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 78,508 tCO_2e, and total GHG emission reductions for the fixed 10 years crediting period are 785,080 tCO_2e. The date of crediting period is 15-November-2021 to 14-November-2031.

Emission reductions achieved in the first monitoring period (15-November-2021 to 18-March-2023 (first and last days included)) is 67,637 tCO_2e.

Audit Type	Period	Program	VVB Name	Number of years
Validation	24-July-2023 to 26-July-2023 (The date for the period of the onsite validation is provided here.)	VCS	CTI Certification Co., Ltd.	/
Verification	15-November-2021 to 18-March-2023	VCS	CTI Certification Co., Ltd.	488 days, i.e. 1.34 years

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

Total	15-November-2021 to 18-March-2023	VCS	CTI Certification Co., Ltd.	488 days, i.e. 1.34 years

1.2 Sectoral Scope and Project Type

The project is not a grouped project, sectoral scope[2] 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)

1.3 Project Eligibility

In the section 2.1.1 of VCS Standard (version 4.5), the scope of the VCS Program includes:

1) The seven 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 report for more details. Thus, the project applicable to this scope.

2) Ozone-depleting substances (ODS).

NA.

3) Project activities supported by a methodology approved under the VCS Program through the methodology development and review process.

NA.

4) Project activities supported by a methodology approved under an approved GHG program unless explicitly excluded (see the Verra website for exclusions).

The methodology AM0072 (Version 03.0) of the project utilized is a methodology approved under CDM Program and CDM is an 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.

[2] Projects, activities, or methodologies may be developed under any of the 16 VCS sectoral scopes: https://verra.org/programs/verified-carbon-standard/vcs-program-details/#sectoral-scopes

- As per section 2.1.2 of VCS Standard (Version 4.5), the scope of the VCS Program excludes projects that can reasonably be assumed to have generated GHG emissions primarily for the purpose of their subsequent reduction, removal, or destruction.

  The Project avoids GHG emissions by using geothermal energy instead of the combustion of fossil fuel for space heating; the GHG emissions generated by fossil fuel combustion for space heating are not generated primarily for the purpose of their subsequent reduction, removal, or destruction. Therefore, the Project is not excluded under the scope of the VCS program.

- As per section 2.1.3 of VCS Standard (Version 4.5), the VCS Program also excludes the following project activities under the circumstances indicated in Table 1.

  The project is not belonged to the projects excluded in Table 1. Thus, the project activity is included under the scope of the VCS Program.

- As per section 3.8 of VCS Standard (Version 4.5), 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-November-2021. Thus, the project start date is 15-November-2021.

- As per section 3.8.1 of VCS Standard (Version 4.5), Non-AFOLU projects shall complete validation within two years of the project start date.

- As per section 4.1.5 of VCS Standard (Version 4.5), the validation/verification body shall ensure that the project is listed on the project pipeline with a status of under validation before the opening meeting with the project proponent, such opening meeting representing the beginning of the validation process. Further, validation shall not begin until the 30-day public comment period has begun, and the validation/verification body shall not complete validation until after the 30-day public comment period has ended.

  The project start date is 15-November-2021. Thus, the validation deadline is 15-November-2023. The project initiated the project pipeline listing process on 24-April-2023.

  In addition, the date of the opening meeting with CTI Certification Co., Ltd. (the validation/verification body) is from 24-July-2023 to 26-July-2023. At that moment, the status of the project was "under validation" and the 30-day public comment period has begun. Further, the validation process will be completed after a 30-day public comment period.

  In summary, the project meets requirements related to the pipeline listing deadline, the opening meeting with the validation/verification body, and the validation deadline.

- Eligibility of the project under VCS Standard (Version 4.5):

The proposed project falls under section 3.1 General Requirements of VCS Standard (Version 4.5) with the following eligibility criteria:

Eligibility Criteria	Justification
Section 3.1.1 of VCS Standard (Version 4.5) 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 4.5) 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 3.14.1. The list of methodologies and their validity periods is available on the Verra website.	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 report below for more details.
Section 3.1.3 of VCS Standard (Version 4.5) Projects shall apply the latest version of the applicable methodology in all cases unless a grace period applies to the project as set out in 3.22 below. Projects shall update to the latest version of the methodology when reassessing the baseline or renewing a crediting period.	The project applies CDM approved methodology AM0072 (version 03.0) which is the latest version.
Section 3.1.4 of VCS Standard (Version 4.5) 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.	The project is 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 3.1.5 of VCS Standard (Version 4.5)Where projects apply methodologies that permit the project proponent its own choice of model (see the *VCS Program Definitions for*	Not applicable. There is no model need to be chosen by the project proponent as per the applied methodology AM0072 (version 03.0).

definition of model), the model shall meet the requirements set out in the *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 carbon dioxide removals).	
Section 3.1.6 of VCS Standard (Version 4.5) Where projects apply methodologies that permit the project proponent to choose a 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 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 3.1.7 of VCS Standard (Version 4.5) 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 4.5) Where projects apply methodologies from approved GHG programs, they shall conform with any specified capacity limits (see the *VCS 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 4.5) Where Verra issues new VCS Program rules, the effective dates of these requirements are set out in Appendix 3 *Document History and*	Not applicable.

Effective Dates or equivalent for other program documents, and are listed in a companion *Summary of Effective Dates* document which corresponds with each update.	

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 (but not a grouped project).

1.4.1 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
Telephone	-
Email	xuanyinglan@luter.cn

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 the 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.

Furthermore, the 36 Geothermal wells involved in this project include 12 production wells and 24 injection wells. Each production well corresponds to a sub-area and there are totally 12 sub-areas. Each sub-area has 1 production well, 2-3 injection wells and 1-4 heat substations (refer to Table 1-2 for details). Each of the sub-area should have an individual Water Extraction Permit. All the 10 sub-areas (10 production wells) currently in operation have their respective Water Extraction Permit. The 2 remaining Sub-areas (Jinxiuyuan Station and Tianshenggongguan Station), corresponding to 2 production wells have not been put into operation yet, will obtain their Water Extraction Permit in following years. Each Water Extraction Permit proves that the project owner has a legally permissible right to abstract water.

1.8 Project Start Date

As per section 3.8 of VCS Standard (Version 4.5), 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, corresponding to 17 heat substations, 12 production wells and 24 injection wells involved in the project activity. Not all the substations started operation on the same day. The earliest group of geothermal space heating systems to be constructed started commissioning on 15-November-2021, including 6 sub-areas (6 production wells) with a total of 11 heat substations. Thus, the project start date is 15-November-2021.

Until the end of this monitoring period (18-March-2023), there are 10 sub-areas (10 production wells) in operation with a total of 14 heat substations. Detailed information regarding the commissioning date of all 10 sub-areas in operation and the expected date of commissioning of the two remaining sub-areas are summarized in section 4.1 of this JPD-MR.

1.9 Project Crediting Period

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

1.10 Project Scale and Estimated GHG Emission Reductions or Removals

The project annual average CO_2 emission reductions are estimated as 78,508 tCO_2e, which is less than 300,000 tCO_2e. As per Section 3.10 of VCS Standard (Version 4.5), it is a project.

Project Scale	
Project	x
Large project	

Year	Estimated GHG emission reductions or removals (tCO_2e)
15-November-2021 to 14-November-2022	78,508
15-November-2022 to 14-November-2023	78,508
15-November-2023 to 14-November-2024	78,508
15-November-2024 to 14-November-2025	78,508
15-November-2025 to 14-November-2026	78,508
15-November-2026 to 14-November-2027	78,508
15-November-2027 to 14-November-2028	78,508
15-November-2028 to 14-November-2029	78,508
15-November-2029 to 14-November-2030	78,508
15-November-2030 to 14-November-2031	78,508
Total estimated ERs	**785,080**
Total number of crediting years	**10**
Average annual ERs	**78,508**

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.

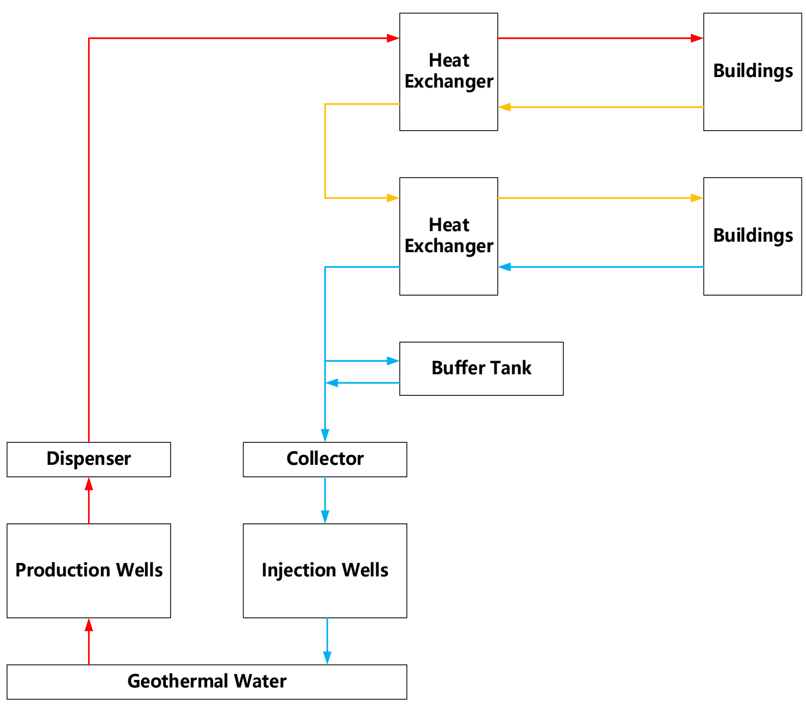

Figure 1-1 Technologies and Measures Employed by the Project Activity

Full operation of the project is scheduled on 15-November-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[3]. 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, the actual heating area is affected not only by the residential construction period, but also by the actual occupancy rate.

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).[4] Lankao County is part of Kaifeng City, so it carries out the same winter heating implementation plan.

The first monitoring period is from 15-November-2021 to 18-March-2023, including:

- the heating season 2021-2022 (from 15-November-2021 to 21-March-2022),
- non-heating times (from 22-March-2022 to 14-November-2022) and
- the heating season 2022-2023 (from 15-November-2022 to 18-March-2023)

The project has started to heat 1,927.91 thousand m^2 of residential buildings with the occupancy rate of 62.65% during the heating season 2021-2022 (from 15-November-2021 to 21-March-2022). And the project 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% during the heating season 2022-2023 (from 15-November-2022 to 18-March-2023). The occupancy rate 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-November-2021 to 21-March-2022, 1,207.8[5] thousand m^2 of residential buildings with a heating load of 36.23 MW [6].
- For the monitoring period from 22-March-2022 to 14-November-2022, the project is not implementing heating for the residential buildings.
- For the monitoring period from 15-November-2022 to 18-March-2023, 1,469.5 [7] thousand m^2 of residential buildings with a heating load of 44.08 MW [8].

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[3] According to the applied Heating Index (30W/m^2), the total heating load is calculated: 3,736.1 thousand m^2*30W/ m^2/1000=112.08 MW.

[4] https://www.kaifeng.gov.cn/sitegroup/root/html/8a28897b41c403ec0141c41c883b00c8/ed8c81d3259842f9952246b306e10121.html

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

[6] According to the design area and heat load can be obtained the actual heat load is 1,207.8 thousand m^2/3,736.1 thousand m^2*112.08MW=36.23MW.

[7] According to the occupancy rate is 2,539.30 thousand m^2*57.87%=1,469.5 thousand m^2.

[8] According to the design area and heat load can be obtained the actual heat load is 1,469.5 thousand m^2/3,736.1 thousand m^2*112.08MW=44.08 MW.

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	
Circulating pumps	Q=110 m^3/h, Head=36.1 m, P=15kW	Unit	2	One for use and one for backup
Fixed-pressure water-supplying device	Diameter of pressure tank: 1 m Q=4 m^3/h, Head=61 m, P=1.5kW	Unit	1	
Water-softening tank	Volume: 2 m^3	Unit	1	
Water-softening facility	Treatment capacity: 4 m^3/h	Unit	1	
Water buffer tank	Volume: 1.5 m^3	Unit	1	
Cyclone desander	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 pump	Heating Capacity: 1047kW	Unit	1	
Circulating pumps of load side-1	Q=110 m^3/h, Head=36.1 m, P=15kW	Unit	2	One for use and one for backup
Circulating pumps of load side-2	Q=200 m^3/h, Head=30.1 m, P=22kW	Unit	2	One for use and one for backup
Circulating pumps of host unit	Q=80 m^3/h, Head=24 m, P=7.5kW	Unit	2	One for use and one for backup
Fixed-pressure water-supplying device	Q=4 m^3/h, Head=70 m, P=2.2kW	Unit	1	
Water-softening tank	Volume: 2 m^3	Unit	1	
Automatic dosing device	Treatment capacity: 4 m^3/h	Unit	1	
Cyclone desander	Treatment capacity: 30 m^3/h	Unit	1	

Submersible pump	Q=130 m³/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 pump-1	Heating Capacity: 1047kW	Unit	1	
Water source heat pump-2	Heating Capacity: 1631kW	Unit	1	
Circulating pumps of host unit-1	Q=90.4 m³/h, Head=21.7 m, P=7.5 kW	Unit	2	One for use and one for backup
Circulating pumps of host unit-2	Q=160 m³/h, Head=20 m, P=15 kW	Unit	2	One for use and one for backup
Circulating pumps-1	Q=300 m³/h, Head=44 m, P=55kW	Unit	4	Two for use and two for backup
Circulating pumps-2	Q=200 m³/h, Head=33 m, P=30kW	Unit	2	One for use and one for backup
Fixed-pressure water-supplying device-1	Volume: 5.1 m³/h, Q=16 m3/h, Head=94 m, P=7.5kW	Unit	1	

Fixed-pressure water-supplying device-2	Volume: 2.45 m^3/h, Q=4 m^3/h, Head=64 m, P=1.5kW	Unit	1	
Water-softening facility	Treatment capacity: 4 m^3/h	Unit	1	
Water-softening tank	Volume: 21 m^3	Unit	1	
Cyclone desander	Treatment capacity: 100 m^3/h	Unit	1	
4#FHC				
Water source heat pump	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 device	Volume: 0.15 m^3/h, Q=2.5 m^3/h, Head=50 m, P=2.2kW	Unit	1	
Water-softening facility	Treatment capacity: 4 m^3/h	Unit	1	
Water-softening tank	Volume: 1.65 m^3	Unit	1	
Cyclone desander	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 pump - 1	Heating Capacity: 1460kW	Unit	1	
Water source heat pump - 2	Heating Capacity: 1458kW	Unit	1	
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 facility	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	2	
Water source heat pumps	Heating Capacity :691kW	Unit	2	
Circulating pumps-1	Q=138 m^3/h, Head=37.5 m, P=22kW	Unit	2	Two for use and one for backup

Circulating pumps-2	Q=87 m^3/h, Head=38 m, P=15kW	Unit	3	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 m^3	Unit	1	
Water-supplying pump	Q=4 m^3/h, Head=61 m, P=3kW	Unit	2	One for use and one for backup
Tank	Volume: 20 m^3	Unit	1	
Circulation pump for hot water	Q=4 m^3/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 – 1	Q=70 m^3/h, Head=36.5m, P=11kW	Unit	2	One for use and one for backup
Circulating pumps – 2	Q=110 m^3/h, Head=36.1 m, P=15kW	Unit	2	One for use and one for backup
Automatic dosing device	Treatment capacity: 4 m^3/h	Unit	1	
Water-softening tank	Volume: 1 m^3	Unit	1	
Fixed-pressure water-supplying device – 1	Q=4 m^3/h, Head=81 m, P=2.2kW	Unit	1	

Fixed-pressure water-supplying device	Q=4 m³/h, Head=40 m, P=1.1kW	Unit	1	
Cyclone desander	Treatment capacity: 60 m³/h	Unit	1	
Submersible pumps	Q=70 m³/h, Head=150 m, P=75kW	Unit	2	
3#DFYJ				
Equipment Name	**Specifications**	**Unit**	**Quantity**	**Remarks**
Water source heat pump	Heating Capacity: 1275kW	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 for direct supply	Q=216 m³/h, Head=38 m, P=45kW	Unit	2	One for use and one for backup
Circulating pumps of host unit	Q=92.7m³/h, Head=20 m, P=22kW	Unit	3	Two for use and one for backup
Circulating pumps of end side	Q=136 m³/h, Head=38 m, P=18.5kW	Unit	3	Two for use and one for backup

Fixed-pressure water-supplying device	Q=2 m^3/h, Head=45 m, P=2.2kW	Unit	1	
Water-softening facility	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 device	Q=20 m³/h, Head=45 m, P=4kW	Unit	1	
Water-softening facility	Treatment capacity: 20 m³/h	Unit	1	
Water-softening tank	Volume: 8 m³	Unit	1	
Cyclone desander	Treatment capacity: 120 m³/h	Unit	1	
Submersible pump	Q=110 m³/h, Head=100 m, P=75kW	Unit	1	
1#QHY				
Equipment Name	**Specifications**	**Unit**	**Quantity**	**Remarks**
Water source heat pump – 1	Heating Capacity: 952kW	Unit	1	
Water source heat pump – 2	Heating Capacity: 1519kW	Unit	1	
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=262 m^3/h, Head=60 m, P=75kW	Unit	2	One for use and one for backup
Circulating pumps of host unit	Q=138m^3/h, Head=60 m, P=37kW	Unit	2	Two for use and one for backup
Circulating pumps of end side	Q=143 m^3/h, Head=16 m, P=11kW	Unit	2	Two for use and one for backup
Fixed-pressure water-supplying device	Q=10 m^3/h, Head=71 m, P=3kW	Unit	1	
Water-softening facility	Treatment capacity: 15 m^3/h	Unit	1	
Water-softening tank	Volume: 11.25 m^3	Unit	1	
Cyclone desander	Treatment capacity: 100 m^3/h	Unit	1	
Submersible pump	Q=90 m^3/h, Head=100 m, P=75kW	Unit	1	
1#XXHT				
Equipment Name	**Specifications**	**Unit**	**Quantity**	**Remarks**
Water source heat pump	Heating Capacity: 1519kW	Unit	1	
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;	Unit	1	

	Secondary heat exchange temperature of supply water and return water: 10/18 °C			
Circulating pumps – 1	Q=47 m^3/h, Head=44 m, P=11 kW	Unit	2	One for use and one for backup
Circulating pumps – 2	Q=374 m^3/h, Head=44 m, P=75 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 device – 1	Q=1.2 m^3/h, Head=63 m, P=1.1 kW	Unit	1	
Fixed-pressure water-supplying device – 2	Q=17 m^3/h, Head=42 m, P=4 kW	Unit	1	
Water-softening facility	Treatment capacity: 15 m^3/h	Unit	1	
Water-softening tank	Volume: 12.5 m^3	Unit	1	
Cyclone desander	Treatment capacity: 100 m^3/h	Unit	1	
Submersible pump	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	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	1	One for use and one for backup
Circulating pumps-4	Q=290 m^3/h, Head=60 m, P=90 kW	Unit	1	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=72 m, P=2.2 kW	Unit	2	
Fixed-pressure water-supplying device-2	Q=15 m^3/h, Head=42 m, P=4 kW	Unit	1	
Water-softening facility	Treatment capacity: 20 m^3/h	Unit	1	
Water-softening tank	Volume: 12.5 m^3	Unit	1	

Cyclone desander	Treatment capacity: 150 m³/h	Unit	1	
Submersible pump	Q=70 m³/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=115 m³/h, Head=36 m, P=45 kW	Unit	2	One for use and one for backup
Circulating pumps-2	Q=95 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=2m³/h, Head=68 m, P=1.1 kW	Unit	1	

Fixed-pressure water-supplying devices-2	Q=6 m^3/h, Head=44 m, P=1.1 kW	Unit	1	
Water-softening facility	Treatment capacity: 10 m^3/h	Unit	1	
Water-softening tank	Volume: 6 m^3	Unit	1	
Cyclone desander	Treatment capacity: 100 m^3/h	Unit	1	
Submersible pump	Q=90 m^3/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	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-2	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 device-1	Q=17 m^3/h, Head=42 m, P=4 kW	Unit	1	
Fixed-pressure water-supplying device-2	Q=3 m^3/h, Head=60 m, P=1.1 kW	Unit	1	
Water-softening facility	Treatment capacity: 20 m^3/h	Unit	1	
Water-softening tank	Volume: 12.5 m^3	Unit	1	
Cyclone desander	Treatment capacity: 110 m^3/h	Unit	1	
Submersible pump	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;	Unit	1	

	Secondary heat exchange temperature of supply water and return water: 10/18 °C			
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-2	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 device-1	Q=2 m^3/h, Head=60 m, P=1.1 kW	Unit	1	
Fixed-pressure water-supplying device-2	Q=8 m^3/h, Head=42 m, P=4 kW	Unit	1	
Water-softening facility	Treatment capacity: 10 m^3/h	Unit	1	
Water-softening tank	Volume: 12.5 m^3	Unit	1	
Cyclone desander	Treatment capacity: 80 m^3/h	Unit	1	
Submersible pump	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-2	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=28 m, P=22 kW	Unit	3	Two for use and one for backup
Fixed-pressure water-supplying device-1	Q=4 m^3/h, Head=81 m, P=2.2 kW	Unit	1	
Fixed-pressure water-supplying device-2	Q=12 m^3/h, Head=50 m, P=3 kW	Unit	1	
Water-softening facility	Treatment capacity: 12 m^3/h	Unit	1	
Water-softening tank	Volume: 18 m^3	Unit	1	
Cyclone desander	Treatment capacity: 125 m^3/h	Unit	1	

Pressurized rejection pump	Q=150 m^3/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 device-1	Q=10 m^3/h, Head=44 m, P=2.2 kW	Unit	1	

Fixed-pressure water-supplying device-2	Q=2.5 m³/h, Head=66 m, P=1.1 kW	Unit	1	
Water-softening facility	Treatment capacity: 15 m³/h	Unit	1	
Water-softening tank	Volume: 6 m³	Unit	1	
Cyclone desander	Treatment capacity: 120 m³/h	Unit	1	
Submersible pump	Q=120 m³/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>
</table>

11	Qianxizhuangyuan Station	1	1	2	11.05	368.23
12	Yehaowanghu Station	1	1		8.63	287.82
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. KML files of the project including the location of the geothermal wells, sub-areas and heated areas have been submitted to Verra.

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°49'17.9" N 114°47'11.6" E
			Injection Well a	34°49'17.5" N 114°47'11.6" E
			Injection Well b	34°49'17.2" N 114°47'11.6" E
			Injection Well c	34°49'17.4" N 114°47'11.6" 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 (Production Well) 24 (Injection Well)	-

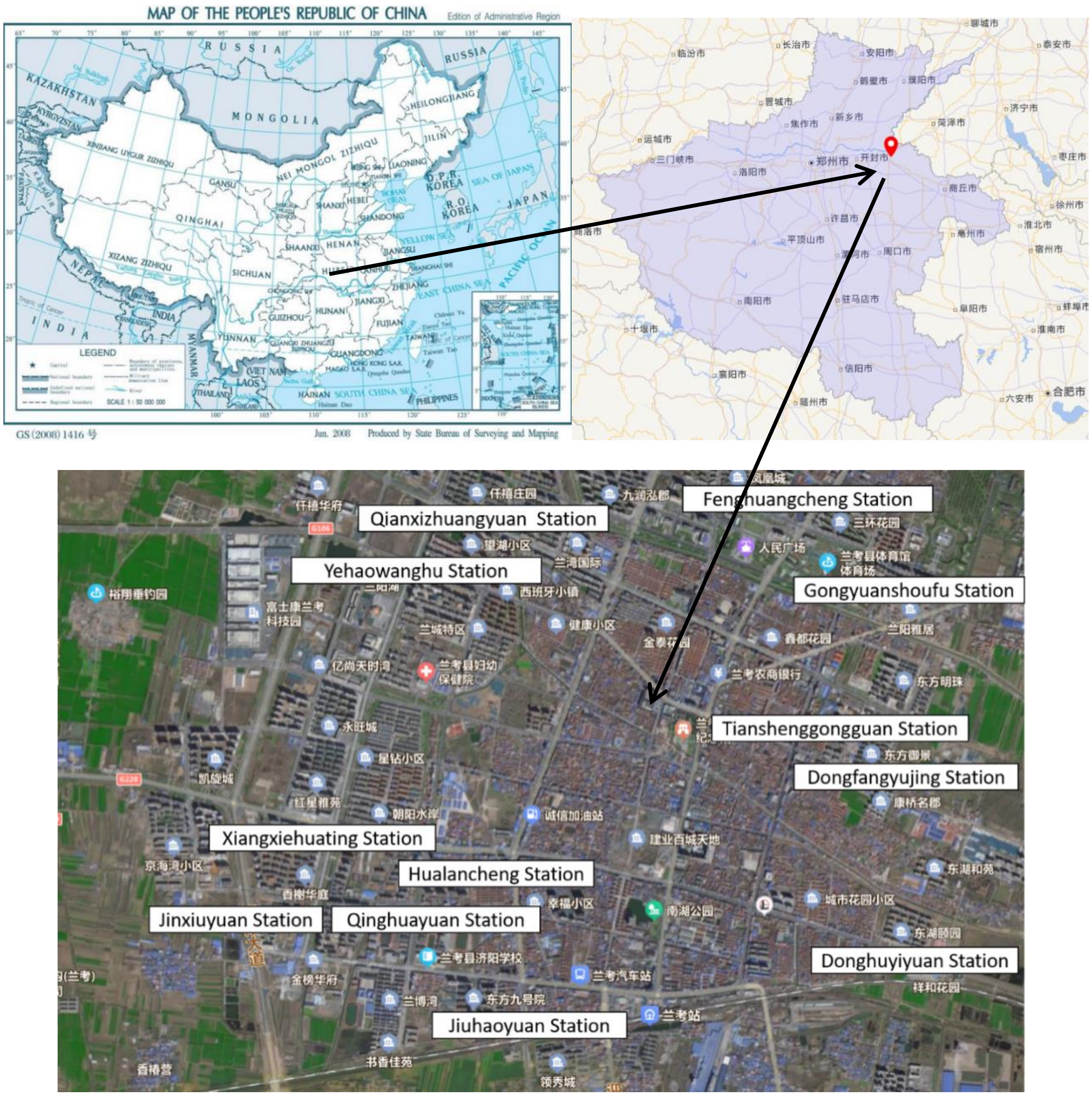

Figure 1-2 Location of the Project

Figure 1-3 Location of the Heated Areas

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[9]. 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)[10]. 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.

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

[10]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) [11]. 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) [12]. 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 extraction permit from governmental authorities: Lankao Environment Protection 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.

The project activity is not participating in other environment credits, other GHG programs and has not been rejected by any other GHG Programs.

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

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

[12] 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 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

According to update 23# of the August 2023 Overview of VCS Program Updates and Effective Dates (PDF), only a public statement from project proponents and authorized representatives who are buyers or sellers of a product in a supply chain is requested after 1-March-2024".

As this monitoring period covers 15-November-2021 to 18-March-2023 and this document is submitted prior to 1-March-2024, this section is not applicable for this report.

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 3,736.1 thousand m^2 of newly built 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. 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

SDG 13 Climate Action

The residential area where the project located is newly built. So, during the first monitoring period, the actual heating area 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% during the heating season 2021-2022 (from 15-November-2021 to 21-March-2022). And the project 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% during the heating season 2022-2023 (from 15-November-2022 to 18-March-2023). The occupancy rate 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-November-2021 to 21-March-2022, 1,207.8 thousand m^2 of residential buildings with a heating load of 36.23 MW, generating an actual emission reduction of 31,096 tCO_2e
- For the monitoring period from 22-March-2022 to 14-November-2022, the project is not implementing heating for the residential buildings, generating an actual emission reduction of 0 tCO_2e.
- For the monitoring period from 15-November-2022 to 18-March-2023, 1,469.5 thousand m^2 of residential buildings with a heating load of 44.08 MW, generating an actual emission reduction of 36,541 tCO_2e.

Besides, the project provides 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

During the monitoring period, the 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

During the monitoring period, 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). Replaced heating from isolated coal-fired boilers is as a normal business scenario in the project area. Emissions credits would be reduced by using geothermal energy rather than burning fossil fuels.

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% during the heating season 2021-2022 (from 15-November-2021 to 21-March-2022). Actual heating area is 1,207.8 thousand m². ● 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% during the heating season 2022-2023 (from 15-November-2022 to 18-March-2023). Actual heating area is 1,469.5 thousand m².	From the operation start date (15-November-2021) of this project activity to the end of this monitoring period (18-March-2023), the cumulative heating area is 2,677.3 thousand m².

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 during the construction period. From the operation start date of this project activity to the end of this monitoring period, 60 people were employed. Among them, the number of female workers is at least 30%.
3)	13.0	Tonnes of greenhouse gas emissions avoided or removed	Implemented activities to increase	● For the monitoring period from 15-November-2021 to 21-March-2022, 1,207.8 thousand m^2 of residential buildings with a heating load of 36.23 MW, generating an actual emission reduction of 31,096 tCO_2e ● For the monitoring period from 22-March-2022 to 14-November-2022, the project is not implementing heating for the residential buildings, generating an actual emission reduction of 0 tCO_2e. ● For the monitoring period from 15-November-2022 to 18-March-2023, 1,469.5 thousand m^2 of residential buildings with a heating load of 44.08 MW, generating an actual emission reduction of 36,541 tCO_2e.	From the operation start date (15-November-2021) of this project activity to the end of this monitoring period (18-March-2023), the project has achieved cumulative GHG emission reductions of 67,637 tCO_2e.

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) Reports for the project were compiled by Henan Zhengde Environmental Protection Technology Co., Ltd. The EIA for the project divides the entire project into three phases.

The EIA report (Phase I) was approved by Lankao Environment Protection Bureau on 5-January-2018. The respective approval number is “[2018] No.01”.

The EIA report (Phase II) was approved by Lankao Environment Protection Bureau on 9-May-2019. The respective approval number is “[2019] No.129”.

The EIA report (Phase III) was approved by Lankao Environment Protection 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 adopted on-site visits and questionnaires to explore the main opinions and demands of the stakeholders from 13-August -2020 to 15-August -2020.

In order to fully and truly understand the opinions and demands of the stakeholders on the construction and implementation of the project, all stakeholders within the scope of the project were collected.

The project team selected some resident representatives from each community involved in the project and government departments related to the project to visit and listen to their suggestions face to face. The questionnaires were distributed proportionally to the resident representatives from each community involved in the project and to the government departments related to the project. The survey questionnaire was designed to assess the project impacts on the local environment and social economic development. The resident and government representatives accepted and filled in the visiting questionnaire. A total of 100 questionnaires were distributed and 100 questionnaires were recovered, a recovery rate of 100%. The structure of the survey respondents is listed below.

Item		Quantity	Percentage
Number of stakeholders surveyed	Male	61	61%
	Female	39	39%
Age	<30	18	18%
	30-50	70	70%
	>50	12	12%
Occupation	Worker	13	13%
	Peasant	8	8%
	Management personnel	15	15%
	Civil servant	4	4%
	Unspecified	60	60%

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		No	43	43%

	Do you know the technology of using geothermal energy for centralized heating? (Single choice)	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 (Ongoing communication):

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. Besides, the project owner has opened 24-hour online customer service telephone. Within one hour after receiving the heat problem reflected by the user, the technician will enter the house to measure the temperature and investigate to ensure the fastest speed to solve the user's problem.

Some stakeholders worried that the project would bring noise pollution on employees and local residents' living. For this issue, the project owner will offer some measures: i.e., installation of soundproof devices and plating of green isolation belts are used for mitigating noise. So, the effect of the noise from the plant is little to local residents. These measures are a part of the project design. Thus, no updates to the project design are needed. The impacts of construction of the project are basically positive. The local stakeholders are pleased with the development of the project.

Stakeholder input:

During the monitoring period, there are customers who would call the customer service number provided by the project owner to raise repair requests. Technicians entered the house and completed repairs within one hour. The work performed for each service is recorded on a "Repair Order". For example, a customer called on the night of 12 November 2023 to report that the indoor heating was not hot. The technician on duty immediately came to the house to check the situation and found that the return valve was clogged, and the problem was solved successfully after treatment. All repair requests from the customers during this monitoring period have been properly handled.

Some stakeholders worried that the project would bring noise pollution on employees and local residents' living. For this issue, the project owner will offer some measures: i.e., installation of soundproof devices and plating of green isolation belts are used for mitigating noise. So, the effect of the noise from the plant is little to local residents. These measures are a part of the project design. Thus, no updates to the project design are needed. The impacts of construction of the project are basically positive. The local stakeholders are pleased with the development of the project.

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 (Phase I) was approved by Lankao Environment Protection Bureau on 5-January-2018.

The EIA report (Phase II) was approved by Lankao Environment Protection Bureau on 9-May-2019.

The EIA report (Phase III) was approved by Lankao Environment Protection 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 is reduced by preferentially selecting low-noise machinery and equipment, rationally arranging the working frequency of strong-noise construction machinery, and shortening the operation period.

After taking the corresponding measures mentioned above, the noise impact on the surrounding sound environment have been effectively reduced meeting the limits (Day<=70dB(A), night<=55dB(A)) specified in the *"Emission Standard of Environment Noise for Boundary of Construction Site (GB12532-2011)*[13]*"* After the completion of construction, the mechanical noise has ended.

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

[13] https://www.mee.gov.cn/ywgz/fgbz/bz/bzwb/wlhj/hjzspfbz/201112/t20111222_221680.shtml

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 (the sound level is 70 ~ 85dB(A)) during the operation has been attenuated by distance after the basic measures of sound insulation and vibration reduction of the building.

Through these measures, the noise reduction value reaches more than 25dB(A). At 1m outside the facility, the noise value is lower than 45dB(A). meeting the limits specified in the "*Emission Standard for Industrial Enterprise Noise at Boundary (GB12348-2008)*[14]".

That is to say, 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

[14] https://www.mee.gov.cn/ywgz/fgbz/bz/bzwb/wlhj/hjzspfbz/200809/t20080918_128936.shtml

As per section 3.18.9 of the VCS Standard (Version 4.5), all projects are subject to a 30-day public comment period. The date on which the project is listed on the project pipeline marks the beginning of the project's 30-day public comment period.

This project has been put up for public comment on the verra website and no public comment has been received. This project was open for public comment from 30-June-2023 to 30-July-2023.

According to update 19# of the August 2023 Overview of VCS Program Updates and Effective Dates (PDF), added requirements for comments received outside of the public comment period for both project proponents and validation/verification bodies are requested after 1-March-2024".

As this monitoring period covers 15-November-2021 to 18-March-2023 and this document is submitted prior to 1-March-2024, summary of comments received outside of the public comment period is not applicable for this report.

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) [15]

Tool 05 Baseline, project and/or leakage emissions from electricity consumption and monitoring of electricity generation (Version 03.0) [16]

Tool 07 Tool to calculate the emission factor for an electricity system (Version 07.0) [17]

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

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

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

Tool 24 Common practice (Version 03.1) [18]

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 are newly built, and the project activity doesn't involve any capacity expansion through the addition of extra geothermal wells.
The methodology is applicable under the following conditions: (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;	The geographical extent of the project boundary includes the 36 geothermal wells, 17 heat substations, 12 sub-areas of residential 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.

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

(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	The project activity is designed to introduce geothermal energy-based space heating system to realize heat supply to a series of

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.	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 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	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 are provided as evidence.

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 (c) Scenario III: Electricity is supplied to the grid and consumers/electricity consuming facilities.	This methodological tool is applied only for calculating for emission by electricity consumption in project activity. So, this criterion is not applicable.
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 only 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	In baseline scenario, heating supply in winter for the building areas were provided by coal-

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).	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 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.	The project activity uses electricity from Centre China Power Grid (CCPG) only. Electricity bill and contract with the power grid company are provided as evidence. Emission factor for the project electricity system will be calculated for grid power plants only as per Tool 07.
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 methodological tool, the requirements contained in the methodology shall prevail.	It is consistent of Tool 24 (Version 03.1) and AM0072 (Version 03.0) on approaches for the conduction of the common practice test.

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 17 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.

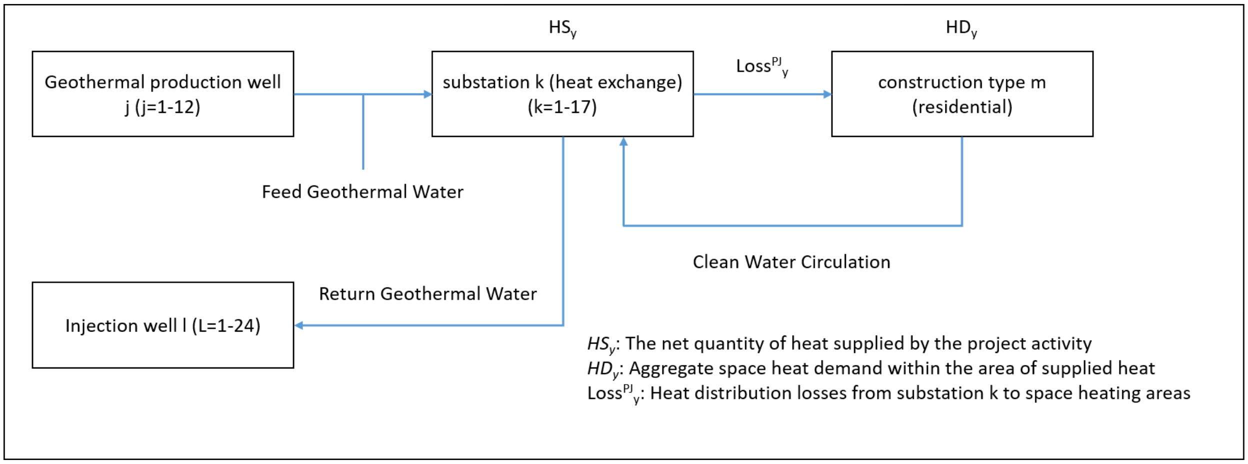

Figure 3-1 Project Boundary

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		CO_2	No	No fuel is used for geothermal extraction/operation.

Source		Gas	Included?	Justification/Explanation
	Fuel used for geothermal extraction /operations	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 identify 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.

Overview of heat supply in the relevant geographical area

At present, there is no municipal central heating system in the urban area of Lankao County and Lankao County mainly adopts the form of distributed central heating to provide heating services in winter[19], distributed central heating is mainly based on a heating unit or facility as the center,

[19] http://www.lankao.gov.cn/sitesources/lkxrmzf/page_pc/ztzl/jyta/xrddbzdjy/article4bdba844db7f4b09a9e1ace042459b52.html

supplying several surrounding buildings through a heat distribution network[20]. Thus, the heating demand for new buildings can only be met by constructing new heating facilities.

As per the Planning of Clean Heating in Winter of Northern China (2017-2021), coal is the main energy used for heating in northern China, with coal heating area accounting for about 83% of the total heating area[21]*.* According to an article published on WANGFANG DATA*,* Kaifeng City (where Lankao County belongs to) belongs to the traditional heating area and traditional heating refers to the use of methods such as coal-fired boilers and cogeneration for heating [22]. As per the *Research on Heating in Winter of Kaifeng City* published by Housing and Urban Rural Development Department of Kaifeng City*,* at present, coal-fired boiler is still the main source of heating energy and geothermal energy is still under development. .

Overall, there are no project activities at the project sites before the construction of the proposed project activities. All the buildings covered by the project activity were newly built and there was no existing heating system prior to the project activity.

Ten facilities (or projects) that provide the same output as the proposed project activity

As per Para 15 of TOOL02 (Version 07.0), The applicable geographical area should include preferably ten facilities (or projects), reflecting the variety of the available technologies, that provide the same output as the proposed project activity. If less than ten facilities (or projects) that provide the same output as the proposed project activity are found in the applicable geographical area, the applicable geographical area may be expanded to an area that covers if possible, ten such facilities (or projects) or the whole host country.

The applicable geographical area is Lankao County. Due to the most of the existing coal-fired boiler capacity is small and the management is decentralised, it is difficult to query the information of each heating facilities. There are less than ten facilities (or projects) that provide the same output as the proposed project activity are found in Lankao County, thus, the applicable geographical area is expanded to the whole host country. Following are the ten facilities (or projects) that provide the same output as the proposed project activity:

1) Heating project of 40ton coal-fired boiler for a heat power company in Henan Province

https://www.ydglzg.com/cases/61.html

2) Henan Thermal Power Company 40 tonne coal-fired boiler

http://www.hnydgl.com/case/hangye/gongnuan/145.html

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[20] https://www.163.com/dy/article/ID0K3O00005562F0W.html

https://b2b.baidu.com/q/aland?q=7E1F7B75037470600C661A2275661F1970600C667C0D0E317839&id=qidbcd8d62d6950778416f5c2e5374a3a89&answer=1761485997690948014O&utype=2

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

[22] https://d.wanfangdata.com.cn/thesis/ChJUaGVzaXNOZXdTMjAyNDAxMDkSCUQwMjgzODg5NBoIbmVia2Y5YnA%3D

3) Coal-fired Boiler Heating Project in Zhengzhou City, Henan Province

https://www.zzboiler.com/prltgl/109.html

4) Henan University 2*7MW (10 tonnes) Coal-fired Boiler Heating Project in Henan Province

https://www.zzboiler.com/prltgl/80.html

5) Dongfang Thermal Power 2×75t/h coal-fired boiler heating project in Henan Province

https://www.zzboiler.com/prltgl/219.html

6) Coal-fired Boiler Project for Winter Heating in Yan'an Drug Rehabilitation Centre, Shanxi Province

https://www.ccgp.gov.cn/cggg/dfgg/zbgg/202401/t20240125_21474277.htm

7) Dunhua Heating Company 46MW (65 tons/hour) coal-fired boiler heating project in Jilin Province

https://www.zzboiler.com/prltgl/58.html

8) 35t Coal-fired Boiler Heating Project in Tongxiang City, Zhejiang Province

https://www.zzboiler.com/prltgl/243.html

9) Heating project of Coal-fired boiler for 900,000 m2 in Beijing

https://www.youqiguolu.com/news/8184.html

10) Coal-fired heating boilers in Wuwei City

https://www.youqiguolu.com/news/23037.html

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;	According to the Feasibility Study Report (FSR), there was no municipal centralized heating system in the urban area of Lankao County and this area mainly adopts the form of distributed central	Excluded

		heating to provide heating services in winter [23]. The location of the project is not in the central heating area. District heating is not provided in the project area. Thus, this is not considered as a realistic and credible alternative scenario.	
	(ii) The replacement of the heat-only boilers in the existing network(s) by new heat-only boilers.	According to the Feasibility Study Report (FSR), the project is a greenfield project, there are no existing networks in all the residential buildings of the 12 sub-areas. Thus, this is not considered as a realistic and credible alternative scenario.	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. Thus, this is a realistic and credible alternative scenario.	Included
	(ii) Natural gas fired boilers in boiler houses, supplying several buildings through a heat distribution network:	This is a realistic and credible alternative scenario.	Included
	(iii) Oil fired boilers in boiler houses, supplying several	Oil-fired boilers have the problem of insufficient environmental cleanliness and the oil-fired boiler	Excluded

23 http://www.lankao.gov.cn/sitesources/lkxrmzf/page_pc/ztzl/jyta/xrddbzdjy/article4bdba844db7f4b09a9e1ace042459b52.html

	buildings through a heat distribution network:	will have the possibility of black smoke after a long time of use[24]. Besides, oil fired boilers must be configured with a set of more complex oil supply system, such as tanks, pumps, filters, etc., must occupy a certain amount of space.[25] In addition, the transportation and storage of oil is dangerous and more prone to accidents[26]. There is no public information that there is a form of oil-fired boiler heating distributing network in Lankao County. Therefore, compared with the mainstream heating method (coal-fired boilers), oil fired boilers will not be considered. Thus, this is not considered as a realistic and credible alternative scenario.	
	(iv) Decentralized cogeneration plants;	Decentralized cogeneration plants do not cover the project area. Thus, this is not considered as a realistic and credible alternative scenario.	Excluded
	(v) Renewable energy sources, such as biomass or solar thermal collectors, connected to a heat distribution network.	According to the *Notice on Issuing the 13th Five Year Plan for Energy Development in Henan Province* issued by the People's Government of Henan Province, it is known that due to the limit on biomass technique level, renewable energy sources, such as biomass energy,	Excluded

[24] https://www.hbzhan.com/tech_news/detail/637134.html

[25] https://yuzhixianedu.com/information/detail/post-796.html

[26]https://www.zjgbxny.com/news_Detail_1/10.html

		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 China. [27] Therefore, this option is not considered as a realistic and credible alternative scenario.	
4	(d) Continued use or introduction of individual heat supply solutions:		
	(i) Coal fired boilers for individual buildings;	This is a realistic and credible alternative scenario.	Included
	(ii) Coal fired stoves for individual apartments;	It's dangerous to use coal fired stoves inside the apartments due to carbon monoxide poisoning. Carbon monoxide poisoning incidents have occurred in many places, it sounds the alarm on safety of home heating in winter[28] Thus, this is not considered as a realistic and credible alternative scenario.	Excluded
	(iii) Natural gas fired boilers for individual buildings;	This is a realistic and credible alternative scenario.	Included
	(iv) Natural gas fired stoves for individual apartments;	This is a realistic and credible alternative scenario.	Included
	(v) Oil fired boilers for individual buildings;	Oil-fired boilers have the problem of insufficient environmental cleanliness and the oil-fired boiler will have the possibility of black smoke after a long time of use[29]. Besides, oil fired boilers must be configured with a set of more	Excluded

[27] http://m.henan.gov.cn/2017/01-25/248661.html

[28] http://m.xinhuanet.com/gz/2019-01/10/c_1123971640.htm

[29] https://www.hbzhan.com/tech_news/detail/637134.html

		complex oil supply system, such as tanks, pumps, filters, etc., must occupy a certain amount of space.[30] In addition, the transportation and storage of oil is dangerous and more prone to accidents[31]. There is no public information that there is a form of oil-fired boiler heating for individual buildings in Lankao County. Thus, this is not considered as a realistic and credible alternative scenario.	
	(vi) Oil fired stoves for individual apartments;	This is a realistic and credible alternative scenario.	Included
	(vii) Electricity (e.g., off-peak storage heating);	At present, the area of electric heating in the northern part of China accounts for only 2%.[32] The power consumption of electricity-based heating technology is very high. A general household consume 25-35 kwh of electricity per day for electric heating.[33] According to the article *Power demand response capability calculation and reserve objective optimized decomposition of Henan province* published *on the POWER DEMAND SIDE MANAGEMENT (ISSN 1009-1831),* it is also known that the gap between power supply and demand in Henan province continues to increase.[34] It can be	Excluded

30 https://yuzhixianedu.com/information/detail/post-796.html

31https://www.zjgbxny.com/news_Detail_1/10.html

32 http://www.cnste.org/html/jishu/2020/0604/6438.html

33 https://www.sohu.com/a/355884111_99999190

34 http://sgdsm.cnjournals.com/ch/reader/view_abstract.aspx?file_no=20210315

		seen that in Henan Province, long-term use of electric heating in winter is unrealistic. As to the off-peak storage heating technology is currently one of the research directions, which is still in the laboratory validation stage, not yet a large number of commercial applications in China.[35] Thus, this is not considered as a realistic and credible alternative scenario.	
	(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 are no stable individual space heating devices using solar thermal collectors[36]. Thus, this is not considered as a realistic and credible alternative scenario.	Excluded
	(ix) Individual heating devises using non renewable biomass.	As illustration of 3 (v) above, there is no sufficient biomass in the project area. Thus, this is not considered as a realistic and credible alternative scenario.	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.

Outcome of Step 1a:

35 http://www.cnste.org/html/jishu/2020/0604/6438.html

36 http://www.cqvip.com/qk/85154x/201718/673315149.html

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.

3 (ii) Natural gas fired boilers in boiler houses, supplying several buildings through a heat distribution network.

4(i) Coal fired boilers for individual buildings.

4(iii) Natural gas fired boilers for individual buildings.

4(iv) Natural gas fired stoves for individual apartments.

4(vi) Oil fired stoves for individual apartments;

Step 1b: Consistency with mandatory laws and regulations

As per *Three-year Action Plan to Win the Blue Sky Defense War*[37], coal fired boilers for individual buildings should be eliminated gradually. New coal fired boilers built for individual buildings are forbidden by the government. Thus, the alternative 4(i) is not consistent with mandatory laws and regulations and eliminated under this step.

As per the following laws and regulations regarding space heating in China:

1. Environmental Protection Law of the People's Republic of China;

2. Plan for Clean Heating in Winter in Northern China (2017-2021) (Development and Reform of Energy resources (2017) No. 2100);

3. Catalogue for the Guidance of Industrial Structure Adjustment (2019 version);

4. Green Industry Guidance Directory;

5. Technical specification for geothermal space heating engineering;

6. Three-year Action Plan to Win the Blue Sky Defense War;

The remaining options 1(a), 3(i), 3(ii), 4(iii), 4(iv), 4(vi) are considered to follow all mandatory applicable legal and regulatory requirements.

Outcome of Step 1b

In summary, the alternative 4(i) is not consistence with mandatory laws and regulations, the other alternatives are considered to follow all mandatory applicable legal and regulatory requirements.

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

Thus, the remaining realistic and credible alternative scenarios following mandatory legislation and regulations are:

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

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

3 (ii) Natural gas fired boilers in boiler houses, supplying several buildings through a heat distribution network.

4(iii) Natural gas fired boilers for individual buildings.

4(iv) Natural gas fired stoves for individual apartments.4(vi) Oil fired stoves for individual apartments;

Step 2: Barrier analysis

As per the applied methodology AM0072 Fossil Fuel Displacement by Geothermal Resources for Space Heating version 3.0 and TOOL02 Combined tool to identify the baseline scenario and demonstrate additionality, version 07.0, Scenarios that face prohibitive barriers should be eliminated under this step.

As per the methodology, realistic and credible barriers may include:

(a) Technological barriers

(b) Acceptability barriers

(c) Financial barriers

For alternatives: *3 (ii) Natural gas fired boilers in boiler houses, supplying several buildings through a heat distribution network, 4(iii) Natural gas fired boilers for individual buildings and 4(iv) Natural gas fired stoves for individual apartments.*

The laying of natural gas pipeline is relatively complicated, and the construction cost is high. Once destroyed, it will cause great harm to the surrounding environment, people's life and property safety.[38] According to the *Feasibility Study Report (FSR)*, natural gas reserves in Lankao County are strained. The area where the project is located is temporarily not covered by natural gas pipe network. As per the CDM Tool02 v07.0, "lack of infrastructure for implementation and logistics for maintenance of the technology (e.g. natural gas cannot be used because of the lack of a gas transmission and distribution network)" is a kind of Technological barriers for Scenarios. Thus, **there are technology barriers of the alternative scenario 3(ii), 4(iii) and 4(iv).**

For alternative 4(vi): Oil fired stoves for individual apartments

[38] http://old2022.bulletin.cas.cn/publish_article/2020/9/20200914.htm

Since the technology of using oil fired stoves for heat supply is mainly used in the industrial field. It is not yet mature for using in residential apartments[39], **there are technology barriers of the alternative scenario 4(vi) a**s per the CDM Tool02 v07.0.

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

Lankao Green Energy Clean Energy Co., Ltd. has about 60 key technicians on geothermal energy, All the skilled technicians have ability to maintain and repair the related equipment. Furthermore, they can provide training for the employees hired the project on operation and maintenance of the whole geothermal space heating system. As per FSR of the project, it is rich in geothermal resources of Kaifeng City. The normal operation of the equipment can be guaranteed in the perspective of renewable energy supply. The geothermal heating technology used in the project is relatively mature. **There are no technology barriers of the project scenario (alternative 1(a))**.

Clean heating is promoted by the related policies of China. Geothermal energy is used by the project activity instead of coal, which will not only reduce the GHG emissions, but also be in line with the national policy orientation. The project uses geothermal resources in the middle and deep layers, which has the advantage of stability, continuity and high efficiency. Design heating index of the project residential buildings is 30 W/m^2, which meets the requirement of *DBJ411 062 – 2012 Henan Province design standard for energy efficiency of residential buildings (cold zone)* published by Henan Housing and Urban-Rural Construction Development. The average indoor temperature can be kept to around 20 ℃, which can provide a comfortable living environment. According to the results of local stakeholder consultation, the geothermal space heating system is acceptable to the end-users. In summary, **there are no acceptability barriers of the project scenario (alternative 1(a)).**The project owner is not included in the list of serious dishonest organization[40]. Besides, cleaning heating supply with geothermal or other renewable energy is encouraged by the Chinese government. **There are no financial barriers for the project owner to apply for bank loans or other fundings of the project scenario (alternative 1(a))**. Financial returns of the project activity are analyzed in Step 3.

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

Without the project activity, heating supply to the project aera is provided by isolated coal fired boilers. **There are no barriers for alternative 3(i).**

Outcome of Step 2

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

[40] https://www.creditchina.gov.cn/xinyongxinxixiangqing/xyDetail.html?searchState=1&entityType=1&keyword=%E5%85%B0%E8%80%83%E7%BB%BF%E8%83%BD%E6%B8%85%E6%B4%81%E8%83%BD%E6%BA%90%E6%9C%89%E9%99%90%E5%85%AC%E5%8F%B8&uuid=c0d9044c61b825d8a549adb6f99f1ccc&tyshxydm=91410225MA44AJRQ9C

In summary, options 3(ii). 4(ii), 4(iv) and 4(vi) are eliminated due to technology barriers. For options 1(a) and 3(i), 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[41]:

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

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

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

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
Investment expenditures (10,000 RMB)	56,042.42[42]	9,340.25[43]
O&M Cost (10,000 RMB/year)	1,617.78[44]	1,587.84
Fuel expenditure (10,000 RMB/year)	0[45]	2,220.58
Residual value (10,000 RMB)	2,802.12[46]	467.01[47]
Annual heat supply (GJ)	1,162,076.54[48]	1,162,076.54
Discount rate[49]	8%	8%
Project lifetime[50]	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*

[42] The data is from the feasibility study report

[43] 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).

[44] The data is from the feasibility study report

[45] The data is from the feasibility study report

[46] The data is from the feasibility study report

[47] 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)

[48] 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)

[49] 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

[50] The data is from the Feasibility study report

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.

b. O&M costs; and

c. Total heat supply

d. Coal price

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	

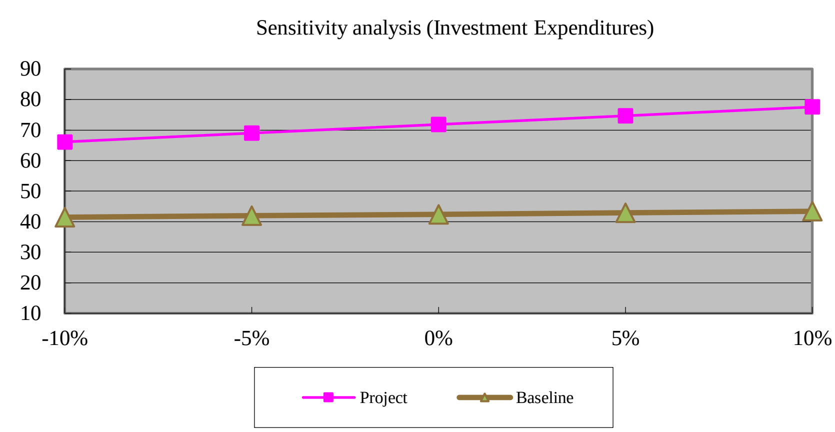

Figure 3-2 Sensitivity Analysis (Investment expenditures)

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.[51] 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	

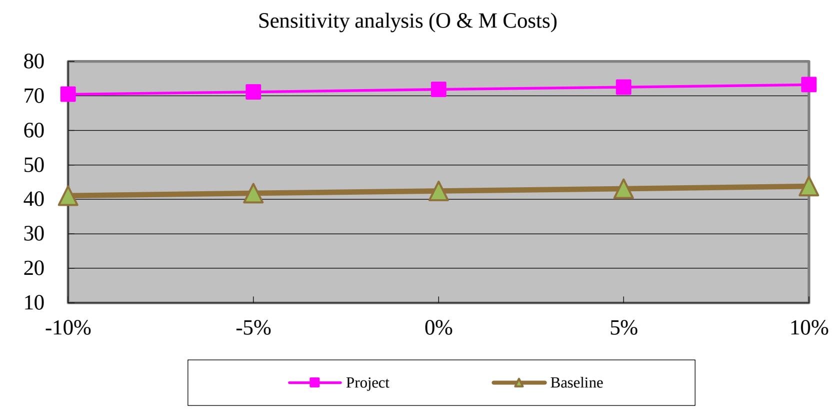

Figure 3-3 Sensitivity Analysis (O&M Costs)

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[52], 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	

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

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

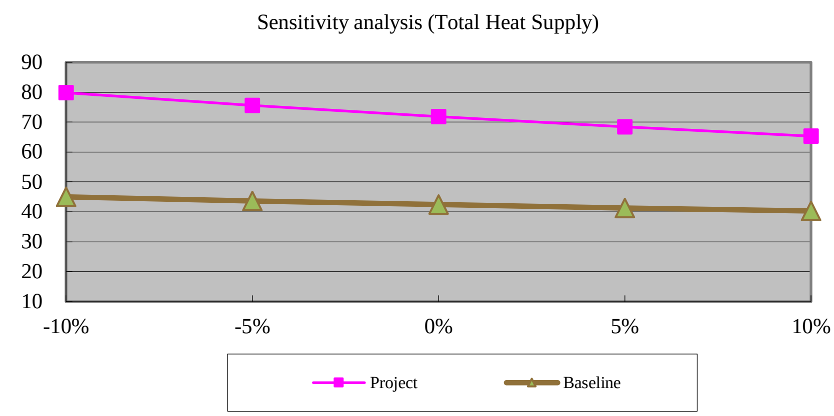

Figure 3-4 Sensitivity Analysis (Annual Heat Supply)

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.

Table 3-7 Sensitivity Analysis of LCOH on Coal price (Unit: (RMB/t raw coal)

Item	-10%	-5%	0	5%	10%	Critical Point
Proposed Project 1(a)	71.84	71.84	71.84	71.84	71.84	153.95%
Alternative Baseline 3(i)	40.51	41.47	42.42	43.38	44.34	

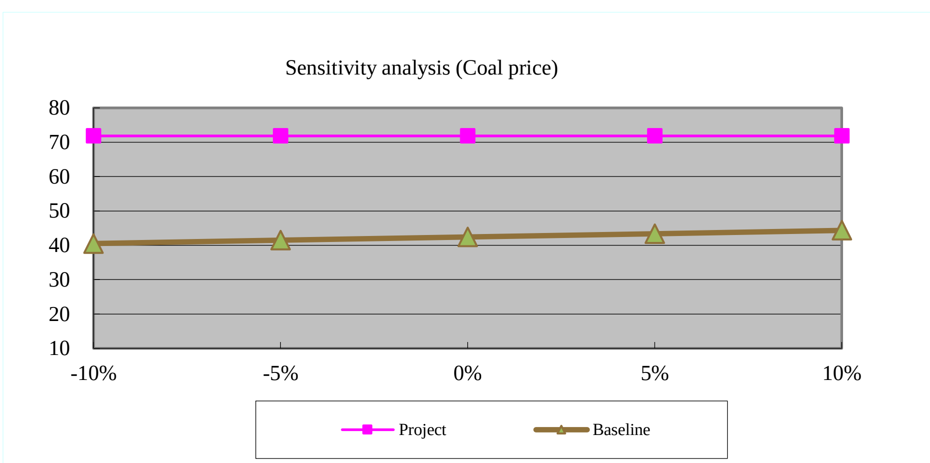

Figure 3-5 Sensitivity Analysis (Coal price)

The proposed project 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 geothermal. Therefore, the LCOH for the proposed project is not affected by the price of coal.

When the Coal price increased by 153.95%, the LCOH of alternative baseline 3 (i) would be as high as in the proposed project. According to the *Notice on Further Improving the Coal Market Price Formation Mechanism* published by the National Development and Reform Commission[53], when coal prices rise significantly or are likely to rise significantly, price intervention measures will be initiated in a timely manner in accordance with Article 30 of the Chinese Price Law to guide coal prices back to a reasonable range. It can be learnt from this Notice that the maximum reasonable coal price is 770 RMB/t, which is a 92.5% increase relative to the coal price for the alternative baseline 3 (i). It is therefore unlikely that the coal price will rise by as much as 153.95%. Thus, alternative baseline 3 (i) still remains more financially attractive.

Besides, from the Feasibility Study Report of the project, as the price of coal rises, the energy supply is getting tighter and tighter. In order to ensure the stability of residents' heating costs, it is urgent to promote the development of clean energy. Although, the LCOH of geothermal energy heating is higher, the proposed project has been developed and constructed due to the stability of residents' heating costs as well as the environmental benefits.

Outcome of Step 3:

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

Regulatory surplus

The relevant laws and regulations regarding minimum energy requirements of new buildings in China include:

[53] https://www.ndrc.gov.cn/xwdt/tzgg/202202/t20220225_1317006_ext.html

(a) *Environmental Protection Law of the People's Republic of China*[54] which encourages the production and use of clean energy.

(b) *Plan for Clean Heating in Winter in Northern China (2017-2021)*[55] which encourages the use of clean energy for space heating.

(c) *Catalogue for the Guidance of Industrial Structure Adjustment*[56], which lists projects in three categories: encouragement category, restriction category and elimination category. The development of geothermal energy utilization technology belongs to the encouragement category of the Catalogue.

(d) Green Industry Guidance Directory (2019 version) [57]. 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.

(e) *Technical specification for geothermal space heating engineering (CJJ 138-2010)*[58], which stipulates technical requirements for geothermal space heating engineering and it does not mandatory the utilization of geothermal space heating.

Based on the analysis above, it is concluded that in China, there is no law, statute nor regulatory framework mandates the application of geothermal space heating projects. Thus, the regulatory surplus has been achieved.

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:

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[54] https://www.mee.gov.cn/ywgz/fgbz/fl/201404/t20140425_271040.shtml

[55] https://www.gov.cn/xinwen/2017-12/20/content_5248855.htm

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

https://www.gov.cn/zhengce/zhengceku/202312/P020231230491146853988.pdf

[57]http://kj.jdz.gov.cn/zwzx/ggs/P020210823363389433184.pdf

[58] http://cnspc.sinopec.com/cnspc/Resource/Pdf/CJJ%20138-2010.pdf

(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:

- 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;
- 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;
- 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, whichever is earlier for the proposed project activity.

According to the “Glossary CDM terms”, start date is defined that “for the CDM project activity, where a contract is signed for such expenditure, it is the date on which the contract is signed. In other cases, it is the date on which such expenditures are incurred. If the CDM project activity or CPA involves more than one of such contracts or incurred expenditures, it is the first of the respective dates.

The first contract signed for the project activity is the Project construction contract between the project owner and Zhejiang Lute Energy Technology Co., Ltd. on 15-August-2020. Thus, for Common practice analysis, the start date of proposed project activity is 15-August-2020.

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-August-2020). Through searching the following website:

UNFCC website: https://unfccc.int

China CDM website: http://www.cdmcenter.com

China CER exchange info-platform: https://cdm.ccchina.org.cn/

GS website: https://www.goldstandard.org/

VCS website: https://verra.org/

Local DRC (Development and Reform Commission) of Henan province website: https://fgw.henan.gov.cn/

there are no similar projects.

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.

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

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

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

The earliest group of geothermal space heating systems to be constructed started commissioning on 15-November-2021, including 6 sub-areas with a total of 11 heat substations. Until the end of this monitoring period, there are 10 sub-areas in operation with a total of 14 heat substations and the remaining two sub-areas have not commissioned yet. The detailed information regarding the commissioning date of all 10 sub-areas in operation and the expected dated of commissioning of the two remaining sub-areas are summarized in following table.

Table 4.1 Information regarding the commissioning date

Sub-areas	Heat-Substations	Commissioning date
Fenghuangcheng Station	1#FHC	15-November-2021
	2#FHC	15-November-2021
	3#FHC	15-November-2021
	4#FHC	15-December-2023 (After this monitoring period)
Gongyuanshoufu Station	1#GYSF	15-November-2021
Dongfangyujing Station	1#DFYJ	15-November-2021
	2#DFYJ	15-November-2021
	3#DFYJ	15-November-2021
Donghuyiyuan Station	1#DHYY	22-December-2021
Qinghuayuan Station	1#QHY	15-November-2021
Xiangxiehuating Station	1#XXHT	15-November-2021

Hualancheng Station	1#HLC	15-November-2021
Jiuhaoyuan Station	1#JHY	14-January-2023
Jinxiuyuan Station	1#JXY	End of 2024 (Expected)
Tianshenggongguan Station	1#TSGG	End of 2024 (Expected)
Qianxizhuangyuan Station	1#QXZY	15-November-2021
Yehaowanghu Station	1#YHWH	19-January-2023

After this monitoring period, a new heat substation (4#FHC) started commissioning. Full operation of the project are scheduled at the end of 2024. 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, the actual heating area is affected not only by the residential construction period, but also by the actual occupancy rate.

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). Lankao County is part of Kaifeng City, so it carries out the same winter heating implementation plan.

The first monitoring period is from 15-November-2021 to 18-March-2023, including:

- the heating season 2021-2022 (from 15-November-2021 to 21-March-2022),
- non-heating times (from 22-March-2022 to 14-November-2022) and
- the heating season 2022-2023 (from 15-November-2022 to 18-March-2023)

The project has started to heat 1,927.91 thousand m^2 of residential buildings with the occupancy rate of 62.65% during the heating season 2021-2022 (from 15-November-2021 to 21-March-2022). And the project 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% during the heating season 2022-2023 (from 15-November-2022 to 18-March-2023). The occupancy rate 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-November-2021 to 21-March-2022, 1,207.8 thousand m^2 of residential buildings with a heating load of 36.23 MW, generating an actual emission reduction of 31,096 tCO_2e

- For the monitoring period from 22-March-2022 to 14-November-2022, the project is not implementing heating for the residential buildings, generating an actual emission reduction of 0 tCO_2e.
- For the monitoring period from 15-November-2022 to 18-March-2023, 1,469.5 thousand m^2 of residential buildings with a heating load of 44.08 MW, generating an actual emission reduction of 36,541 tCO_2e.

From the operation start date (15-November-2021) of this project activity to the end of this monitoring period (18-March-2023), the project has achieved cumulative GHG emission reductions of 67,637 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 district heating 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:

$$HS_y - Loss^{PJ}_y = \sum_i HS^{BL}_{i,y} - Loss^{BL}_y \quad (3)$$

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 (*$HS^{BL}_{i,y}$*)

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

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 in the methodology AM0072 (Version 03.0)). 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;

Three manufacturers of coal-fired boiler were checked, and the efficiencies of their products were from 75% to 85%[59]. 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.

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[59] Zozen Boiler: 79% https://www.zhongzhengguolu.cn/product/DZL-ran-mei-zheng-qi.html

Xinli Boiler: 75%-85% https://kfxlgl.com/product/youjirezaitilu/ylwmeilu.html#xjzs

Henan Hengde Boiler: 85% http://www.hengdeguolu.com/product/172.html

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.

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.

$$HS_y = min\{H_{CAP}, HS_{y,estimated}\} \quad (5)$$

$HS_{y,estimated}$ 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.

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

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).

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

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).
$\Delta t_{j,d,y}$	=	Average temperature difference between inlet and outlet temperatures at the downstream of heat exchanger (upstream of which is connected with water supply from the geothermal well j) in year y (°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.

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

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 (m^2).
HI_m	=	Heating index for construction type m (GW/m^2).
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).

As per the methodology AM0072, v.03.0, if 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 following options:

(a) Design heat losses as provided by manufacturer/supplier of heating network;

(b) Measurement and estimation of surface heat losses (through radiation and convection) by measuring surface temperature (maximum), surface area of pipeline, valves and fittings (use engineering handbooks for calculating surface area of valves and fittings). Follow the recognized engineering handbooks/publications or national or international standards for calculation of surface heat losses.

Option (a) is selected to determine the heat losses.

The manufacturer of the heat network has provided the engineering specifications of the heating project, 10% design heat losses is provided

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

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:

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

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*.

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

The electricity consumed by facilities of the geothermal system is sourced from local power grid connected to central China Power Grid (CCPG). Thus, **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 $TDL_{j,y}$.

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 07 *Tool to calculate the emission factor for an electricity system* (Version 07.0). $EF_{EL,j,y}=EF_{grid,CM,y}$.

Calculation of grid electricity emission factor

The grid electricity emission factor $EF_{grid,CM,y}$ is calculated through the TOOL07: Tool to calculate the emission factor for an electricity system (version 07.0). The following six steps are applied:

Step 1: Identify the relevant electricity systems;

Step 2: Choose whether to include off-grid power plants in the project electricity system (optional);

Step 3: Select a method to determine the operating margin (OM);

Step 4: Calculate the operating margin emission factor according to the selected method;

Step 5: Calculate the build margin (BM) emission factor;

Step 6: Calculate the combined margin (CM) emission factor.

Step 1: Identify the relevant electricity systems

The delineation of the electricity systems in China is provided by the Chinese DNA. As per *2019 baseline emission factors for regional power grids in China,* among the six regional power grids, the Central China Power Grid (CCPG), which covers Henan Province, Hubei Province, Hunan Province, Jiangxi Province, Sichuan Province and Chongqing City, is the relevant electricity system as the project located in Henan Province.

Step 2: Choose whether to include off-grid power plants in the project electricity system (optional)

Project participants may choose between the following two options to calculate the operating margin and build margin emission factor:

Option I: Only grid power plants are included in the calculation.

Option II: Both grid power plants and off-grid power plants are included in the calculation.

Considering the structure of China's power system, only grid power plants (**Option I**) are included in the calculation.

Step 3: Select a method to determine the operating margin (OM)

The calculation of the operating margin emission factor $EF_{grid,OM,y}$ is based on one of the following methods:

(a) Simple OM, or

(b) Simple adjusted OM, or

(c) Dispatch data analysis OM, or

(d) Average OM.

In China, detailed data from each power plant are sensitive business information and are mostly confidential and thus not publicly available. Therefore, method (b) and method (c) are not suitable for the calculation.

The simple OM method can be used if low-cost/must-run resources constitute less than 50% of total grid generation in average of the five most recent years. According to China Electric Power Yearbook released from 2014 to 2018, for CCPG to which the project activity is connected, the low-cost/must-run power generation accounted for 39.13%, 45.07%, 47.01%, 49.05% and 49.08% of total grid generation in 2013, 2014, 2015, 2016 and 2017, respectively; considering the average of the five years from 2013 to 2017, the low-cost/must-run power generation accounted for 45.87% of total grid generation, lower than 50%. Therefore, method (a) is applicable, and the simple OM method is applied for the calculation of the operating margin emission factor $EF_{grid,OM,y}$.

For the simple OM, the emissions factor can be calculated using either of the two following data vintages:

(a) Ex ante option: if the ex-ante option is chosen, the emission factor is determined once at the validation stage, thus no monitoring and recalculation of the emissions factor during the crediting period is required. For grid power plants, use a 3-year generation-weighted average, based on the most recent data available at the time of submission of the CDM-PDD to the DOE for validation. For off-grid power plants, use a single calendar year within the five most recent calendar years prior to the time of submission of the CDM-PDD for validation.

(b) Ex post option: if the ex-post option is chosen, the emission factor is determined for the year in which the project activity displaces grid electricity, requiring the emissions factor to be updated annually during monitoring. If the data required to calculate the emission factor for year y is usually only available later than six months after the end of year y, alternatively the emission factor of the previous year y–1 may be used. If the data is usually only available 18 months after the end of year y, the emission factor of the year proceeding the previous year y–2 may be used. The same data vintage (y, y–1 or y–2) should be used throughout all crediting periods.

Based on the most recent data available at the time of this Joint PD&MR submission, the first option (ex-ante) for the calculation of the OM emission factor is chosen for the project, in line with *2019 baseline emission factors for regional power grids in China* published by the Chinese DNA.

Step 4: Calculate the operating margin emission factor according to the selected method;

The simple OM emission factor is calculated as the generation-weighted average CO_2 emissions per unit net electricity generation (tCO_2/MWh) of all generating power plants serving the system, not including low-cost /must-run power plants /units. It may be calculated by one of the two following options:

Option A: Based on the net electricity generation and a CO_2 emission factor of each power unit; or

Option B: Based on the total net electricity generation of all power plants serving the system and the fuel types and total fuel consumption of the project electricity system. Option B can only be used if:

i. The necessary data for Option A is not available; and

ii. Only nuclear and renewable power generation are considered as low-cost/must-run power sources and the quantity of electricity supplied to the grid by these sources is known; and

iii. Off-grid power plants are not included in the calculation (i.e. if Option I has been chosen in Step 2)

The data of each power plant serving the system is difficult to obtain. In this case, Option A is not preferred. In addition, according to the China Energy Statistical Yearbook, only nuclear and renewable power generation are considered as low-cost/must-run power sources and the quantity of electricity supplied to the grid by these sources is known; also, off-grid power plants are not included in the calculation, as discussed in Step 2), which justifies the applicability of Option B for the calculation of the OM emission factor.

Therefore, **Option B is chosen to calculate the OM emission factor.**

Under this option, the simple OM emission factor is calculated based on the net electricity supplied to the grid by all power plants serving the system, not including low-cost/must-run power plants/units, and based on the fuel type(s) and total fuel consumption of the project electricity system, as the following equation:

$$EF_{grid,OMsimple,y} = \frac{\sum_i FC_{i,y} \times NCV_{i,y} \times EF_{CO2,i,y}}{EG_y} \quad (14)$$

where:

$EF_{grid,OMsimple,y}$	=	Simple operating margin CO_2 emission factor in year y (t CO_2/MWh)
$FC_{i,y}$	=	Amount of fuel type i consumed in the project electricity system in year y (mass or volume unit)
$NCV_{i,y}$	=	Net calorific value (energy content) of fuel type i in year y (GJ/mass or volume unit)
$EF_{CO2,i,y}$	=	CO_2 emission factor of fuel type i in year y (tCO_2/GJ)
EG_y	=	Net electricity generated and delivered to the grid by all power sources serving the system, not including low-cost / must-run power plants/units, in year y (MWh)
i	=	All fuel types combusted in power sources in the project electricity system in year y

If available, values of $NCV_{i,y}$ and $EF_{CO2,i,y}$ provided by the fuel supplier of the power plants in invoices may be used; otherwise, regional or national average default values may be used. For the Project, the values of $NCV_{i,y}$ for each type of fuel are obtained from China Energy Statistical Yearbook 2018, and the emission factors $EF_{CO2,i,y}$ for each type of fossil fuel come from default values in 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Fuel consumption data and electricity generation data are obtained from China Electric Power Yearbook 2016~2018 and China Energy Statistical Yearbook 2016~2018.

The above simple OM calculation is derived from the notification ‘2019 Baseline Emission Factors for Regional Power Grids in China’ published by China’s DNA, which is the only most recent available official statistics at the time of submission for the crediting renewal request.

Therefore, based on the latest data published by China DNA, the Simple OM emission factor $EF_{grid,OMsimple,y}$ for the CCPG is 0.8587 tCO_2/MWh.

Step 5: Calculate the build margin (BM) emission factor;

As per Section 6.5 of TOOL07 (version 07.0), in terms of vintage of data, project participants can choose between one of the following two options:

(a) **Option 1** - for the first crediting period, calculate the build margin emission factor ex ante based on the most recent information available on units already built for sample group m at the time of CDM-PDD submission to the DOE for validation. For the second crediting period, the build margin emission factor should be updated based on the most recent information available on units already built at the time of submission of the request for renewal of the crediting period to the DOE. For the third crediting period, the build margin emission factor calculated for the second crediting period should be used. This option does not require monitoring the emission factor during the crediting period;

(b) **Option 2** - For the first crediting period, the build margin emission factor shall be updated annually, ex post, including those units built up to the year of registration of the project activity or, if information up to the year of registration is not yet available, including those units built up to the latest year for which information is available. For the second crediting period, the build margin emissions factor shall be calculated ex ante, as described in Option 1 above. For the third crediting period, the build margin emission factor calculated for the second crediting period should be used.

In line with *2019 baseline emission factors for regional power grids in China* published by the Chinese DNA, **Option 1 is chosen for the project**; the BM emission factor is calculated ex ante for the first crediting period based on the most recent information available on units already built for sample group m at the time of this project description submission.

The sample group of power units m used to calculate the build margin should be determined as per the following procedure, consistent with the data vintage selected above:

(a) Identify the set of five power units, excluding power units registered as CDM project activities, that started to supply electricity to the grid most recently ($SET_{5\text{-}units}$) and determine their annual electricity generation ($AEG_{SET\text{-}5\text{-}units}$, in MWh);

(b) Determine the annual electricity generation of the project electricity system, excluding power units registered as CDM project activities (AEG_{total}, in MWh). Identify the set of power units, excluding power units registered as CDM project activities, that started to supply electricity to the grid most recently and that comprise 20% of AEG_{total} (if 20% falls on part of the generation of a unit, the generation of that unit is fully included in the calculation) ($SET_{\geq 20\%}$) and determine their annual electricity generation ($AEG_{SET-\geq 20\%}$, in MWh);

(c) From $SET_{5-units}$ and $SET_{\geq 20\%}$ select the set of power units that comprises the larger annual electricity generation (SET_{sample});

Identify the date when the power units in SET_{sample} started to supply electricity to the grid. If none of the power units in SET_{sample} started to supply electricity to the grid more than 10 years ago, then use SET_{sample} to calculate the build margin. In this case ignore Steps (d), (e) and (f).

(d) Exclude from SET_{sample} the power units which started to supply electricity to the grid more than 10 years ago. Include in that set the power units registered as CDM project activities, starting with power units that started to supply electricity to the grid most recently, until the electricity generation of the new set comprises 20% of the annual electricity generation of the proposed project electricity system (if 20% falls on part of the generation of a unit, the generation of that unit is fully included in the calculation) to the extent is possible. Determine for the resulting set ($SET_{sample-CDM}$) the annual electricity generation ($AEG_{SET-sample-CDM}$, in MWh); If the annual electricity generation of that set comprises at least 20% of the annual electricity generation of the proposed project electricity system (i.e. $AEG_{SET-sample-CDM} \geq 0.2 \times AEG_{total}$), then use the sample group $SET_{sample-CDM}$ to calculate the build margin. Ignore steps (e) and (f).

Otherwise:

(e) Include in the sample group $SET_{sample-CDM}$ the power units that started to supply electricity to the grid more than 10 years ago until the electricity generation of the new set comprises 20% of the annual electricity generation of the proposed project electricity system (if 20% falls on part of the generation of a unit, the generation of that unit is fully included in the calculation);

(f) The sample group of power units m used to calculate the build margin is the resulting set ($SET_{sample-CDM->10yrs}$).

The build margin emissions factor is the generation-weighted average emission factor (tCO_2/MWh) of all power units m during the most recent year y for which power generation data is available, calculated as follows:

$$EF_{grid,BM,y} = \frac{\sum_m EG_{m,y} \times EF_{EL,m,y}}{\sum_m EG_{m,y}} \quad (15)$$

Where:

$EF_{grid,BM,y}$ = Build margin CO_2 emission factor in year y (t CO_2/MWh)

$EG_{m,y}$	=	Net quantity of electricity generated and delivered to the grid by power unit m in year y (MWh)
$EF_{EL,m,y}$	=	CO_2 emission factor of power unit m in year y (t CO_2/MWh)
m	=	Power units included in the build margin
y	=	Most recent historical year for which electricity generation data is available

Since the data of installed capacities can not be separated to coal fired, oil fired and gas fired currently, BM is calculated with the following steps and formula:

As it is difficult to obtain the detailed data on the power generation, fuel consumption and thermal efficiency of each newly built power unit from public documents, a deviation of TOOL07 is adopted following the clarifications given by the CDM EB concerning the BM emission factor calculation: adopted following the clarifications given by the CDM EB concerning the BM emission factor calculation:

(1) The CDM EB suggested using the efficiency level of the best technology commercially available in the provincial/regional or national grid of China, as a conservative proxy, for each fuel type in estimating the fuel consumption to estimate the build margin.

(2) The EB agreed the use of capacity additions during last 1 ~ 3 years for estimating the build margin emission factor for grid electricity.

(3) The EB also agreed to use of weights estimated using installed capacity in place of annual electricity generation.

The newly built power plants in the past few years are bundled into “grouped new power plant” according to their construction year, their province and their fuel type. The annual net electricity generation in the year y of each “grouped new power plant” $EG_{m,y}$ is estimated according to their total capacity and the average utilization hours, as the following equation:

$$EG_{m,y} = CAP_m \times H_{m,y} \qquad (16)$$

where:

$EG_{m,y}$	=	Annual net electricity generation the unit m in year y (MWh)
CAP_m	=	Installed capacity of the unit m (MW)

$H_{m,y}$	=	Utilization hour of the unit m in the year y (h), determined according to the average utilization hour of the same type of unit in the same province
y	=	The most recent year for which the generation data is available. For the calculation of BM in 2019, y=2017
m	=	grouped new power plant

Since the newly built power plants in the same province (A), in the same year (t) and using the same fuel type (k) are grouped into "a grouped new power plant", CAP_m represents the total installed capacity of fuel type k power plants located in the province A and in the year t:

$$CAP_m = CAP_{A,t,k} \tag{17}$$

where:

CAP_m	=	Installed capacity of the unit m (MW), with m representing the specified combination of A, t, and k
$CAP_{A,t,k}$	=	Total installed capacity of fuel type k power plants located in the province A and in the year t
A	=	Provinces covered by the CCPG, namely, Henan Province, Hubei Province, Hunan Province, Jiangxi Province, Sichuan Province and Chongqing City
t	=	Years related to the grouped new power plants, for the 2019 calculation, t represents 2017, 2016, 2015.... Until the aggregated electricity generation of the grouped new power plants reaches 20% of the total electricity generation of the Central China Power Grid
k	=	Fuel type of the grouped new power plants, including hydro, thermal (coal, gas, oil, waste incineration, other thermal), nuclear, wind, solar and others.

Figure 4.1 shows the procedure to determine the sample group of power units m.

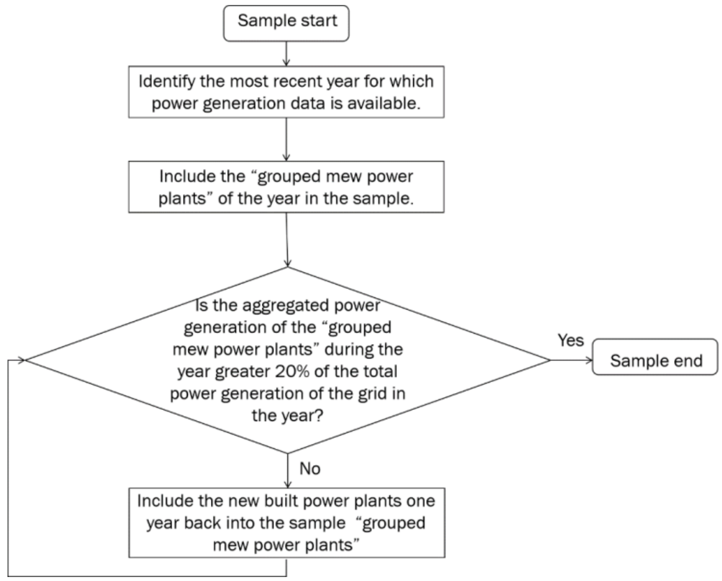

Figure 4.1 Procedure to determine the sample group of power units m

The emission factors of each fuel type $EF_{EL,m,y}$ are determined according to the Option A2 in the TOOL07, as the following equation:

$$EF_{EL,m,y} = \frac{EF_{CO2,m,i,y} \times 3.6}{\eta_{m,y}} \quad (18)$$

where:

$EF_{EL,m,y}$	=	CO_2 emission factor of power unit m in year y (t CO_2/MWh)
$EF_{CO2,m,i,y}$	=	Average CO_2 emission factor of fuel type i used in power unit m in year y (tCO_2/GJ)
$\eta_{m,y}$	=	Average net energy conversion efficiency of power unit m in year y (ratio)
m	=	All power units serving the grid in year y except low-cost/must-run power units
3.6	=	Conversion factor (GJ/MWh)

Among the fuel types, the emission factors of hydro, nuclear, wind, solar, other thermal and others are 0. Concerning the emission factors of coal, gas, oil and waste incineration, the Equation (19) takes the following form due to conservativeness:

$$EF_{best,m,y} = \frac{EF_{CO2,m,i,y} \times 3.6}{\eta_{best,y}} \quad (19)$$

where:

$EF_{best,m,y}$	=	Emission factor of power unit m with the best technology commercially available in year y (t CO_2/MWh)
$\eta_{best,y}$	=	Power generation efficiency of the best technology commercially
m	=	Power units serving the grid with coal, gas, oil or waste incineration in year y

$EF_{grid,BM,y}$ of the project adopts the calculation results published by the national development and Reform Commission. According to the latest and available data at the time of this PSF submission, $EF_{grid,BM,y}$ =0.2854 tCO_2/MWh.

<u>*Step 6: Calculate the combined margin (CM) emission factor.*</u>

The combined margin (CM) emission factor $EF_{grid,CM,y}$ of the baseline scenario is calculated as follows:

$$EF_{grid,CM,y} = EF_{grid,OM,y} \times \omega_{OM} + EF_{grid,BM,y} \times \omega_{BM} \quad (20)$$

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[60], $EF_{grid,OM,y}$= of Central China Power Grid (CCPG) is 0.8587 tCO_2/MWh [61].
$EF_{grid,BM,y}$	=	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[62], $EF_{grid,BM,y}$= of Central China Power Grid (CCPG) is 0.2854 tCO_2/MWh [63].

60 http://www.mee.gov.cn/ywgz/ydqhbh/wsqtkz/202012/W020201229610353816665.pdf

61 https://www.mee.gov.cn/ywgz/ydqhbh/wsqtkz/202012/W020201229610353340851.pdf

62 http://www.mee.gov.cn/ywgz/ydqhbh/wsqtkz/202012/W020201229610354442145.pdf

63 https://www.mee.gov.cn/ywgz/ydqhbh/wsqtkz/202012/W020201229610353340851.pdf

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:

$$ER_y = BE_y - PE_y - LE_y \tag{21}$$

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)

Baseline emissions

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

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

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.
$\eta_{BL,i}$	=	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 (75%-85%), 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

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

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

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

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

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

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:

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

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

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

Where:

A_m = Net heating area for construction type m (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*[64] 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	89.57	89.57

64 https://www.henan.gov.cn/2019/03-26/739961.html

Gongyuanshoufu Station	447,507	13.92	153.11	89.57	89.57
Dongfangyujing Station	271,931	8.46	93.04	89.57	89.57
Donghuyiyuan Station	270,013	8.40	92.38	89.57	89.57
Qinghuayuan Station	329,986	10.26	112.90	89.57	89.57
Xiangxiehuating Station	272,665	8.48	93.29	89.57	89.57
Hualancheng Station	360,000	11.20	123.17	89.57	89.57
Jiuhaoyuan Station	203,561	6.33	69.65	89.57	69.65
Jinxiuyuan Station	240,846	7.49	82.40	89.57	82.40
Tianshenggongguan Station	266,807	8.30	91.29	89.57	89.57
Qianxizhuangyuan Station	368,232	11.45	125.99	89.57	89.57
Yehaowanghu Station	287,821	8.95	98.48	89.57	89.57
Total	3,736,100	116	1,278	1,075	1,048

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	1,048	116	0	931,50	95,670
2	1,048	116	0	931,50	95,670
3	1,048	116	0	931,50	95,670
4	1,048	116	0	931,50	95,670
5	1,048	116	0	931,50	95,670
6	1,048	116	0	931,50	95,670

7	1,048	116	0	931,50	95,670
8	1,048	116	0	931,50	95,670
9	1,048	116	0	931,50	95,670
10	1,048	116	0	931,50	95,670

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

$ER_y = BE_y - PE_y - LE_y$= (95,670- 17,162) tCO_2e/yr = 78,508 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	95,670	17,162	0	78,508
15/11/2022-14/11/2023	95,670	17,162	0	78,508
15/11/2023-14/11/2024	95,670	17,162	0	78,508
15/11/2024-14/11/2025	95,670	17,162	0	78,508
15/11/2025-14/11/2026	95,670	17,162	0	78,508
15/11/2026-14/11/2027	95,670	17,162	0	78,508
15/11/2027-14/11/2028	95,670	17,162	0	78,508
15/11/2028-14/11/2029	95,670	17,162	0	78,508
15/11/2029-14/11/2030	95,670	17,162	0	78,508
15/11/2030-14/11/2031	95,670	17,162	0	78,508
Total	956,700	171,620	0	785,080

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. CO_2 emission factor of other bituminous coal and sub-bituminous coal are 89.5 tCO_2/TJ and 92.8 tCO_2/TJ separately, which are higher than that of coking coal. Coking coal and brown coal briquettes have the same CO_2 emission factor. Coking coal is usually used for heating in coal boiler, which was also stated in the Feasibility Study Report (FSR).

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 (75%-85%), 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	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

measurement methods and procedures applied	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

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. Serial No. of the bimetallic thermometer are:

Sub-areas	Heat-Substations	Serial No. (Outlet)	Serial No. (Inlet)
Fenghuangcheng Station	1#FHC	HY69531500532	HY69531599065
	2#FHC	B20110586	HY69531501405
	3#FHC	18101366 2105340	18101760 HY69531508387
	4#FHC	Constructing	Constructing
Gongyuanshoufu Station	1#GYSF	416240455 80306	416240435 416240485
Dongfangyujing Station	1#DFYJ	HY69531500710	18101362
	2#DFYJ	HY69531108854 HY68561104083	HY68561105862 HY68603106637
	3#DFYJ	18101350	18101335
Donghuyiyuan Station	1#DHYY	416240531	416240487
Qinghuayuan Station	1#QHY	HY68602808589	HY68603107913
Xiangxiehuating Station	1#XXHT	7060-8 1020-8	2060-8 2060-6
Hualancheng Station	1#HLC	4070-6 7060-6	1070-8 7050-8
Jiuhaoyuan Station	1#JHY	220615480	220730009

		220911372	220730019
Jinxiuyuan Station	1#JXY	Constructing	Constructing
Tianshenggongguan Station	1#TSGG	Constructing	Constructing
Qianxizhuangyuan Station	1#QXZY	4006-8 A1901987	4020-6 A1902001
Yehaowanghu Station	1#YHWH	220911388 220911347	220911390 220911312

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. 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	Bimetallic thermometers are checked regularly for potentially performance-reducing anomalies by the VCS monitoring team. The accuracy level of the bimetallic thermometers is 1.5. Calibration of the bimetallic thermometers is done according to national standard (*JJF 1664-2017 Calibration Specification for Temperature Indicators*) by qualified organizations. All bimetallic

thermometers are calibrated before the operation period of the geothermal heating system. Calibration of the bimetallic thermometers during the 1st monitoring period is shown as the following table. If the bimetallic thermometers can be used normally, re-calibration is not required. The calibration interval is 12 months.

No.	Serial No.	Purpose	Calibration Date	Calibration interval
1	HY69531500532	To monitor supply water temperature of 1#FHC heat exchange system	1. 2021-10-14 2. 2022-10-14	12 months
2	B20110586	To monitor supply water temperature of 2#FHC heat exchange system	1. 2021-10-14 2. 2022-10-14	12 months
3	18101366	To monitor supply water temperature of 3#FHC heat exchange system	1. 2021-10-14 2. 2022-10-14	12 months
4	2105340	To monitor supply water temperature of 3#FHC heat exchange system	1. 2021-10-14 2. 2022-10-14	12 months
5	416240455	To monitor supply water temperature of 1#GYSF heat exchange system	1. 2021-10-14 2. 2022-10-14	12 months
6	80306	To monitor supply water temperature of 1# GYSF heat exchange system	1. 2021-10-14 2. 2022-10-14	12 months
7	HY69531500710	To monitor supply water temperature of 1#DFYJ heat exchange system	1. 2021-10-14 2. 2022-10-14	12 months
8	HY69531108854	To monitor supply water temperature of 2#DFYJ heat exchange system	1. 2021-10-14 2. 2022-10-14	12 months
9	HY68561104083	To monitor supply water temperature of 2#DFYJ heat exchange system	1. 2021-10-14 2. 2022-10-14	12 months

10	18101350	To monitor supply water temperature of 3#DFYJ heat exchange system	1. 2021-10-14 2. 2022-10-14	12 months
11	416240531	To monitor supply water temperature of 1#DHYY heat exchange system	1. 2021-10-14 2. 2022-10-14	12 months
12	HY68602808589	To monitor supply water temperature of 1#QHY heat exchange system	1. 2021-10-14 2. 2022-10-14	12 months
13	7060-8	To monitor supply water temperature of 1#XXHT heat exchange system	1. 2021-10-14 2. 2022-10-14	12 months
14	1020-8	To monitor supply water temperature of 1#XXHT heat exchange system	1. 2021-10-14 2. 2022-10-14	12 months
15	4070-6	To monitor supply water temperature of 1#HLC heat exchange system	1. 2021-10-14 2. 2022-10-14	12 months
16	7060-6	To monitor supply water temperature of 1#HLC heat exchange system	1. 2021-10-14 2. 2022-10-14	12 months
17	220615480	To monitor supply water temperature of 1#JHY heat exchange system	1. 2022-12-14	12 months
18	220911372	To monitor supply water temperature of 1#JHY heat exchange system	1. 2022-12-14	12 months
19	4006-8	To monitor supply water temperature of 1#QXZY heat exchange system	1. 2021-10-14 2. 2022-10-14	12 months
20	A1901987	To monitor supply water temperature of	1. 2021-10-14 2. 2022-10-14	12 months

		1#QXZY heat exchange system		
21	220911388	To monitor supply water temperature of 1#YHWH heat exchange system	1. 2022-12-14	12 months
22	220911347	To monitor supply water temperature of 1#YHWH heat exchange system	1. 2022-12-14	12 months
23	HY69531599065	To monitor return water temperature of 1#FHC heat exchange system	1. 2021-10-14 2. 2022-10-14	12 months
24	HY69531501405	To monitor return water temperature of 2#FHC heat exchange system	1. 2021-10-14 2. 2022-10-14	12 months
25	18101760	To monitor return water temperature of 3#FHC heat exchange system	1. 2021-10-14 2. 2022-10-14	12 months
26	HY69531508387	To monitor return water temperature of 3#FHC heat exchange system	1. 2021-10-14 2. 2022-10-14	12 months
27	416240435	To monitor return water temperature of 1#GYSF heat exchange system	1. 2021-10-14 2. 2022-10-14	12 months
28	416240485	To monitor return water temperature of 1# GYSF heat exchange system	1. 2021-10-14 2. 2022-10-14	12 months
29	18101362	To monitor return water temperature of 1#DFYJ heat exchange system	1. 2021-10-14 2. 2022-10-14	12 months
30	HY68561105862	To monitor return water temperature of 2#DFYJ heat exchange system	1. 2021-10-14 2. 2022-10-14	12 months
31	HY68603106637	To monitor return water	1. 2021-10-14	12 months

		temperature of 2#DFYJ heat exchange system	2. 2022-10-14	
32	18101335	To monitor return water temperature of 3#DFYJ heat exchange system	1. 2021-10-14 2. 2022-10-14	12 months
33	416240487	To monitor return water temperature of 1#DHYY heat exchange system	1. 2021-10-14 2. 2022-10-14	12 months
34	HY68603107913	To monitor return water temperature of 1#QHY heat exchange system	1. 2021-10-14 2. 2022-10-14	12 months
35	2060-8	To monitor return water temperature of 1#XXHT heat exchange system	1. 2021-10-14 2. 2022-10-14	12 months
36	2060-6	To monitor return water temperature of 1#XXHT heat exchange system	1. 2021-10-14 2. 2022-10-14	12 months
37	1070-8	To monitor return water temperature of 1#HLC heat exchange system	1. 2021-10-14 2. 2022-10-14	12 months
38	7050-8	To monitor return water temperature of 1#HLC heat exchange system	1. 2021-10-14 2. 2022-10-14	12 months
39	220730009	To monitor return water temperature of 1#JHY heat exchange system	1. 2022-12-14	12 months
40	220730019	To monitor return water temperature of 1#JHY heat exchange system	1. 2022-12-14	12 months
41	4020-6	To monitor return water temperature of 1#QXZY heat exchange system	1. 2021-10-14 2. 2022-10-14	12 months

42	A1902001	To monitor return water temperature of 1#QXZY heat exchange system	1. 2021-10-14 2. 2022-10-14	12 months
43	220911390	To monitor return water temperature of 1#YHWH heat exchange system	1. 2022-12-14	12 months
44	220911312	To monitor return water temperature of 1#YHWH heat exchange system	1. 2022-12-14	12 months

There were no missing data or damaged data during the 1st monitoring period. The average temperature change of the 12 heat exchange system of the 2021-2022 heating season (8.01°C) and the average temperature change of the 14 heat exchange system of the 2022-2023 heating season (8.02°C) were 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 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 electromagnetic flowmeters 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. Serial No. of the electromagnetic flowmeters are:

Sub-areas	Heat-Substations	Serial No.
Fenghuangcheng Station	1#FHC	2011885
	2#FHC	20174847
	3#FHC	20175745
	4#FHC	Constructing
Gongyuanshoufu Station	1#GYSF	1511947
Dongfangyujing Station	1#DFYJ	1513164
	2#DFYJ	1513470
	3#DFYJ	20172136
Donghuyiyuan Station	1#DHYY	1513565
Qinghuayuan Station	1#QHY	1513597
Xiangxiehuating Station	1#XXHT	1513458
Hualancheng Station	1#HLC	1513148
Jiuhaoyuan Station	1#JHY	1513145
Jinxiuyuan Station	1#JXY	Constructing
Tianshenggongguan Station	1#TSGG	Constructing
Qianxizhuangyuan Station	1#QXZY	1513165
Yehaowanghu Station	1#YHWH	AY202209390

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 are exported by the VCS monitoring team to form the monthly record at the beginning of the next month. The average daily volume flow rate is calculated based

	on the 24-hourly data. The average monthly volume flow rate is calculated based on all the daily data of this month. Finally, the operation record of the geothermal heating system during the related heating season are 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. 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	Electromagnetic flowmeters are checked regularly for potentially performance-reducing anomalies by the VCS monitoring team. The accuracy level of the electromagnetic flowmeters is mainly 0.5 (a few electromagnetic flowmeters have an accuracy level of 1.0). Calibration of the electromagnetic flowmeters is done according to national standard *(JJG 257-2007 Verification Regulation of Float Meter)* by qualified organizations. All the electromagnetic flowmeters are calibrated before the operation period of the geothermal heating system. Calibration of the 14 electromagnetic flowmeters during the 1st monitoring period is shown as the following table. If the electromagnetic flowmeters can be used normally, re-calibration is not required. The calibration interval is 12 months.

NO.	Serial No.	Purpose	Calibration Date	Calibration interval
1	2011885	To monitor flow rate of 1#FHC heat exchange system	1. 2021-10-14 2. 2022-10-14	12 months
2	20174847	To monitor flow rate of 2#FHC heat exchange system	1. 2021-10-14 2. 2022-10-14	12 months
3	20175745	To monitor flow rate of 3#FHC heat exchange system	1. 2021-10-14 2. 2022-10-14	12 months

4	1511947	To monitor flow rate of 1#GYSF heat exchange system	1. 2021-10-14 2. 2022-10-14	12 months
5	1513164	To monitor flow rate of 1#DFYJ heat exchange system	1. 2021-10-14 2. 2022-10-14	12 months
6	1513470	To monitor flow rate of 2#DFYJ heat exchange system	1. 2021-10-14 2. 2022-10-14	12 months
7	20172136	To monitor flow rate of 3#DFYJ heat exchange system	1. 2021-10-14 2. 2022-10-14	12 months
8	1513565	To monitor flow rate of 1#DHYY heat exchange system	1. 2021-10-14 2. 2022-10-14	12 months
9	1513597	To monitor flow rate of 1#QHY heat exchange system	1. 2021-10-14 2. 2022-10-14	12 months
10	1513458	To monitor flow rate of 1#XXHT heat exchange system	1. 2021-10-14 2. 2022-10-14	12 months
11	1513148	To monitor flow rate of 1#HLC heat exchange system	1. 2021-10-14 2. 2022-10-14	12 months
12	1513145	To monitor flow rate of 1#JHY heat exchange system	1. 2022-12-14	12 months
13	1513165	To monitor flow rate of 1#QXZY heat exchange system	1. 2021-10-14 2. 2022-10-14	12 months
14	AY202209390	To monitor flow rate of 1#YHWH heat exchange system	1. 2022-12-14	12 months

There were no missing data or damaged data during the 1st monitoring period. The average volume flow rate of the 12 heat exchange system of the 2021-2022 heating season (331.99 m^3/h) and the average volume flow rate of the 14 heat exchange system of the 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. The average volume flow rate of the heat

	exchange system in operation was lower than the least rated flow of the circulating pumps.
Purpose of data	To calculate baseline emissions and project 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*[65] 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 heat exchange systems in operation are exported by the VCS monitoring team at the beginning of the next month. The operation record of the geothermal heating system during the related heating season were summarized by all the monthly record. 3024h (126 days*24h) during heating season 2021-2022 (from 15-November-2021 to 21-March-2022).

[65] https://www.henan.gov.cn/2019/03-26/739961.html

	2952h (123 days*24h) during heating season 2022-2023 (from 15-November-2022 to 18-March-2023).
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 the news published on the portal of the People's Government of Henan Province.[66] [67].
Purpose of data	To calculate baseline emissions
Calculation method	-
Comments	NA.

Data / Parameter	HI_m
Data unit	W/m^2
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/m^2 for residential buildings.
Monitoring equipment	-
QA/QC procedures to be applied	As per feedback from the space heating experts at the project site, heating index of the Lankao geothermal heating system is 30 W/m^2 for residential buildings, which is comply with the

[66] https://www.henan.gov.cn/2022/03-15/2414579.html

[67] https://www.henan.gov.cn/2023/03-16/2708234.html

	requirement of *DBJ411 062 – 2012 Henan Province design standard for energy efficiency of residential buildings (cold zone)* published by Henan Housing and Urban-Rural Construction Development.
Purpose of data	To calculate baseline emissions
Calculation method	-
Comments	NA.

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 and a three-phase four-wire electricity meter installed at the 2#DFYJ heat substation. Refer to Figure 6-2 of the Joint-PD-MR for more details on installation and configuration of the electricity meters. Serial No. of the electricity meters are:

Sub-areas	Heat-Substations	User number	Serial No.
Fenghuangcheng Station	1#FHC	5156891478	413000100000054824 1939
	2#FHC		
	3#FHC	5171423708	41300010000000548240321
	4#FHC	Constructing	
Gongyuanshoufu Station	1#GYSF	5163472334	41300010000000320791997
Dongfangyujing Station	1#DFYJ	5199700090	41300010000000319456753
		522282665	4130001000000429 2272

		0	74
	2#DFYJ	-	201291014517
	3#DFYJ	5194569920	4130001000000319502566
Donghuyiyuan Station	1#DHYY	5156750289	4130001000000548244664
Qinghuayuan Station	1#QHY	5194569597	4130001000700000067328
Xiangxiehuating Station	1#XXHT		
Hualancheng Station	1#HLC	5216416065	4130001000000320794967
Jiuhaoyuan Station	1#JHY	5275416639	4130001000000194027970
Jinxiuyuan Station	1#JXY	Constructing	
Tianshenggongguan Station	1#TSGG	Constructing	
Qianxizhuangyuan Station	1#QXZY	5197228868	4130001000000319489423
Yehaowanghu Station	1#YHWH	5223570844	4130001000000461572776

Before test run of the whole geothermal space heating system, base number of the 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/recordi	Measured Hourly/Recording Monthly

ng	
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.
QA/QC procedures to be applied	Calibration of the electricity meters installed at the State Grid Lankao County Power Supply Company is done by the Power Supply Company. State Grid Company is a wholly state-owned company directly managed by the central government. These meters owned by the State Grid Lankao County Power Supply Company are calibrated according to national standard (*JJG596-2012 Verification Regulation of Electrical Meters for Measuring Alternating-current Electrical Energy*). These electricity meters are calibrated before the operation period of the geothermal heating system. The calibration information of these meters are provided by the Power Supply Company, as shown in the following table. If the meters can be used normally, re-calibration is not required. The validity is 5 years. Calibration of the three-phase four-wire electricity meter installed at the 2#DFYJ heat substation is done by the project owner. The three-phase four-wire electricity meter installed at the 2#DFYJ heat substation is checked regularly for potentially performance-reducing anomalies by the VCS monitoring team. The accuracy level of the electricity meter is 2.0. Calibration of the three-phase four-wire electricity meter is done according to national standard *(JJG596-2012 Verification Regulation of Electrical Meters for Measuring Alternating-current Electrical Energy)* by qualified organizations. The three-phase four-wire electricity meter is calibrated before the operation period of the geothermal heating system. Calibration of the three-phase four-wire electricity meter during the 1st monitoring period is shown as the following table. If the three-phase four-wire electricity meter can be used normally, re-calibration is not required. The validity is 12 months.

NO.	Serial No.	Heat-Substations	Calibration Date	Term of Validity
1	413000100000 0548241939	1#FHC&2#FHC heat substation	2021-10-11	2026-10-10
2	413000100000 0548240321	3#FHC heat substation	2021-10-11	2026-10-10

3	413000100000 0320791997	1#GYSF heat substation	2021-10-11	2026-10-10
4	413000100000 0319456753	1#DFYJ heat substation	2021-10-11	2026-10-10
5	413000100000 0429227274		2021-10-11	2026-10-10
6	201291014517	2#DFYJ heat substation	1. 2021-10-14 2. 2022-10-14	1. 2022-10-13 2. 2023-10-13
7	413000100000 0319502566	3#DFYJ heat substation	2021-10-11	2026-10-10
8	413000100000 0548244664	1#DHYY heat substation	2021-10-12	2026-10-11
9	413000100070 0000067328	1#QHY/1#XXHT heat substation	2021-10-12	2026-10-11
10	413000100000 0320794967	1#HLC heat substation	2021-10-12	2026-10-11
11	413000100000 0194027970	1#JHY heat substation	2022-12-12	2027-10-11
12	413000100000 0319489423	1#QXZY/1#YHWH heat substation	2021-10-12	2026-10-11
13	413000100000 0461572776		2021-10-12	2026-10-11

There were no missing data or damaged data during the 1st monitoring period. All the electricity consumption data are 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 *Certificate of Enterprise Investment Project in Henan Province* issued by Lankao Development and Reform Commission and the heating supply contracts between the project owner and communities. The actual heating area is lower than that of the government approval. Because all the communities covered by the project are newly built, some of the local residents haven't moved in yet, and there is no need for heating during the 2021-2022 and 2022-2023 heating season.
Purpose of data	To calculate baseline emissions
Calculation method	-
Comments	-

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.
Description of measurement methods and procedures to be applied	Lankao county is in Henan province, which belongs to Central China Regional Power Grid (CCPG). The data of CCPG's $EF_{grid,OM,y}$ and $EF_{grid,BM,y}$ were taken from Baseline emission factors of China's regional power grid for emission reduction projects in 2019.
Frequency of monitoring/recording	Once each monitoring period
Value applied	The data were the same before and after the project began. 0.5721 (=0.8587*0.5+0.2854*0.5)
Monitoring equipment -	-
QA/QC procedures to be applied	The latest version of Baseline emission factors of China's regional power grid for emission reduction projects published by Ministry of Ecology and Environment of the People's Republic of China were used for the 1st monitoring period. It calculated $EF_{grid,OM,y}$ and $EF_{grid,BM,y}$ based on the latest version of *Tool 07 Tool to calculate the emission factor for an electricity system* (Version 07.0).
Purpose of Data	To calculate project emissions
Calculation method	-
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.
Description of measurement methods and procedures to be 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 $TDL_{j,y}$.
Frequency of monitoring/recording	Annually. In the absence of data from the relevant year, most recent figures should be used, but not older than 5 years.
Value applied	20%
Monitoring equipment -	-
QA/QC procedures to be applied	-
Purpose of Data	To calculate project 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). Monthly operation time of the heat exchange system will be exported by the VCS monitoring team at the beginning of the next month. The operation record of the geothermal heating system during the related heating season will be summarized by all the monthly record. Besides, 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.

Average technical transmission and distribution losses for providing electricity to source j in year y ($TDL_{j,y}$) shall be determined using the latest version of Tool 05.

Combined margin emission factor for the grid in year y ($EF_{EL,j,y}$ ($EF_{grid,CM,y}$)) is calculated using the procedures in the latest version of Tool 07. It shall be determined per the latest Baseline emission factors of China's regional power grid for emission reduction projects published by Ministry of Ecology and Environment of the People's Republic of China.

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).

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.

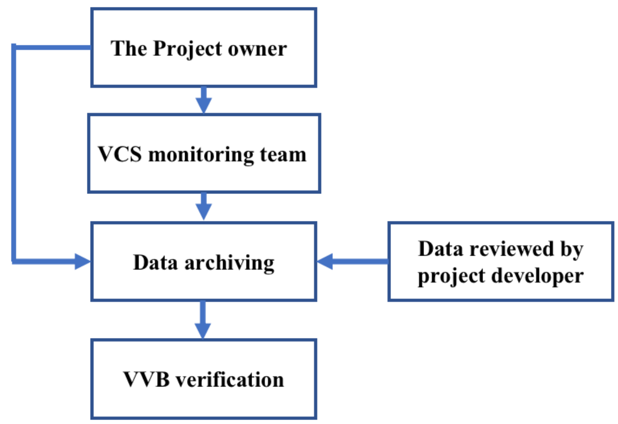

Figure 6-1 Organization Structure of the Monitoring Team

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.

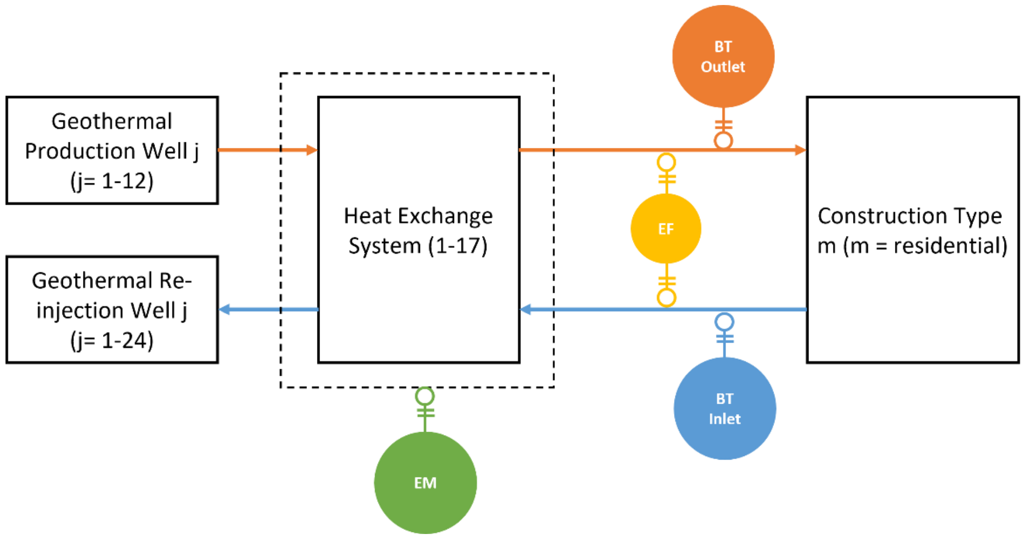

Figure 6-2 Installation and Configuration of Meters

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-November-2021 to 21-March-2022 (actual heating period during monitoring period)

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	7.77
	2#FHC	7.60	8.23	8.16	8.08	8.58
	3#FHC	8.80	8.31	8.14	7.99	8.28

	4#FHC	constructing				
Gongyuanshoufu Station	1#GYSF	8.68	9.16	8.54	7.71	7.91
Dongfangyujing Station	1#DFYJ	8.93	7.14	7.52	7.46	8.00
	2#DFYJ	7.43	8.00	8.00	8.00	8.00
	3#DFYJ	8.00	8.00	8.04	8.00	8.00
Donghuyiyuan Station	1#DHYY	Const ructing	8.30	8.39	7.00	8.60
Qinghuayuan Station	1#QHY	8.44	7.53	8.71	8.04	7.59
Xiangxiehuating Station	1#XXHT	8.38	8.19	7.57	7.73	7.58
Hualancheng Station	1#HLC	8.88	7.81	7.94	8.86	7.81
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	7.21
Yehaowanghu Station	1#YHWH	constructing				

22-March-2022 to 14-November-2022

The project is not implementing heating for the residential buildings.

15-November-2022 to 18-March-2023 (actual heating period during monitoring period)

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*. Density of the water is 1,000 kg/m^3. Mass flow can be calculated as volume flow rate times density of water.
Value applied:	15-November-2021 to 21-March-2022 (actual heating period during monitoring period) Unit: m^3/h

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				

22-March-2022 to 14-November-2022

The project is not implementing heating for the residential buildings.

15-November-2022 to 18-March-2023 (actual heating period during monitoring period)

Unit: m^3/h

Sub-areas	Heat-	Nov-22	Dec-22	Jan-23	Feb-23	Mar-23

		Substations				
	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-November-2021 to 21-March-2022 (actual heating period during monitoring period)

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	Constructing	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				

22-March-2022 to 14-November-2022

The project is not implementing heating for the residential buildings.

15-November-2022 to 18-March-2023 (actual heating period during monitoring period)

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-November-2021 to 21-March-2022 (actual heating period during monitoring period)

Sub-areas	Heat-Substations	Residential
	1#FHC	73806.45

Fenghuangcheng Station	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

22-March-2022 to 14-November-2022

The project is not implementing heating for the residential buildings.

15-November-2022 to 18-March-2023 (actual heating period during monitoring period)

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
	Qinghuayuan Station	1#QHY	174664.59
	Xiangxiehuating Station	1#XXHT	95477.43
	Hualancheng Station	1#HLC	137039.37
	Jiuhaoyuan Station	1#JHY	65439.14
	Jinxiuyuan Station	1#JXY	constructing
	Tianshenggongguan Station	1#TSGG	constructing
	Qianxizhuangyuan Station	1#QXZY	249371.65
	Yehaowanghu Station	1#YHWH	59661.25
	Total		1,469,504.68
Comments	N/A		

Data / Parameter	$EC_{PJ,j,y}$ (EC_y)
Data unit	MWh
Description	Electricity consumption for the year *y* in operating the geothermal heating system. Electricity consumptions of the geothermal heating system are monitored by the electricity meters. All the electricity consumption data are cross checked with the electricity bill confirmed by the state Grid Lankao County Power Supply Company.
Value applied:	15-November-2021 to 21-March-2022 (actual heating period during monitoring period)

Sub-areas	Heat-Substations	Nov-21	Dec-21	Jan-22	Feb-22	Mar-22
Fenghuangcheng Station	1#FHC	132.60	234.48	254.24	234.36	155.20
	2#FHC					
	3#FHC	142.88	239.06	279.87	259.41	160.05
	4#FHC	constructing				

Gongyuanshoufu Station	1#GYSF	61.83	125.97	211.77	304.77	103.74
Dongfangyujing Station	1#DFYJ	96.69	190.67	208.18	190.93	76.75
	2#DFYJ	16.95	22.71	21.75	21.27	14.94
	3#DFYJ	36.09	44.85	52.98	40.11	30.51
Donghuyiyuan Station	1#DHYY	constructing	23.33	72.29	71.09	60.98
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	470.06	436.00	110.75
Yehaowanghu Station	1#YHWH	constructing				

22-March-2022 to 14-November-2022

The project is not implementing heating for the residential buildings.

15-November-2022 to 18-March-2023 (actual heating period during monitoring period)

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
Xiangxiehuati ng Station	1#XXHT					
Hualancheng Station	1#HLC	61.94	109.58	114.24	104.28	53.96
Jiuhaoyuan St ation	1#JHY	constructing		50.02	39.47	23.69
Jinxiuyuan Sta tion	1#JXY	constructing				
Tianshenggon gguan Station	1#TSGG	constructing				
Qianxizhuang yuan 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)**
15/11/2021 – 30/11/2021	821.17
01/12/2021 – 31/12/2021	1,545.79
01/01/2022 – 31/01/2022	1,845.54
01/02/2022 – 28/02/2022	1,840.14
01/03/2022 – 21/03/2022	885.90
15/11/2021 –21/03/2022	6,977.53
15/11/2022 – 30/11/2022	965.72
01/12/2022 – 31/12/2022	2,207.18
01/01/2023 – 31/01/2023	2,440.61
01/02/2023 – 28/02/2023	1,791.73

	01/03/2023 – 18/03/2023	608.63
	15/11/2022 –18/03/2023	8,013.87
	Total	**14,991.40**
Comments	N/A	

Data / Parameter	HI_m
Data unit	W/m^2
Description	Heating index for construction type *m*.
Value applied:	30 W/m^2 for residential buildings.
Comments	NA.

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.
Value applied:	0.5721 (=0.8587*0.5+0.2854*0.5)
Comments	NA.

Data / Parameter	$TDL_{j,y}$
Data unit	-
Description	Average technical transmission and distribution losses for providing electricity to source *j* in year *y*.
Value applied:	20%

Comments	NA.

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 (75%-85%), 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,

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

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
15/11/2021 – 30/11/2021	48.89	47.15	47.15	4.44	42.70	87.3	85	4,385
01/12/2021 – 31/12/2021	99.83	92.93	92.93	9.08	83.86			8,612
01/01/2022 – 31/01/2022	105.17	97.31	97.31	9.56	87.75			9,012
01/02/2022 – 28/02/2022	95.97	86.26	86.26	8.72	77.53			7,962
01/03/2022 – 21/03/2022	70.89	63.81	63.81	6.44	57.36			5,891
22/03/2022 – 14/11/2022	0	0	0	0	0			0
15/11/2021 – 14/11/2022	420.74	387.45	387.45	38.25	349.20			35,862
15/11/2022 – 30/11/2022	61.08	55.42	55.42	5.55	49.86			5,121
01/12/2022 – 31/12/2022	118.25	110.65	110.65	10.75	99.90			10,259
01/01/2023 – 31/01/2023	122.70	112.82	112.82	11.15	101.67			10,441
01/02/2023 – 28/02/2023	116.49	105.77	105.77	10.59	95.18			9,775
01/03/2023 – 18/03/2023	70.94	69.24	69.24	6.45	62.79			6,448

15/11/2022 – 18/03/2023	489.46	453.89	453.89	44.50	409.40			42,044
Total of the 1st monitoring period	**910.20**	**841.34**	**841.34**	**82.75**	**758.59**			**77,906**

Baseline emissions are:

35,862 tCO_2e from 15/11/2021 to 14/11/2022,

42,044 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) are 77,906tCO_2e.

7.3 Project Emissions

As per the signed heating contract, heating areas (heating season 2021-2022 and heating season 2022-2023) are summarized as the following table.

Sub-areas	**Heat-Substations**	**15/11/2021 - 21/3/2022**		**15/11/2022 - 18/03/2023**	
		A_m (m^2) - heating contract	**A_m (m^2) – Actual heating areas**	**A_m (m^2) - heating contract**	**A_m (m^2) –Actual 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 21/03/2022, 1,927,914.8 m^2 of residential buildings can access to geothermal energy-based space heating system in winter season.

From 22/03/2022 to 14/11/2022, the project is not implementing heating for the residential buildings.

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 actual heating areas is affected by the actual occupancy rate:

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

From 22/03/2022 to 14/11/2022, the actual heating areas is 0 m^2.

From 15/112022 to 18/03/2023, the actual 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 the 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)	$EF_{EL,j,y}$ (tCO_2/MWh)	(1+$TDL_{j,y}$)	$PE_{EC,y}$ (tCO_2e/yr)
15/11/2021 – 30/11/2021	821,165.00	821.17	0.5721	1.2	564
01/12/2021 – 31/12/2021	1,545,789.00	1,545.79			1,062
01/01/2022 – 31/01/2022	1,845,538.00	1,845.54			1,267
01/02/2022 – 28/02/2022	1,840,140.00	1,840.14			1,264
01/03/2022 – 21/03/2022	885,899.00	885.90			609
22/03/2022 – 14/11/2022	0	0			0
15/11/2021 – 14/11/2022	6,938,531.00	6,938.53			4,766
15/11/2022 – 30/11/2022	965,718.00	965.72			663
01/12/2022 – 31/12/2022	2,207,176.00	2,207.18			1,516
01/01/2023 – 31/01/2023	2,440,613.00	2,440.61			1,676
01/02/2023 – 28/02/2023	1,791,728.00	1,791.73			1,230

01/03/2023 – 18/03/2023	608,633.00	608.63			418
15/11/2022 – 18/03/2023	8,013,868.00	8,013.87			5,503
Total of the 1st monitoring period	**14,952,399.00**	**14,952.40**	-	-	**10,269.00**

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

4,766 tCO_2e from 15/11/2021 to 14/11/2022,

5,503 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 10,269 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)
15/11/2021 – 30/11/2021	4,385	564	0	3,821
01/12/2021 – 31/12/2021	8,612	1,062	0	7,550
01/01/2022 – 31/01/2022	9,012	1,267	0	7,745
01/02/2022 – 28/02/2022	7,962	1,264	0	6,698

01/03/2022 – 21/03/2022	5,891	609	0	5,282
22/03/2022 – 14/11/2022	0	0	0	0
15/11/2021 – 14/11/2022	35,862	4,766	0	31,096
15/11/2022 – 30/11/2022	5,121	663	0	4,458
01/12/2022 – 31/12/2022	10,259	1,516	0	8,743
01/01/2023 – 31/01/2023	10,441	1,676	0	8,765
01/02/2023 – 28/02/2023	9,775	1,230	0	8,545
01/03/2023 – 18/03/2023	6,448	418	0	6,030
15/11/2022 – 18/03/2023	42,044	5,503	0	36,541
15/11/2021 – 18/03/2023	77,906	10,269	0	67,637

Year	Ex-ante emissions reductions/ removals	Achieved emissions reductions/ removals	Percent difference	Justification for the difference
15/11/2021 –14/11/2022	78,508	31,096	-60.39%	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.
15/11/2022 –18/03/2023	78,508	36,541	-53.46%	