 日至 2018 年 3 月 20 日止。

第二条 收费标准

双方商定，煤渣收运处置费为每个采暖季乙方付给甲方 25 万元。

第三条 付款方式

本协议经双方签字生效后，乙方向甲方支付 10 万元人民币，2018 年 1 月 15 日前乙方支付甲方 10 万元人民币，2018 年 2 月 15 日前乙方支付甲方 5 万元人民币。

第四条 甲方的权利和义务

1、协议期间，甲方要为乙方的清运工作提供便利。

2、甲方有权在乙方违反相关规定时解除协议。

3、甲方有权根据工作需要对乙方的清运时间进行调整。

4、甲方有权对乙方进入厂区的车辆及人员进行管理。

第五条 乙方的权利和义务

1、乙方负责收集/处置煤渣的行为必须符合国家关于环保政策的要求。

2、负责上门收集(运输)煤渣，每 2 天清运一次。必须做到完成当日清运。

3、上车，卸货乙方自行负责。车辆进出厂前擦盖好，乙方自行配备所有运输清理机工具，如铲车等。

4、乙方应做好，保质，保量的好煤渣收集运输工作，运输中不遗漏，避免二次污染，卸货方作业时造成污染的，责任由乙方承担，并清理干净。

5、乙方车辆必须进行全覆盖，保证无跑冒滴漏，厂内车速不超过

Source: Environment Specialist.

19. Hazardous wastes are temporarily stored on site with proper measures, and sent to a certificated company for treatment and final disposal by certificated trucks. The certificated company is Shandong Tengyao Hazardous Waste Treatment Company. No non-compliance punishment records were published at Jinan EPB's website.

7. Noise

20. Noise sources during operation are mainly from boiler rooms, coal transportation system, fans and desulfurization equipment, and also include pumps, and cooling equipment. To reduce noise level, the Hengtai HSP used low-noise equipment as far as possible and also utilized noise elimination, shock absorption, insulated enclosures and sound dampening materials to mitigate noise impacts. These measures can typically reduce noise intensity. Also, appropriate personal noise protective equipment (PPE) is provided to the workers who are likely to be exposed to high noise level environment. The staff reports that noise levels at Hengtai HSP boundaries can meet PRC *Environmental Quality Standards for Noise* (GB3096-2008) based on their monitoring. No complaints were received by the EPB regarding noise emission. No non-compliance punishment records were published at Jinan EPB's website.

8. Chemicals

21. During the audit, the team reviewed the systems used by Hengtai HSP for chemicals management which emphasizes the need for obtaining and retaining a Material Safety Data Sheet (MSDS) for each chemical stored and/or used on site, and providing employee access to this information. Hengtai HSP has now installed a computerized system for keeping the MSDS records. For hazardous materials and hazardous wastes, Hengtai HSP keeps copies of permits and

licenses for all handlers that deliver or remove such materials.

D. Compliance for Standards, Approvals, and Permits Requirements

1. EIA and environmental acceptance

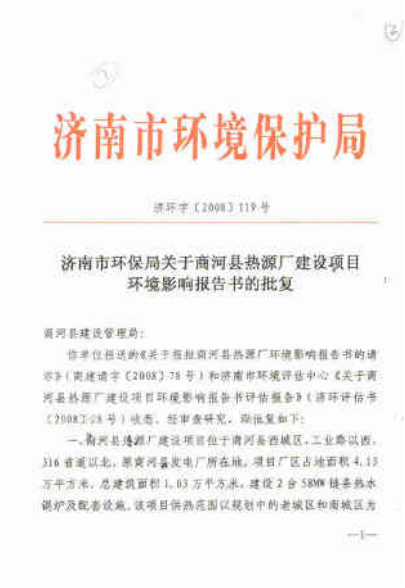
22. Based on the due diligence, The Hengtai HSP is in compliance with all relevant PRC EIA requirements. All the EIA approvals below were provided to the team for check and review.

(i) Approval of EIA Report for Hengtai HSP project (2 x 58 MW coal fired boilers) by Jinan EPB, November 10, 2008;

(ii) Approval of tabular EIA Report for Hengtai HSP desulfurization and denitration system project by Shanghe EPB, October 13, 2017;

(iii) Approval of tabular EIA Report for Hengtai HSP coal fired boiler replacement project by Shanghe EPB, March 21, 2018.

Figure 6: All EIA approvals



济南市环境保护局

济环字〔2008〕119号

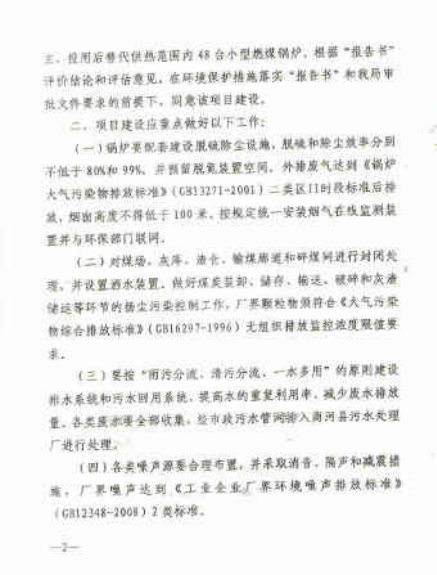
济南市环保局关于商河县热源厂建设项目环境影响报告书的批复

商河县建设管理局：

你单位报送的《关于报批商河县热源厂环境影响报告书的请示》（商建请字〔2008〕78号）和济南市环境评估中心《关于商河县热源厂建设项目环境影响报告书评估报告》（济环评估书〔2008〕28号）收悉。经审查研究，现批复如下：

一、商河县热源厂建设项目位于商河县西城区，工业路以西，316省道以北，原商河县发电厂所在地。项目厂区占地面积4.13万平方米，总建筑面积1.03万平方米，建设2台58MW链条热水锅炉及配套设施。该项目供热范围以规划中的老城区和南城区为

—1—



三、拉闸后替代供热范围内48台小型燃煤锅炉，根据"报告书"评价结论和评估意见，在环境保护措施落实"报告书"和我局审批文件要求的前提下，同意该项目建设。

二、项目建设应重点做好以下工作：

（一）锅炉要配套建设脱硫除尘设施，脱硫和除尘效率分别不低于80%和99%，并预留脱氮装置空间。外排废气达到《锅炉大气污染物排放标准》（GB13271-2001）二类区II时段标准后排放，烟囱高度不得低于100米。按规定统一安装烟气在线监测装置并与环保部门联网。

（二）对煤场、灰库、渣仓、输煤廊道和碎煤间进行封闭处理，并设置洒水装置，做好煤炭装卸、储存、输送、破碎和灰渣储运等环节的扬尘污染控制工作。厂界颗粒物须符合《大气污染物综合排放标准》（GB16297-1996）无组织排放监控浓度限值要求。

（三）坚持"雨污分流、清污分流、一水多用"的原则建设排水系统和污水回用系统，提高水的重复利用率，减少废水排放量。各类废水要全部收集，经市政污水管网输入商河县污水处理厂进行处理。

（四）各类噪声源要合理布置，并采取消音、隔声和减震措施，厂界噪声达到《工业企业厂界环境噪声排放标准》（GB12348-2008）2类标准。

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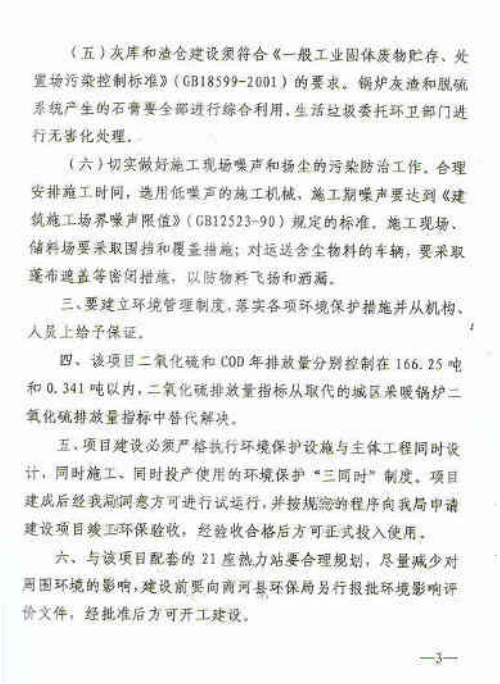

（五）灰库和油仓建设须符合《一般工业固体废物贮存、处置场污染控制标准》（GB18599-2001）的要求。锅炉灰渣和脱硫系统产生的石膏要全部进行综合利用，生活垃圾委托环卫部门进行无害化处理。

（六）切实做好施工现场噪声和扬尘的污染防治工作。合理安排施工时间，选用低噪声的施工机械，施工期噪声要达到《建筑施工场界噪声限值》（GB12523-90）规定的标准。施工现场、储料场要采取围挡和覆盖措施；对运送含尘物料的车辆，要采取蓬布遮盖等密闭措施，以防物料飞扬和洒漏。

三、要建立环境管理制度，落实各项环境保护措施并从机构、人员上给予保证。

四、该项目二氧化硫和 COD 年排放量分别控制在 166.25 吨和 0.341 吨以内，二氧化硫排放量指标从取代的城区采暖锅炉二氧化硫排放量指标中替代解决。

五、项目建设必须严格执行环境保护设施与主体工程同时设计，同时施工、同时投产使用的环境保护“三同时”制度。项目建成后经我局同意方可进行试运行，并按规定的程序向我局申请建设项目竣工环保验收，经验收合格后方可正式投入使用。

六、与该项目配套的 21 座热力站要合理规划，尽量减少对周围环境的影响，建设前要向商河县环保局另行报批环境影响评价文件，经批准后方可开工建设。

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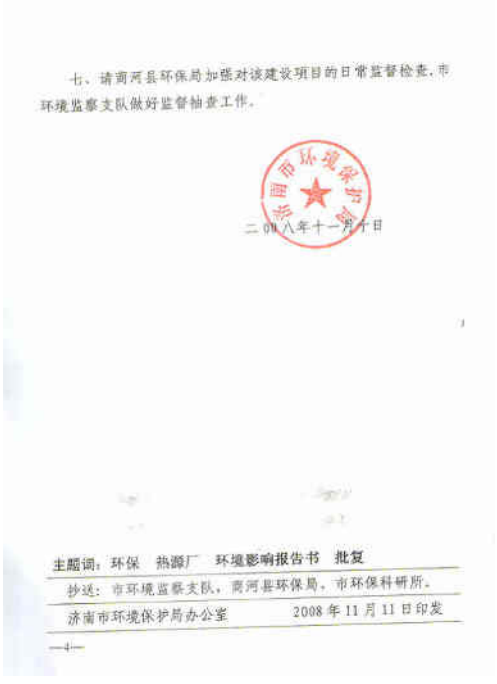

七、请商河县环保局加强对该建设项目的日常监督检查，市环境监察支队做好监督抽查工作。

二〇〇八年十一月十日

主题词：环保　热源厂　环境影响报告书　批复

抄送：市环境监察支队，商河县环保局，市环保科研所。

济南市环境保护局办公室　　2008 年 11 月 11 日印发

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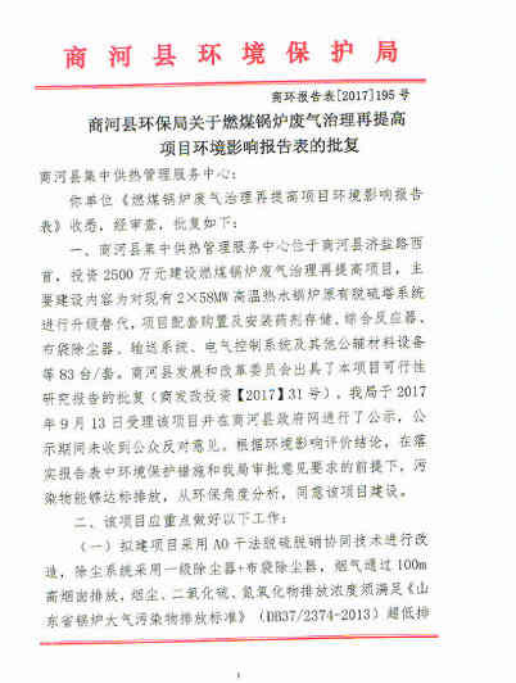


商 河 县 环 境 保 护 局

商环报告表[2017]195 号

商河县环保局关于燃煤锅炉废气治理再提高项目环境影响报告表的批复

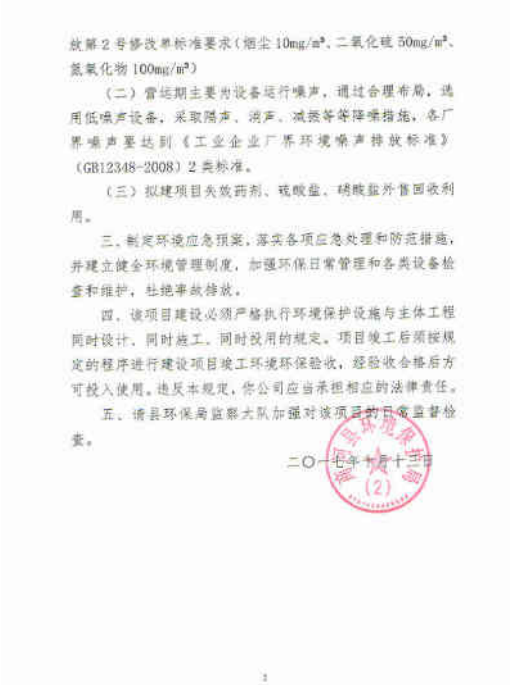
商河县集中供热管理服务中心：

你单位《燃煤锅炉废气治理再提高项目环境影响报告表》收悉，经审查，批复如下：

一、商河县集中供热管理服务中心位于商河县济盐路西首，投资 2500 万元建设燃煤锅炉废气治理再提高项目，主要建设内容为对现有 2×58MW 高温热水锅炉原有脱硫塔系统进行升级替代，项目配套购置及安装药剂存储、综合反应器、布袋除尘器、输送系统、电气控制系统及其他公辅材料设备等 83 台/套。商河县发展和改革委员会出具了本项目可行性研究报告的批复（商发改投资【2017】31 号），我局于 2017 年 9 月 13 日受理该项目并在商河县政府网进行了公示，公示期间未收到公众反对意见。根据环境影响评价结论，在落实报告表中环境保护措施和我局审批意见要求的前提下，污染物能够达标排放，从环保角度分析，同意该项目建设。

二、该项目应重点做好以下工作：

（一）拟建项目采用 AO 干法脱硫脱硝协同技术进行改造，除尘系统采用一级除尘器+布袋除尘器，烟气通过 100m 高烟囱排放，烟尘、二氧化硫、氮氧化物排放浓度须满足《山东省锅炉大气污染物排放标准》（DB37/2374-2013）超低排



放第 2 号修改单标准要求（烟尘 10mg/m³、二氧化硫 50mg/m³、氮氧化物 100mg/m³）

（二）营运期主要为设备运行噪声，通过合理布局，选用低噪声设备，采取隔声、消声、减振等降噪措施，各厂界噪声要达到《工业企业厂界环境噪声排放标准》（GB12348-2008）2 类标准。

（三）拟建项目失效药剂、硫酸盐、硝酸盐外售回收利用。

三、制定环境应急预案，落实各项应急处理和防范措施，并建立健全环境管理制度，加强环保日常管理和各类设备检查和维护，杜绝事故排放。

四、该项目建设必须严格执行环境保护设施与主体工程同时设计、同时施工、同时投用的规定。项目竣工后须按规定的程序进行建设项目竣工环境环保验收，经验收合格后方可投入使用。违反本规定，你公司应当承担相应的法律责任。

五、请县环保局监察大队加强对该项目的日常监督检查。

二〇一七年十月十三日

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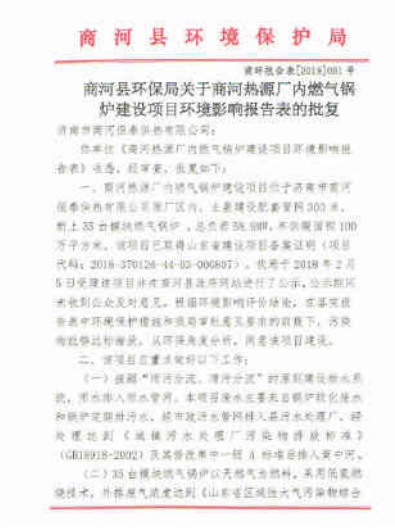

商 河 县 环 境 保 护 局

商环报告表[2018]001 号

商河县环保局关于商河热源厂内燃气锅炉建设项目环境影响报告表的批复

济南市商河恒泰供热有限公司：

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1. Relevant Environmental Standards

23. **Table 1** presents a summary of relevant emission standards for the Hengtai HSP. **Table 2** presents the relevant ambient air quality standards for the Hengtai HSP surrounding area. **Table 3** presents ambient noise standards. **Table 4** presents groundwater standards. Because the Hengtai HSP will not discharge any wastewater to surface water body. No surface water quality standard is applicable. These standards were met by the Hengtai HSP. No non-compliance punishment records were published at Jinan EPB's website.

Table 1: Summary of Environmental Pollution Standards Applicable to the Hengtai HSP

Pollutant	Limit	Standards Source
Stack Emissions		
SO_2	50 mg/m^3	Table 2 of Integrated Emission Standard of Air Pollutants for Shandong Province (dB 37/2376-2013)
NOx	100 mg/m^3	
PM	10 mg/m^3	
Other		
Fugitive PM	1.0 mg/m^3 at site boundary	Table 2 of *Integrated Emission Standard of Air Pollutants* (GB 16297-1996)
Daytime Noise (06:00-22:00 h)	60dB(A) at site boundary	Class II of *Emission Standard for Industrial Enterprises at Site Boundary* (GB 12348-2008)
Nighttime noise (22:00-06:00 h)	50dB(A) (at site boundary)	

Table 2: Applicable ambient air quality standards – Class II, Ambient Air Quality Standards (GB 3095—2012) (unit: mg/m^3)

Pollutants	Annual mean (class 2)	24-hr mean (class 2)	1-hr mean (class 2)
TSP	0.200	0.300	--
PM_{10}	0.070	0.150	--
$PM_{2.5}$	0.035	0.075	--
SO_2	0.060	0.150	0.500
NO_2	0.040	0.080	0.200

Table 3: Applicable ambient environment noise standard – Class III, Environmental Quality Standards for Noise (GB3096-2008)

Item	Class II	Class III
Daytime Noise (06:00-22:00 h)	60 dB(A)	65 dB(A)
Nighttime noise (22:00-06:00 h)	50 dB(A)	55 dB(A)

Table 4: Applicable groundwater standards (Class III, *GB/T14848-2017 Quality Standard for Ground Water*)

No	Item	Unit	Limit
1	pH	-	6.5-8.5
2	Total hardness ($CaCO_3$)	mg/L	≤450
3	Fluoride	mg/L	≤1.0
4	Chloride	mg/L	≤250
5	Ammonia nitrogen	mg/L	≤0.2
6	Nitrate	mg/L	≤20
7	Nitrite	mg/L	≤0.02
8	Volatile Phenols	mg/L	≤0.002
9	Total dissolved solids	mg/L	≤1000
10	Permanganate index	mg/L	≤3.0
11	Total coliforms	/L	≤3.0

2. Environmental Monitoring

24. The Hengtai HSP is equipped with a continuous emissions monitoring system (CEMS) that monitors in real time SO_2, NOx, PM and air flow. Data is sent electronically to the Shandong Jinan Data Center. Jinan EPB monitors the CEMS data, and staff indicates that Jinan EPB can be on site within as little as 1 hour if the CEMS indicates serious noncompliance. No non-compliance punishment records were published at Jinan EPB's website.

25. Manual stack emissions monitoring is also undertaken on a quarterly basis by Jinan EPB for calibration. A 3rd party company is also hired by the Hengtai HSP on a quarterly basis for calibration. Internal monitoring of stack emission operational parameters is also implemented which are used to manage operation. One stack monitoring report (monitored three times) implemented in February 9, 2018 is presented in **Figure 7**.

26. Monitoring results (SO_2 <15 mg/m^3, NOx: 18-24 mg/m^3, and PM: 3.22-4.67 mg/m^3) in **Figure 7** are compliance with Integrated Emission Standard of Air Pollutants for Shandong Province (dB 37/2376-2013).

27. Noise monitoring is undertaken at the site boundary on a quarterly basis and the noise level met national standard.

Figure 7: Monitoring report of gas modular boiler in February 9, 2018

山东省冶金产品质量监督检验站检验报告附页

No. 2018HJ0073 第 2 页 共 2 页

表 1 燃气锅炉排气中颗粒物、烟气监测结果

点位	序号	监测项目	监测时间频次	2018-02-07 第一次	第二次	第三次
金顺环保上料仓1排气筒	1	颗粒物	标干气量 (m^3/h)	3640	3452	3377
			温度（℃）	51	51	52
			实测浓度 (mg/m^3)	4.67	3.29	3.22
			排放速率 (kg/h)	0.012	0.011	0.011
	2	SO_2	实测浓度 (mg/m^3)	<15	<15	<15
			排放速率 (kg/h)	/	/	/
	3	NO_x	实测浓度 (mg/m^3)	24	23	18
			排放速率 (kg/h)	0.087	0.079	0.061
	4	排气筒	高度（m）	10		
			直径（mm）	350		

表 2 汞及其化合物检测结果（单位:ug/m³）

序号	检验项目	第一次	第二次	第三次
1	汞及其化合物	<0.003	<0.003	0.13

Table 5: Boiler emission monitoring results

No.			1st time	2nd time	3rd time
1	PM	Flow (m^3/h)	3640	3452	3377
		Temperature (^0C)	51	51	52
		Monitoring result	4.67	3.29	3.22
		Emission rate (kg/h)	0.012	0.011	0.011
2	SO_2	Monitoring result	<15	<15	<15
		Emission rate (kg/h)	/	/	/
3	NOx	Monitoring result	24	23	18
		Emission rate (kg/h)	0.087	0.078	0.061
4	Stack	Height (m)	10		
		Diameter (mm)	350		
	Mercury and mercury compound		<0.003	<0.003	0.13

3. Emission Controls and Compliance

28. All gas modular boilers are equipped with low-NOx burners. Coal fired boilers are equipped with dry simultaneous desulfurization and denitration system, dust remove equipment and bag filters. The plant is in full compliance with the current *Integrated Emission Standard of Air Pollutants for Shandong Province (dB 37/2376-2013)* The monitoring data in **Figure 7** shows that Hengtai HSP met the requirements.

29. Fugitive emission control measures are listed below:

(i) Coal storage site is closed and installed with spray equipment which sprays water periodically;

(ii) Fly ash and coal slag are mixed with water then transported for reuse;

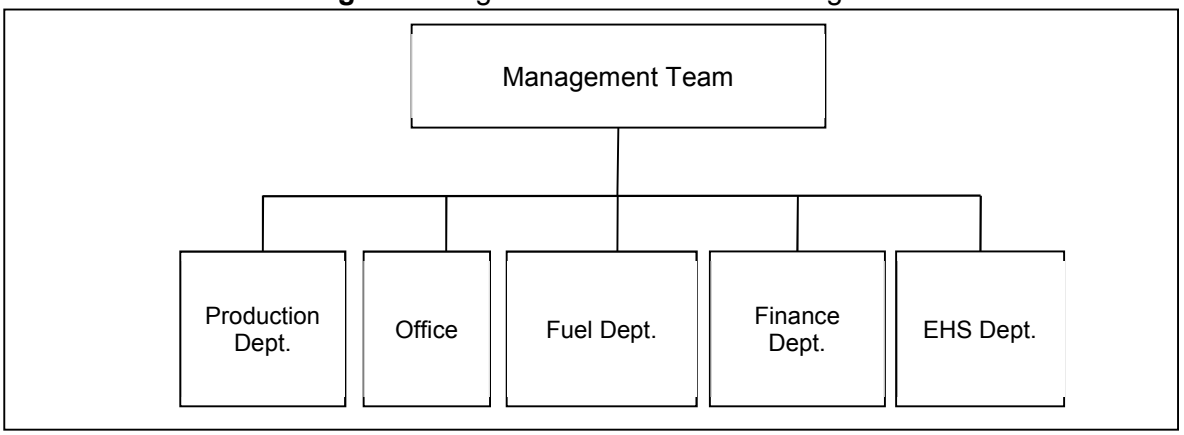
(iii) Fly ash, gypsum and coal slag are stored at storage site. This site is installed with spray equipment which sprays water periodically. In strong wind weather, water spray frequency will be increased.

E. Environmental Management

1. Staffing and Environmental Management

30. The Hengtai HSP has a total of 40 staff. Environmental, health and safety (EHS) responsibilities are assigned to the EHS Department, which has a staff of 12 and 4 staff is responsible for environment, 3 staff is for health and 5 is for safety. (**Figure 8**).

Figure 8: Organization structure of Hengtai HSP



31. This structural arrangement aims to ensure EHS issues are well incorporated in other aspects like technical, finance, and others. All EHS staff have regular meeting with the head of EHS department for close coordination and effective implementation of EHS management systems. The site has an EHS Committee that meets regularly to discuss progress and set targets and objectives going forward.

2. Staff training and PPE provision

32. Hengtai HSP organizes various types of safety education and trainings for employees. Also, external construction personnel receive EHS trainings from Hengtai HSP.

33. In 2017, Hengtai HSP provided EHS training to more than 100 persons. Hengtai HSP

provides employees with Personal Protective Equipment (PPE) that is essential for performing work activities safely. During the audit visit, at the entrance of the site, a full range of PPE was provided to the audit team. The staff and workers on-site were also wearing proper PPEs.

34. Hengtai HSP maintains a comprehensive Emergency Response capability that includes an onsite Fire Department trained for a full range of emergencies that may occur at the plant. Hengtai HSP also has a detailed Emergency Response Plan (ERP). The ERP is tested regularly with drills, simulations, and exercises. EHS records are reviewed. There was no incident or accident in the last 5 years.

F. Conclusion

35. The audit confirmed that the EHS management systems were comprehensive and there was clear evidence of continual improvement. The audit confirmed that senior management and employees have sincere commitment to EHS.

36. Based on this environmental audit and due diligence, it can be concluded:

(i) the Hengtai HSP has undergone an appropriate EIA process by Shandong EPB and has received the necessary EIA approvals and environmental acceptance approvals;

(ii) EHS polices and systems are in place and the respective EHS management programs were effective;

(iii) Comprehensive environmental monitoring programs were in place;

(iv) Combustion products are recycled into construction materials, and wastewater is either recycled on site or discharged to domestic sewer system following the PRC standards;

(v) Hazardous waste is stored according to Standard for pollution control on hazardous waste storage (GB18599- 2001, revised in 2013), then transported and treated by certified company;

(vi) No corrective action plan is needed.