LANKAO GEOTHERMAL BASED SPACE HEATING SYSTEM

杭州超腾能源技术股份有限公司
Hangzhou Chaoteng energy technology Co.,Ltd

Document Prepared by Hangzhou Chaoteng Energy Technology Co., Ltd.

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1 PROJECT DETAILS

1.1 Summary Description of the Project

Geothermal is a non-polluting, renewable and clean energy compared with traditional fossil energy such as coal, oil and natural gas. According to the Plan for Clean Heating in Winter in Northern China (2017-2021) (Development and Reform of Energy resources (2017) No. 2100) [1], the proportion of clean heating in northern China is low, especially in some areas, where bulk burning coal is used in winter and air pollutant emissions are high, so it is urgent to promote clean heating.

At present, there is no municipal central heating system in the urban area of Lankao County, so a new central heating source is needed to ensure the heating demand. The purpose of the project activity is to introduce geothermal energy-based space heating system to realize heat supply to a series of residential buildings in Lankao County over winter season, which will displace heat supply from isolated coal-fired boilers as a business-as-usual scenario in the project area.

The project owner is Lankao Green Energy Clean Energy Co., Ltd. It can supply geothermal heat to 3,736.1 thousand m^2 of newly built residential buildings with a total heating load of 112.08 MW. The scenario prior to the implementation of the proposed project activity is that heat supplied to the building areas in winter would be provided by isolated coal-fired boilers.

Emission reduction credits will be earned using geothermal energy instead of the combustion of fossil fuel for space heating. The annual average CO_2 emission reductions are estimated as 81,289 tCO_2e, and total GHG emission reductions for the fixed 10 years crediting period are 812,890 tCO_2e. The date of crediting period is 15/11/2021–14/11/2031.

Emission reductions achieved in the first monitoring period (15/11/2021–18/03/2023 (first and last days included)) is 67,621 tCO_2e.

1.2 Sectoral Scope and Project Type

The project is not a grouped project, sectoral scope and methodologies are as follows:

Sectoral Scope 1: Energy industries (renewable - / non-renewable sources)

The project type of this project falls into Type II: End-use energy efficiency project improvement.

Project Methodology: AM0072 Fossil Fuel Displacement by Geothermal Resources for Space Heating (Version 03.0)

[1] https://www.gov.cn/xinwen/2017-12/20/5248855/files/7ed7d7cda8984ae39a4e9620a4660c7f.pdf

1.3 Project Eligibility

The scope of the VCS Program includes:

1) The six Kyoto Protocol greenhouse gases: The project only considers the reduction of Carbon Dioxide (CO_2) Emissions for VCS Standard crediting. Refer to section 3.3 of the PD for more details. Thus, the project applicable to this scope.

2) Ozone-depleting substances: NA.

3) Project activities supported by a methodology approved under the VCS Program through the methodology approval process: NA.

4) Project activities supported by a methodology approved under a VCS approved GHG program unless explicitly excluded under the terms of Verra approval: The methodology AM0072 (Version 03.0) of the project utilized is a methodology approved under CDM Program, which is a VCS approved GHG program.

5) Jurisdictional REDD+ programs and nested REDD+ projects as set out in the VCS Program document Jurisdictional and Nested REDD+ (JNR) Requirements: NA.

Meanwhile, the project is not belonged to the projects excluded in Table 1 of VCS Standard 4.2. Thus, the project is eligible under the scope of VCS program.

Eligibility of the project under VCS Standard:

The proposed project falls under section 3.1 General Requirements of VCS Standard with the following eligibility criteria:

Eligibility Criteria	Justification
Section 3.1.1 of VCS Standard (Version 4.2) Projects shall meet all applicable rules and requirements set out under the VCS Program, including this document. Projects shall be guided by the principles set out in Section 2.2.1.	The project meets all applicable rules and requirements as set out under the VCS Program.
Section 3.1.2 of VCS Standard (Version 4.2) Projects shall apply methodologies eligible under the VCS Program. Methodologies shall be applied in full, including the full application of any tools or modules referred to by a methodology, noting the exception set out in Section 3.13.1. The list of methodologies and	The project applies CDM approved methodology AM0072 (version 03.0) which is an eligible VCS methodology along with tool or modules as applicable. Refer to section 3.1 and 3.2 of the PD below for more details.

their validity periods is available on the Verra website.	
Section 3.1.3 of VCS Standard (Version 4.2) Projects and the implementation of project activities shall not lead to the violation of any applicable law, regardless of whether or not the law is enforced.	Projects are following currently applicable laws. According to the environmental impact assessment report (EIA) of the project, the project complies with all Chinese relevant laws and regulations. Refer to section 1.14 of the report below for more details.
Section 3.1.4 of VCS Standard (Version 4.2) Where projects apply methodologies that permit the project proponent its own choice of model (see the VCS Program document *Program Definitions for definition of model*), such model shall meet with the requirements set out in the VCS Program document *VCS Methodology Requirements* and it shall be demonstrated at validation that the model is appropriate to the project circumstances (i.e., use of the model will lead to an appropriate quantification of GHG emission reductions or removals).	Not applicable. There is no model need to be chosen by the project proponent as per the applied methodology AM0072 (version 03.0).
Section 3.1.5 of VCS Standard (Version 4.2) Where projects apply methodologies that permit the project proponent its own choice of third party default factor or standard to ascertain GHG emission data and any supporting data for establishing baseline scenarios and demonstrating additionality, such default factor or standard shall meet with the requirements set out in the VCS Program document *VCS Methodology Requirements*.	Not applicable. There is no third-party default factor or standard need to be chosen by the project proponent as per the applied methodology AM0072 (version 03.0).
Section 3.1.6 of VCS Standard (Version 4.2) Projects shall preferentially apply methodologies that use performance methods (see the VCS Program document *VCS Methodology Requirements* for further information on performance methods) where	Baseline scenario and additionality have been analysed as per the applied methodology AM0072 (version 03.0) and tool 02 (Version 07.0). Refer to section 3.4 and 3.5 of the PD for more details.

a methodology is applicable to the project that uses a performance method for determining both additionality and the crediting baseline (i.e., a project shall not apply a methodology that uses a project method where such a performance method is applicable to the project). Methodologies approved under the VCS Program that use performance methods provide a list of similar methodologies that use project methods (that were approved under the VCS Program or an approved GHG program at the time the performance method was developed). Such lists are not necessarily exhaustive but can serve as the starting point for determining whether a performance method is applicable to the project. Following the approval of a methodology that uses a performance method, projects may use any applicable pre-existing methodology that uses a project method for a six-month grace period.	
Section 3.1.7 of VCS Standard (Version 4.2) Where the rules and requirements under an approved GHG program conflict with the rules and requirements of the VCS Program, the rules and requirements of the VCS Program shall take precedence.	Not applicable.
Section 3.1.8 of VCS Standard (Version 4.2) Where projects apply methodologies from approved GHG programs, they shall comply with any specified capacity limits (see the VCS Program document *Program Definitions* for definition of capacity limit) and any other relevant requirements set out with respect to the application of the methodology and/or tools referenced by the methodology under those programs.	Not applicable. There is no specified capacity limits and any other relevant requirements set out as per the applied methodology and tools.
Section 3.1.9 of VCS Standard (Version 4.2)	This is the first crediting period of the project, and it has fellow all the latest requirements of Verra.

Where Verra issues new requirements relating to projects, registered projects do not need to adhere to the new requirements for the remainder of their project crediting periods (i.e., such projects remain eligible to issue VCUs through to the end of their project crediting period without revalidation against the new requirements). The new requirements shall be adhered to at project crediting period renewal, as set out in Section 3.8.9.	

1.4 Project Design

The project is designed to introduce geothermal energy-based space heating system to realize heat supply to a series of new residential buildings in Lankao county over winter season. There are totally 12 sub-areas involved in the project activity, the project has been designed to include the multiple project activity instances.

Eligibility Criteria

The project is not a grouped project. So, it’s not applicable.

1.5 Project Proponent

Organization name	Lankao Green Energy Clean Energy Co., Ltd.
Contact person	Yinglan Xuan
Title	General Manager
Address	3rd Floor, Chengchun Community, Intersection of Health Road and Shengli Road, Lankao County, Henan Province, China
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1.6 Other Entities Involved in the Project

Organization name	Hangzhou Chaoteng Energy Technology Co., Ltd.
Role in the project	VCS Consultant

Contact person	Sandy Xie
Title	General Manager
Address	Floor 27, International Sunyard Building A, No.1750 Jianghong Rd, Binjiang District, Hangzhou, Zhejiang Province, China
Telephone	-
Email	sandy@ct-cdm.com

1.7 Ownership

The project owner of the project is Lankao Green Energy Clean Energy Co., Ltd. The approval of Environmental Impact Assessment (EIA), Feasibility Study Report (FSR), and the business license of the project owner are evidence for legislative right. Heating supply contracts including carbon waiver agreement were signed with each community to make sure Lankao Green Energy Clean Energy Co., Ltd. has the legal ownership of the carbon credits generated by the project activity.

1.8 Project Start Date

As per section 3.7 of VCS Standard (Version 4.2), the project start date of a non-AFOLU project is the date on which the project began generating GHG emission reductions or removals. The project has been designed to include multiple project activity instances. There are 12 sub-areas involved in the project activity and the geothermal space heating system of the project started commissioning on 15/11/2021. Thus, the project start date is 15/11/2021.

1.9 Project Crediting Period

This project adopts fixed crediting periods of 10 years. The crediting period is 10 years from 15/11/2021 to 14/11/2031 (both days included).

1.10 Project Scale and Estimated GHG Emission Reductions or Removals

The estimated annual GHG emission reductions/removals of the project are:

☐ <20,000 tCO_2e/year

☒ 20,000 – 100,000 tCO_2e/year

☐ 100,001 – 1,000,000 tCO_2e/year

☐ >1,000,000 tCO_2e/year

The project annual average CO_2 emission reductions are estimated as 81,289 tCO_2e, which is less than 300,000 tCO_2e. As per Section 3.9.1 of VCS Standard (Version 4.2), it is a project.

Project Scale	
Project	x
Large project	

Year	Estimated GHG emission reductions or removals (tCO_2e)
15/11/2021-14/11/2022	81,289
15/11/2022-14/11/2023	81,289
15/11/2023-14/11/2024	81,289
15/11/2024-14/11/2025	81,289
15/11/2025-14/11/2026	81,289
15/11/2026-14/11/2027	81,289
15/11/2027-14/11/2028	81,289
15/11/2028-14/11/2029	81,289
15/11/2029-14/11/2030	81,289
15/11/2030-14/11/2031	81,289
Total estimated ERs	812,890
Total number of crediting years	10
Average annual ERs	81,289

1.11 Description of the Project Activity

The project uses geothermal resources in cascade levels. The high-temperature water can be used to supply heat directly through plate heat exchanger, and the low-temperature water enters the geothermal heat pumps after the heat exchange. Through the secondary heat exchange of the geothermal heat pumps, the temperature of the feed water can be increased to meet the requirements of the terminal heating design parameters.

A total of 36 thermal wells with a design depth of 2,000 meters are constructed, of which the 12 production wells with an average flow rate of 120 m^3/h will supply the feed geothermal water at temperature of 72°C to 17 heat substations through primary heating network. The 24 injection wells will receive the return water at temperature of 10°C after secondary heat exchange. The 17 heat substations will supply the feed water at temperature of 45°C to the project buildings and receive the return water at temperature of 35°C from them. In terms of terminal devices of heating configuration of users, floor radiation will be used as per Feasibility Study Report of the project. Technologies and measures employed by the project activity are shown in Figure 1-1 below.

A total of 17 heat substations in 12 sub-areas are constructed to enable the heat exchange between geothermal water transported by the primary heating network and the clean circulation water transported by the secondary network. The main equipment of the heat substations includes plate heat exchangers, water source heat pumps, circulating pumps, submersible pumps, fixed-pressure water-supplying devices, cyclone desanders, tanks, and water-softening facilities. All the geothermal wells, heat substations and related facilities are newly constructed.

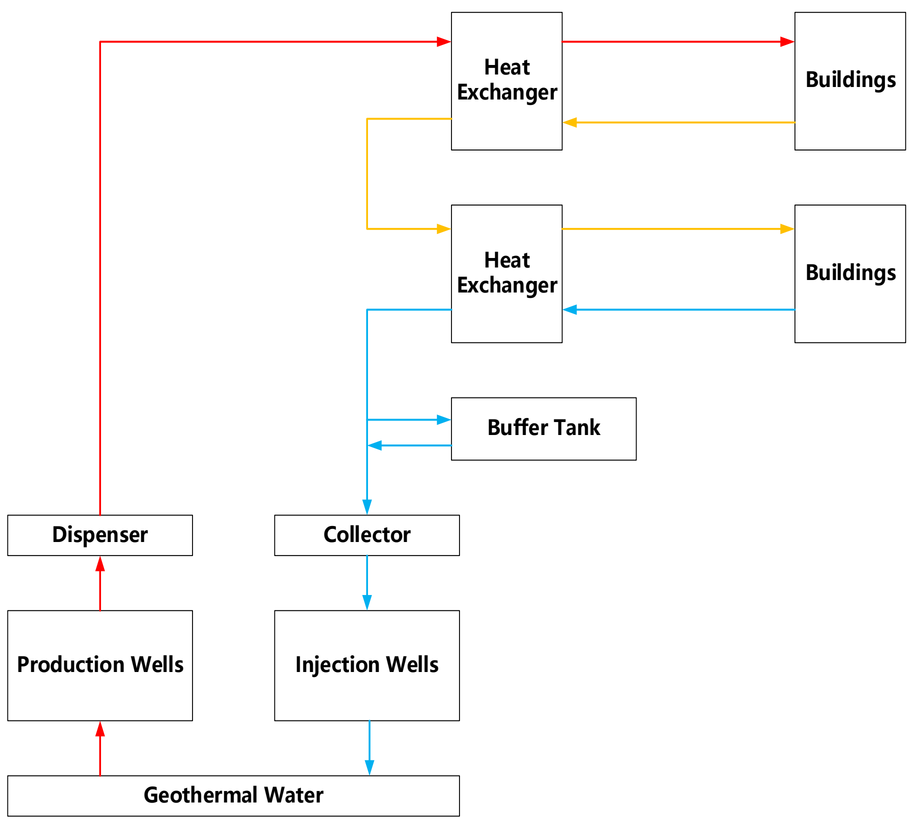


Figure 1-1 Technologies and Measures Employed by the Project Activity

Full operation of the project are scheduled on 15/11/2023. The whole project can supply geothermal heat to 3,736.1 thousand m² of residential buildings with a total heating load of 112.08 MW. The heating load of different sub-areas is calculated based on the heating area. The residential area where the project located is newly built, so it is affected not only by the residential construction period, but also by the actual occupancy rate.

The project has started to heat 1,927.91 thousand m² of residential buildings with the occupancy rate of 62.65% from 15/11/2021 - 21/03/2022, has started to heat 611.38 thousand m² more of residential buildings, totaling 2,539.30 thousand m² with the occupancy rate of 57.87% from 15/11/2022 - 18/03/2023, which leads to the actual heating area and load in the first monitoring period being smaller than the design value.

For the monitoring period from 15/11/2021 to 14/11/2022, 1,207.8[2] thousand m² of residential buildings with a heating load of 36.23 MW[3]. For the monitoring period from 15/11/2022 to 18/3/2023, 1,469.5[4] thousand m² of residential buildings with a heating load of 44.08 MW[5]. The main equipment and parameters of the 17 heat substations are shown in Table 1-1, Table 1-2 below.

Table 1-1 Main Equipment of Each Heat Substation

1#FHC				
Equipment Name	**Specifications**	**Unit**	**Quantity**	**Remarks**
Primary plate heat exchanger	Primary heat exchange temperature of supply water and return water: 70/40 °C; Secondary heat exchange temperature of supply water and return water:35/45 °C	Unit	1	
Secondary plate heat exchanger	Primary heat exchange temperature of supply water and return water: 40/15 °C; Secondary heat exchange temperature of supply water and return water: 7/15 °C	Unit	1	
Water source heat pumps	Heating Capacity: 1519kW	Unit	2	

[2] According to the occupancy rate is 1,927.91 thousand m2*62.65%=1,207.8 thousand m2.

[3] According to the design area and heat load can be obtained the actual heat load is 1,207.8 thousand m2/3,736.1 thousand m2*112.08MW=36.23MW.

[4] According to the occupancy rate is 2,539.30 thousand m2*57.87%=1,469.5 thousand m2.

[5] According to the design area and heat load can be obtained the actual heat load is 1,469.5 thousand m2/3,736.1 thousand m2*112.08MW=44.08 MW.

Circulating pumps of load side-1	Q=90 m^3/h, Head=35 m, P=18.5kW	Unit	2	One for use and one for backup
Circulating pumps of load side-2	Q=163 m^3/h, Head=36 m, P=30kW	Unit	2	One for use and one for backup
Circulating pumps of host unit	Q=133 m^3/h, Head=24 m, P=15kW	Unit	2	One for use and one for backup
Fixed-pressure water-supplying devices	Diameter of pressure tank: 1 m Q=6.3 m^3/h, Head=50 m, P=41kW	Unit	1	
Water-softening tank	Volume: 2 m^3	Unit	1	
Water-softening facilities	Treatment capacity: 4 m^3/h	Unit	1	
Water buffer tank	Volume: 1.5 m^3	Unit	1	
Cyclone desanders	Treatment capacity: 30 m^3/h	Unit	1	
2#FHC				
Equipment Name	**Specifications**	**Unit**	**Quantity**	**Remarks**
Primary plate heat exchanger	Primary heat exchange temperature of supply water and return water: 70/40 °C; Secondary heat exchange temperature of supply water and return water:35/45 °C	Unit	1	
Secondary plate heat exchanger	Primary heat exchange temperature of supply water and return water: 40/15 °C; Secondary heat exchange temperature of supply water and return water: 7/15 °C	Unit	1	

Water source heat pumps	Heating Capacity: 1047kW	Unit	1	
Circulating pumps of load side-1	Q=87 m^3/h, Head=38 m, P=18.5kW	Unit	2	One for use and one for backup
Circulating pumps of load side-2	Q=113 m^3/h, Head=38 m, P=18.5kW	Unit	2	One for use and one for backup
Circulating pumps of host unit	Q=87.5 m^3/h, Head=20 m, P=11kW	Unit	2	One for use and one for backup
Fixed-pressure water-supplying devices	Q=6.3 m^3/h, Head=50 m	Unit	1	
Water-softening tank	Volume: 2 m^3	Unit	1	
Automatic dosing device	Treatment capacity: 4 m^3/h	Unit	1	
Cyclone desanders	Treatment capacity: 30 m^3/h	Unit	1	
Submersible pumps	Q=130 m^3/h, Head=144 m, P=75kW	Unit	1	
3#FHC				
Equipment Name	**Specifications**	**Unit**	**Quantity**	**Remarks**
Primary plate heat exchanger	Primary heat exchange temperature of supply water and return water: 70/40 °C; Secondary heat exchange temperature of supply water and return water:35/45 °C	Unit	2	

Secondary plate heat exchanger	Primary heat exchange temperature of supply water and return water: 40/10 °C; Secondary heat exchange temperature of supply water and return water: 7/15 °C	Unit	1	
Water source heat pumps-1	Heating Capacity: 1047kW	Unit	1	
Water source heat pumps-2	Heating Capacity: 1735kW	Unit	1	
Circulating pumps of host unit-1	Q=95 m^3/h, Head=20 m, P=11 kW	Unit	2	One for use and one for backup
Circulating pumps of host unit-2	Q=165 m^3/h, Head=20 m, P=18.5 kW	Unit	2	One for use and one for backup
Circulating pumps-1	Q=300 m^3/h, Head=44 m, P=55kW	Unit	4	Two for use and two for backup
Circulating pumps-2	Q=200 m^3/h, Head=38 m, P=37kW	Unit	2	One for use and one for backup
Fixed-pressure water-supplying devices-1	Volume: 5.1 m^3/h, Q=16 m3/h, Head=94 m, P=7.5kW	Unit	1	
Fixed-pressure water-supplying devices-2	Volume: 2.45 m^3/h, Q=4 m^3/h, Head=64 m, P=1.5kW	Unit	1	
Water-softening facilities	Treatment capacity: 4 m^3/h	Unit	1	

Water-softening tank	Volume: 21 m^3	Unit	1	
Cyclone desanders	Treatment capacity: 100 m^3/h	Unit	1	
4#FHC				
Water source heat pumps	Heating Capacity: 820kW	Unit	1	
Primary plate heat exchanger	Primary heat exchange temperature of supply water and return water: 72/40 °C; Secondary heat exchange temperature of supply water and return water:35/45 °C	Unit	1	
Secondary plate heat exchanger	Primary heat exchange temperature of supply water and return water: 40/12 °C; Secondary heat exchange temperature of supply water and return water: 10/18 °C	Unit	1	
Circulating pumps of host unit	Q=74 m^3/h, Head=25 m, P=11 kW	Unit	2	One for use and one for backup
Circulating pumps for direct supply	Q=84 m^3/h, Head=36 m, P=18.5 kW	Unit	2	One for use and one for backup
Circulating pumps of the end side	Q=88 m^3/h, Head=36 m, P=18.5 kW	Unit	2	One for use and one for backup
Fixed-pressure water-supplying devices	Volume: 0.15 m^3/h, Q=2.5 m^3/h, Head=50 m, P=2.2kW	Unit	1	
Water-softening facilities	Treatment capacity: 4 m^3/h	Unit	1	

Water-softening tank	Volume: 1.65 m^3	Unit	1	
Cyclone desanders	Treatment capacity: 50 m^3/h	Unit	1	
1#GYSF				
Equipment Name	**Specifications**	**Unit**	**Quantity**	**Remarks**
Primary plate heat exchanger-1	Primary heat exchange temperature of supply water and return water: 70/37 °C; Secondary heat exchange temperature of supply water and return water:35/45 °C	Unit	2	
Secondary plate heat exchanger	Primary heat exchange temperature of supply water and return water: 37/15 °C; Secondary heat exchange temperature of supply water and return water: 12/20 °C	Unit	1	
Water source heat pumps	Heating Capacity: 1450kW	Unit	2	
Circulating pumps-1	Q=100 m^3/h, Head=65 m, P=30kW	Unit	2	One for use and one for backup
Circulating pumps-2	Q=290 m^3/h, Head=65 m, P=75kW	Unit	2	One for use and one for backup
Circulating pumps-3	Q=155 m^3/h, Head=65 m, P=37kW	Unit	3	Two for use and one for backup
Circulating pumps of host unit	Q=130 m^3/h, Head=25 m, P=15kW	Unit	3	Two for use and one for backup
Fixed-pressure water-supplying devices-1	Q=4 m^3/h, Head=81 m, P=2.2kW	Unit	1	

Fixed-pressure water-supplying devices-2	Q=18 m^3/h, Head=50 m, P=4kW	Unit	1	
Water-softening facilities	Treatment capacity: 10 m^3/h	Unit	1	
Water-softening tank	Volume: 16.2 m^3	Unit	1	
Cyclone desanders	Treatment capacity: 100 m^3/h	Unit	1	
Submersible pumps	Q=100 m^3/h, Head=100 m, P=55kW	Unit	1	
1#DFYJ				
Equipment Name	**Specifications**	**Unit**	**Quantity**	**Remarks**
Secondary Plate heat exchanger	Primary heat exchange temperature of supply water and return water: 40/10 °C; Secondary heat exchange temperature of supply water and return water: 7/15 °C	Unit	3	
Water source heat pumps	Heating Capacity :691kW	Unit	2	
Circulating pumps-1	Q=138 m^3/h, Head=37.5 m, P=22kW	Unit	3	Two for use and one for backup
Circulating pumps-2	Q=87 m^3/h, Head=38 m, P=15kW	Unit	2	One for use and one for backup
Plate exchange circulation pump	Q=65 m^3/h, Head=28 m, P=7.5kW	Unit	3	Two for use and one for backup

Water-supplying tank	Volume: 3 m3	Unit	1	
Water-supplying pump	Q=12.5 m3/h, Head=32 m, P=3kW	Unit	2	One for use and one for backup
Tank	Volume: 20 m3	Unit	1	
Circulation pump for hot water	Q=4 m3/h, Head=36 m, P=5.5 kW	Unit	2	One for use and one for backup
2#DFYJ				
Equipment Name	**Specifications**	**Unit**	**Quantity**	**Remarks**
Primary plate heat exchanger	Primary heat exchange temperature of supply water and return water: 70/41 °C; Secondary heat exchange temperature of supply water and return water:35/45 °C	Unit	2	
Circulating pumps for high zone	Q=50 m^3/h, Head=35 m, P=18.5kW	Unit	2	One for use and one for backup
Circulating pumps for low zone	Q=125 m^3/h, Head=35 m, P=30kW	Unit	2	One for use and one for backup
Automatic dosing device	Treatment capacity: 4 m3/h	Unit	1	
Water-softening tank	Volume: 1 m3	Unit	1	
Fixed-pressure water-supplying devices for high zone	Q=5.5 m3/h, Head=60 m	Unit	1	

Fixed-pressure water-supplying devices for low zone	Q=4 m3/h, Head=35 m	Unit	1	
Cyclone desanders	Treatment capacity: 60 m3/h	Unit	1	
Submersible pumps	Q=70 m^3/h, Head=150 m, P=75kW	Unit	2	
3#DFYJ				
Equipment Name	**Specifications**	**Unit**	**Quantity**	**Remarks**
Water source heat pumps	Heating Capacity: 1268kW	Unit	2	
Primary plate heat exchanger	Primary heat exchange temperature of supply water and return water: 72/40 °C; Secondary heat exchange temperature of supply water and return water: 35/45 °C	Unit	1	
Secondary plate heat exchanger	Primary heat exchange temperature of supply water and return water: 40/12 °C; Secondary heat exchange temperature of supply water and return water: 10/18 °C	Unit	1	
Circulating pumps for direct supply	Q=216 m^3/h, Head=38 m, P=30kW	Unit	2	One for use and one for backup
Circulating pumps of host unit	Q=116 m^3/h, Head=38 m, P=7.5kW	Unit	3	Two for use and one for backup
Circulating pumps of end side	Q=136 m^3/h, Head=38 m, P=18.5kW	Unit	3	Two for use and one for backup

Fixed-pressure water-supplying devices	Q=2 m^3/h, Head=45 m, P=2.2kW	Unit	1	
Water-softening facilities	Treatment capacity: 2 m^3/h	Unit	1	
Water-softening tank	Volume: 6 m^3	Unit	1	
Cyclone desanders	Treatment capacity: 80 m^3/h	Unit	1	
1#DHYY				
Equipment Name	**Specifications**	**Unit**	**Quantity**	**Remarks**
Water source heat pumps	Heating Capacity: 2050kW	Unit	2	
Primary plate heat exchanger	Primary heat exchange temperature of supply water and return water: 74/40 °C; Secondary heat exchange temperature of supply water and return water: 35/45 °C	Unit	1	
Secondary plate heat exchanger	Primary heat exchange temperature of supply water and return water: 40/12 °C; Secondary heat exchange temperature of supply water and return water: 10/18 °C	Unit	1	
Circulating pumps for direct supply	Q=445 m^3/h, Head=50 m, P=75kW	Unit	2	One for use and one for backup
Circulating pumps of host unit	Q=183 m^3/h, Head=25 m, P=18.5kW	Unit	3	Two for use and one for backup

Circulating pumps of end side	Q=220 m³/h, Head=50 m, P=37kW	Unit	3	Two for use and one for backup
Fixed-pressure water-supplying devices	Q=20 m3/h, Head=45 m, P=5.5kW	Unit	1	
Water-softening facilities	Treatment capacity: 20 m³/h	Unit	1	
Water-softening tank	Volume: 8 m³	Unit	1	
Cyclone desanders	Treatment capacity: 120 m³/h	Unit	1	
Submersible pumps	Q=110 m³/h, Head=100 m, P=75kW	Unit	1	
1#QHY				
Equipment Name	**Specifications**	**Unit**	**Quantity**	**Remarks**
Water source heat pumps	Heating Capacity: 1700kW	Unit	2	
Primary plate heat exchanger	Primary heat exchange temperature of supply water and return water: 74/40 °C; Secondary heat exchange temperature of supply water and return water: 35/45 °C	Unit	1	
Secondary plate heat exchanger	Primary heat exchange temperature of supply water and return water: 40/12 °C; Secondary heat exchange temperature of supply water and return water: 10/18 °C	Unit	1	
Circulating pumps for	Q=368 m³/h, Head=45 m, P=55kW	Unit	2	One for use and one for backup

direct supply				
Circulating pumps of source side	Q=152 m^3/h, Head=25 m, P=18.5kW	Unit	3	Two for use and one for backup
Circulating pumps of end side	Q=182 m^3/h, Head=45 m, P=30kW	Unit	3	Two for use and one for backup
Fixed-pressure water-supplying devices	Q=17 m^3/h, Head=42 m, P=4kW	Unit	1	
Water-softening facilities	Treatment capacity: 15 m^3/h	Unit	1	
Water-softening tank	Volume: 11.25 m^3	Unit	1	
Cyclone desanders	Treatment capacity: 100 m^3/h	Unit	1	
Submersible pumps	Q=90 m^3/h, Head=100 m, P=75kW	Unit	1	
1#XXHT				
Equipment Name	**Specifications**	**Unit**	**Quantity**	**Remarks**
Water source heat pumps	Heating Capacity: 1890kW	Unit	2	
Primary plate heat exchanger	Primary heat exchange temperature of supply water and return water: 74/40 °C; Secondary heat exchange temperature of supply water and return water:35/45 °C	Unit	2	

Secondary plate heat exchanger	Primary heat exchange temperature of supply water and return water: 40/12 °C; Secondary heat exchange temperature of supply water and return water: 10/18 °C	Unit	1	
Circulating pumps	Q=44 m^3/h, Head=45 m, P=75 kW	Unit	2	One for use and one for backup
Circulating pumps for direct supply	Q=372 m^3/h, Head=45 m, P=11 kW	Unit	2	One for use and one for backup
Circulating pumps of host unit	Q=162 m^3/h, Head=25 m, P=18.5 kW	Unit	3	Two for use and one for backup
Circulating pumps of end side	Q=203 m^3/h, Head=45 m, P=37 kW	Unit	3	Two for use and one for backup
Fixed-pressure water-supplying devices-1	Q=1.2 m^3/h, Head=63 m, P=1.1 kW	Unit	1	
Fixed-pressure water-supplying devices-2	Q=17 m^3/h, Head=42 m, P=4 kW	Unit	1	
Water-softening facilities	Treatment capacity: 15 m^3/h	Unit	1	
Water-softening tank	Volume: 12.5 m^3	Unit	1	
Cyclone desanders	Treatment capacity: 100 m^3/h	Unit	1	

Submersible pumps	Q=100 m^3/h, Head=100 m, P=75 kW	Unit	1	
1#HLC				
Equipment Name	**Specifications**	**Unit**	**Quantity**	**Remarks**
Water source heat pumps	Heating Capacity: 2650 kW	Unit	2	
Primary plate heat exchanger-1	Primary heat exchange temperature of supply water and return water: 74/40 °C; Secondary heat exchange temperature of supply water and return water:35/45 °C	Unit	3	
Secondary plate heat exchanger	Primary heat exchange temperature of supply water and return water: 40/12 °C; Secondary heat exchange temperature of supply water and return water: 10/18 °C	Unit	1	
Circulating pumps-1	Q=180 m^3/h, Head=60 m, P=45 kW	Unit	2	One for use and one for backup
Circulating pumps-2	Q=210 m^3/h, Head=60 m, P=55 kW	Unit	2	One for use and one for backup
Circulating pumps-3	Q=190 m^3/h, Head=60 m, P=55 kW	Unit	2	One for use and one for backup
Circulating pumps-4	Q=290 m^3/h, Head=60 m, P=90 kW	Unit	3	One for use and one for backup
Circulating pumps of host unit	Q=240 m^3/h, Head=25 m, P=22 kW	Unit	3	Two for use and one for backup
Fixed-pressure water-supplying devices-1	Q=4 m^3/h, Head=65 m, P=2.2 kW	Unit	1	
Fixed-pressure	Q=5 m^3/h, Head=65 m, P=2.2 kW	Unit	1	

water-supplying devices-2				
Fixed-pressure water-supplying devices	Q=15 m^3/h, Head=42 m, P=4 kW	Unit	1	
Water-softening facilities	Treatment capacity: 20 m^3/h	Unit	1	
Water-softening tank	Volume: 12.5 m^3	Unit	1	
Cyclone desanders	Treatment capacity: 150 m^3/h	Unit	1	
Submersible pumps	Q=70 m^3/h, Head=100 m, P=75 kW	Unit	1	
1#JHY				
Equipment Name	**Specifications**	**Unit**	**Quantity**	**Remarks**
Water source heat pumps	Heating Capacity: 1513 kW	Unit	2	
Primary plate heat exchanger	Primary heat exchange temperature of supply water and return water: 72/40 °C; Secondary heat exchange temperature of supply water and return water:35/45 °C	Unit	2	
Secondary plate heat exchanger	Primary heat exchange temperature of supply water and return water: 40/15 °C; Secondary heat exchange temperature of supply water and return water: 10/18 °C	Unit	1	
Circulating pumps-1	Q=250 m^3/h, Head=36 m, P=45 kW	Unit	2	One for use and one for backup

Circulating pumps-2	Q=128 m³/h, Head=36 m, P=22 kW	Unit	2	One for use and one for backup
Circulating pumps of host unit	Q=136 m³/h, Head=20 m, P=15 kW	Unit	3	Two for use and one for backup
Circulating pumps of end side	Q=163 m³/h, Head=36 m, P=30 kW	Unit	3	Two for use and one for backup
Fixed-pressure water-supplying devices-1	Q=3 m³/h, Head=62 m, P=2.2 kW	Unit	1	
Fixed-pressure water-supplying devices-2	Q=6 m³/h, Head=37 m, P=2.2 kW	Unit	1	
Water-softening facilities	Treatment capacity: 10 m³/h	Unit	1	
Water-softening tank	Volume: 6 m³	Unit	1	
Cyclone desanders	Treatment capacity: 100 m³/h	Unit	1	
Submersible pumps	Q=90 m³/h, Head=100 m, P=75 kW	Unit	1	
1#JXY				
Equipment Name	**Specifications**	**Unit**	**Quantity**	**Remarks**
Water source heat pumps	Heating Capacity: 2010 kW	Unit	2	

Primary plate heat exchanger-1	Primary heat exchange temperature of supply water and return water: 74/40 °C; Secondary heat exchange temperature of supply water and return water:35/45 °C	Unit	2	
Secondary plate heat exchanger	Primary heat exchange temperature of supply water and return water: 40/12 °C; Secondary heat exchange temperature of supply water and return water: 10/18 °C	Unit	1	
Circulating pumps-1	Q=108 m^3/h, Head=45 m, P=22 kW	Unit	2	One for use and one for backup
Circulating pumps for direct supply	Q=343 m^3/h, Head=45 m, P=55 kW	Unit	2	One for use and one for backup
Circulating pumps of host unit	Q=180 m^3/h, Head=25 m, P=18.5 kW	Unit	3	Two for use and one for backup
Circulating pumps of the end side	Q=216 m^3/h, Head=45 m, P=37 kW	Unit	3	Two for use and one for backup
Fixed-pressure water-supplying devices-1	Q=17 m^3/h, Head=42 m, P=4 kW	Unit	1	
Fixed-pressure water-supplying devices-2	Q=3 m^3/h, Head=60 m, P=1.1 kW	Unit	1	
Water-softening facilities	Treatment capacity: 20 m^3/h	Unit	1	
Water-softening tank	Volume: 12.5 m^3	Unit	1	

Cyclone desanders	Treatment capacity: 110 m^3/h	Unit	1	
Submersible pumps	Q=110 m^3/h, Head=100 m, P=75 kW	Unit	1	
1#TSGG				
Equipment Name	**Specifications**	**Unit**	**Quantity**	**Remarks**
Water source heat pumps	Heating Capacity: 1478 kW	Unit	2	
Primary plate heat exchanger	Primary heat exchange temperature of supply water and return water: 74/40 °C; Secondary heat exchange temperature of supply water and return water:35/45 °C	Unit	2	
Secondary plate heat exchanger	Primary heat exchange temperature of supply water and return water: 40/12 °C; Secondary heat exchange temperature of supply water and return water: 10/18 °C	Unit	1	
Circulating pumps-1	Q=130 m^3/h, Head=45 m, P=22 kW	Unit	2	One for use and one for backup
Circulating pumps for direct supply	Q=200 m^3/h, Head=45 m, P=55 kW	Unit	2	One for use and one for backup
Circulating pumps of host unit	Q=135 m^3/h, Head=25 m, P=18.5 kW	Unit	3	Two for use and one for backup
Circulating pumps of the end side	Q=160 m^3/h, Head=45 m, P=37 kW	Unit	3	Two for use and one for backup
Fixed-pressure water-supplying devices-1	Q=2 m^3/h, Head=60 m, P=1.1 kW	Unit	1	

Fixed-pressure water-supplying devices-2	Q=8 m^3/h, Head=42 m, P=4 kW	Unit	1	
Water-softening facilities	Treatment capacity: 10 m^3/h	Unit	1	
Water-softening tank	Volume: 12.5 m^3	Unit	1	
Cyclone desanders	Treatment capacity: 80 m^3/h	Unit	1	
Submersible pumps	Q=80 m^3/h, Head=100 m, P=75 kW	Unit	1	
1#QXZY				
Equipment Name	**Specifications**	**Unit**	**Quantity**	**Remarks**
Water source heat pumps	Heating Capacity: 1856 kW	Unit	2	
Primary plate heat exchanger	Primary heat exchange temperature of supply water and return water: 74/37 °C; Secondary heat exchange temperature of supply water and return water:35/45 °C	Unit	2	
Secondary plate heat exchanger	Primary heat exchange temperature of supply water and return water: 37/12 °C; Secondary heat exchange temperature of supply water and return water: 10/18 °C	Unit	1	
Circulating pumps-1	Q=60 m^3/h, Head=60 m, P=30 kW	Unit	2	One for use and one for backup
Circulating pumps for direct supply	Q=380 m^3/h, Head=60 m, P=110 kW	Unit	2	One for use and one for backup

Circulating pumps of host unit-1	Q=320 m^3/h, Head=60 m, P=90 kW	Unit	3	Two for use and one for backup
Circulating pumps of host unit-2	Q=200 m^3/h, Head=24 m, P=22 kW	Unit	3	Two for use and one for backup
Fixed-pressure water-supplying devices-1	Q=5 m3/h, Head=65 m, P=1.1 kW	Unit	1	
Fixed-pressure water-supplying devices-2	Q=12 m3/h, Head=50 m, P=3 kW	Unit	1	
Water-softening facilities	Treatment capacity: 12 m3/h	Unit	1	
Water-softening tank	Volume: 18 m3	Unit	1	
Cyclone desanders	Treatment capacity: 125 m3/h	Unit	1	
Pressurized rejection pump	Q=125 m3/h, Head=44 m, P=30 kW	Unit	2	One for use and one for backup
1#YHWH				
Equipment Name	**Specifications**	**Unit**	**Quantity**	**Remarks**
Water source heat pumps	Heating Capacity: 2296 kW	Unit	2	

Primary plate heat exchanger	Primary heat exchange temperature of supply water and return water: 74/40 °C; Secondary heat exchange temperature of supply water and return water:35/45 °C	Unit	2	
Secondary plate heat exchanger	Primary heat exchange temperature of supply water and return water: 40/12 °C; Secondary heat exchange temperature of supply water and return water: 10/18 °C	Unit	1	
Circulating pumps for direct supply-1	Q=228 m^3/h, Head=50 m, P=55 kW	Unit	2	One for use and one for backup
Circulating pumps for direct supply-2	Q=361 m^3/h, Head=50 m, P=75 kW	Unit	2	One for use and one for backup
Circulating pumps of host unit	Q=230 m^3/h, Head=25 m, P=22 kW	Unit	3	Two for use and one for backup
Circulating pumps of end side	Q=247 m^3/h, Head=50 m, P=55 kW	Unit	3	Two for use and one for backup
Fixed-pressure water-supplying devices-1	Q=10 m^3/h, Head=44 m, P=3 kW	Unit	1	
Fixed-pressure water-supplying devices-2	Q=2.5 m^3/h, Head=66 m, P=2.2 kW	Unit	1	
Water-softening facilities	Treatment capacity: 15 m^3/h	Unit	1	

Water-softening tank	Volume: 6 m^3	Unit	1	
Cyclone desanders	Treatment capacity: 120 m^3/h	Unit	1	
Submersible pumps	Q=140 m^3/h, Head=100 m, P=75 kW	Unit	1	

Table 1-2 Main Parameters of the 17 Heat Substations

<table>
<tr><th rowspan="2">No.</th><th rowspan="2">Sub-area</th><th rowspan="2">Heat Substation</th><th colspan="2">Geothermal Wells</th><th rowspan="2">Heat Load (MW)</th><th rowspan="2">Heating Area (thousand m²)</th></tr>
<tr><th>Number of Production Wells</th><th>Number of Rejection Wells</th></tr>
<tr><td>1</td><td>Fenghuangcheng Station</td><td>4</td><td>1</td><td>3</td><td>12.50</td><td>416.73</td></tr>
<tr><td>2</td><td>Gongyuanshoufu Station</td><td>1</td><td>1</td><td>3</td><td>13.43</td><td>447.51</td></tr>
<tr><td>3</td><td>Dongfangyujing Station</td><td>3</td><td>1</td><td>2</td><td>8.16</td><td>271.93</td></tr>
<tr><td>4</td><td>Donghuyiyuan Station</td><td>1</td><td>1</td><td>2</td><td>8.10</td><td>270.01</td></tr>
<tr><td>5</td><td>Qinghuayuan Station</td><td>1</td><td>1</td><td rowspan="2">3</td><td>9.90</td><td>329.99</td></tr>
<tr><td>6</td><td>Xiangxiehuating Station</td><td>1</td><td>1</td><td>8.18</td><td>272.66</td></tr>
<tr><td>7</td><td>Hualancheng Station</td><td>1</td><td>1</td><td>2</td><td>10.80</td><td>360</td></tr>
<tr><td>8</td><td>Jiuhaoyuan Station</td><td>1</td><td>1</td><td>2</td><td>6.11</td><td>203.56</td></tr>
<tr><td>9</td><td>Jinxiuyuan Station</td><td>1</td><td>1</td><td>3</td><td>7.23</td><td>240.85</td></tr>
<tr><td>10</td><td>Tianshenggongguan Station</td><td>1</td><td>1</td><td>2</td><td>8.00</td><td>266.81</td></tr>
<tr><td>11</td><td>Qianxizhuangyuan Station</td><td>1</td><td>1</td><td rowspan="2">2</td><td>11.05</td><td>368.23</td></tr>
<tr><td>12</td><td>Yehaowanghu Station</td><td>1</td><td>1</td><td>8.63</td><td>287.82</td></tr>
</table>

Total	12	17	12	24	112.08	3,736.10

All the building covered by the project were newly built buildings and there was no existing heating system prior to the project activity. In baseline scenario, heating supply in winter for the building areas will be provided by newly built coal-fired boilers in boiler house.

1.12 Project Location

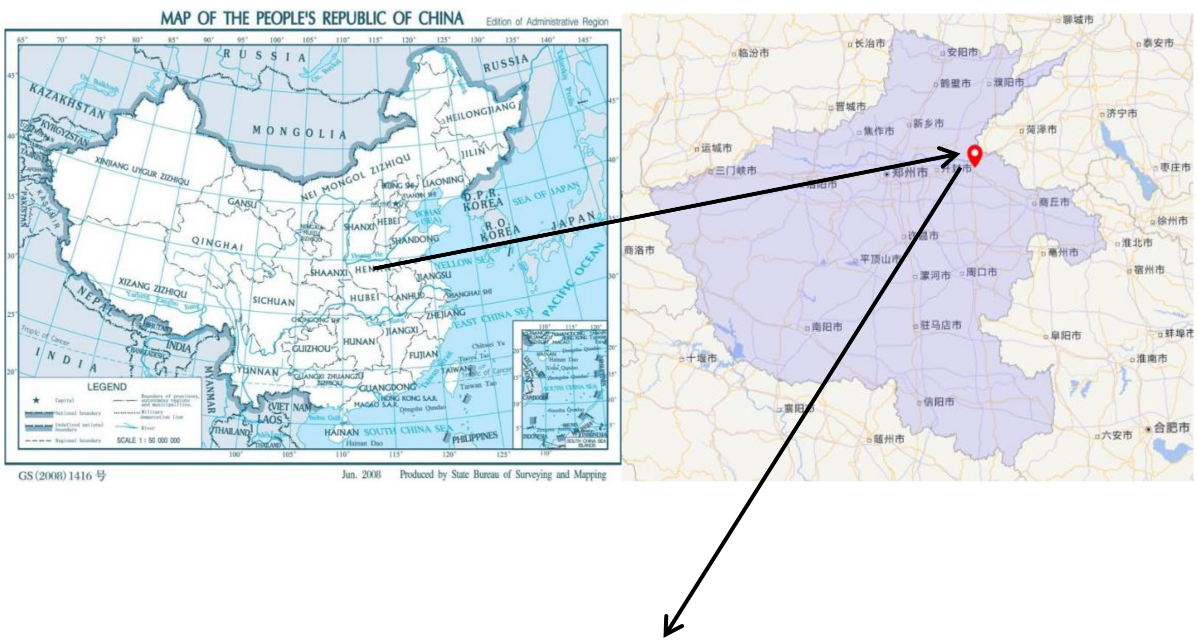
The project is in Lankao County of Henan Province. The geographical coordinates are Longitude east 114°47' E to 114°50' E and Latitude North 34°48' N to 34°51' N. The detailed coordinates of the 36 geothermal Wells are provided in Table 1-3 below.

Table 1-3 Coordinates of 36 Geothermal Wells

No.	Sub-area	Heat Substation	Geothermal Wells	Coordinate
1	Fenghuangcheng Station	1#FHC 2#FHC 3#FHC 4#FHC	Production Well	34°50'53.2" N 114°49'18.4" E
			Injection Well a	34°50'52.5" N 114°49'20.9" E
			Injection Well b	34°50'52.5" N 114°49'31.4" E
			Injection Well c	34°50'53.2" N 114°49'18.2" E
2	Gongyuanshoufu Station	1#GYSF	Production Well	34°50'42.7" N 114°50'0.3" E
			Injection Well a	34°50'39.9" N 114°50'0.3" E
			Injection Well b	34°50'39.8" N 114°49'59.4" E
			Injection Well c	34°50'42.6" N 114°49'59.4" E
3	Dongfangyujing Station	1#DFYJ 2#DFYJ 3#DFYJ	Production Well	34°49'55.5" N 114°49'51.5" E
			Injection Well a	34°49'47.1" N 114°49'48.0" E
			Injection Well b	34°49'47.3" N 114°49'48.0" E
4	Donghuyiyuan Station	1#DHYY	Production Well	34°49'9.7" N 114°49'51.3" E
			Injection Well a	34°49'9.7" N

				114°49'52.4" E
			Injection Well b	34°49'9.5" N 114°49'52.4" E
5	Qinghuayuan Station	1#QHY	Production Well	34°49'6.2" N 114°47'2.4" E
			Injection Well a	34°49'31.8" N 114°47'15.9" E
			Injection Well b	34°49'13.6" N 114°47'7.9" E
			Injection Well c	34°49'22.5" N 114°47'19.9" E
6	Xiangxiehuating Station	1#XXHT	Production Well	34°49'18.7" N 114°47'5.6" E
			Injection Well	Sharing three injection wells with Qinghuayuan Station
7	Hualancheng Station	1#HLC	Production Well	34°49'28.2" N 114°47'53.1" E
			Injection Well a	34°49'28.4" N 114°47'52.7" E
			Injection Well b	34°49'28.6" N 114°47'52.3" E
8	Jiuhaoyuan Station	1#JHY	Production Well	34°48'51.0" N 114°48'1.5" E
			Injection Well a	34°48'51.0" N 114°48'2.0" E
			Injection Well b	34°48'51.1" N 114°48'2.2" E
9	Jinxiuyuan Station	1#JXY	Production Well	34°49'11.9" N 114°47'51.6" E
			Injection Well a	34°49'11.5" N 114°47'51.6" E
			Injection Well b	34°49'11.2" N 114°47'51.6" E
			Injection Well c	34°49'11.4" N 114°47'51.6" E
10	Tianshenggongguan Station	1#TSGG	Production Well	34°50'17.6" N 114°49'42.4" E
			Injection Well a	34°49'59.8" N 114°49'38.9" E
			Injection Well b	34°50'3.2" N

				114°49'41.3" E
11	Qianxizhuangyuan Station	1#QXZY	Production Well	34°50'40.9"N 114°48'1.3"E
			Injection Well a	34°50'41.3"N 114°48'1.5"E
			Injection Well b	34°50'41.5"N 114°48'1.8"E
12	Yehaowanghu Station	1#YHWH	Production Well	34°50'39.3"N 114°47'52.5"E
			Injection Well	Sharing two injection wells with Qianxizhuangyuan Station
Total	12	17	12	24



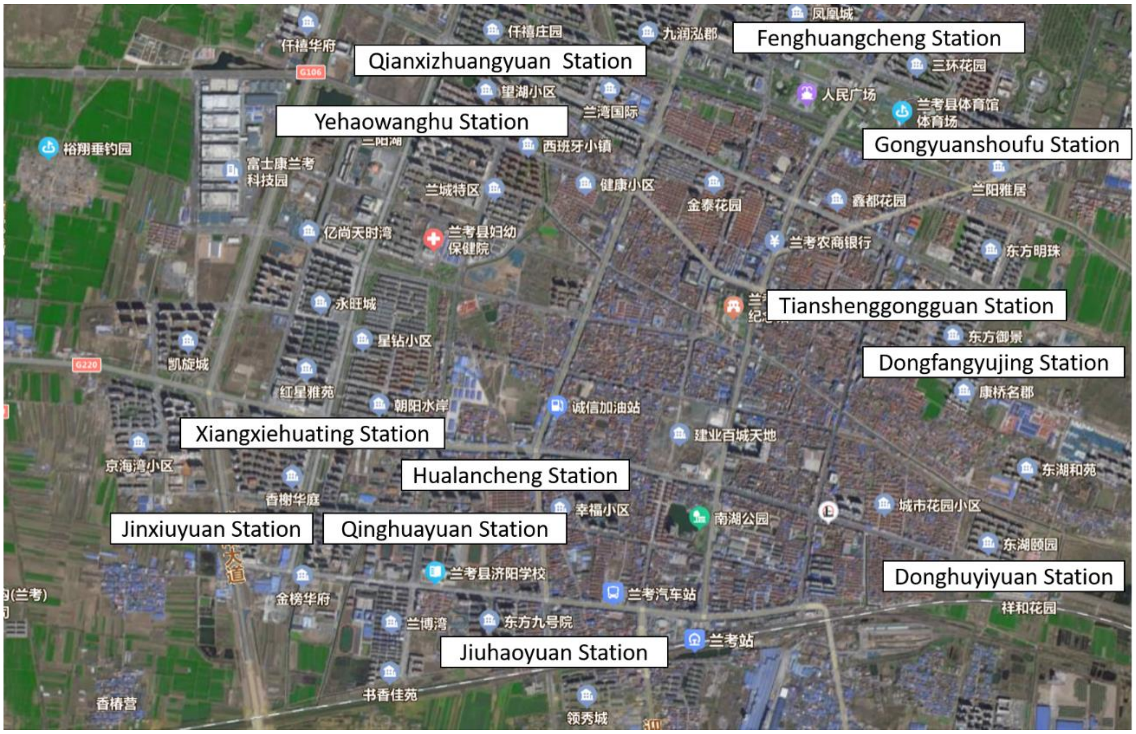


Figure 1-2 Location of the Project

1.13 Conditions Prior to Project Initiation

The multiple project activity instances involve geothermal space heating system. There are no project activities at the project sites before the construction of the proposed project activities. The baseline scenario is the same as the conditions existing prior to the project initiation. Refer section 3.4 below for detailed baseline scenario.

1.14 Compliance with Laws, Statutes and Other Regulatory Frameworks

The project complies with all Chinese relevant laws and regulations. Mainly include:

1. Implementation Plan of Air Pollution Prevention and Control in Henan Province in 2018[6]. It points out that the development of "double substitute" heating will be accelerated. In areas not covered by natural gas pipelines, great efforts should be made to develop electric heating methods such as heat pumps, electric boilers and air conditioners.

2. Green Industry Guidance Directory (2019 version) [7]. It demonstrates that the Chinese Government's commitment to the development of renewable energy as part of the overall energy development strategy, and encourages clean heating from renewable sources.

[6] http://www.henan.gov.cn/2018/02-23/249520.html

[7] http://kj.jdz.gov.cn/zwzx/gggs/P020210823363389433184.pdf

3. The Plan for Clean Heating in Winter in Northern China (2017-2021) (Development and Reform of Energy resources (2017) No. 2100) [8]. It is pointed out in the Plan that at present, the proportion of clean heating in northern China is low, especially in some areas, where bulk burning coal is used in winter and air pollutant emissions are high. So, it is urgent to promote clean heating. This will have a bearing on the winter warmth of the people in northern China and whether smog can be reduced. It is an important part of the revolution in energy production and consumption and the revolution in rural lifestyles.

4. Catalogue for the Guidance of Industrial Structure Adjustment (2019 version) [9]. The "Guidance Catalogue for Industrial Restructuring" was revised and issued by the Development and Reform Commission of the Republic of China. Geothermal energy utilization technology development and equipment manufacturing belongs to the encouraged industries, receiving strong support and development from the state.

Moreover, EIA approval and Water drawing permit from governmental authorities: Lankao Ecological Environment Bureau and Lankao Water Conservancy Bureau. The two approvals well demonstrate that local government permits the construction of the project. Consequently, the project is compliance with laws, status, and other regulatory frameworks.

1.15 Participation under Other GHG Programs

1.15.1 Projects Registered (or seeking registration) under Other GHG Program(s)

The project has neither been registered nor seeking registration under any other GHG programs. The project is seeking registration only in VCS program.

1.15.2 Projects Rejected by Other GHG Programs

NA.

1.16 Other Forms of Credit

1.16.1 Emissions Trading Programs and Other Binding Limits

Does the project reduce GHG emissions from activities that are included in an emissions trading program or any other mechanism that includes GHG allowance trading?

☐ Yes ☒ No

[8] https://www.gov.cn/xinwen/2017-12/20/5248855/files/7ed7d7cda8984ae39a4e9620a4660c7f.pdf

[9] http://www.gov.cn/xinwen/2019-11/06/5449193/files/26c9d25f713f4ed5b8dc51ae40ef37af.pdf

The project proponent is not part of any emission trading program. The net GHG emission reductions from the project will not be used for compliance with emission trading programs or to meet binding limits on GHG emissions. The project activity has not participated under any other GHG programs.

There is a cap & trade scheme in China. However, the project activity is not included the mandatory emission control scheme since the scheme only cover the high-emission industries, such as power generation sector that emitted at least 26,000 tons of CO_2e/year. There is no emission cap enforced for the project owner. In addition, the heating system of each heat substation can be identified through its GPS coordinates and unique identification code, which will prevent the geothermal heating system counted in the project activity to be part of any other voluntary market or emission reduction mechanism (CDM, CCER, GS etc.) as well. The project will not apply for emission reduction credits or labels under any other schemes except VCS. In addition, the project owner provided “Declaration of No Double Counting” and “Declaration of not involved in other GHG scheme”.

1.16.2 Other Forms of Environmental Credit

Has the project sought or received another form of GHG-related credit, including renewable energy certificates?

☐ Yes ☒ No

1.16.3 Supply Chain (Scope 3) Emissions

Scope 3 emissions are indirect emissions that occur in a corporate value chain, including both upstream and downstream activities. These emissions are not directly controlled or owned by the company but are a result of its activities.

A geothermal-based space heating system primarily involves the extraction of heat from the Earth's crust and using it to heat buildings or other structures. This process can be more sustainable and have a lower carbon footprint compared to traditional heating methods that rely on fossil fuels.

However, Scope 3 emissions could still be associated with a geothermal-based space heating system project in several ways:

Manufacturing and transportation of equipment: The production and transportation of the equipment needed for the geothermal system can lead to greenhouse gas emissions. This includes the drilling equipment, heat exchangers, pumps, and other components.

Construction and installation: The construction and installation of the geothermal system at the project site can lead to indirect emissions, such as those associated with the use of construction machinery and the transportation of workers and materials.

Upstream emissions: Emissions can be associated with the extraction, processing, and transportation of raw materials required for manufacturing the equipment used in the geothermal system.

End-of-life management: At the end of the system's life, decommissioning, dismantling, and disposing of the equipment can lead to indirect emissions.

Purchased goods and services: The emissions associated with the goods and services purchased by the company to support the geothermal system, such as office supplies, can also be considered Scope 3 emissions.

While a geothermal-based space heating system itself may have lower direct emissions (Scope 1) and energy indirect emissions (Scope 2), it can still be associated with Scope 3 emissions. However, the overall carbon footprint of a geothermal system is generally lower than traditional fossil fuel-based heating systems.

1.17 Sustainable Development Contributions

1.17.1 Sustainable Development Contributions Activity Description

SDG 13 Climate Action

The project introduces a geothermal energy-based space heating system to provide heating for a series of new residential buildings in the winter of Lankao (off-grid solution for target users and/or applications). And replaced heating from isolated coal-fired boilers as a normal business scenario in the project area. And emissions credits would be reduced by using geothermal energy rather than burning fossil fuels. The residential area where the project located is newly built, so it is affected not only by the residential construction period, but also by the actual occupancy rate. The project has started to heat 1,927.91 thousand m^2 of residential buildings with the occupancy rate of 62.65% from 15/11/2021 - 21/03/2022, has started to heat 611.38 thousand m^2 more of residential buildings, totaling 2,539.30 thousand m^2 with the occupancy rate of 57.87% from 15/11/2022 - 18/03/2023, which leads to the actual heating area and load in the first monitoring period being smaller than the design value.

For the monitoring period from 15/11/2021 to 14/11/2022, 1,207.8 thousand m^2 of residential buildings with a heating load of 36.23 MW, generating an actual Emission reduction of 31,074 tCO_2e. For the monitoring period from 15/11/2022 to 18/11/ 2023, 1,469.5 thousand m^2 of residential buildings with a heating load of 44.08 MW, generating an actual Emission reduction of 36,546 tCO_2e. Besides, the project will provide an opportunity for local residents to learn and raise awareness on climate change and mitigation measures on the stakeholder consultation fiscal meeting.

SDG 8 Decent Work and Economic Growth

Project activities provide employment opportunities for local people, regardless of gender or any other status, during project implementation and monitoring activities. Both men and women received equal pay for equal work. The project creates 60 jobs, among them, the number of female workers is at least 30%.

SDG 7 Affordable and Clean Energy

The project introduces a geothermal energy-based space heating system to provide heating for a series of new residential buildings in the winter of Lankao (off-grid solution for target users and/or applications). And replaced heating from isolated coal-fired boilers as a normal business scenario in the project area. And emissions credits would be reduced by using geothermal energy rather than burning fossil fuels.

1.17.2 Sustainable Development Contributions Activity Monitoring

Table 1-4: Sustainable Development Contributions

Row number	SDG Target	SDG Indicator	Net Impact on SDG Indicator	Current Project Contributions	Contributions Over Project Lifetime
1)	7.2	7.2.1 Renewable energy share in the total final energy consumption	Implemented activities to increase	During this monitoring period, the project has started to heat 1,927.91 thousand m² of residential buildings with the occupancy rate of 62.65% from 15/11/2021 - 21/03/2022, which the actual heating area is 1,207.8 thousand m². And the project has started to heat 611.38 thousand m² more of residential buildings, totaling 2,539.30 thousand m² with the occupancy rate of 57.87%, which the actual heating area is 1,469.5 thousand m² from 15/11/2022 - 18/03/2023. From the operation start date (15/11/2021) of this project activity to the end of this monitoring period (18/03/2023), the cumulative heating area is 2,677.3 thousand m².	The project can totally supply geothermal heat to 3,736.1 thousand m² of newly built residential buildings. The project in still under construction and affected by the actual occupancy rate. Due to unknown future occupancy rates, it is not possible to quantify the cumulative heating area over the project lifetime at this moment.
2)	8.3	8.3.1 Proportion of informal employment in non - agriculture employment, by sex	Implemented activities to increase	During this monitoring period, 60 people were employed for operation, and maintenance of this project. Among them, the number of female workers is at least 30%.	The project activity generates long-term working opportunities for 60 people over the project lifetime.

3)	13.0	Tonnes of greenhouse gas emissions avoided or removed	Implemented activities to increase	For the monitoring period from 15/11/2021 to 14/11/2022, 1,207.8 thousand m^2 of residential buildings with a heating load of 36.23 MW, generating an actual emission reduction of 31,074 tCO_2e. For the monitoring period from 15/11/2022 to 18/11/ 2023, 1,469.5 thousand m_2 of residential buildings with a heating load of 44.08 MW, generating an actual Emission reduction of 36,546 tCO_2e. From the operation start date (15/11/2021) of this project activity to the end of this monitoring period (18/03/2023), the project has achieved cumulative GHG emission reductions of 67,621 tCO_2e.	The project can totally supply geothermal heat to 3,736.1 thousand m^2 of newly built residential buildings. The project in still under construction and affected by the actual occupancy rate. Due to unknown future occupancy rates, it is not possible to quantify the cumulative GHG emission reductions over the project lifetime at this moment.

1.18 Additional Information Relevant to the Project

Leakage Management

No leakage emissions have been identified for the project activity. Therefore, LE_y=0 tCO_2.

Refer to section 5.3 of the Joint-PD-MR for more details.

Commercially Sensitive Information

No commercially sensitive information has been excluded from the public version of the project description.

Further Information

NA.

2 SAFEGUARDS

2.1 No Net Harm

The Environmental Impact Assessment (EIA) Report for the project was compiled by Henan Zhengde Environmental Protection Technology Co., Ltd. The EIA report was approved by Lankao Ecological environment Bureau on 29-June-2020. The respective approval number is "[2020] No.47".

Every aspect of environmental impact has been considered in the EIA report with corresponding measures during project development, and no net harm has been detected. Meanwhile, the implementation of the project will improve local socio-economic development through creating career opportunities and paying taxes.

2.2 Local Stakeholder Consultation

The Project owner collected comments by local stakeholders on the project activity. Survey questionnaires were distributed to local villagers and government officials by the Project owner in August 2020. The survey questionnaire was designed to assess the project impacts on the local environment and social economic development. One hundred questionnaires were distributed to local stakeholders, and all questionnaires have been recollected. The interviewed local stakeholders include 61 males and 39 females, who are mainly 30-50 years old and concentrated in high school and college education level. Comments from these questionnaires are summarized in Table 2-1 below.

Table 2-1 Summary of stakeholders' comments

No.	Questions	Attitude or Opinion	Amount	Percentage
1	Do you know about the project activity? (Single choice)	Heard of	91	91%
		Nothing	9	9%
2	Do you know the technology of using geothermal energy for centralized heating? (Single choice)	No	43	43%
		Yes, but don't pay attention	12	12%
		Yes, and simply understood	26	26%
		Yes, and know very well	19	19%
3	What impact do you think the use of geothermal energy for centralized heating has on the ground? (Single choice)	No impact	53	53%
		Less impact	38	38%
		General impact	5	5%
		Higher impact	4	4%
4	Do you think the project will promote local economic development? (Single choice)	Yes	73	73%
		No	10	10%
		Don't know	17	17%
5	Do you think the project is conducive to the improvement of the ecological environment? (Single choice)	Yes	75	75%
		No	4	4%
		Don't know	21	21%
6	What do you think are the local contributions generated by the project? (Multiple choice)	Increase tax revenue	9	9%
		Provide employment opportunities	38	38%
		Solve energy problems	20	20%
		Improve infrastructure conditions	40	40%
		Improved life quality	56	56%
		Other	4	4%

7	Do you think the project is in line with the national and local industrial development guidelines? (Single choice)	Yes	75	75%
		Yes, basically	15	15%
		No	3	3%
		Indifferent	7	7%
8	After the project is constructed and put into commission, what factors do you think have an impact on your life? (Multiple choice)	No impact	75	75%
		Air pollution	2	2%
		Noise pollution	11	11%
		Water pollution	9	9%
		Soil erosion	3	3%
		Electromagnetic radiation effects	2	2%
9	What is your attitude to the project activity after understanding the introduction of the project?	Support	83	83%
		Against	0	0%
		Indifferent	17	17%

In general, local stakeholders are supportive of the project construction. The survey shows that many local stakeholders think the Project will help improve the life of local people and infrastructure conditions without much adverse environmental impact. The survey shows that almost all the stakeholders are supportive to the project, believing that the project will provide more employment opportunities, help the ecological environment improvement. Therefore, the implementation of the Project is regarded as beneficial by most of the local stakeholders.

Local Stakeholder Consultation during the project implementation stage:

Communications with Local stakeholders are being carried out at periodic intervals. Key implementation schedules or changes of the project will be communicated to the local authority, who will inform the neighborhood committee and the residents, the comments and suggestions from residents will be collected by the local authority meanwhile. And the local government agencies and competent authorities will conduct spot checks on the implementation of the project from time to time and give suggestions on the involved rectification problems. There are no negative comments received for the project. In line with VCS requirements all the processes have been implemented to receive comments from local stakeholders as well as communicate with them at periodic intervals.

2.3 Environmental Impact

The EIA report was approved by Lankao Ecological environment Bureau on 29-June-2020.

The environmental impacts of the project in construction period and in operation period are summarized as follows.

1. Construction Phase

1.1 Air Pollution

During the construction period, the impact on the regional atmospheric environment is mainly ground dust and fugitive dust pollution. Through strengthening management, setting up hard fences, cleaning up, sprinkling dust suppression and other measures, construction dust has little impact on the surrounding environment. The amount of pollutant gas generated by construction machinery and automobile is not large. with the completion of the construction, the exhaust gas emission will stop, and the concentration of pollutants in the atmosphere will gradually decrease, which will have little impact on the regional environment.

1.2 Wastewater

The wastewater during the construction period is mainly drilling wastewater, test wastewater, domestic sewage of construction workers, etc. Among them, the drilling wastewater is discharged into the anti-seepage mud pool at the site for the preparation of mud, which is recycled and disposed harmlessly together with the waste mud after drilling. The test wastewater quality is relatively clear, and the amount of wastewater produced each time is not large. After sedimentation, it is used for greening and sprinkling at the site and surrounding roads to reduce dust. The domestic sewage of the construction workers relies on the existing drainage system in the community to be discharged into the existing urban sewage pipe network nearby. The project construction period is short, the amount of wastewater produced is small, and the impact on the environment is little.

1.3 Noise

During the construction period, the main noise sources are mud pumps, drilling rigs, transport vehicles, etc. During drilling operations, noise are reduced by preferentially selecting low-noise machinery and equipment, rationally arranging the working frequency of strong-noise construction machinery, and shortening the operation period.

1.4 Solid Waste

The construction unit is required to transport the spoiled soil and slag to the waste slag field designated by the local environmental protection department for disposal. After taking disposal measures, the impact of the spoiled soil and slag on the environment can be effectively mitigated . An anti-seepage mud pool is set up at the drilling site, and the mud is disposed of in a sanitary landfill after completion. Drilling cores are stored and archived by the construction unit. Garbage cans are set up at the construction site to collect domestic garbage and send it to designated garbage dumping site, the domestic garbage has little impact on the environment.

2. Operation Phase

2.1 Wastewater

During the operation period of the project, the wastewater in the production process is mainly generated by the softening equipment of the heat exchange station, which is mainly clean sewage and discharged into the municipal rainwater pipeline. The domestic sewage of the heat exchange station is discharged into the septic tanks of the districts where the heat exchange stations are located, and then discharged into Lankao County Sewage Treatment Plant for treatment.

2.2 Groundwater

After the completion of the project, the geothermal water is extracted from the production well and enters the circulating water pipe system. During the whole process, the heat exchanger and the circulating pump collect and utilize the heat in the geothermal water through heat exchange, the temperature of the water is lowered and finally injected into the injection well. The whole process is a closed system, and the extracted geothermal water is not used in other ways. Among them, the dissolved substances in the geothermal water may be precipitated due to the decrease of the water temperature. In order to reduce the environmental impact caused by the precipitation of substances, a recharge filter device is set up in this project before the backwater is injected into the injection well. The quality and quantity of outgoing and recharging water are basically unaffected.

2.3 Noise

After the heating pipe network of this project is put into operation, the noise generated during the operation will be attenuated by distance after the basic measures of sound insulation and vibration reduction of the building, and the noise reduction value can reach more than 25dB (A). Therefore, the noise generated by this project will have little impact on the surrounding environment after the above measures are taken.

2.4 Solid Waste

The solid wastes generated during the operation period are mainly fine sand and household garbage generated by the filtration and de-sanding equipment. After being collected, they are regularly disposed by the environmental sanitation department, which has little impact on the surrounding environment.

2.4 Public Comments

This project will be open for public comment on the verra website.

2.5 AFOLU-Specific Safeguards

NA.

3 APPLICATION OF METHODOLOGY

3.1 Title and Reference of Methodology

Approved baseline and monitoring methodology: AM0072 Fossil Fuel Displacement by Geothermal Resources for Space Heating (Version 03.0).

Tools applied:

Tool 02 Combined tool to identify the baseline scenario and demonstrate additionality (Version 07.0) [10]

Tool 05 Baseline, project and/or leakage emissions from electricity consumption and monitoring of electricity generation (Version 03.0) [11]

Tool 07 Tool to calculate the emission factor for an electricity system (Version 07.0) [12]

Tool 24 Common practice (Version 03.1) [13]

3.2 Applicability of Methodology

Justification for the choice of the selected methodology is shown in the following table:

AM0072 Fossil Fuel Displacement by Geothermal Resources for Space Heating (Version 03.0)	
Eligibility Criteria	**Justification for the Project Activity**
The methodology is applicable for space heating in buildings by introducing centralized geothermal heat supply system. The methodology can apply to new build facilities, or to a geothermal district heating system seeking to expand its operations through the addition of extra geothermal wells to the system.	The project activity is designed to introduce geothermal energy-based space heating system to realize heat supply to a series of residential buildings in Lankao County over winter season. All the facilities related to the geothermal heating system were newly built, and the project activity didn't involve any capacity expansion through the addition of extra geothermal wells.
The methodology is applicable under the following conditions:	The geographical extent of the project boundary includes the 36 geothermal wells, 17 heat substations, 12 sub-areas of residential

[10] https://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-02-v7.0.pdf

[11] https://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-05-v3.0.pdf

[12] https://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-07-v7.0.pdf

[13] https://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-24-v1.pdf

(a) The geographical extent of the project boundary can be clearly established, in terms of the location of buildings connected to existing heating systems and new buildings to be constructed that will use geothermal heat, in the case of expansion of existing facilities, the location and capacity of existing geothermal wells, and heating system infrastructure can be clearly identified;	buildings, the primary networks and secondary network. No existing facilities were involved.
(b) Project will use geothermal resources for centralized space-heating system of residential areas, commercial areas and/or industrial areas;	As per Feasibility Study Report, the project activity is designed to introduce geothermal energy-based space heating system to realize heat supply to a total of 12 sub-areas in Lankao County. It can supply geothermal heat to 3,736.1 thousand m^2 of residential buildings.
(c) The methodology is applicable for installing new heating systems in new buildings and replacing existing fossil fuel space heating systems. Current use of fossil fuel(s) for space heating is partially or completely replaced by heat drawn from geothermal water, in the case of expansion of existing facilities the methodology is applicable to expanding the existing geothermal heating system;	As per Feasibility Study Report, the project involves installation of new geothermal based centralized space heating systems in residential buildings of the project, which will replace the use of isolated coal-fired boilers in baseline scenario completely.
(d) The installed heat capacity may increase as a result of the project activity. But this increase is limited to 10 percent of the previous existing capacity; otherwise, a new baseline scenario has to be determined for the new capacity;	There is no existing capacity prior to implementation of the project. This condition is not applicable.
(e) All fossil fuel heat-only boiler(s) used in the baseline must operate to supply the heat to the district heating system which is only used for heating of buildings and/or hot tap water supply in the residential and/or commercial sector, but not for industrial processes;	As per Feasibility Study Report, only the residential were supplied by the fossil fuel heat-only boilers used in the baseline. No industrial processes were involved.

(f) The use of GHG emitting refrigerants is not permitted under this methodology.	As per the Feasibility Study Report, the project is a closed circulating cycle and no GHG emitting refrigerants is used.
In addition, the applicability conditions included in the tools referred to below apply.	Justification for the choice of the selected tools is shown in the following tables.

Tool 02 Combined tool to identify the baseline scenario and demonstrate additionality (Version 07.0)	
Eligibility Criteria	**Justification for the Project Activity**
The tool is applicable to all types of proposed project activities. However, in some cases, methodologies referring to this tool may require adjustments or additional explanations as per the guidance in the respective methodologies. This could include, inter alia, a listing of relevant alternative scenarios that should be considered in Step 1, any relevant types of barriers other than those presented in this tool and guidance on how common practice should be established.	The project activity is designed to introduce geothermal energy-based space heating system to realize heat supply to a series of residential buildings in Lankao County. Alternative scenarios, barrier analysis, investment analysis and common practice analysis will be carried out based on Tool 02. Refer to section 5.1 of the Report for more details.

Tool 05 Baseline, project and/or leakage emissions from electricity consumption and monitoring of electricity generation (Version 03.0)	
Eligibility Criteria	**Justification for the Project Activity**
If emissions are calculated for electricity consumption, the tool is only applicable if one out of the following three scenarios applies to the sources of electricity consumption: (a) Scenario A: Electricity consumption from the grid. The electricity is purchased from the grid only, and either no captive power plant(s) is/are installed at the site of	The project activity will use electricity from grid (the Project is connected to the Centre China Power Grid (CCPG), which falls under scenario A of Tool 05 (Version 03.0). Therefore, emissions related to electricity consumption need to be calculated. Electricity bill and invoice with the power grid company were provided as evidence.

electricity consumption or, if any captive power plant exists on site, it is either not operating or it is not physically able to provide electricity to the electricity consumer. (b) Scenario B: Electricity consumption from (an) off-grid fossil fuel fired captive power plant(s). One or more fossil fuel fired captive power plants are installed at the site of the electricity consumer and supply the consumer with electricity. The captive power plant(s) is/are not connected to the electricity grid; or (c) Scenario C: Electricity consumption from the grid and (a) fossil fuel fired captive power plant(s). One or more fossil fuel fired captive power plants operate at the site of the electricity consumer. The captive power plant(s) can provide electricity to the electricity consumer. The captive power plant(s) is/are also connected to the electricity grid. Hence, the electricity consumer can be provided with electricity from the captive power plant(s) and the grid.	
This tool can be referred to in methodologies to provide procedures to monitor amount of electricity generated in the project scenario, only if one out of the following three project scenarios applies to the recipient of the electricity generated: (a) Scenario I: Electricity is supplied to the grid; (b) Scenario II: Electricity is supplied to consumers/electricity consuming facilities; or	This methodological tool is applied for calculating for emission by electricity consumption in project activity. So, this criterion is not applicable.

(c) Scenario III: Electricity is supplied to the grid and consumers/electricity consuming facilities.	
This tool is not applicable in cases where captive renewable power generation technologies are installed to provide electricity in the project activity, in the baseline scenario or to sources of leakage. The tool only accounts for CO_2 emissions.	The project will install geothermal based space heating system to displace fossil fuel consumption. No captive renewable power generation technologies will be installed to provide electricity in the project activity. Tool 05 is used for calculating project emissions of CO_2. This criterion is not applicable.

Tool 07 Tool to calculate the emission factor for an electricity system (Version 07.0)	
Eligibility Criteria	**Justification for the Project Activity**
This tool may be applied to estimate the OM, BM and/or CM when calculating baseline emissions for a project activity that substitutes grid electricity that is where a project activity supplies electricity to a grid or a project activity that results in savings of electricity that would have been provided by the grid (e.g. demand-side energy efficiency projects).	In baseline scenario, heating supply in winter for the building areas were provided by coal-fired boilers in boiler house. No electricity will be used, this criterion is not applicable.
Under this tool, the emission factor for the project electricity system can be calculated either for grid power plants only or, as an option, can include off-grid power plants. In the latter case, two sub options under the step 2 of the tool are available to the project participants, i.e., option II a and option IIb. If option IIa is chosen, the conditions specified in "Appendix 1: Procedures related to off-grid power generation" should be met. Namely, the total capacity of off-grid power plants (in MW) should be at least 10 percent of the total capacity of grid power plants in the electricity system; or the total electricity	The project activity uses electricity from Centre China Power Grid (CCPG) only. Electricity bill and contract with the power grid company were provided as evidence. Emission factor for the project electricity system will be calculated for grid power plants only as per Tool 07.

generation by off-grid power plants (in MWh) should be at least 10 percent of the total electricity generation by grid power plants in the electricity system; and that factors which negatively affect the reliability and stability of the grid are primarily due to constraints in generation and not to other aspects such as transmission capacity.	
In case of CDM projects the tool is not applicable if the project electricity system is located partially or totally in an Annex I country.	The project electricity system is located totally in Henan Province of China, which is not an Annex I country.
Under this tool, the value applied to the CO_2 emission factor of biofuels is zero.	The project activity will use electricity from Centre China Power Grid (CCPG) only. As per requirements of this criterion, the value applied to the CO_2 emission factor of biofuels were zero.

Tool 24 Common practice (Version 03.1)	
Eligibility Criteria	**Justification for the Project Activity**
This methodological tool is applicable to project activities that apply the methodological tool "Tool for the demonstration and assessment of additionality", the methodological tool "Combined tool to identify the baseline scenario and demonstrate additionality", or baseline and monitoring methodologies that use the common practice test for the demonstration of additionality.	The project applies the methodological tool "Combined tool to identify the baseline scenario and demonstrate additionality" for the demonstration of additionality.
In case the applied approved baseline and monitoring methodology defines approaches for the conduction of the common practice test that are different from those described in this	It is consistent of Tool 24 (Version 03.1) and AM0072 (Version 03.0) on approaches for the conduction of the common practice test.

methodological tool, the requirements contained in the methodology shall prevail.	

3.3 Project Boundary

As per AM0072 Fossil Fuel Displacement by Geothermal Resources for Space Heating (Version 03.0), the spatial extent of the project boundary includes:

(a) The site of geothermal heat extraction including, geothermal wells, injection wells, pumps, geothermal water storage tanks etc.

The project includes 12 production wells and 24 injection wells as shown in Figure 3-1.

(b) Centralized heating systems, including pipes, stations, sub-stations, and buildings that are or will be connected to the geothermal heating system.

The project includes 16 substations, residential in 12 sub-areas as shown in Figure 3-1.

(c) Decentralized heating equipment, including fossil fuel fired stoves etc.

The floor radiation system was installed in buildings connected to the substations. There is no decentralized heating equipment involved in the project boundary.

Figure 3-1 shows the project boundary in which the geothermal based space heating system is operated. Ground water extracted from geothermal production well j is pumped and transmitted, through primary heating network, to substation k where water at the downstream side of substation k will receive heat through heat exchangers and be subsequently supplied to end-users of construction type m through secondary heating network. Substation k (heat exchanger) is the primary point of measurement for monitoring parameters. The geothermal water returned from the exchanger will be re-injected into the injection well.

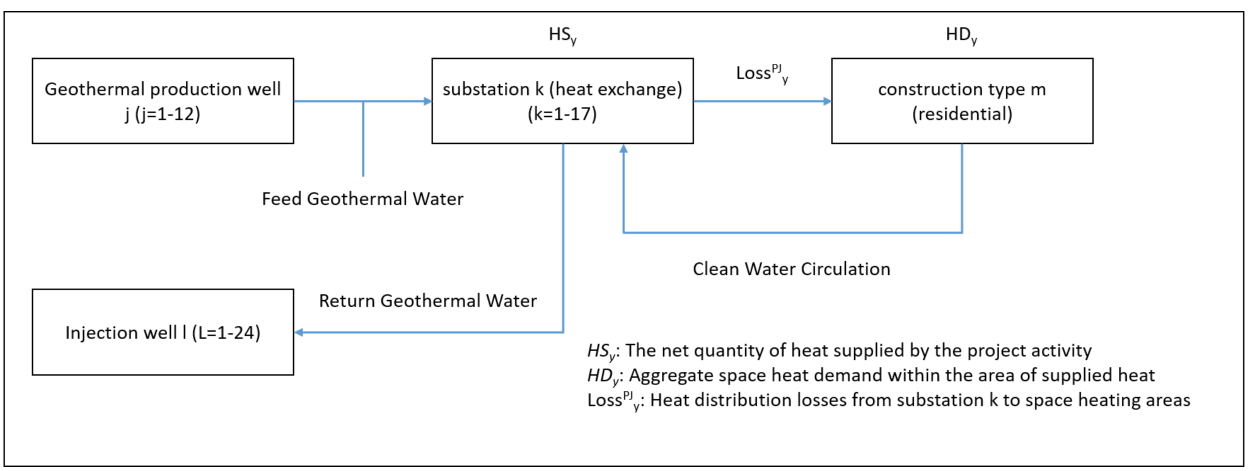


Figure 3-1 Project Boundary

The greenhouse gases included or excluded from the project boundary are summarized in Table 3-1 below.

Table 3-1 Emission Sources Included in or Excluded from the Project Boundary

Source		Gas	Included?	Justification/Explanation
Baseline	Fossil fuel used for space heating	CO_2	Yes	Main emission source
		CH_4	No	Minor source. Neglected for simplicity and conservativeness.
		N_2O	No	Minor source. Neglected for simplicity and conservativeness.
	Electricity used for geothermal extraction /operations	CO_2	Yes	Significant emission source
		CH_4	No	Minor source
		N_2O	No	Minor source
Project	Fuel used for geothermal extraction /operations	CO_2	No	No fuel is used for geothermal extraction/operation.
		CH_4	No	Minor source
		N_2O	No	Minor source
	Fugitive emissions from geothermal resource extraction	CO_2	No	No fugitive emissions will be considered by the project as the low-temperature geothermal system is designed to operate by extracting geothermal water at approximately 72°C.
		CH_4	No	Minor source
		N_2O	No	Minor source

3.4 Baseline Scenario

As per section 5.2 of AM0072 Fossil Fuel Displacement by Geothermal Resources for Space Heating (Version 03.0), the most plausible baseline scenario shall be determined with Tool 02

Combined tool to identify the baseline scenario and demonstrate additionality (Version 07.0) by the application of the following steps:

Step 1 Identification of alternative scenarios

Step 1a: Define alternative scenarios to the proposed project activity

The identification of alternative baseline scenario should include all realistic and credible alternatives to the project activity that are consistent with current laws and regulations of the host country and that provide output or service (i.e., heat supply) with comparable quality as the proposed project activity. To identifying relevant alternative scenarios, provide an overview of other technologies or practices used for generation of heat that have been implemented prior to the start of the project activity or are currently underway in the relevant geographical area. The realistic and credible alternative(s) for the implementation of a new geothermal facility may include:

No.	Alternative scenarios	Pre-screening	Conclusion
1	(a) Implementation of the project activity without the benefits.	This is a realistic and credible alternative scenario.	Included
2	(b) Introduction of a new integrated district heating system(s) connected by a new primary network:		
	(i) Introduction of a district heating system;	District heating is not provided in the project area.	Excluded
	(ii) The replacement of the heat-only boilers in the existing network(s) by new heat-only boilers.	There are no existing networks in all the residential buildings of the 12 sub-areas.	Excluded
3	Continued operation or rehabilitation of an existing [isolated] district heating network(s) or establishment of a new [isolated] district heating network(s). Such [isolated] district heating network(s) employ the following technologies:		
	(i) Coal fired boilers in boiler houses, supplying several buildings through a heat distribution network:	Some areas of Lankao are still not covered by district heating system. It is normal practice in Lankao County for residential buildings of the project area.	Included
	(ii) Natural gas fired boilers in boiler houses, supplying	The laying of natural gas pipeline is relatively complicated, and the cost is high, once destroyed, it will cause	Excluded

	several buildings through a heat distribution network:	great harm to the surrounding environment and people's life and property safety. The area where the project is located is temporarily not covered by natural gas pipe network.[14]	
	(iii) Oil fired boilers in boiler houses, supplying several buildings through a heat distribution network:	Oil fired boilers are more expensive than gas-fired boilers in order to produce the same volume of heat. According to “China Energy Statistical Yearbook 2020”[15], Coal-fired heating is still the mainstream method in Henan province.	Excluded
	(iv) Decentralized cogeneration plants;	Decentralized cogeneration plants do not cover the project area.	Excluded
	(v) Renewable energy sources, such as biomass or solar thermal collectors, connected to a heat distribution network.	Due to the limit on biomass reserves and technique level, renewable energy sources, such as biomass energy, wind energy, and solar energy, are not stable for space heating. Renewable energy can only be used as supplementary energy sources in long term in Henan Province.	Excluded
4	(d) Continued use or introduction of individual heat supply solutions:		
	(i) Coal fired boilers for individual buildings;	As per *Three-year Action Plan to Win the Blue Sky Defense War*[16], coal fired boilers for individual buildings should be eliminated gradually. New coal fired boilers built for individual buildings are forbidden by local government.	Excluded
	(ii) Coal fired stoves for individual apartments;	It's dangerous to use coal fired stoves inside the apartments due to carbon monoxide poisoning. Carbon	Excluded

[14]http://www.bulletin.cas.cn/publish_article/2020/9/20200914.pdf

[15]https://www.yearbookchina.com/navibooklist-n3020013309-1.html

[16]http://www.gov.cn/zhengce/content/2018-07/03/content_5303158.htm

	monoxide poisoning incidents have occurred in many places, it sounds the alarm on safety of home heating in winter	
(iii) Natural gas fired boilers for individual buildings;	As illustration of 3 (ii) above, sufficiently supply of natural gas can't be guaranteed in Henan Province and the current natural gas network cannot cover most of the rural area. Besides, some shortcomings cannot be neglected of the natural gas fired boilers, such as a short service life, a certain potential of safety hazard, a certain impact on air quality, certain expenses for maintenance and equipment depreciation[17].	Excluded
(iv) Natural gas fired stoves for individual apartments;	The price of natural gas is expensive and is increasing, which is too expensive to be afforded by many residents.	Excluded
(v) Oil fired boilers for individual buildings;	Oil-fired boilers generally use light oil and heavy oil as fuel, in which diesel oil is most used. The hourly fuel cost of a one-ton diesel boiler is about 382.8 RMB, which is nearly two times than that of natural gas fired boilers[18].	Excluded
(vi) Oil fired stoves for individual apartments;	Oil fired stoves are mainly used in the industrial field. It is not yet completely mature for using in apartments[19].	Excluded
(vii) Electricity (e.g., off-peak storage heating);	Electricity-based heating technologies are more costly and	Excluded

[17] Guozhong Zheng, Wentao Bu. Review of Heating Methods for Rural Houses in China. Energies 11(12):3402. December 2018. https://www.researchgate.net/publication/329410501_Review_of_Heating_Methods_for_Rural_Houses_in_China

[18] https://www.guolujiage.cn/news/news1/512.html

[19] https://www.sohu.com/a/355884111_99999190

		thus not comparable with other alternatives in terms of cost-effectiveness. The operating costs of electricity boilers are about four times than that of coal-fired boilers[20].	
	(viii) Individual heating devises using renewable energy sources, e.g., solar thermal collectors;	Due to the low solar energy density, a larger collection area is required to meet the heating demands. The efficiency of the air heating solar system is low and the water heating solar system is easy to ruin by freezing. There is no stable individual space heating devices using solar thermal collectors[21].	Excluded
	(ix) Individual heating devises using non renewable biomass.	As illustration of 3 (v) above, there is no sufficient biomass in the project area. Technical barriers for the commercialization of household biomass heating devices are still existing.	Excluded

There is no existing geothermal based heat supply system, so it is not necessary to analysis the options for expansion of a geothermal heat supply system.

In summary, the remaining realistic and credible alternative scenarios for the geothermal heating system are:

1 (a) Implementation of the project activity without the benefits of VCS; and

3 (i) Coal fired boilers in boiler houses, supplying several buildings through a heat distribution network.

Step 1b: Consistency with mandatory laws and regulations

The above options are all considered to follow all mandatory applicable legal and regulatory requirements. The outcome of Step 1b is unchanged from Step 1a.

Step 2: Barrier analysis

[20] https://www.zzboiler.com/baike/explanation/3750.html

[21] https://www.ixueshu.com/h5/document/10a911bfed7419ce82f3a2eb1bb17fed318947a18e7f9386.html

There are no technology barriers, acceptability barriers and financial barriers that may prevent these two alternative scenarios to occur. As per Tool 02 Combined tool to identify the baseline scenario and demonstrate additionality (Version 07.0), go to Step 3 investment analysis.

Step 3: Investment analysis

The comparison of economic attractiveness is carried out by applying Step 3 Investment analysis of Tool 02 Combined tool to identify the baseline scenario and demonstrate additionality (Version 07.0). The compared alternatives are: 1 (a) the proposed project activity undertaken without being registered as a VCS project; and 3 (i) coal fired boilers in the boiler houses, supplying several buildings through a small heat distribution network.

The levelized cost of heat (LCOH, RMB/GJ) is used as a financial indicator in the investment analysis for all alternatives. The formula applied to calculate the levelized cost of provided heat is the following[22]:

$$LCOH = \frac{Sum\ of\ costs\ over\ lifetime}{Sum\ of\ heat\ produced\ over\ lifetime} = \frac{\sum_{t=1}^{n} \frac{l_t + M_t + F_t}{(1+n)^t}}{\sum_{t=1}^{n} \frac{H_t}{(1+n)^t}} \quad (1)$$

Where:

$LCOH$	=	Levelized cost of heat (RMB/GJ)
l_t	=	Investment expenditures in the year t
M_t	=	Operation and maintenance cost in the year t
F_t	=	Fuel expenditures in the year t
H_t	=	Total heat supplied to the buildings in the year t
n	=	Discount rate

Inputs to the financial analysis

The parameters required in calculating LCOH for the two remaining alternatives after step 2 are listed in Table 3-2 below.

Table 3-2 Key Inputs to Calculate LCOH

Item	Value	
	Proposed Project	Alternative Baseline

[22] https://en.wikipedia.org/wiki/Levelized_cost_of_energy

Investment expenditures (10,000 RMB)	56,042.42[23]	9,340.25[24]
O&M Cost (10,000 RMB/year)	1,617.78[25]	1,587.84
Fuel expenditure (10,000 RMB/year)	0[26]	2,220.58
Residual value (10,000 RMB)	2,802.12[27]	467.01[28]
Annual heat supply (GJ)	1,162,076.54[29]	1,162,076.54
Discount rate[30]	8%	8%
Project lifetime[31]	20 years	20 years

The levelized cost of provided heat for the proposed project and the plausible baseline scenarios are calculated respectively, and the results are in Table 3.3 below.

Table 3.3 Calculated Results of *LCOH*

Parameter	Proposed Project 1(a)	Alternative Baseline 3(i)
LCOH (RMB/GJ)	71.84	42.42

As indicated in Table 3-3, the levelized cost of alternative 3 (i) is the lowest. To further demonstrate that the financial attractiveness of these scenarios is robust to reasonable variations in the critical assumptions, a sensitivity analysis is performed.

Sensitivity analysis

A sensitivity analysis of +/- 10% on the following parameters was conducted:

a. Investment expenditures.

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[23] The data is from the feasibility study report

[24] As per to the feasibility study report, the construction cost of a coal-fired boiler house in Lankao City is 25 RMB/m^2, the operating cost per unit of heating area is 4.25 RMB. so, the Investment expenditures can be calculated as: 373.61(10,000 m^2) * 25 RMB/m^2= 9,340.25 (10,000 RMB), so the O&M Cost can be calculated as: 373.61 (10,000 m^2) * 4.25 RMB/m^2=1,587.84 (10,000 RMB); Fuel expenditure for alternative baseline can be calculated as: 400 RMB/ton* 462.62 ton (Anthracite)/day*120 day=2,220.58 (10,000 RMB/year).

[25] The data is from the feasibility study report

[26] The data is from the feasibility study report

[27] The data is from the feasibility study report

[28] The data is from the feasibility study report, residual value can be calculated as: 9,340.25 (10,000 RMB) *5%=467.01(10,000 RMB)

[29] The data is from the feasibility study report, Annual heat supply (GJ) can be calculated as: 3.6*(373.61 (10,000 m^2) * 30W/m^2 * 2880h) *10^-6 = 1,162,076.54 (GJ)

[30] https://www.researchgate.net/publication/224096086_The_Newest_Development_of_Economic_Evaluation_of_Contruction_Project_in_China_The_3rd_Edition_of_Construction_Projects_Economic_Evaluation_Method_and_Parameter

[31] The data is from the Feasibility study report

b. O&M costs; and

c. Total heat supply

Table 3-4 Sensitivity Analysis of *LCOH* on Investment Expenditures (Unit: RMB/GJ)

Item	-10%	-5%	0	5%	10%	Critical Point
Proposed Project 1(a)	66.12	68.98	71.84	74.70	77.56	-51.43%
Alternative Baseline 3(i)	41.46	41.94	42.42	42.91	43.39	

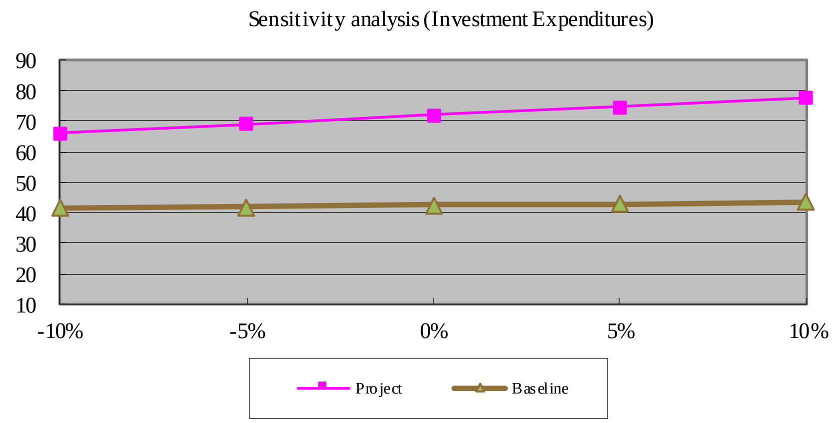

Figure 3-2 Sensitivity Analysis (Investment expenditures)

According to Table 3-4, scenario 3 (i) is the most economical attractive alternative. When the investment expenditure decreases 51.43%, the project becomes economical attractive. The price index of investment in fixed asset for Henan Province increased 4.3% in 2020.[32] Therefore, it is not likely to implement the project activity with the investment expenditure reducing by 51.43%.

Table 3-5 Sensitivity Analysis of *LCOH* on O&M Costs (Unit: RMB/GJ)

Item	-10%	-5%	0	5%	10%	Critical Point
Proposed Project 1(a)	70.44	71.14	71.84	72.53	73.23	-211.32%
Alternative Baseline 3(i)	41.06	41.74	42.42	43.11	43.79	

[32] https://www.henan.gov.cn/2021/03-08/2104927.html

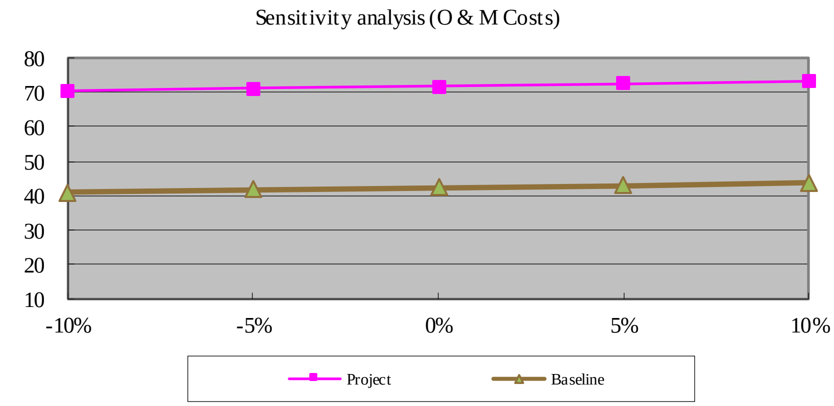

Figure 3-3 Sensitivity Analysis (O&M Costs)

When the O&M expenditure decrease by 211.32%, the project activity becomes more financial attractive than the scenario 3 (i). The O&M costs mainly consist of salary for the employees, management fee etc. The average salary keeps increasing by about 9.8% annually during the past five years[33], it is not likely to decrease the O&M cost by 211.32%.

Table 3-6 Sensitivity Analysis of *LCOH* on Annual Heat Supply (Unit: RMB/GJ)

Item	-10%	-5%	0	5%	10%	Critical Point
Proposed Project 1(a)	79.82	75.62	71.84	68.42	65.31	69.35%
Alternative Baseline 3(i)	45.02	43.65	42.42	41.31	40.31	

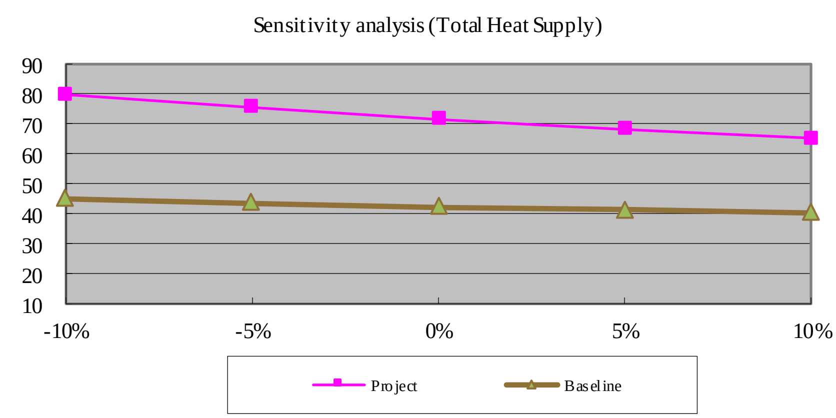

Figure 3-4 Sensitivity Analysis (Annual Heat Supply)

[33] https://www.gszybw.com/gs/shuju/henan/9318.html

When the total heat supply increased by 69.35%, the proposed project becomes financially attractive than alternative 3 (i). However, from the Feasibility Study Report of the project, the capacity load of the geothermal system is fixed, and the heating supply areas are also fixed. There is no possible for the project geothermal system to supply 69.35% more than its installed capacity. The increase in total heat supply by 69.35% is unrealistic.

The sensitivity analysis further confirms that construction of alternative 3 (i) is the most economically attractive option. Compared with the proposed project activity under taken without being registered as a VCS project activity, construction of new coal fired boilers in boiler houses, supplying several buildings through a small heat distribution network is the lowest cost option and is selected as the most economically attractive alternative.

According to the levelized cost of provided heat, alternative 3 (i) is the most economically attractive option. Furthermore, the sensitivity analysis is conclusive and confirms the result of the investment comparison analysis.

Therefore, the lowest levelized cost of provided heat (alternative 3 (i)) is considered as the baseline scenario.

3.5 Additionality

Additionality for the project activity is demonstrated using Tool 02 Combined tool to identify the baseline scenario and demonstrate additionality (Version 07.0). Step 1-3 were already done in section 3.4 of this Report for selection of alternative 1 (a) and 3 (i).

Step 4 Common practice analysis

Step 1: calculate applicable capacity or output range as +/-50% of the total design capacity or output of the proposed project activity.

As above, power projects with the heating load between 56.04 MW-168.12 MW are included in the range of similar projects.

Step 2: identify similar projects (both CDM and non-CDM) which fulfil all of the following conditions:

(a) The projects are located in the applicable geographical area;

Henan Province is selected as the applicable geographical area for the common practice, and the reasons are detailed as follows:

a. Due to the differences of economic development level, population size, industrial structure, fundamental infrastructure, strategic planning etc, the investment environment of each province in China varies widely. All of these factors can affect the final investment decision;

b. The unique geological conditions in Henan Province results in the different natural resources, such as geothermal resource, compared to the other provinces in north China that must supply space heating service in winter time;

c. Finally, many key economic factors of power generation projects vary from province to province, including the tariff rates, the cost of labor and services, and the types of loan that can be obtained. These all vary between provinces.

In summary, the space heating projects within the same province are selected for the common practice analysis.

(b) The projects apply the same measure as the proposed project activity.

Geothermal based space heating system should be used.

(c) The projects use the same energy source/fuel and feedstock as the proposed project activity if a technology switch measure is implemented by the proposed project activity.

Geothermal energy should be used in cascade levels. The heat exchanger medium can be water or air.

Besides, the following conditions should also be fulfilled:

(d) The plants in which the projects are implemented produce goods or services with comparable quality, properties and applications areas (e.g., clinker) as the proposed project plant.

(e) The capacity or output of the projects is within the applicable capacity or output range calculated in Step 1.

(f) The projects started commercial operation before the project design document is published for global stakeholder consultation or before the start date of proposed project activity, which ever is earlier for the proposed project activity.

Based on above analysis, similar projects are all geothermal based space heating system in Henan province that deliver the same output or capacity as calculated in step 1 (range of 56.04 MW-168.12 MW), use the same energy source/fuel and feedstock as the proposed project activity and have started commercial operation before the start date of the project (15/11/2021).

Through searching UNFCC website、China CDM website、China CER exchange info-platform、GS website、VCS、local DRC (Development and Reform Commission) of Henan province website, there are two similar projects:

No.	Project Name	Heating Area (thousand m^2)	Heating Load (MW)	Project Type

1	Taishan Geothermal Central Heating System	2,480.907 (Residential) 94.516 (Commercial)	116.84	GS
2	Jinquan Geothermal Based Space Heating System	1,247.260 (Residential)	62.363	VCS

Step 3: within the projects identified in Step 2, identify those that are neither registered CDM project activities, project activities submitted for registration, nor project activities undergoing validation. Note their number, N_{all}=0.

Step 4: within similar projects identified in Step 3, identify those that apply technologies that are different to the technology applied in the proposed project activity. Note their number N_{diff}.

In summary, N_{all}=0, N_{diff}=0.

Step 5: calculate factor $F=1-N_{diff}/N_{all}$ representing the share of similar projects (penetration rate of the measure/technology) using a measure/technology similar to the measure/technology used in the proposed project activity that deliver the same output or capacity as the proposed project activity.

$F=1-N_{diff}/N_{all}=0-0=0<0.2$

$N_{all} - N_{diff} = 0<3$

As per paragraph 18 of Tool 24 Common practice (Version 03.1), the proposed project activity is not a “common practice” within a sector in the applicable geographical area. As per paragraph 40 of Tool 02 Combined tool to identify the baseline scenario and demonstrate additionality (Version 07.0), the project activity is additional.

3.6 Methodology Deviations

There is no methodology deviation for the project.

4 IMPLEMENTATION STATUS

4.1 Implementation Status of the Project Activity

Full operation of the project are scheduled on 15/11/2023. The whole project can supply geothermal heat to 3,736.1 thousand m^2 of residential buildings with a total heating load of 112.08 MW. The heating load of different sub-areas is calculated based on the heating area. The residential area where the project located is newly built, so it is affected not only by the residential construction period, but also by the actual occupancy rate.

The project has started to heat 1,927.91 thousand m^2 of residential buildings with the occupancy rate of 62.65% from 15/11/2021 - 21/03/2022, has started to heat 611.38 thousand m^2 more of residential buildings, totaling 2,539.30 thousand m^2 with the occupancy rate of 57.87% from 15/11/2022 - 18/03/2023, which leads to the actual heating area and load in the first monitoring period being smaller than the design value.

For the monitoring period from 15/11/2021 to 14/11/2022, 1,207.8 thousand m^2 of residential buildings with a heating load of 36.23 MW, generating an actual emission reduction of 31,074 tCO_2e. For the monitoring period from 15/11/2022 - 18/03/2023, 1,469.5 thousand m^2 of residential buildings with a heating load of 44.08 MW, generating an actual Emission reduction of 36,546 tCO_2e.

From the operation start date (15/11/2021) of this project activity to the end of this monitoring period (18/03/2023), the project has achieved cumulative GHG emission reductions of 67,621 tCO_2e.

5 ESTIMATED GHG EMISSION REDUCTIONS AND REMOVALS

5.1 Baseline Emissions

As per section 5.1 of this Report, the project reduces CO_2 emissions using geothermal heat to replace heat generated from the coal-fired isolated district heating system. As per paragraph 39 of the applied methodology, there are three possibilities for the baseline as follows:

(a) Baseline scenario is identified as a fossil fuel based centralized heat supply system, different than cogeneration, using a single decentralized heat supply fossil fuel technology.

(b) The baseline scenario, is a fossil fuel based decentralized heat supply system with multiple technologies (of type *i*), the baseline emissions are specified as the summation over the technology suffix *i*;

(c) The baseline scenario is identified as a combination of the two following alternatives:

(i) Fossil fuel based centralized heat supply systems, different than cogeneration, using a single decentralized heat supply fossil fuel technology (as described in baseline scenario a above); and

(ii) Existing geothermal centralized heat supply systems.

For the proposed project, the baseline scenario is the establishment of new isolated districtheating networks using isolated coal-fired boilers in boiler houses. Therefore, it falls into (a) of the above categories, and the baseline emissions BE_y in a year y are calculated as:

$$BE_y = \sum_{i} (HS^{BL}{}_{i,y}) \times EF_{CO2,i} / \eta_{BL,i} \tag{2}$$

Where:

BE_y	=	The baseline emissions from heat displaced by the project activity during the year y (t CO_2e/yr).
$EF_{CO2,i}$	=	The CO_2 emission factor per unit of energy of the fuel of technology *i* that would have been used in the baseline heating technology in (t CO_2/TJ). Where several fuel types are used in the boiler, use the fuel type with the lowest CO_2 emission factor.
$\eta_{BL,i}$	=	The net thermal efficiency of the heating technology *i* using fossil fuel that would have been used in the absence of the project activity.
$HS^{BL}{}_{i,y}$	=	The net output of heat generated by the baseline heat supply system using the technology *i* measured at the end point of the heat facility, during the year y (TJ/yr).

Relationship between the baseline scenario and the project activity

The relationship between the baseline scenario and the project activity that the heat demand at the end-use points is the same. For project activities that involve new heating systems:

$$HS_y \text{ - } Loss^{PJ}{}_y = \sum_{i} HS^{BL}{}_{i,y} \text{ - } Loss^{BL}{}_y \tag{3}$$

Where:

HS_y	=	Net quantity of heat supplied by the geothermal heat resource(s) in the project activity, during the year y (TJ/yr).
$Loss^{PJ}{}_y$	=	The net distribution losses of the geothermal heat supply system during the year y (TJ/yr).
$Loss^{BL}{}_y$	=	The net distribution losses of the heat supply system, in the absence of project activity, during the year y (TJ/yr).

Procedure to determine the heat generated by technology i ($HS^{BL}{}_{i,y}$)

$$HS^{BL}{}_{i,y} = w_i \times \left(HS_y - Loss^{PJ}{}_y + Loss^{BL}{}_y\right) \tag{4}$$

Where:

$HS^{BL}{}_{i,y}$	=	The net output of heat generated by the baseline heat supply system using the technology *i* measured at the end point of the heat facility, during the year y (TJ/yr).

w_i	=	Assign weights for heat generated by technology *i*. As per section 3.4 of this report, the baseline scenario of the project is 3(i) "Coal fired boilers in boiler houses, supplying several buildings through a heat distribution network". Only one technology will be used. As per paragraph 51(a)(ii) option 2 Assign weights based on available historical records of *AM0072* (Version 03.0), w_i is equal to 1.
HS_y	=	Net quantity of heat supplied by the geothermal heat resource(s) in the project activity, during the year y (TJ/yr).
$Loss^{PJ}_y$	=	The net distribution losses of the geothermal heat supply system during the year y (TJ/yr).
$Loss^{BL}_y$	=	The net distribution losses of the heat supply system, in the absence of project activity, during the year y (TJ/yr).

The parameters used for calculating baseline emissions can be grouped as ex ante measurement and ex post measurement categories.

Ex ante measurement parameters

(a) $\eta_{BL,i}$;

(b) $EF_{CO2,i}$;

(c) $Loss^{BL}_y$.

Ex post measurement parameters

(a) HS_y;

(b) $Loss^{PJ}_y$.

Step 1: Determine the baseline ex ante parameters of the project

Sub-step 1.a: For each identified technology *i*, efficiency of the baseline units shall be determined by adopting one of the following criteria:

The net thermal efficiency of the fossil fuel technology *i* ($\eta_{BL,i}$) remains fixed for the duration of the crediting period.

Project participants will determine $\eta_{BL,i}$ based on historical data of fuel consumption and output energy. In the case that actual baseline data for a boiler at the project activity site is not available, the following data can be used (from highest to lowest priority):

(a) Actual measurements of thermal efficiency and adjusted for conservativeness (project participants shall select (and justify) the appropriate conservativeness factor from the Table 3 below). Methods from recognized international standards shall be used to determine thermal efficiency, and uncertainty estimated (as directed in the standard). This uncertainty level shall be used to select the appropriate conservativeness factor from the table. For example, an uncertainty of 40 percent would mean that the project participant must multiply the baseline thermal efficiency by 1.12;

The boilers do not actually exist but would only exist in the assumed baseline scenario. This option is not applicable.

(b) A conservative thermal efficiency based on other boilers in the region, which are similar to that of the boiler on the project activity site (in terms of age, technology, capacity, etc.). This shall be justified using data and/or published reports. The uncertainty level in this case will be assumed to be greater than 100 percent unless based on assessment of the above data/information an independent expert justifies a lower level of uncertainty. The DOE is to check the credentials of the independent expert at the time of validation and also verify that there is no conflict of interest.

Other boilers used by the buildings in Lankao County were old boilers but the boilers used in the baseline of the proposed project would be new boilers. The efficiency of old boiler is lower than the efficiency of new boiler. Thus, it is not reasonable to use the measured efficiency (lower value) of old boiler instead of the efficiency (higher) of new boiler in the calculation of the baseline emission, which is not conservative. This option is not applicable.

(c) The highest efficiency value provided by two or more manufacturers for units with similar specifications;

Two manufacturers of coal-fired boiler were checked, and the efficiencies of their products were from 79% to 85%[34]. Thus, the highest efficiency value provided by the two manufacturers is 85%.

(d) Use the default values from Table 4 of AM0072 (Version 03.0)

As per Table 4 Default baseline efficiency for different boilers of AM0072 (Version 03.0), the highest value of 85% for new coal-fired boiler is applicable for the proposed project.

In summary, the efficiency of 85% is applied for the proposed project.

Sub-step 1.b: Fossil fuel emission factors for each identified technology *i*, shall be determined using the following guidelines for data sources

As per Table 5 Data source for fossil fuel emission factors for each identified technology of *AM0072* (Version 03.0), Data source (a) and (b) are unavailable. As discussed in section 5.1 of the report, the boilers are not actually existing and there is no fuel supplier for the baseline coal-fired boilers. Data source (c) can only be used for liquid fuels. Therefore, data source (d) IPCC default values (87.3 tCO_2/TJ for coking coal) at the lower limit of the uncertainty at a 95% confidence interval as provided in table 1.4 of Chapter 1 of Vol.2 (Energy) of 2006 IPCC Guidelines on National GHG Inventories is applied.

[34] Zozen Boiler: 79% https://www.zhongzhengguolu.cn/product/DZL-ran-mei-zheng-qi.html
Xinli Boiler: 82% https://www.kfxlgl.com/product/liantiaolu/dzlmeizhengqi.html
Henan Hengde Boiler: 85% http://www.hengdeguolu.com/221.html#pa

Sub-step 1.c: Baseline Losses ($Loss^{BL}_{i,y}$) for each identified technology *i* shall be determined using the following guidelines

Option 1 A conservative value of 0% of loss is used as historic information is not available.

Step 2: Determine the baseline ex post parameters of the project

Sub-step 2.a: Estimate net quantity of heat supplied by the geothermal heat resource in the project activity

The net quantity of heat supplied by the project activity is estimated based on the heat provided by the geothermal well. It considers flow rates, temperature and usage time for each geothermal well to be considered by the project activity.

$$HS_y = min\{H_{CAP}, HS_{y,estimated}\} \tag{5}$$

$HS_{y,estimated}$ can be determined by the use of the flow and temperature of water supplied by the substation heat exchanger k to the demand side space heating.

$$HS_{y,estimated} = \sum_{j} (Q_{j,d,y} \times T_j \times CF) \tag{6}$$

Where:

$HS_{y,estimated}$	=	Estimated quantity of heat supplied by the geothermal heat resource(s) in the project activity, during the year y (TJ)
$Q_{j,d,y}$	=	Heat supplied at the downstream of heat exchanger (upstream of which is connected with water supply from the geothermal well j) (GW). It can be calculated as formula (7).
T_j	=	Number of hours per year heat utilization at well j.
CF	=	Conversion factor from GWh to TJ (3.6).

$$Q_{j,d,y} = \frac{FR_{j,d,y} \times \Delta t_{j,d,y} \times 4.18}{3.6} \times 10^{-9} \tag{7}$$

Where:

$FR_{j,d,y}$	=	Average flow rate at the downstream of heat exchanger (upstream of which is connected with water supply from the geothermal well j) in year y (kg/hr).
$\Delta t_{j,d,y}$	=	Heat supplied at the downstream of heat exchanger (upstream of which is connected with water supply from the geothermal well j) (°C).

To ensure that the geothermal well is providing the required amount of energy a cap is defined.

The basis to define the cap is from the space heating design, which considers the net heating area, the heating index, the type of construction that will utilize the heat and the time used throughout the year for each construction type.

$$H_{CAP} = (\sum_{m} A_m \times HI_m \times T_j) \times CF + Loss^{PJ}{}_y - H_{ff} \quad (8)$$

Where:

H_{CAP}	=	The net quantity of heat supplied by the geothermal heat resource(s) in the project activity, during the year y (TJ).
A_m	=	Net heating area for construction type m (m²).
HI_m	=	Heating index for construction type m (GW/m²).
T_j	=	Number of hours per year heat utilization at well *j*.
CF	=	Conversion factor from GWh to TJ (3.6).
$Loss^{PJ}{}_y$	=	Heat distribution losses from substation *k* to space heating areas (To be determined in Sub-step 2.b).
H_{ff}	=	Heat supplied by fossil fuel boiler, in case a boiler is used to meet the heat demand of network. No fossil fuel boiler is utilized in the project activity and H_{ff} is 0 TJ.

Sub-step 2.b: Project emissions losses ($Loss^{PJ}{}_y$)

Heat distribution losses will be obtained as the difference between the heat supplied by the geothermal heat source and the aggregated heat demand of the end-use points.

$$Loss^{PJ}{}_y = HS_y - HD_y \quad (9)$$

Where:

HD_y	=	Aggregate space heat demand within the area of supplied heat (TJ).

It is not possible to determine HD_y, the heat losses ($Loss^{PJ}{}_y$) are determined based on heat losses from pipeline, valves, fittings based on maximum of option (a) 10% design heat losses provided by the engineering specifications of the manufacturer of the heat network.

$$Loss^{PJ}{}_y = \sum_{m} 10\% \times A_m \times HI_m \times T_j \times CF \times 10^{-9} \quad (10)$$

Step 3: Calculate baseline emissions from heat produced

Baseline emissions from displacement of fossil fuels are calculated as follows:

$$BE_y = \sum_{i} (HS^{BL}_{i,y} \times EF_{CO2,i} / \eta_{BL,i}) \quad (11)$$

5.2 Project Emissions

Project emissions are calculated taking into consideration fugitive carbon dioxide and methane released from geothermal vents (PE_{FE}), electricity consumption from the use the pumps to extract the geothermal water (PE_{EC}) and fossil fuel used to operate the geothermal facility (PE_{FF}).

$$PE_y = PE_{FE,y} + PE_{EC,y} + PE_{FF,y} \quad (12)$$

Where:

PE_y	=	Project emissions during the year *y* (t CO_2e/yr)
$PE_{FE,y}$	=	Fugitive emissions of carbon dioxide and methane due to release of non-condensable gases from geothermal resources (t CO_2e/yr)
$PE_{EC,y}$	=	Project emissions from additional electricity consumption as a result of the project activity (t CO_2e/yr)
$PE_{FF,y}$	=	Project emissions from fossil fuel consumed as a direct result of the operations of the project activity (t CO_2e/yr)

Step 1: Calculate project emissions from fugitive emissions resulting from non-condensable gases from the geothermal vents during the year *y*

The geothermal system of the proposed project is designed to operate by extracting geothermal water at approximately 72°C, which is considered to be a low-temperature system. As per paragraph 84 of *AM0072* (Version 03.0), fugitive emissions from low temperature geothermal system are considered negligible. Therefore, $PE_{FE,y}$=0 tCO_2.

Step 2: Calculate project emissions from additional electricity consumption as a result of the project activity

Project emissions from electricity consumption (PE_{EC}) used to pump geothermal water and operate the geothermal facility shall be calculated using *Tool 05 Baseline, project and/or leakage emissions from electricity consumption and monitoring of electricity generation* (Version 03.0). Electricity consumption from each relevant source should be monitored and summed up to EC_y.

As per paragraph 16 of *Tool 05* (Version 03.0), project emissions from consumption of electricity are calculated based on the quantity of electricity consumed, an emission factor for electricity generation and a factor to account for transmission losses, as follows:

$$PE_{EC,y} = \sum_{j} EC_{PJ,j,y} \times EF_{EL,j,y} \times (1+TDL_{j,y}) \quad (13)$$

Where:

$PE_{EC,y}$	=	Project emissions from electricity consumption in year y (t CO_2/yr).
$EC_{PJ,j,y}$	=	Quantity of electricity consumed by the project electricity consumption source *j* in year y (MWh/yr).
$EF_{EL,j,y}$	=	Emission factor for electricity generation for source *j* in year y (t CO_2/MWh).
$TDL_{j,y}$	=	Average technical transmission and distribution losses for providing electricity to source *j* in year *y*.

The electricity consumed by facilities of the geothermal system is sourced from local power grid connected to central China Power Grid (CCPG). Scenario A: Electricity consumption from th e grid is applied to the proposed project. For project electricity consumption sources, a default value of 20% is used for $TDL_{j,y}$.

Determination of the emission factor for electricity generation ($EF_{EL,j,y}$)

The determination of the emission factor for generation is performed as per Option A1: Calculate the combined margin emission factor of the applicable electricity system using *Tool to calculate the emission factor for an electricity system* (Version 07.0). $EF_{EL,j,y}$=$EF_{grid,CM,y}$.

The tool determines the CO_2 emission factor for the displacement of electricity generated by power plants in an electricity system, by calculating the “combined margin” emission factor (*CM*) of the electricity system. The *CM* is the result of a weighted average of two emission factors pertaining to the electricity system: the “operating margin” (*OM*) and the “building margin” (*BM*). The operating margin is the emission factor that refers to the group of existing power plants whose current electricity generation would be affected by the proposed project activity. The build margin is the emission factor that refers to the group of power plants whose construction and future operation would be affected by the proposed project activity.

$$EF_{grid,CM,y} = EF_{grid,OM,y} \times \omega_{OM} + EF_{grid,BM,y} \times \omega_{BM} \quad (14)$$

Where:

$EF_{grid,OM,y}$	=	Operating margin CO_2 emission factor in year y, tCO_2/MWh. As per *2019 China regional power grid carbon dioxide baseline emission factor OM calculation instructions* published by Ministry of Ecology and Environment of the People's Republic of China[35], $EF_{grid,OM,y}$= of Central China Power Grid (CCPG) is 0.8587 tCO_2/MWh [36].
$EF_{grid,BM,y}$	=	Building margin CO_2 emission factor in year y, tCO_2/MWh. As per *2019 China regional power grid carbon dioxide baseline emission factor BM calculation instructions* published by Ministry of Ecology and Environment of the People's Republic of China[37], $EF_{grid,BM,y}$= of Central China Power Grid (CCPG) is 0.2854 tCO_2/MWh [38].
ω_{OM}	=	Weighting of operating margin emissions factor. As per paragraph 86(b) of *Tool 07* (Version 07.0), ω_{OM}=0.5 is used for the 1st crediting period.
ω_{BM}	=	Weighting of build margin emissions factor. As per paragraph 86(b) of *Tool 07* (Version 07.0), ω_{BM}=0.5 is used for the 1st crediting period.

Based on formula (14), $EF_{grid,CM,y}$ can be calculated as 0.8587 tCO_2/MWh *0.5+0.2854 tCO_2/MWh *0.5=0.5721 tCO_2/MWh.

Step 3: Calculate project emissions from fossil fuel consumed as a direct result of the operations of the project activity

No fossil fuel will be used to operate the geothermal facilities. Therefore, $PE_{FF,y}$=0 tCO_2.

5.3 Leakage

No leakage emissions have been identified for the project activity. Therefore, LE_y=0 tCO_2.

5.4 Estimated Net GHG Emission Reductions and Removals

Emission reductions are calculated as follows:

$$ER_y = BE_y - PE_y - LE_y \tag{15}$$

Where:

ER_y	=	Emission reductions in year y (t CO_2e/yr).
BE_y	=	Baseline emissions in year y (t CO_2e/yr).
PE_y	=	Project emissions in year y (t CO_2/yr).
LE_y	=	Leakage emissions in year y (t CO_2/yr)

[35] http://www.mee.gov.cn/ywgz/ydqhbh/wsqtkz/202012/W020201229610353816665.pdf
[36] https://www.mee.gov.cn/ywgz/ydqhbh/wsqtkz/202012/W020201229610353340851.pdf
[37] http://www.mee.gov.cn/ywgz/ydqhbh/wsqtkz/202012/W020201229610354442145.pdf
[38] https://www.mee.gov.cn/ywgz/ydqhbh/wsqtkz/202012/W020201229610353340851.pdf

Baseline emissions

As per section 5.1 of the Report, Baseline emissions can be calculated as follows:

$$BE_y = \sum_{\mathrm{i}} (HS^{BL}{}_{i,y}) \times EF_{CO2,i} \,/\, \eta_{BL,i}$$

Where:

$EF_{CO2,i}$	=	The CO_2 emission factor per unit of energy of the fuel of technology *i* that would have been used in the baseline heating technology in (t CO_2/TJ). Where several fuel types are used in the boiler, use the fuel type with the lowest CO_2 emission factor. Values provided by the fuel supplier are unavailable. IPCC default values at the lower limit of the uncertainty at a 95% confidence interval as provided in table 1.4 of Chapter 1 of Vol.2 (Energy) of 2006 IPCC Guidelines on National GHG Inventories are used. For coking coal, it is 87.3 tCO_2/TJ.10[4]
$\eta_{BL,i}$	=	The net thermal efficiency of the heating technology *i* using fossil fuel that would have been used in the absence of the project activity. The highest efficiency of coal-fired boilers provided by Zozen Boilers (79%), Xinli Boiler (82%), Henan Hengde Boiler (85%). As per Table 4 Default baseline efficiency for different boilers of *AM0072* (Version 03.0), the highest value of 85% for new coal-fired boiler is applicable for the proposed project. In summary, the efficiency of 85% is applied for the proposed project.

Relationship between the baseline scenario and the project activity

$$HS_y\text{-}Loss^{PJ}{}_y = \sum_{\mathrm{i}} HS^{BL}{}_{i,y}\text{-}Loss^{BL}{}_y$$

Procedure to determine the heat generated by technology *i* ($HS^{BL}{}_{i,y}$)

$$HS^{BL}{}_{i,y} = w_i \times \left(HS_y - Loss^{PJ}{}_y + Loss^{BL}{}_y\right)$$

Where:

w_i	=	Assign weights for heat generated by technology *i*. As per section 5.1 of this report, the baseline scenario of the project is 3(i) "Coal fired boilers in boiler houses, supplying several buildings through a heat distribution network". Only one technology will be used. As per paragraph 51(a)(ii) option 2 Assign weights based on available historical records of *AM0072* (Version 03.0), w_i is equal to 1.
$Loss^{BL}{}_y$	=	The net distribution losses of the heat supply system, in the absence of project activity, during the year y (TJ/yr). Option 1 A conservative value of 0% of loss is used as historic information is not available.

Estimate net quantity of heat supplied by the geothermal heat resource in the project activity

$$HS_y = min\{H_{CAP}, HS_{y,estimated}\}$$

$$HS_{y,estimated} = \sum_{\mathrm{j}} (Q_{j,d,y} \times T_j \times CF)$$

$$Q_{j,d,y} = \frac{FR_{j,d,y} \times \Delta t_{j,d,y} \times 4.18}{3.6} \times 10^{-9}$$

Where:

T_j	=	Number of hours per year heat utilization at well *j*. As per *Kaifeng City Central Heating Management Measures* published by Kaifeng City Urban Administration, winter heating season of Kaifeng City is usually from November 15 to March 15 of the next year (120 days). Therefore, T_j can be calculated as 120*24=2,880 h.
CF	=	Conversion factor from GWh to TJ (3.6).

Average temperature difference between inlet and outlet temperatures at the downstream of substation heat exchanger ($\Delta t_{j,d,y}$) and average flow rate at the downstream of heat exchanger ($FR_{j,d,y}$) are unavailable. For ex ante estimation, average temperature difference between inlet and outlet temperatures, and average flow rate at upstream of heat exchanger (water supply from the geothermal well *j*) will be used. As per Feasibility Study Report of the project, the average flow rate of the geothermal well is 120 m^3/h (120,000 kg/h)[The density of water is 1,000 kg/m^3.]. The 12 production wells will supply the feed geothermal water at temperature of 72°C to 17 heat substations through primary heating network. The 24 injection wells will receive the return water at temperature of 10°C after secondary heat exchange. Therefore, average temperature difference between inlet and outlet temperatures of the geothermal wells can be calculated as 72°C-10°C=62°C. For ex ante estimation, $HS_{y,estimated}$ can be calculated as follows:

$$HS_{y,estimated} = （120{,}000\mathrm{kg/h} * 62℃ * 4.18/3.6 * 10^{-9} * 2{,}880 * 3.6 * 12）\mathrm{TJ} = 1{,}075\ \mathrm{TJ}$$

$$H_{CAP} = (\sum_{\mathrm{m}} A_m \times HI_m \times T_j) \times CF + Loss^{PJ}{}_y - H_{ff}$$

$$Loss^{PJ}{}_y = \sum_{\mathrm{m}} 10\% \times A_m \times HI_m \times T_j \times CF \times 10^{-9}$$

Where:

A_m	=	Net heating area for construction type m (m^2). Heating area of residential buildings is 3,736.1 thousand m^2.
HI_m	=	Heating index for construction type m (GW/m^2). As per Feasibility Report of the project, HI_m is 30 W/m^2 for residential buildings.
T_j	=	Number of hours per year heat utilization at well *j*. As per *Kaifeng City Central Heating Management Measures* published by Kaifeng City Urban Administration, winter heating season of Kaifeng City is usually from November 15 to March 15 of the next year (120 days). Therefore, T_j can be calculated as 120*24=2,880 h.
CF	=	Conversion factor from GWh to TJ (3.6).
H_{ff}	=	Heat supplied by fossil fuel boiler, in case a boiler is used to meet the heat demand of network. There are no fossil fuel boilers used to meet the heat demand of the project heating network. Therefore, H_{ff}=0 TJ.

The results of HS_y can be summarized as the following table. Refer to the ER calculation sheet for more details.

Sub-area	A_m (m^2) Residential	$Loss^{PJ}_y$ (TJ)	H_{CAP} (TJ)	$HS_{y,estimated}$ (TJ)	HS_y (TJ)
Fenghuangcheng Station	416,731	12.96	142.58	-	-
Gongyuanshoufu Station	447,507	13.92	153.11	-	-
Dongfangyujing Station	271,931	8.46	93.04	-	-
Donghuyiyuan Station	270,013	8.40	92.38	-	-
Qinghuayuan Station	329,986	10.26	112.90	-	-
Xiangxiehuating Station	272,665	8.48	93.29	-	-
Hualancheng Station	360,000	11.20	123.17	-	-
Jiuhaoyuan Station	203,561	6.33	69.65	-	-
Jinxiuyuan Station	240,846	7.49	82.40	-	-
Tianshenggongguan Station	266,807	8.30	91.29	-	-

Qianxizhuangyuan Station	368,232	11.45	125.99	-	-
Yehaowanghu Station	287,821	8.95	98.48	-	-
Total	3,736,100	116	1,278	1,075	1,075

Calculate baseline emissions from heat produced

Baseline emissions can be summarized as the following table. Refer to the ER calculation sheet for more details.

Year	HS_y (TJ)	$Loss^{PJ}_y$ (TJ)	$Loss^{BL}_y$ (TJ)	$HS^{BL}_{i,y}$ (TJ)	BE_y (tCO_2e/yr)
1	1,075	116	0	958.58	98,451
2	1,075	116	0	958.58	98,451
3	1,075	116	0	958.58	98,451
4	1,075	116	0	958.58	98,451
5	1,075	116	0	958.58	98,451
6	1,075	116	0	958.58	98,451
7	1,075	116	0	958.58	98,451
8	1,075	116	0	958.58	98,451
9	1,075	116	0	958.58	98,451
10	1,075	116	0	958.58	98,451

Project emissions

$$PE_y = PE_{FE,y} + PE_{EC,y} + PE_{FF,y}$$

Where:

$PE_{FE,y}$ = Project emissions from fugitive emissions resulting from non-condensable gases from the geothermal vents during the year y (tCO_2). The geothermal system of the proposed project is designed to operate by extracting geothermal water at approximately 72°C, which is considered to be a low-temperature system. As per paragraph 84 of *AM0072* (Version 03.0), fugitive emissions from low temperature geothermal systems are considered negligible. Therefore, $PE_{FE,y}$=0 tCO_2.

$PE_{FF,y}$ = Project emissions from fossil fuel consumed as a direct result of the operations of the project activity. No fossil fuel will be used to operate the geothermal facilities. Therefore, $PE_{FF,y}$=0 tCO_2.

So here is obtained : $PE_y = PE_{FF,y}$.

Calculate project emissions from additional electricity consumption as a result of the project activity

$$PE_{EC,y} = \sum_{j} EC_{PJ,j,y} \times EF_{EL,j,y} \times (1 + TDL_{j,y})$$

Where:

$EF_{EL,j,y}$ = Emission factor for electricity generation for source *j* in year y ($t\ CO_2$/MWh). $EF_{EL,j,y} = EF_{grid,CM,y}$ = 0.5721 tCO_2/MWh.

$TDL_{j,y}$ = Average technical transmission and distribution losses for providing electricity to source *j* in year *y*. The electricity consumed by facilities of the geothermal system is sourced from local power grid connected to central China Power Grid (CCPG). Scenario A: Electricity consumption from the grid is applied to the proposed project. For project electricity consumption sources, a default value of 20% is used for $TDL_{j,y}$.

Estimated quantity of electricity consumed by the project electricity consumption source *j* in year y ($EC_{PJ,j,y}$)

As per *Feasibility Study Report* of the project, estimate of annual electricity consumption of heating space for residential buildings is 25,000 MWh. For ex ante estimation, $EC_{PJ,j,y}$ can be estimated as 25,000 MWh. The actual values will be monitored.

Project emissions can be summarized as the following table. Refer to the ER calculation sheet for more details.

Year	$EC_{PJ,j,y}$ (MWh)	$EF_{EL,j,y}$ (tCO_2/MWh)	($1+TDL_{j,y}$)	$PE_{EC,y}$ (tCO_2e/yr)
1	25,000	0.5721	1.2	17,162
2	25,000	0.5721	1.2	17,162
3	25,000	0.5721	1.2	17,162
4	25,000	0.5721	1.2	17,162
5	25,000	0.5721	1.2	17,162
6	25,000	0.5721	1.2	17,162
7	25,000	0.5721	1.2	17,162

8	25,000	0.5721	1.2	17,162
9	25,000	0.5721	1.2	17,162
10	25,000	0.5721	1.2	17,162

Leakage

No leakage emissions have been identified for the project activity. Therefore, LE_y=0 tCO_2.

Emission reductions

$ER_y = BE_y - PE_y - LE_y$ = (98,451 - 17,162) tCO_2e/yr = 81,289 tCO_2e/yr (average)

Year	Estimated baseline emissions or removals (tCO_2e)	Estimated project emissions or removals (tCO_2e)	Estimated leakage emissions (tCO_2e)	Estimated net GHG emission reductions or removals (tCO_2e)
15/11/2021-14/11/2022	98,451	17,162	0	81,289
15/11/2022-14/11/2023	98,451	17,162	0	81,289
15/11/2023-14/11/2024	98,451	17,162	0	81,289
15/11/2024-14/11/2025	98,451	17,162	0	81,289
15/11/2025-14/11/2026	98,451	17,162	0	81,289
15/11/2026-14/11/2027	98,451	17,162	0	81,289
15/11/2027-14/11/2028	98,451	17,162	0	81,289
15/11/2028-14/11/2029	98,451	17,162	0	81,289
15/11/2029-14/11/2030	98,451	17,162	0	81,289
15/11/2030-14/11/2031	98,451	17,162	0	81,289
Total	984,510	171,620	0	812,890

6 MONITORING

6.1 Data and Parameters Available at Validation

Data / Parameter	$EF_{CO2,i}$
Data unit	tCO_2/TJ
Description	The CO_2 emission factor per unit of energy of the fuel of technology *i* that would have been used in the baseline heating technology.
Source of data	Option (d) IPCC default values at the lower limit of the uncertainty at a 95% confidence interval as provided in table 1.4 of Chapter 1 of Vol.2 (Energy) of 2006 IPCC Guidelines on National GHG Inventories is used as per Table 5 of the applied methodology *AM0072* (Version 03.0).
Value applied	87.3
Justification of choice of data or description of measurement methods and procedures applied	Values provided by the fuel supplier are unavailable. IPCC default values at the lower limit of the uncertainty at a 95% confidence interval as provided in table 1.4 of Chapter 1 of Vol.2 (Energy) of 2006 IPCC Guidelines on National GHG Inventories are used. For coking coal, it is 87.3 tCO_2/TJ.
Purpose of Data	To calculate baseline emissions
Comments	Where several fuel types are used in the boiler, use the fuel type with the lowest CO_2 emission factor.

Data / Parameter	$\eta_{BL,i}$
Data unit	Dimensionless
Description	Net thermal efficiency of the boiler technology *i* using fossil fuel that would have been used in the absence of the project activity.
Source of data	Follow the guidance given in the applied methodology *AM0072* (Version 03.0).
Value applied	85
Justification of choice of data or description of measurement methods and procedures applied	The highest efficiency of coal-fired boilers provided by Zozen Boilers (79%), Xinli Boiler (82%), Henan Hengde Boiler (85%). As per Table 4 Default baseline efficiency for different boilers of *AM0072* (Version 03.0), the highest value of 85% for new coal-fired boiler is applicable for the proposed project. In summary, the efficiency of 85% is applied for the proposed project.

Purpose of Data	To calculate baseline emissions
Comments	N/A

Data / Parameter	$Loss^{BL}_{i,y}$
Data unit	TJ/yr
Description	The net distribution losses of the heat supply system, in the absence of project activity, during the year *y*.
Source of data	Section 5.4.6.3 of *AM0072* (Version 03.0).
Value applied	0
Justification of choice of data or description of measurement methods and procedures applied	The historic information is not available, a conservative value of 0% of losses can be used as per paragraph 66 option 1 of *AM0072* (Version 03.0).
Purpose of Data	To calculate baseline emissions
Comments	N/A

Data / Parameter	*Subscript i*
Data unit	-
Description	Type of technology used in the baseline scenario.
Source of data	*Feasibility Study Report* of the proposed project
Value applied	Coal fired boilers in boiler houses, supplying several buildings through a heat distribution network.
Justification of choice of data or description of measurement methods and procedures applied	As per section 5.2 of *AM0072 Fossil Fuel Displacement by Geothermal Resources for Space Heating* (Version 03.0), the most plausible baseline scenario shall be determined through the use of *Tool 02 Combined tool to identify the baseline scenario and demonstrate additionality* (Version 07.0). Heat supply system using coal-fired boilers is identified as the baseline scenario of the proposed project activity.
Purpose of Data	To calculate baseline emissions
Comments	Data shall be stored in an excel sheet/database

Data / Parameter	*Subscript j*
Data unit	-
Description	Geothermal well number.
Source of data	*Feasibility Study Report* of the proposed project
Value applied	Geothermal wells number j = 1 to 36.
Justification of choice of data or description of measurement methods and procedures applied	There are a total of 36 geothermal wells including 12 production wells and 24 injection wells in the boundary of the proposed project activity as per *Feasibility Study Report*, which can be identified through unique identification code.
Purpose of Data	To calculate baseline emissions
Comments	Distinct geothermal well with distinct properties of temperature, pressure and flow volume.

Data / Parameter	*Subscript m*
Data unit	-
Description	Space heating construction type
Source of data	*Feasibility Study Report* of the proposed project
Value applied	Residential
Justification of choice of data or description of measurement methods and procedures applied	Identified by local urban planners under a short to medium term development plan for the area.
Purpose of Data	To calculate baseline emissions
Comments	Areas designated for space heating under the categories of residential, commercial and industrial space heat

Data / Parameter	*Subscript k*
Data unit	-
Description	Sub-station number
Source of data	*Feasibility Study Report* of the proposed project
Value applied	Sub-station number k=1 to 17

Justification of choice of data or description of measurement methods and procedures applied	There is a total of 17 sub-stations in the boundary of the proposed project activity.
Purpose of Data	To calculate baseline emissions
Comments	Includes a heat exchanger as part of the sub-station.

Data / Parameter	$Loss^{PJ}_{y}$
Data unit	TJ/yr
Description	Net distribution loss of the geothermal heat supply system during the year *y*.
Source of data	Calculated based on design heat losses from heat network manufacturer per the methodology.
Value applied	Refer to ER calculation sheet for more details.
Justification of choice of data or description of measurement methods and procedures applied	$Loss^{PJ}_{y} = \sum_{m} 10\% \times A_m \times HI_m \times T_j \times CF \times 10^{-9}$ Where: A_m=Net heating area for construction type *m* HI_m=Heating index for construction type *m* T_j=Hours per hear heat utilization in well *j* *CF*=Conversion factor from GWh to TJ (3.6).
Purpose of Data	To calculate baseline emissions
Comments	N/A

Data / Parameter	w_i
Data unit	-
Description	Heat generation ratio for baseline heating technology *i*
Source of data	Paragraph 51(a)(ii) option 2 Assign weights based on available historical records of *AM0072* (Version 03.0).
Value applied	1
Justification of choice of data or description of measurement methods and procedures applied	As per section 5.1 of this report, the baseline scenario of the project is 3(i) “Coal fired boilers in boiler houses, supplying several buildings through a heat distribution network”. Only one technology would be used. As per paragraph 51(a)(ii) option 2 Assign weights based on available historical records of *AM0072* (Version 03.0), w_i is equal to 1.

Purpose of Data	To calculate baseline emissions
Comments	N/A

Data / Parameter	H_{ff}
Data unit	TJ
Description	Heat supplied by fossil fuel boiler, in case a boiler is used to meet the heat demand of network.
Source of data	On site metering of heat (e.g. flow of steam/hot water multiplied by enthalpy) at the outlet of the boiler.
Value applied	There are no fossil fuel boilers used to meet the heat demand of the project heating network. Therefore, H_{ff}=0 TJ.
Justification of choice of data or description of measurement methods and procedures applied	-
Purpose of Data	To calculate baseline emissions
Comments	Yearly average data to be used

Data / Parameter	$EF_{EL,j,y}$ ($EF_{grid,CM,y}$)
Data unit	tCO_2/MWh
Description	Combined margin emission factor for the grid in year y.
Source of data	Calculate the combined margin emission factor, using the procedures in *Tool 07 Tool to calculate the emission factor for an electricity system* (Version 07.0). The data of $EF_{grid,OM,y}$ and $EF_{grid,BM,y}$ are from *Baseline emission factors of China's regional power grid for emission reduction projects in 2019* published by Ministry of Ecology and Environment of the People's Republic of China.
Value applied	0.5721 (=0.8587*0.5+0.2854*0.5)
Justification of choice of data or description of measurement methods and procedures applied	As per *Tool 07 Tool to calculate the emission factor for an electricity system* (Version 07.0).
Purpose of Data	To calculate project emissions
Comments	-

Data / Parameter	$TDL_{j,y}$
Data unit	-
Description	Average technical transmission and distribution losses for providing electricity to source *j* in year *y*.
Source of data	In case of scenario B and scenario C, case C.II, assume $TDL_{j,y}$=0 as a simplification. In case of other scenarios (scenario A and scenario C, cases C.I and C.III), choose one of the following options: 1. Use annual average value based on the most recent data available within the host country; 2. Use as default values of 20% for: (a) project or leakage electricity consumption sources; (b) baseline electricity consumption sources if the electricity consumption by all project and leakage electricity consumption sources to which scenario A or scenario C (cases C.I or C.III) applies is larger than the electricity consumption of all baseline electricity consumption sources to which scenario A or scenario C (cases C.I or C.III) applies; 3. Use as default values of 3% for: (a) baseline electricity consumption sources; (b) project and leakage electricity consumption sources if the electricity consumption by all project and leakage electricity consumption sources to which scenario A or scenario C (cases C.I or C.III) applies is smaller than the electricity consumption of all baseline electricity consumption sources to which scenario A or scenario C (cases C.I or C.III) applies.
Value applied	20%
Justification of choice of data or description of measurement methods and procedures applied	Scenario A: Electricity consumption from the grid is applied to the proposed project. For project electricity consumption sources, a default value of 20% is used for $TDL_{j,y}$.
Purpose of Data	To calculate project emissions
Comments	-

6.2 Data and Parameters Monitored

Data / Parameter	$\Delta t_{j,d,y}$
Data unit	°C

Description	Average temperature difference between inlet and outlet temperatures at the downstream of each heat exchanger in year *y*.
Source of data	Bimetallic thermometer installed at downstream inlet and outlet points of each heat exchanger.
Description of measurement methods and procedures to be applied	Outlet temperature minus inlet temperature at the downstream of each heat exchanger *j*. All the temperature data are measured by the bimetallic thermometer installed at downstream inlet and outlet points of each heat exchanger. Inlet and outlet temperatures at the downstream of each heat exchanger are monitored by the bimetallic thermometer. There are 12 production wells and 24 re-injection wells. There are totally 17 sets of heat exchange system. At least 34 bimetallic thermometers are needed to monitor the inlet and outlet temperatures of all the heat exchange system. Refer to Figure 6-2 of the Joint-PD-MR for more details on installation and configuration of the bimetallic thermometer. The bimetallic thermometer can monitor the inlet and outlet temperature of each heat exchange system continuously and record the temperature data per hour. All the hourly temperature data are exported by the VCS monitoring team to form the monthly record at the beginning of the next month. The average daily inlet and outlet temperature are calculated based on the 24-hourly temperature data separately. The average monthly inlet and outlet temperature are calculated based on all the daily inlet and outlet temperature of this month. Finally, the operation record of the geothermal heating system during the related heating season are summarized by all the monthly record.
Frequency of monitoring/recording	Measured Hourly/Recording Monthly
Value applied	Average temperature difference between inlet and outlet temperatures at the downstream of substation heat exchanger is unavailable. For ex ante estimation, average temperature difference between inlet and outlet temperatures was used. As per Feasibility Study Report of the project, the 12 production wells will supply the feed geothermal water at temperature of 72°C to 17 heat substations through primary heating network. The 24 re-injection wells will receive the return water at temperature of 10°C after secondary heat exchange. Therefore, average temperature difference between inlet and outlet temperatures of the geothermal wells can be calculated as 72°C-10°C=62°C.
Monitoring equipment	Bimetallic thermometer
QA/QC procedures to be applied	Calibration of the bimetallic thermometer will be done according to national standard by qualified organizations.

	There were no missing data or damaged data during the 1st monitoring period. The average temperature change of the 17 heat exchange system of the 2021-2022 heating season (8.01°C), 2022-2023 heating season (8.02°C) are cross checked by the design temperature difference of the end-user (7-9°C). As per feedback from the space heating experts at the project site, average temperature change of the 17 heat exchange system of the Lankao geothermal heating system is about 8°C.
Purpose of data	To calculate baseline emissions
Calculation method	-
Comments	The heat exchanger should handle the heat supplied by geothermal well only and not by any other source. The temperature readings should be taken at immediate inlet and outlet point of heat exchanger.

Data / Parameter	$FR_{j,d,y}$
Data unit	kg/h
Description	Average flow rate at the downstream of each heat exchanger (upstream of which is connected with water supply from the geothermal well *j*) in year *y*.
Source of data	Electromagnetic Flowmeters
Description of measurement methods and procedures to be applied	Readings taken from Ultrasonic calorimeters installed at downstream of each heat exchanger. Average flow rate at the downstream of each heat exchanger are monitored by electromagnetic flowmeter. Refer to Figure 6-2 of the Joint-PD-MR for more details on installation and configuration of the electromagnetic flowmeters. The electromagnetic flowmeters can monitor the volume flow rate of each heat exchange system continuously and record it per hour. All the hourly volume flow rate data were exported by the VCS monitoring team to form the monthly record at the beginning of the next month. The average daily volume flow rate was calculated based on the 24-hourly data. The average monthly volume flow rate was calculated based on all the daily data of this month. Finally, the operation record of the geothermal heating system during the related heating season were summarized by all the monthly record. Density of the water is 1,000 kg/m^3. Mass flow can be calculated as volume flow rate times density of water.
Frequency of monitoring/recording	Measured Hourly/Recording Monthly

Value applied	Average flow rate at the downstream of heat exchanger is unavailable. For ex ante estimation, average flow rate at upstream of heat exchanger (water supply from the geothermal well j) was used. As per Feasibility Study Report of the project, the average flow rate of the geothermal well is 120 m^3/h (120,000 kg/h)
Monitoring equipment	Electromagnetic flowmeters
QA/QC procedures to be applied	Calibration of the electromagnetic flowmeters will be done according to national standard by qualified organizations. There were no missing data or damaged data during the 1st monitoring period. The average volume flow rate of the 17 heat exchange system of the 2021-2022 heating season (331.99 m^3/h), 2022-2023 heating season (352.28 m^3/h) were cross checked by the rated flow of the circulating pumps, refer to Table 1-1 of the for more details.
Purpose of data	To calculate baseline emissions
Calculation method	-
Comments	The heat exchanger should handle the heat supplied by geothermal well only and not by any other source.

Data / Parameter	T_j
Data unit	Hours
Description	Hours per hear heat utilization in well *j*.
Source of data	Operation record of the geothermal based space heating system
Description of measurement methods and procedures to be applied	The actual number of heating hours are sourced from the statistical data of the geothermal base space heating system. As per *Kaifeng City Central Heating Management Measures* [39] published by Kaifeng City Urban Administration, winter heating season of Kaifeng City is usually from November 15 to March 31 of the next year (120 days). Therefore, T_j can be calculated as 120*24=2,880 h.
Frequency of monitoring/recording	Monthly
Value applied	The actual number of heating hours are sourced from operation record of the geothermal based space heating system. Monthly operation time of the 17 heat exchange systems were exported by the VCS monitoring team at the beginning of the next month. The operation record of the geothermal heating system

[39] https://www.kaifeng.gov.cn/sitegroup/root/html/8a28897b41c403ec0141c41c883b00c8/ed8c81d3259842f99522 46b306e10121.html

	during the related heating season were summarized by all the monthly record. 3024h (126 days*24h) during 2021-2022 heating season (2021/11/15 – 2022/03/21). 2952h (123 days*24h) during 2022-2023 heating season (2022/11/15 – 2023/03/18).
Monitoring equipment	-
QA/QC procedures to be applied	Time given for heating services provided will be measured. The measured data shall be cross-checked against *Kaifeng City Central Heating Management Measures* published by Kaifeng City Urban Administration.
Purpose of data	To calculate baseline emissions
Calculation method	-
Comments	NA.

Data / Parameter	HI_m
Data unit	W/m²
Description	Heating index for construction type *m*.
Source of data	The conservative standard index for construction type *m* as provided by Feasibility Report of the project
Description of measurement methods and procedures to be applied	-
Frequency of monitoring/recording	-
Value applied	30 W/m² for residential buildings.
Monitoring equipment	-
QA/QC procedures to be applied	Data to be validated by space heating experts at the project site.
Purpose of data	To calculate baseline emissions
Calculation method	-
Comments	-

Data / Parameter	$EC_{PJ,j,y}$ (EC_y)
Data unit	MWh
Description	Electricity consumption for the year *y* in operating the geothermal heating system.
Source of data	Electricity meters.
Description of measurement methods and procedures to be applied	Electricity consumptions of the geothermal heating system are monitored by the electricity meters installed at the State Grid Lankao County Power Supply Company. Before test run of the whole geothermal space heating system, base number of at least 17 electricity meters are recorded by the staff of the State Grid Lankao County Power Supply Company and VCS monitoring team under the supervision of the representative of each sub-area. At the end of each heating month, the VCS monitoring team records readings of the electricity meters, which can calculate the electricity consumption of this month by minus last month's base number of meters. The operation record of the geothermal heating system during the related heating season were summarized by all the monthly record. Electricity settlement agreement was signed between the state Grid Lankao County Power Supply Company. At the end of each heating month, the state Grid Lankao County Power Supply Company prepares electricity bill to the project owner for confirmation, which contains the user number, the user's name, the address of electricity consumption, the total monthly electricity consumption, the total monthly electricity cost and meter reading record. The project owner pay the bill and payment receipt would be provided by the state Grid Lankao County Power Supply Company.
Frequency of monitoring/recording	Measured Hourly/Recording Monthly
Value applied	25,000 MWh. For ex ante estimation, the data is from *Feasibility Study Report* of the project. The actual electricity consumption will be monitored.
Monitoring equipment	Electricity meters. Calibration of the electricity meters will be done by the state Grid Lankao County Power Supply Company.
QA/QC procedures to be applied	The electricity meters are calibrated by the state Grid Lankao County Power Supply Company. There were no missing data or damaged data during the 1st monitoring period. All the electricity consumption data was cross checked with the electricity bill confirmed by the state Grid Lankao County Power Supply Company and payment receipt of the geothermal heating system.

Purpose of data	To calculate project emissions
Calculation method	-
Comments	-

Data / Parameter	A_m
Data unit	m^2
Description	Net heating area for construction type *m*.
Source of data	For ex ante estimation, the data is from *Feasibility Study Report* of the project. Actual measurements may also be available from heating supply contracts.
Description of measurement methods and procedures to be applied	Yearly measurement.
Frequency of monitoring/recording	Yearly
Value applied	3,736.1 thousand m^2 for residential buildings.
Monitoring equipment	-
QA/QC procedures to be applied	The data shall be cross-checked with local development plan and operational data of the project geothermal heating system.
Purpose of data	To calculate baseline emissions
Calculation method	-
Comments	-

6.3 Monitoring Plan

The monitoring plan presented in this Joint-PD-MR assures that real, measurable, long term GHG emission reductions can be monitored, recorded, and reported. It is a crucial procedure to identify the final VCUs of the project. This monitoring plan will be implemented by the project owner during the project operation. The details of the monitoring plan are specified as follows:

Parameters to be monitored

The monitoring requirements for this methodology include the monitoring of parameters for both baseline and project emissions calculations. All provisions in the methodology and relevant tools shall apply, as described for each parameter in section 6.2 of the Report.

For the parameters of A_m, net heating area for construction type m (A_m) will be determined based on heating supply contracts.

Heating index for construction type m (HI_m) is sourced from the conservative standard index as provided by the FSR. The values should be updated according to the latest national and local standards. Local standards take precedence over national standards.

Hours per hear heat utilization in well j (T_j) will be sourced from data logged in the Geothermal plant (Operation Record of the Geothermal Space Heating System). The winter heating season is fixed by local regulations, which is usually from November 15 to March 15 of the next year (120 days). The actual number of heating hours are sourced from operation record of the geothermal based space heating system.

Monitoring framework

Above all, the monitoring system only need to address the monitoring of parameter $\Delta t_{j,d,y}$, $FR_{j,d,y}$ and $EC_{PJ,j,y}$ (EC_y). Figure 6-1 below outlines the organization structure of the monitoring system for the related three parameters. The project owner will be responsible for the whole monitoring work. The VCS monitoring team will be responsible for the monitoring of all the parameters to be monitored. All the data will be reviewed by the project developer and VVB.

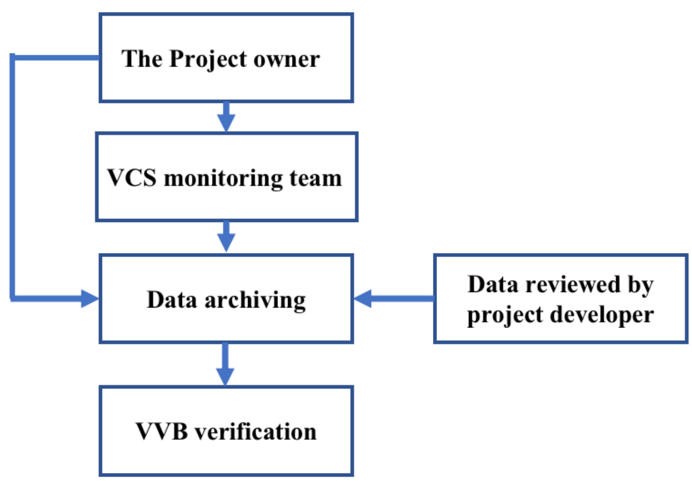

Figure 6-1 Organization Structure of the Monitoring Team

Principle of Monitoring

All heat supplied to end-users shall be measured at each substation *k* as part of the monitoring plan. For each isolated district heating network connected to a heat exchange station (*k*), the quantity of heat supplied should be measured continuously.

Meters shall be installed in a manner that ensures that only the quantity of heat supplied for space heating purposes and supplied by geothermal well *j* is metered. Besides, the meters shall be installed in a manner that ensures that metering of flow conditions at the heat exchanger be satisfied.

If point of heat measurement is changed or added during the crediting period, this should be documented transparently in the monitoring reports, and the procedure for post registration changes shall be followed.

Monitoring equipment and installation

Installation and configuration of meters are shown as Figure 6-2. In order to ensure measurements with a low degree of uncertainty, the data metering equipment and gauges will be calibrated and checked by an appropriately qualified third party according to an appropriate national standard. The calibration records will be appropriately maintained and made available for review by VVB.

The point of heat measurement was not changed or added during the 1st monitoring period.

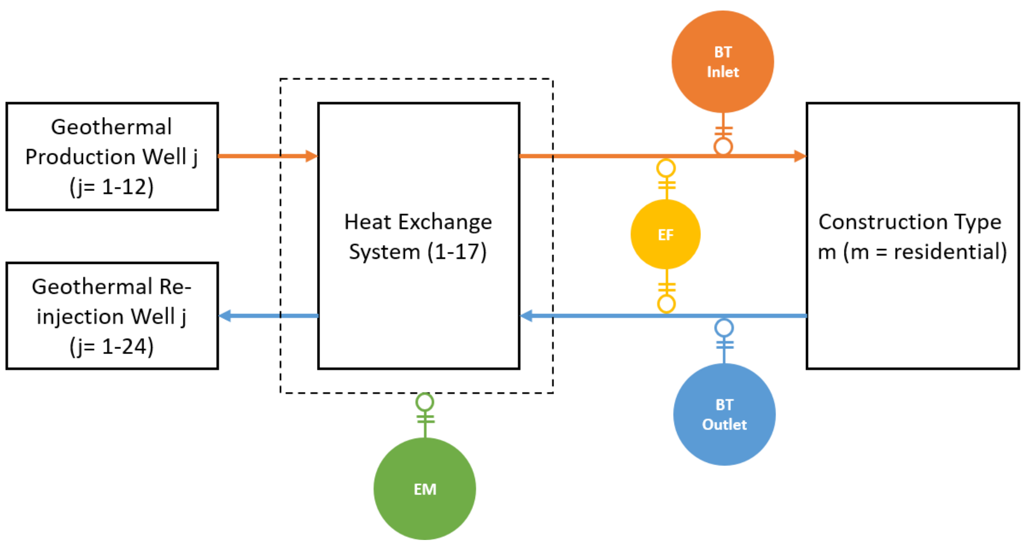

Figure 6-2 Installation and Configuration of Meters

EM: Electricity meters installed at the State Grid Lankao County Power Supply Company

BT Outlet: Bimetallic thermometer installed at downstream of each heat exchange system to monitor the supply water temperature from the geothermal heating system.

BT Inlet: Bimetallic thermometer installed at downstream of each heat exchange system to monitor the supply water temperature from the end users.

EF: Electromagnetic flowmeter installed at downstream of each heat exchange system to monitor the flow rate.

Quality control and quality assurance procedures

A quality management system will be established, which ensures the quality and accuracy of the measured data.

Training

For all members involved in the project, necessary trainings will be provided by the project owner. Besides, the project owner should ensure that only skilled employees are allowed to undertake the monitoring work. The training contents should be regard to the general and technical aspects of the project to the extent appropriate, as well as basic understandings of VCS Standard and climate change.

Data management

All data collected as part of monitoring plan should be saved with at least 1 backup copy until the end of the crediting period. After the crediting period ends, the data should be archived electronically on hard disks and be kept at least 2 years after the end of the last crediting period.

Corrective actions

The whole VCS monitoring team will follow recognized standard data evaluation methods to guarantee that the data is reliable and accurate. The quality control and quality assurance procedures include the handling and correction of nonconformities in the implementation of the project or the monitoring plan. In case such nonconformities are observed:

a. An analysis of the nonconformity and its causes will be carried out immediately by the project owner, with the help of external experts if necessary.

b. A corrective action plan should then be developed to eliminate the nonconformity and its causes to prevent its recurrence.

c. Corrective actions are implemented and reported back to the VCS monitoring team.

Relative information will be included in the monitoring report and reported to VVB during the verification.

- For conservativeness, 0 value will be used for the missing data of $\Delta t_{j,d,y}$ and $FR_{j,d,y}$.

- For $EC_{PJ,j,y}$ (EC_y), average monthly electricity consumption in the Joint-PD-MR or average electricity consumption of the previous months whichever is higher will be used for missing data. This is the most conservative approach.

7 QUANTIFICATION OF GHG EMISSION REDUCTIONS AND REMOVALS

7.1 Data and Parameters Monitored

Data / Parameter	$\Delta t_{j,d,y}$
Data unit	℃
Description	Average temperature difference between inlet and outlet temperatures at the downstream of each heat exchanger in year *y*.
Value applied:	15/11/2021 - 21/03/2022

Sub-areas	Heat-Substations	Nov-21	Dec-21	Jan-22	Feb-22	Mar-22
Fenghuangcheng Station	1#FHC	7.53	7.33	7.42	8.29	8.87
	2#FHC	7.60	8.23	8.16	8.08	7.63
	3#FHC	8.79	8.31	8.14	7.99	8.41
	4#FHC	constructing				
Gongyuanshoufu Station	1#GYSF	8.68	9.16	8.54	7.71	7.37
Dongfangyujing Station	1#DFYJ	8.93	7.14	7.52	7.46	8.09
	2#DFYJ	7.43	8.00	8.00	8.00	6.00
	3#DFYJ	8.00	8.00	8.04	8.00	7.00
Donghuyiyuan Station	1#DHYY	Constructing	8.30	8.39	7.00	8.00
Qinghuayuan Station	1#QHY	8.44	7.53	8.71	8.04	7.69
Xiangxiehuating Station	1#XXHT	8.38	8.19	7.57	7.73	8.06
Hualancheng Station	1#HLC	8.88	7.81	7.94	8.86	7.88
Jiuhaoyuan Station	1#JHY	constructing				
Jinxiuyuan Station	1#JXY	constructing				
Tianshenggongguan Station	1#TSGG	constructing				

Qianxizhuangyuan Station	1#QXZY	8.39	8.08	7.58	7.21	8.25
Yehaowanghu Station	1#YHWH	constructing				

15/11/2022 – 18/11/2023

Sub-areas	Heat-Substations	Nov-21	Dec-21	Jan-22	Feb-22	Mar-22
Fenghuangcheng Station	1#FHC	8.87	7.61	7.53	7.97	8.53
	2#FHC	7.63	8.81	8.53	7.57	8.13
	3#FHC	8.41	8.04	8.60	8.20	7.91
	4#FHC	constructing				
Gongyuanshoufu Station	1#GYSF	7.37	8.35	7.49	8.25	8.00
Dongfangyujing Station	1#DFYJ	8.09	8.43	7.53	7.44	8.00
	2#DFYJ	6.00	7.87	8.00	8.00	8.40
	3#DFYJ	7.00	7.93	8.03	8.00	8.00
Donghuyiyuan Station	1#DHYY	8.00	8.68	7.86	8.00	8.81
Qinghuayuan Station	1#QHY	7.69	8.96	7.29	7.96	8.61
Xiangxiehuating Station	1#XXHT	8.06	7.04	7.97	8.00	8.66
Hualancheng Station	1#HLC	7.88	8.87	8.00	7.00	7.67
Jiuhaoyuan Station	1#JHY	constructing		8.00	8.00	9.34
Jinxiuyuan Station	1#JXY	constructing				
Tianshenggongguan Station	1#TSGG	constructing				
Qianxizhuangyuan Station	1#QXZY	8.25	7.28	8.37	7.80	8.97
Yehaowanghu Station	1#YHWH	constructing		8.46	7.22	8.33

Comments

The heat exchanger should handle the heat supplied by geothermal well only and not by any other source. The temperature readings should be taken at immediate inlet and outlet point of heat exchanger.

Data / Parameter	$FR_{j,d,y}$
Data unit	*Kg/h*
Description	Average flow rate at the downstream of each heat exchanger (upstream of which is connected with water supply from the geothermal well j) in year *y*.
Value applied:	15/11/2021 – 21/03/2022

Sub-areas	Heat-Substations	Nov-21	Dec-21	Jan-22	Feb-22	Mar-22
Fenghuangcheng Station	1#FHC	241.99	243.59	243.69	249.19	240.89
	2#FHC	158.45	157.35	159.25	154.85	157.35
	3#FHC	390.44	395.34	392.14	394.04	392.54
	4#FHC	constructing				
Gongyuanshoufu Station	1#GYSF	455.00	452.00	453.60	450.50	454.90
Dongfangyujing Station	1#DFYJ	159.76	158.26	157.66	157.96	158.66
	2#DFYJ	174.86	171.66	178.46	178.56	173.86
	3#DFYJ	330.33	332.63	333.03	333.33	339.23
Donghuyiyuan Station	1#DHYY	constructing	229.51	229.71	228.70	228.70
Qinghuayuan Station	1#QHY	517.22	516.32	512.72	515.72	512.52
Xiangxiehuating Station	1#XXHT	275.16	274.36	271.56	275.56	275.56
Hualancheng Station	1#HLC	211.26	213.56	212.16	215.16	212.66
Jiuhaoyuan Station	1#JHY	constructing				
Jinxiuyuan Station	1#JXY	constructing				
Tianshenggongguan Station	1#TSGG	constructing				
Qianxizhuangyuan Station	1#QXZY	817.63	819.23	816.73	812.73	817.93
Yehaowanghu Station	1#YHWH	constructing				

15/11/2022 – 18/03/2022

Sub-areas	Heat-Substations	Nov-22	Dec-22	Jan-23	Feb-23	Mar-23
Fenghuangcheng Station	1#FHC	243.29	241.99	242.39	245.69	242.39
	2#FHC	154.65	158.45	156.25	158.35	154.55
	3#FHC	449.59	447.99	442.99	447.53	449.29
	4#FHC	constructing				
Gongyuanshoufu Station	1#GYSF	458.46	454.56	456.36	456.36	456.26
Dongfangyujing Station	1#DFYJ	157.86	157.66	159.96	157.26	158.26
	2#DFYJ	177.66	175.46	178.56	176.56	179.26
	3#DFYJ	332.63	333.13	332.13	336.53	333.63
Donghuyiyuan Station	1#DHYY	283.54	286.24	288.64	286.54	288.24
Qinghuayuan Station	1#QHY	575.18	576.18	575.28	573.58	577.38
Xiangxiehuating Station	1#XXHT	316.35	312.15	312.55	317.25	316.25
Hualancheng Station	1#HLC	443.92	448.22	448.22	447.62	452.32
Jiuhaoyuan Station	1#JHY	constructing		216.26	216.26	216.56
Jinxiuyuan Station	1#JXY	constructing				
Tianshenggongguan Station	1#TSGG	constructing				
Qianxizhuangyuan Station	1#QXZY	819.23	816.53	819.33	818.23	819.23
Yehaowanghu Station	1#YHWH	constructing		194.21	196.21	194.81

Comments	The heat exchanger should handle the heat supplied by geothermal well only and not by any other source.

Data / Parameter	T_j
Data unit	*Hours*

Description	Hours per hear heat utilization in well *j*.
Value applied:	15/11/2021 – 21/03/2022

Sub-areas	Heat-Substations	Nov-21	Dec-21	Jan-22	Feb-22	Mar-22
Fenghuangcheng Station	1#FHC	360	744	744	672	504
	2#FHC	360	744	744	672	504
	3#FHC	360	720	744	672	504
	4#FHC	constructing				
Gongyuanshoufu Station	1#GYSF	312	720	744	672	504
Dongfangyujing Station	1#DFYJ	336	672	744	672	504
	2#DFYJ	336	672	744	672	504
	3#DFYJ	336	648	744	672	504
Donghuyiyuan Station	1#DHYY	Const ructing	240	744	672	360
Qinghuayuan Station	1#QHY	384	744	672	648	504
Xiangxiehuating Station	1#XXHT	384	744	720	672	480
Hualancheng Station	1#HLC	384	744	744	672	504
Jiuhaoyuan Station	1#JHY	constructing				
Jinxiuyuan Station	1#JXY	constructing				
Tianshenggongguan Station	1#TSGG	constructing				
Qianxizhuangyuan Station	1#QXZY	384	744	744	672	504
Yehaowanghu Station	1#YHWH	constructing				

15/11/2022 – 18/03/2023

Sub-areas	Heat-Substations	Nov-21	Dec-21	Jan-22	Feb-22	Mar-22
Fenghuangcheng Station	1#FHC	384	744	719	672	360
	2#FHC	384	744	719	672	360

	3#FHC	384	744	744	672	360
	4#FHC	constructing				
Gongyuanshoufu Station	1#GYSF	384	744	744	672	360
Dongfangyujing Station	1#DFYJ	384	720	719	648	408
	2#DFYJ	384	720	720	648	408
	3#DFYJ	384	720	720	648	408
Donghuyiyuan Station	1#DHYY	360	744	672	648	384
Qinghuayuan Station	1#QHY	384	744	744	672	432
Xiangxiehuating Station	1#XXHT	384	744	744	672	432
Hualancheng Station	1#HLC	384	744	744	672	432
Jiuhaoyuan Station	1#JHY	constructing		432	672	432
Jinxiuyuan Station	1#JXY	constructing				
Tianshenggongguan Station	1#TSGG	constructing				
Qianxizhuangyuan Station	1#QXZY	384	744	744	672	432
Yehaowanghu Station	1#YHWH	constructing		312	672	432

Comments	The heat exchanger should handle the heat supplied by geothermal well only and not by any other source.

Data / Parameter	A_m
Data unit	m^2
Description	Net heating area for construction type m.
Value applied:	15/11/2021 – 21/03/2022

Sub-areas	Heat-Substations	Residential
Fenghuangcheng Station	1#FHC	73806.45

	2#FHC	48326.53
	3#FHC	119080.78
	4#FHC	constructing
Gongyuanshoufu Station	1#GYSF	138638.65
Dongfangyujing Station	1#DFYJ	48727.06
	2#DFYJ	53330.85
	3#DFYJ	100749.96
Donghuyiyuan Station	1#DHYY	69662.23
Qinghuayuan Station	1#QHY	157747.75
Xiangxiehuating Station	1#XXHT	83921.05
Hualancheng Station	1#HLC	64432.99
Jiuhaoyuan Station	1#JHY	constructing
Jinxiuyuan Station	1#JXY	constructing
Tianshenggongguan Station	1#TSGG	constructing
Qianxizhuangyuan Station	1#QXZY	249371.65
Yehaowanghu Station	1#YHWH	constructing
Total		1,207,795.95

15/11/2022 – 18/03/2023

Sub-areas	Heat-Substations	Residential
Fenghuangcheng Station	1#FHC	73806.45
	2#FHC	48326.53
	3#FHC	136634.33
	4#FHC	constructing
Gongyuanshoufu Station	1#GYSF	138638.65
Dongfangyujing Station	1#DFYJ	48727.06
	2#DFYJ	53330.85
	3#DFYJ	100749.96
Donghuyiyuan Station	1#DHYY	87637.42

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<tr><td>Qinghuayuan Station</td><td>1#QHY</td><td>174664.59</td></tr>
<tr><td>Xiangxiehuating Station</td><td>1#XXHT</td><td>95477.43</td></tr>
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<tr><td>Jiuhaoyuan Station</td><td>1#JHY</td><td>65439.14</td></tr>
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<tr><td>Tianshenggongguan Station</td><td>1#TSGG</td><td>constructing</td></tr>
<tr><td>Qianxizhuangyuan Station</td><td>1#QXZY</td><td>249371.65</td></tr>
<tr><td>Yehaowanghu Station</td><td>1#YHWH</td><td>59661.25</td></tr>
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<tr><td>Data / Parameter</td><td>$EC_{PJ,j,y}$ (EC_y)</td></tr>
<tr><td>Data unit</td><td>MWh</td></tr>
<tr><td>Description</td><td>Electricity consumption for the year y in operating the geothermal heating system.</td></tr>
<tr><td>Value applied:</td><td>15/11/2021 – 21/03/2022
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<tr><td>Sub-areas</td><td>Heat-Substations</td><td>Nov-21</td><td>Dec-21</td><td>Jan-22</td><td>Feb-22</td><td>Mar-22</td></tr>
<tr><td rowspan="4">Fenghuangcheng Station</td><td>1#FHC</td><td rowspan="2">132.60</td><td rowspan="2">234.48</td><td rowspan="2">254.24</td><td rowspan="2">234.36</td><td rowspan="2">155.20</td></tr>
<tr><td>2#FHC</td></tr>
<tr><td>3#FHC</td><td>142.88</td><td>239.06</td><td>279.87</td><td>259.41</td><td>160.05</td></tr>
<tr><td>4#FHC</td><td colspan="5">constructing</td></tr>
<tr><td>Gongyuanshoufu Station</td><td>1#GYSF</td><td>61.83</td><td>125.97</td><td>211.77</td><td>340.77</td><td>103.74</td></tr>
<tr><td rowspan="3">Dongfangyujing Station</td><td>1#DFYJ</td><td>96.69</td><td>190.67</td><td>208.18</td><td>190.93</td><td>76.75</td></tr>
<tr><td>2#DFYJ</td><td>16.95</td><td>22.71</td><td>21.75</td><td>21.27</td><td>14.94</td></tr>
<tr><td>3#DFYJ</td><td>36.09</td><td>44.85</td><td>52.98</td><td>40.11</td><td>30.51</td></tr>
<tr><td>Donghuyiyuan Station</td><td>1#DHYY</td><td>constructing</td><td>23.33</td><td>72.29</td><td>71.09</td><td>60.98</td></tr>
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Qinghuayuan Station	1#QHY	101.12	162.92	193.42	209.66	129.58
Xiangxiehuating Station	1#XXHT					
Hualancheng Station	1#HLC	31.20	73.04	80.98	72.54	43.40
Jiuhaoyuan Station	1#JHY	constructing				
Jinxiuyuan Station	1#JXY	constructing				
Tianshenggongguan Station	1#TSGG	constructing				
Qianxizhuangyuan Station	1#QXZY	201.81	428.77	473.06	436.00	110.75
Yehaowanghu Station	1#YHWH	constructing				

15/11/2022 – 18/03/2023

Sub-areas	Heat-Substations	Nov-22	Dec-22	Jan-23	Feb-23	Mar-23
Fenghuangcheng Station	1#FHC	69.64	139.68	150.96	125.72	67.84
	2#FHC					
	3#FHC	100.79	320.40	311.81	231.53	57.42
	4#FHC	constructing				
Gongyuanshoufu Station	1#GYSF	95.91	158.52	151.38	134.85	66.93
Dongfangyujing Station	1#DFYJ	115.23	189.53	183.82	152.96	44.38
	2#DFYJ	17.82	22.41	21.75	19.29	11.34
	3#DFYJ	33.27	140.91	259.65	72.60	24.39
Donghuyiyuan Station	1#DHYY	59.62	99.60	111.60	99.17	41.09
Qinghuayuan Station	1#QHY	153.18	542.70	541.16	418.80	124.16
Xiangxiehuating Station	1#XXHT					
Hualancheng Station	1#HLC	61.94	109.58	114.24	104.28	53.96
Jiuhaoyuan Station	1#JHY	constructing		50.02	39.47	23.69
Jinxiuyuan Station	1#JXY	constructing				

Tianshenggongguan Station	1#TSGG	constructing				
Qianxizhuangyuan Station	1#QXZY	258.33	483.85	544.23	393.07	93.44
Yehaowanghu Station	1#YHWH	constructing				

Date	$EC_{PJ,j,y}$ (EC_y)
2021/11/15-2021/11/30	821.17
2021/12/01-2021/12/31	1,545.79
2022/01/01-2022/01/31	1,848.54
2022/02/01-2022/02/28	1,876.14
2022/03/01-2022/03/21	885.90
2021/11/15-2022/3/21	6,977.53
2022/11/15-2022/11/30	965.72
2022/12/01-2022/12/31	2,207.18
2023/01/01-2023/01/31	2,440.61
2023/02/01-2023/02/28	1,791.73
2023/03/01-2023/03/18	608.63
2022/11/15-2023/3/18	8,013.87
Total	**14,991.40**

Comments	N/A

7.2 Baseline Emissions

The baseline emissions in year y (BE_y) can be calculated as follows:

$$BE_y = \sum_{i} (HS^{BL}{}_{i,y}) \times EF_{CO2,i} / \eta_{BL,i}$$

Where:

BE_y	=	The baseline emissions from heat displaced by the project activity during the year y (t CO_2e/yr).
$EF_{CO2,i}$	=	The CO_2 emission factor per unit of energy of the fuel of technology *i* that would have been used in the baseline heating technology in (t CO_2/TJ). Where several fuel types are used in the boiler, use the fuel type with the lowest CO_2 emission factor. Values provided by the fuel supplier are unavailable. IPCC default values at the lower limit of the uncertainty at a 95% confidence interval as provided in table 1.4 of Chapter 1 of Vol.2 (Energy) of 2006 IPCC Guidelines on National GHG Inventories are used. For coking coal, it is 87.3 tCO_2/TJ.
$\eta_{BL,i}$	=	The net thermal efficiency of the heating technology *i* using fossil fuel that would have been used in the absence of the project activity. The highest efficiency of coal-fired boilers provided by Zozen Boilers (79%), Xinli Boiler (82%), Henan Hengde Boiler (85%). As per Table 4 Default baseline efficiency for different boilers of *AM0072* (Version 03.0), the highest value of 85% for new coal-fired boiler is applicable for the proposed project. In summary, the efficiency of 85% is applied for the proposed project.
$HS^{BL}_{i,y}$	=	The net output of heat generated by the baseline heat supply system using the technology *i* measured at the end point of the heat facility, during the year y (TJ/yr).

$HS^{BL}_{i,y}$ can be calculated as follows,

$$HS^{BL}_{i,y} = w_i \times \left(HS_y - Loss^{PJ}_y + Loss^{BL}_y\right)$$

Where:

$HS^{BL}_{i,y}$	=	The net output of heat generated by the baseline heat supply system using the technology *i* measured at the end point of the heat facility, during the year y (TJ/yr).
w_i	=	Assign weights for heat generated by technology *i*. As per section 3.4 of this report, the baseline scenario of the project is 3(i) "Coal fired boilers in boiler houses, supplying several buildings through a heat distribution network". Only one technology will be used. As per paragraph 51(a)(ii) option 2 Assign weights based on available historical records of *AM0072* (Version 03.0), w_i is equal to 1.
HS_y	=	Net quantity of heat supplied by the geothermal heat resource(s) in the project activity, during the year y (TJ/yr).
$Loss^{PJ}_y$	=	The net distribution losses of the geothermal heat supply system during the year y (TJ/yr).

$Loss^{BL}_{y}$	=	The net distribution losses of the heat supply system, in the absence of project activity, during the year y (TJ/yr). Option 1 A conservative value of 0% of loss is used as historic information is not available.

The net quantity of heat supplied by the project activity is estimated based on the heat provided by the geothermal well. It considers flow rates, temperature, and usage time for each geothermal well to be considered by the project activity.

$$HS_y = min\{H_{CAP}, HS_{y,estimated}\}$$

$HS_{y,estimated}$ can be determined by the use of the flow and temperature of water supplied by the substation heat exchanger k to the demand side space heating.

$$HS_{y,estimated} = \sum_{j} (Q_{j,d,y} \times T_j \times CF)$$

Where:

$HS_{y,estimated}$	=	Estimated quantity of heat supplied by the geothermal heat resource(s) in the project activity, during the year y (TJ)
$Q_{j,d,y}$	=	Heat supplied at the downstream of heat exchanger (upstream of which is connected with water supply from the geothermal well j) (GW). It can be calculated as formula below.
T_j	=	Number of hours per year heat utilization at well j.
CF	=	Conversion factor from GWh to TJ (3.6).

$$Q_{j,d,y} = \frac{FR_{j,d,y} \times \Delta t_{j,d,y} \times 4.18}{3.6} \times 10^{-9}$$

Where:

$FR_{j,d,y}$	=	Average flow rate at the downstream of heat exchanger (upstream of which is connected with water supply from the geothermal well j) in year y (kg/hr).
$\Delta t_{j,d,y}$	=	Heat supplied at the downstream of heat exchanger (upstream of which is connected with water supply from the geothermal well j) (°C).

To ensure that the geothermal well is providing the required amount of energy a cap is defined. The basis to define the cap is from the space heating design, which considers the net heating area, the heating index, the type of construction that will utilize the heat and the time used throughout the year for each construction type.

$$H_{CAP} = (\sum_{m} A_m \times HI_m \times T_j) \times CF + Loss^{PJ}_y - H_{ff}$$

Where:

H_{CAP}	=	The net quantity of heat supplied by the geothermal heat resource(s) in the project activity, during the year y (TJ).
A_m	=	Net heating area for construction type m (m^2).
HI_m	=	Heating index for construction type m (GW/m^2). As per Feasibility Report of the project, HI_m is 30 W/m^2 for residential buildings.
T_j	=	Number of hours per year heat utilization at well *j*.
CF	=	Conversion factor from GWh to TJ (3.6).
$Loss^{PJ}_y$	=	Heat distribution losses from substation *k* to space heating areas.
H_{ff}	=	Heat supplied by fossil fuel boiler, in case a boiler is used to meet the heat demand of network. No fossil fuel boiler is utilized in the project activity and H_{ff} is 0 TJ.

Heat distribution losses will be obtained as the difference between the heat supplied by the geothermal heat source and the aggregated heat demand of the end-use points.

$$Loss^{PJ}_y = HS_y - HD_y$$

Where:

HD_y	=	Aggregate space heat demand within the area of supplied heat (TJ).

It is not possible to determine HD_y, the heat losses ($Loss^{PJ}_y$) are determined based on heat losses from pipeline, valves, fittings based on maximum of option (a) 10% design heat losses provided by the engineering specifications of the manufacturer of the heat network.

$$Loss^{PJ}_y = \sum_{m} 10\% \times A_m \times HI_m \times T_j \times CF \times 10^{-9}$$

Based on the results of monitored parameters, heat supplied by the geothermal based heating system (each heat exchangers) is summarized as Table 7-1. Please refer to the ER calculation sheet for more details.

Table 7-1 Calculation results of baseline emissions

Year	H_{CAP} (TJ)	$HS_{y,estimated}$ (TJ)	HS_y (TJ)	$Loss^{PL}_y$ (TJ)	$HS^{BL}_{i,y}$ (TJ)	$EF_{CO2,i}$ (tCO_2/TJ)	$\eta_{BL,i}$ (%)	BE_y (tCO_2e/yr)
	A	B	C=min(A,B)	D	E=C-D	F	G	H=E*F/G

2021/11/15-2021/11/30	48.89	47.14	47.14	4.44	42.70			4,385
2021/12/01-2021/12/31	99.83	92.93	92.93	9.08	83.85			8,612
2022/01/01-2022/01/31	105.17	97.31	97.31	9.56	87.75			9,012
2022/02/01-2022/02/28	95.97	86.26	86.26	8.72	77.53			7,963
2022/03/01-2022/03/21	70.89	63.81	63.81	6.44	57.36			5,891
2022/03/22-2022/11/14	0	0	0	0	0			0
2021/11/15-2022/11/14	**420.74**	**387.44**	**387.44**	**38.25**	**349.19**			**35,864**
2022/11/15-2022/11/30	61.08	55.42	55.42	5.55	49.86	87.3	85	5,121
2022/12/01-2022/12/31	118.25	110.65	110.65	10.75	99.90			10,260
2023/01/01-2023/01/31	122.70	112.82	112.82	11.15	101.67			10,442
2023/02/01-2023/02/28	116.49	105.77	105.77	10.59	95.18			9,776
2023/03/01-2023/03/18	70.94	69.24	69.24	6.45	62.79			6,449
2022/11/15-2023/3/18	**489.46**	**453.89**	**453.89**	**44.50**	**409.40**			**42,048**
Total of the 1st monitoring period	**910.20**	**841.33**	**841.33**	**82.75**	**758.59**			**77,911.52**

Baseline emissions was:

35,864 tCO_2e from 15/11/2021 to 14/11/2022,

42,048 tCO_2e from 15/11/2022 to 18/03/2023,

Total baseline emissions of the 1st monitoring period (15/11/2021 to 18/03/2023) was 77,911.52 tCO_2e.

7.3 Project Emissions

As per the signed heating contract, heating areas (2021-2023 heating season) are summarized as the following table.

Sub-areas	Heat-Substations	15/11/2021 - 14/11/2022		15/11/2022 - 18/03/2023	
		A_m (m^2) - heating contract	A_m (m^2) – Net heating areas	A_m (m^2) - heating contract	A_m (m^2) – Net heating areas
Fenghuangcheng Station	1#FHC	79,200	73,806.45	79,200	73,806.45
	2#FHC	64,000	48,326.53	64,000	48,326.53
	3#FHC	190,000	119,080.78	222,962	136,634.33
	4#FHC	constructing	constructing	constructing	constructing
Gongyuanshoufu Station	1#GYSF	213,000	138,638.65	213,000	138,638.65
Dongfangyujing Station	1#DFYJ	60,700	48,727.06	60,700	48,727.06
	2#DFYJ	58,283	53,330.85	58,283	53,330.85
	3#DFYJ	152,948.18	100,749.96	152,948.18	100,749.96
Donghuyiyuan Station	1#DHYY	126,247	69,662.23	163,345	87,637.42
Qinghuayuan Station	1#QHY	238,881.47	157,747.75	276,380	174,664.59
Xiangxiehuating Station	1#XXHT	226,422	83,921.05	249,998	95,477.43
Hualancheng Station	1#HLC	150,000	64,432.99	360,000	137,039.37
Jiuhaoyuan Station	1#JHY	constructing	constructing	127,061.00	65,439.14
Jinxiuyuan Station	1#JXY	constructing	constructing	constructing	constructing
Tianshenggongguan Station	1#TSGG	constructing	constructing	constructing	constructing
Qianxizhuangyuan Station	1#QXZY	368,231.84	249,371.65	368,231.84	249,371.65

Yehaowanghu Station	1#YHWH	constructing	constructing	143,187.00	59,661.25
Total		1,927,914.8	1,207,795.95	2,539,296.19	1,469,504.68

For the 1st monitoring period from 15/11/2021 to 18/03/2023:

From 15/11/2021 to 14/11/2022, 1,927,914.8 m^2 of residential buildings can access to geothermal energy-based space heating system in winter season.

From 15/11/2022 to 18/03/2023, 2,539,296.19 m^2 of residential buildings can access to geothermal energy-based space heating system in winter season.

The net heating areas is affected by the actual occupancy rate:

From 15/11/2021 to 14/11/2022, the net heating areas is 1,207,795.95 m^2 (the occupancy rate is 62.65%).

From 15/112022 to 18/03/2023, the net heating areas is 1,469,504.68 m^2 (the occupancy rate is 57.87%,).

Project emissions are calculated taking into consideration fugitive carbon dioxide and methane released from geothermal vents (PE_{FE}), electricity consumption from the use the pumps to extract the geothermal water (PE_{EC}) and fossil fuel used to operate the geothermal facility (PE_{FF}).

$$PE_y = PE_{FE,y} + PE_{EC,y} + PE_{FF,y}$$

Step 1: Calculate project emissions from fugitive emissions resulting from non-condensable gases from the geothermal vents during the year y

The geothermal system of the proposed project is designed to operate by extracting geothermal water at approximately 72°C, which is considered to be a low-temperature system. As per paragraph 84 of *AM0072* (Version 03.0), fugitive emissions from low temperature geothermal system is considered negligible. Therefore, $PE_{FE,y}$=0 tCO_2.

Step 2: Calculate project emissions from additional electricity consumption as a result of the project activity

Project emissions from electricity consumption (PE_{EC}) used to pump geothermal water and operate the geothermal facility shall be calculated using *Tool 05 Baseline, project and/or leakage emissions from electricity consumption and monitoring of electricity generation* (Version 03.0). Electricity consumption from each relevant source should be monitored and summed up to EC_y.

As per paragraph 16 of *Tool 05* (Version 03.0), project emissions from consumption of electricity are calculated based on the quantity of electricity consumed, an emission factor for electricity generation and a factor to account for transmission losses, as follows:

$$PE_{EC,y} = \sum_{j} EC_{PJ,j,y} \times EF_{EL,j,y} \times (1 + TDL_{j,y})$$

Where:

$PE_{EC,y}$	=	Project emissions from electricity consumption in year y (t CO_2/yr).
$EC_{PJ,j,y}$	=	Quantity of electricity consumed by the project electricity consumption source *j* in year y (MWh/yr).
$EF_{EL,j,y}$	=	Emission factor for electricity generation for source *j* in year y (t CO_2/MWh).
$TDL_{j,y}$	=	Average technical transmission and distribution losses for providing electricity to source *j* in year *y*.

The electricity consumed by facilities of the geothermal system is sourced from local power grid connected to central China Power Grid (CCPG). Scenario A: Electricity consumption from th e grid is applied to the proposed project. For project electricity consumption sources, a default value of 20% is used for $TDL_{j,y}$.

Calculation results of project emissions during the year *y* (PE_y) are summarized as Table 7-2,

Table 7-2 Calculation results of project emissions

Year	$EC_{PJ,j,y}$ (kWh)	$EC_{PJ,j,y}$ (MWh)	$EF_{EL,j,y}$ (tCO2/MWh)	$(1+TDL_{j,y})$	$PE_{EC,y}$ (tCO2e/yr)
2021/11/15-2021/11/30	821,165.00	821.17	0.5721	1.2	564
2021/12/01-2021/12/31	1,545,789.00	1,545.79			1,061
2022/01/01-2022/01/31	1,848,538.00	1,848.54			1,269
2022/02/01-2022/02/28	1,876,140.00	1,876.14			1,288
2022/03/01-2022/03/21	885,899.00	885.90			608
2022/03/22-2022/11/14	0	0			0
2021/11/15-2022/11/14	6,977,531.00	6,977.53			4,790

2022/11/15-2022/11/30	965,718.00	965.72			663
2022/12/01-2022/12/31	2,207,176.00	2,207.18			1,515
2023/01/01-2023/01/31	2,440,613.00	2,440.61			1,675
2023/02/01-2023/02/28	1,791,728.00	1,791.73			1,230
2023/03/01-2023/03/18	608,633.00	608.63			418
2022/11/15-2023/3/18	8,013,868.00	8,013.87			5,501
Total of the 1st monitoring period	14,991,399.00	14,991.40	-	-	10,291.00

No fossil fuel was used to operate the geothermal facilities. Therefore, $PE_{FF,y}$=0 tCO_2.

Therefore, for the 1st monitoring period, PE_y=$PE_{EC,y}$. In summary, project emissions are

4,790 tCO_2e from 15/11/2021 to 14/11/2022,

5,501 tCO_2e from 15/11/2022 to 18/03/2023,

Total project emissions of the 1st monitoring period (15/11/2021 to 18/03/2023) is 10,291.00 tCO_2e.

7.4 Leakage

No leakage emissions have been identified for the project activity. Therefore, LE_y=0 tCO_2.

7.5 Net GHG Emission Reductions and Removals

Year	Baseline emissions or removals (tCO_2e)	Project emissions or removals (tCO_2e)	Leakage emissions (tCO_2e)	Net GHG emission reductions or removals (tCO_2e)
2021/11/15-2021/11/30	4,385	564	0	3,822

2021/12/01-2021/12/31	8,612	1,061	0	7,551
2022/01/01-2022/01/31	9,012	1,269	0	7,743
2022/02/01-2022/02/28	7,963	1,288	0	6,675
2022/03/01-2022/03/21	5,891	608	0	5,283
2022/03/22-2022/11/14	0	0	0	0
2021/11/15-2022/11/14	**35,864**	**4,790**	**0**	**31,074**
2022/11/15-2022/11/30	5,121	663	0	4,458
2022/12/01-2022/12/31	10,260	1,515	0	8,745
2023/01/01-2023/01/31	10,442	1,675	0	8,767
2023/02/01-2023/02/28	9,776	1,230	0	8,546
2023/03/01-2023/03/18	6,449	418	0	6,031
2022/11/15-2023/3/18	**42,048**	**5,501**	**0**	**36,546**
Total of the 1st monitoring period	**77,911.52**	**10,291.00**	**0**	**67,621**

<table>
<tr><th>Year</th><th>Ex-ante emissions reductions/ removals</th><th>Achieved emissions reductions/ removals</th><th>Percent difference</th><th>Justification for the difference</th></tr>
<tr><td>2021/ 11/15-2022/ 11/14</td><td>81,289</td><td>31,074</td><td>-61.77%</td><td rowspan="2">The actual heating area lost mainly due to the influence of the residential construction period and the actual occupancy rate in year y (A_m).

Besides, the average temperature difference between inlet and outlet temperatures at the downstream of each substation heat exchanger in year y ($\Delta t_{j,d,y}$), average flow rate at the downstream of each heat exchanger in year y ($FR_{j,d,y}$), hours per hear heat utilization in well j (T_j) and electricity consumption for the year y in operating the geothermal heating system($EC_{PJ,j,y}$ (ECy)) should be monitored.

The changes of the these monitored parameters lead to the difference between the estimated value and actual value for emission reductions.</td></tr>
<tr><td>2022/ 11/15-2023/ 3/18</td><td>81,289</td><td>36,546</td><td>-55.04%</td></tr>
</table>