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Geothermal – the Important Role of Air-Pollution Control in Baoding City, North China

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ABSTRACT

2013 AQI(Air Quality Index) of 74 cities in China shows that Baoding City, Hebei Province is one of the top ten seriously polluted cities especially in Beijing-Tianjin-Hebei circle. "Controlling Air Pollution Action" has been advocated by municipal government to the whole society. Coal boilers would be forcibly replaced by lower emission heaters. Named "China Geothermal City" by MLR(the Ministry of Land & Resources) in 2012, Baoding will regard geothermal as an important source for house heating. Baoding had 6million m^2 house heating less than ten years before 2012, 2million m^2 increment during 2012-2013, and hopefully will have 10 million m^2 including heat pump by 2015, 30million m^2 by 2020. Production-reinjection technology is successfully applied in over 2million m^2 district heating system by SINOPEC. A prospective 4000m± well will be drilled in the urban area in 2014 to determine whether geothermal occurs in so-called "non-geothermal-area".

1. INTRODUCTION

In the early 2014, Ministry of Environmental Protection issued the 2013 annual air quality date of 74 cities from regions including Beijing-Tianjin-Hebei, Yangtze Delta, Pearl River Delta, and municipalities, capital cities and cities with independent planning, etc. The regions of Beijing-Tianjin-Hebei have been seriously polluted, among the top ten cities with poor air, there are 7 cities in Hebei, which respectively are Xingtai, Shijiazhuang, Handan, Tangshan, Baoding, Hengshui and Langfang. PM2.5 is the primary pollutant of the 74 cities, followed by PM10, O_3 and NO_2, which also have varying degrees of exceedance. Air quality present complex pollution characteristics superimposed each other by traditional coal-burning pollution, automobile exhaust pollution and the secondary pollutants. Heavy pollution is most serious in the first and fourth quarter, which presents obvious seasonal characteristics.

Baoding is close to Beijing and Tianjin, whose air pollution has seriously affected the environmental quality of Beijing-Tianjin-Hebei region. According to the monitoring results from Jan 2013 to Feb 2014, the air pollution in Baoding has always been within the top ten in the 74 monitored cities nationwide, so the environment of Baoding must be controlled without delay. (Table 1: Air Quality Composite Index Statistics of Baoding)

Table 1: Air Quality Composite Index Statistics of Baoding

Date	Ranking	I_{sum} (Air Quality Composite Index)
Jan 2013	3	23.3
Feb 2013	3	7.87
Mar 2013	6	6.52
Apr 2013	6	4.96
May 2013	6	5.37
Jun 2013	5	5.73
Jul 2013	7	4.14
Aug 2013	9	3.87
Sep 2013	7	5.04
Oct 2013	3	7.15
Nov 2013	2	6.71
Dec 2013	4	8.80
Jan 2014	3	Not available
Feb 2014	3	15.72
I_{sum} :Composite Index for Individual Air Quality Index such as PM2.5, PM10, SO_2, NO_2, CO, O_3.		

(According to the air quality composite index statistics of 74 cities from www.cnpm25.cn)

To effectively improve air quality and protect people's health, the State Council issued the "Air Pollution Prevention Action Plan" in Sep 2013, which set the action target and identified the specific index that, by 2017, the concentration of particulate matter (PM10) of prefecture-level and above cities nationwide shall be decreased by more than 10% compared with 2012, and the superior air days shall be increased year by year; the concentration of particulate matter (PM2.5) in the regions of Beijing-Tianjin-Hebei,

Yangtze Delta, Pearl River Delta etc., shall be respectively decreased by about 25%, 20% and 15%, among which, the annual average concentration of fine particulate matter in Beijing shall be controlled to about 60μ g/m³.

According to this program of action, each province and region has set out plan for its own administrative regions. Baoding government has published the "The Overall Work Plan for Air Pollution Control of Baoding". Ten key measures have been determined as follows: to eliminate scattered coal-fired boiler and control coal burning pollution, to strictly control industrial pollution and reduce pollutant emissions, to strengthen the control of dust pollution and motor vehicle pollution, to accelerate the adjustment of energy structure and increase clean energy supply, etc.

In regard to clean energy supply in this plan, the total coal consumption is required to be controlled, the supply and promotion of the clean energy such as natural gas, liquefied petroleum gas, synthetic natural gas and solar energy, wind energy, etc., is required to be increased, and the use of geothermal energy is encouraged to be developed. The public buildings invested by the government take the lead in the implementation of green building standards, and the promotion of high-tech equipment such as solar hot water system, ground-source heat-pumps, air-source heat-pumps, building integrated photovoltaic, combined cooling heat and power, etc.

Baoding has rich geothermal resources, which shows great advantages in utilizing alternative energy source other than coal in the unified action of joint air pollution control in Beijing-Tianjin-Hebei.

2. GEOTHERMAL AND ITS UTILIZATION

2.1 Summery of Geothermal Resources

Baoding is located in the middle of Hebei Province (Figure 1). Beijing lies 140km to the north of Baoding, Tianjin 130km to the east and Shijiazhuang City, the Capital of Hebei Province, is 120km to the south. Railways, express ways, national roads, and provincial roads have formed convenient communication grids.



Figure 1: Map of Baoding City

Four geothermal fields, Niutuo Town large scale geothermal field, Gaoyang large scale geothermal field, Liushi large scale geothermal field and Rongcheng medium scale geothermal field, are distributed in flatland area of Baoding (Figure 2). The geothermal reservoir formations are classified into two types: karst-fractural and Tertiary voids. The area of Tertiary formation whose ground temperature gradient is above 2.5℃/100 m is 3700km^2, and the formation with temperature gradient above 3.0℃/100 m is 1850km^2. The largest ground temperature gradient is 6-9℃/100m at Xiongxian County and most are 4-5℃/100m at Gaoyang County, Lixian County, Anguo City and Boye County, etc(Figure 3).

By geothermal resources evaluation assessment, total geothermal resources reach 22006.22×10^{16}J， hot water reserves reach 2702×10^{8}m^3, minable geothermal fluid is 1.08×10^{8}m^3/a, suitable heat energy is 584.72MW in 4 geothermal fields. It is equal to 6292×10^{4}t of coal and can reduce 15170×10^{4}t of emission of CO_2、SO_2 and dust (《Report of Geothermal Resource Evaluation of Baoding City, Hebei Province》, 2012).

Shallow ground formation heat resources within 200m underground is quite rich in Baoding urban area, which has great potential for ground-source heat pump and groundwater-source heat pump for building heating and cooling. Statistic building area suitable for heat-pump is 19.85×10^{4}m^2, which is equal to 35.11×10^{4}t of coal and reduces 84.66×10^{4}t of emission of CO_2、SO_2 and dust(《Scheme of Geothermal Resources Prospecting, Exploitation and Utilization of Baoding City》,2012).

2.2 Geothermal Resources Calculation and Assessment

2.2.1 Geological model of geothermal fields

Four geothermal fields in Baoding area are heat-conductive low-moderate temperature geothermal fields including west-south part of Niutuo geothermal field, Gaoyang geothermal field, Liushi geothermal field and Rongcheng geothermal field. The geothermal system is formed by cover, geothermal reservoir; heat channel and heat source (Figure 4).

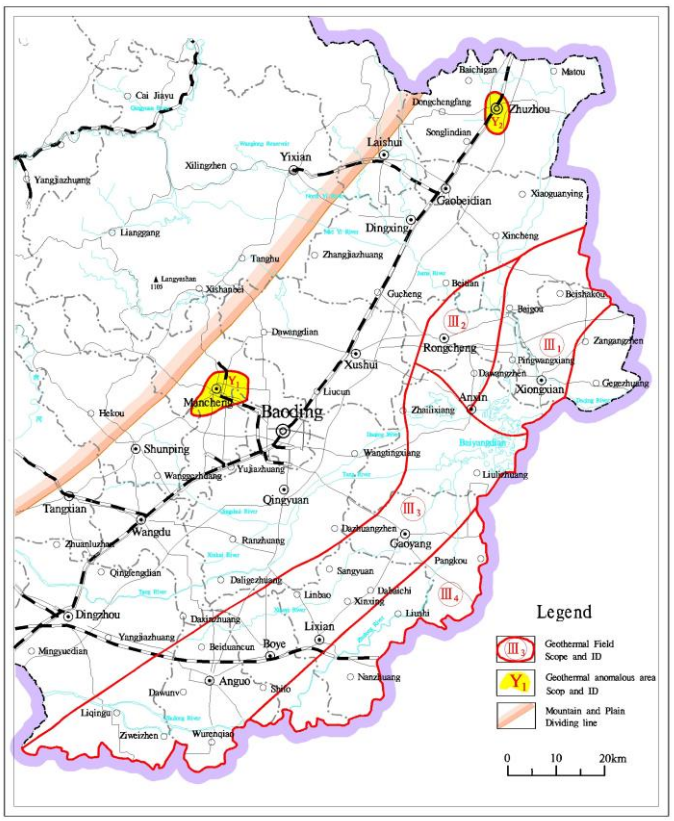


Figure 2: Geothermal Fields of Baoding City

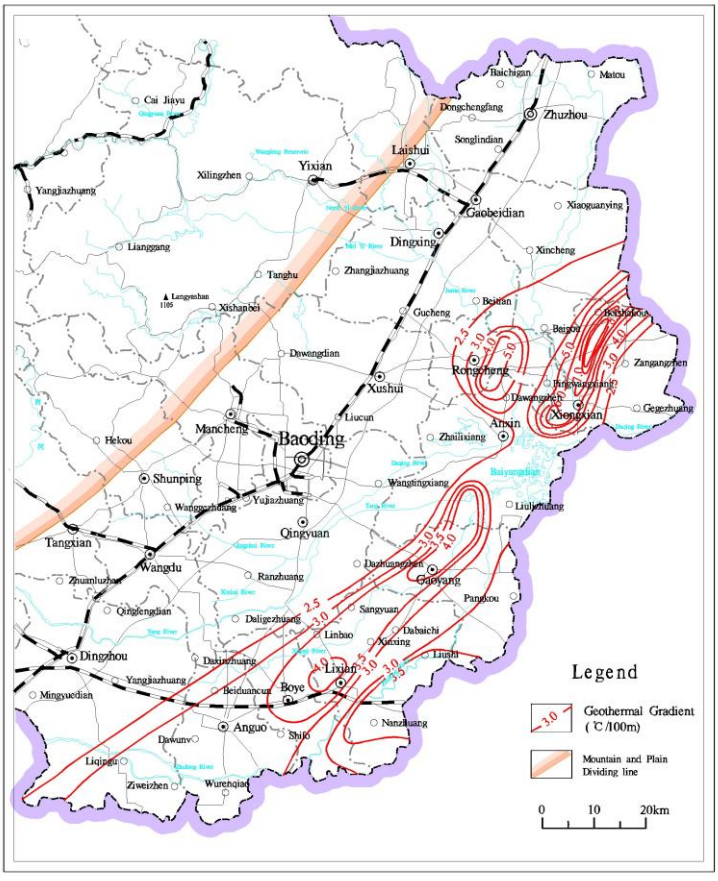


Figure 3: Isograms of Tertiary Temperature Gradient of Baoding Flatland

(1) Cover

The Quarternary layer is a good cover because of its thick formation (200-550m) and poor heat conductivity for the Tertiary geothermal reservoir beneath;

(2) Geothermal reservoirs

Three layers are main geothermal reservoirs but unhomogeneously distributed in total areas:

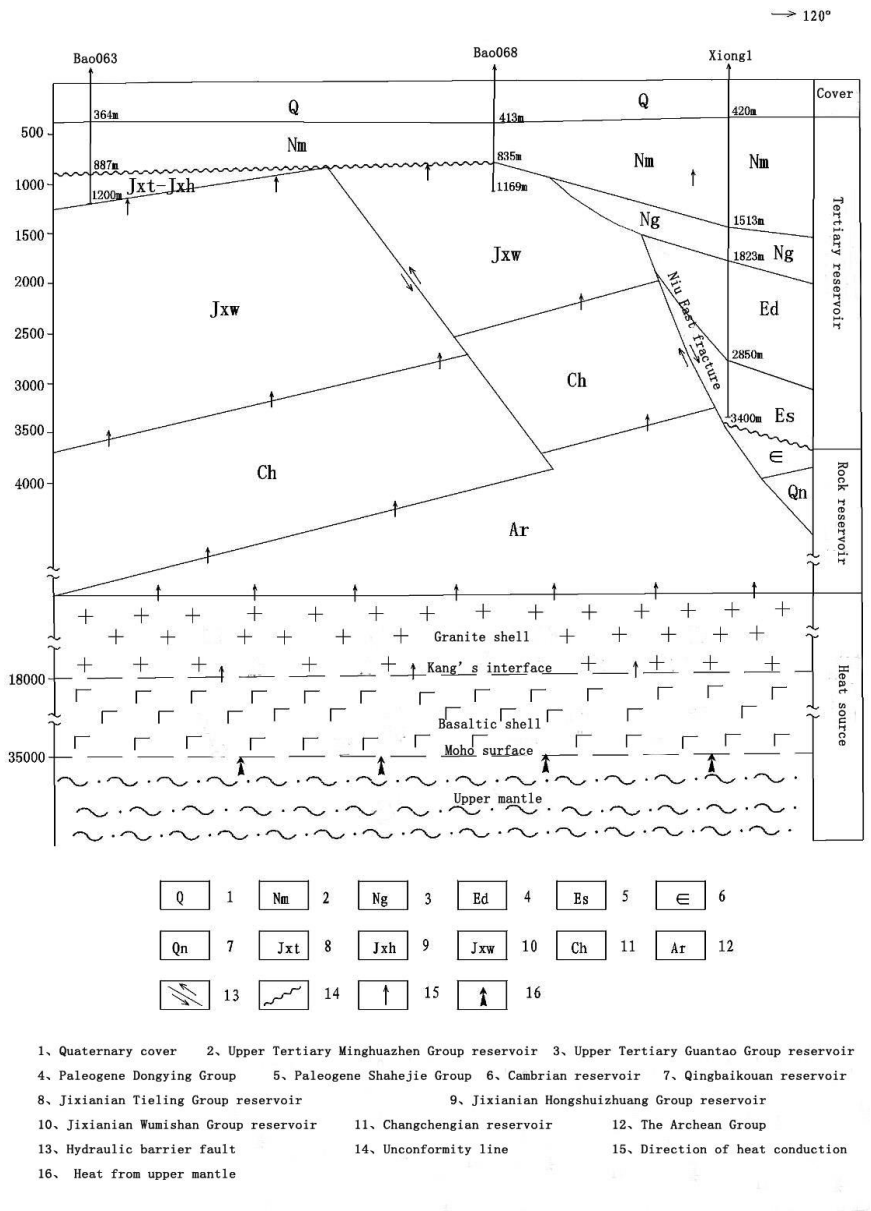


Figure 4: Geological Model of geothermal fields in Baoding City

① The Tertiary Minghuazhen Group formation geothermal reservoir is distributed in the whole area except Mancheng. The depth of its bottom boundary is 200-1600m and the thickness is 200-1000m. There is no hydraulic connection with Guantao Group formation below by thick mudstone between.

② The Tertiary Guantao Group formation geothermal reservoir is distributed in most area except Rongcheng geothermal field, Zhuozhou geothermal field, west-south part of Niutuo geothermal field and Mancheng. Above it is Minghuazhen Group geothermal reservoir and below is rock geothermal reservoir but all insulated against heat by thick mudstone. The depth of bottom boundary is 1137-2215m and its thickness is 200-893m.

③ Rock geothermal reservoirs are all carbonate (karst) formations but from different geological age in several geothermal fields, i.e. , the Ordovician karst formation is distributed in Gaoyang geothermal field, its depth of bed floor is 2561-2891m, and thickness is 18-140m, water temperature is 90-100℃; the Proterozoic karst formation is distributed only 800-1100m depth in Niutuo geothermal field, however it is distributed 3000m in Gaoyang geothermal field.

(3) Heat source

The heat comes from the earth's upper mantle as well as radioactive element decay heat from thick granite.

(4) Heat channel

High ratio of heat conductivity of Carbonate rock created good condition for heat conduction in the area. Besides, several tectonic faults provide heat channels for heat upflow from deep in the earth.

2.2.2 Principles of calculation and assessment

(1) According to GB/T11615-2010 “Geological Exploration Regulation of Geothermal Resources”;

(2) The total calculated area of 4 geothermal fields is rounded by basis Ⅳ tectonic units distribution, meanwhile, the Tertiary ground temperature gradient ≥2.5℃/100m, and include, when ≤2.5℃/100m but proved by exploited geothermal wells. The calculated area is 3700km^2.

(3) Economic Tertiary and rock reservoir reserves, geothermal fluid quantity, minable fluid quantity and heat energy above 3000m depth (4000m in Gaoyang geothermal field and Liushi geothermal field) are calculated respectively.

2.2.3 Calculation of geothermal reserves for geothermal reservoir

Calculation of geothermal reserves is adopted by heat-reserve method. Calculation parameters are given in table 2.

(1) Calculation equations:

$$Q=Q_r+Q_w$$

$$Q_r=Ad\rho_r c_r(1-\varphi)(t_r-t_0)$$

$$Q_w=Q_l C_w \rho_w(t_r-t_0)$$

$$Q_L=Q_1+Q_2$$

$$Q_1= A\varphi d$$

$$Q_2 =ASH$$

Where, Q = total thermal energy in reservoir (J)

Q_r = thermal energy in the rock (J)

Q_w = thermal energy in water (J)

Q_L = water quantity in reservoir (m^3)

Q_1 = net water reserve in the reservoir by the time of calculation (m^3)

Q_2 = water discharge by maximum depth of water extraction (m^3)

A =area of calculate area (m^2)

d= thickness of reservoir (m)

ρ_r = density of rock (kg/m^3)

c_r = heat capacity of rock (J/kg• ℃)

φ = porosity

t_r = initial reservoir temperature (℃)

t_0 = reference temperature(℃)

ρ_w = density of water (kg/m^3)

c_w = heat capacity of water (J/kg• ℃)

S = storativity of reservoir

H = height above from calculate dot (m)

Table 2: Parameters of Geothermal Resources Calculation in Baoding City

Name of field	Era	A 10^6m^2	D m	t_r ℃	Φ %	ρ_r kg/m^3	c_r J/kg• ℃	G_r 10^{-10}	S 10^{-5}
Rongcheng	Ng	31	63.44	50.8	22.00	2600	878	3.83	5.2
	Ch -Jx	330	596.661	62.2	3.30	2700	920	4.10	7.8
Niutuo	Nm	324	171.306	48.7	34.51	2600	878	4.37	28.4
	Ng	205	81.466	56.6	30.00	2600	878	3.95	9.2
	Ch -Jx	482	384.387	82.7	3.30	2700	920	4.30	5.2
Gaoyang	Nm	1080	291.428	45.8	23.00	2600	878	4.22	26.1
	Ng	2066	157.834	61.54	22.00	2600	878	3.82	12.8
	ϵ+o	469	150.867	122.9	3.00	2700	920	4.14	1.4
	Ch -Jx	632	114.957	142.3	3.30	2700	920	4.05	1.7
Liushi	Nm	652	352.195	47.8	23.00	2600	878	4.13	32.5
	Ng	652	208.804	65.6	22.00	2600	878	4.13	18.2
	ϵ+o	298	71.909	133.0	3.00	2700	920	4.05	0.8

(2) Calculation method

The calculation is adopted by Arc MAP units from ArcGIS Desktop. ArcGIS is the GIS System developed by Environmental System Research Institution of America (ESRI). It can realize all functions based on map system and deal with complicated database, and has powerful space analysis ability (Figure 5,6,7).

(3) Calculation results (see Table 3 and Table 4)

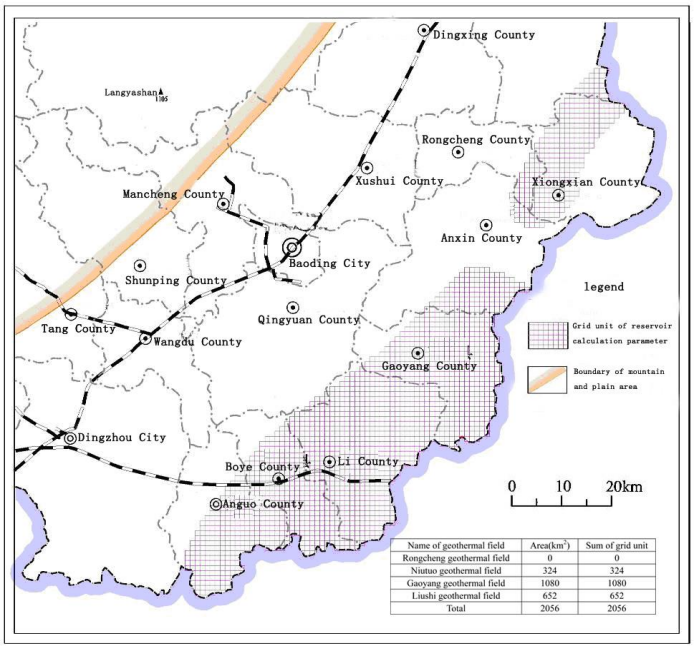
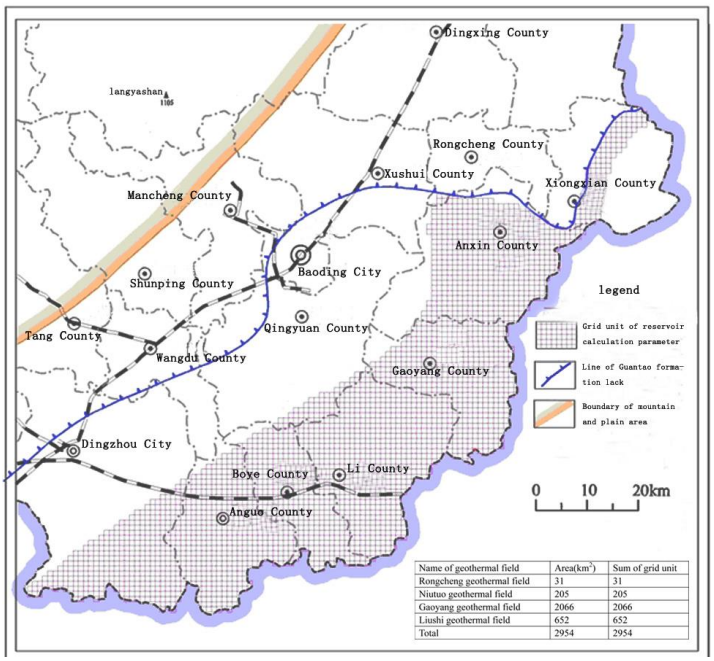
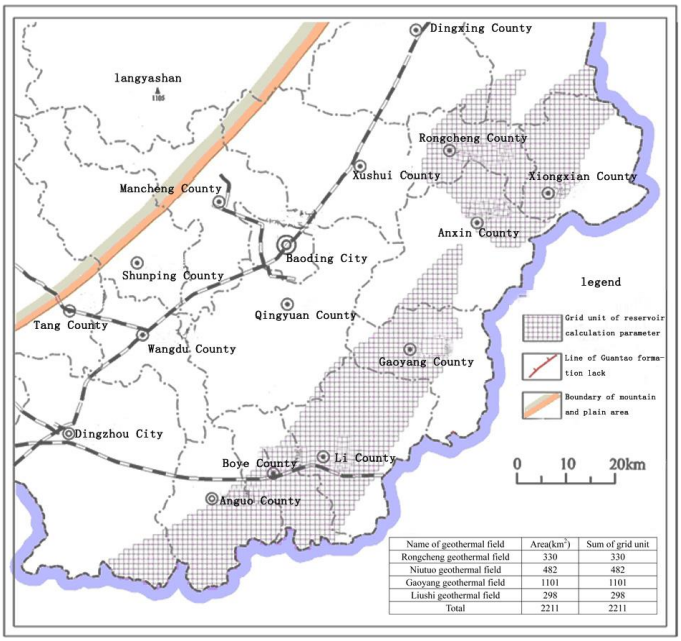


Figure 5: Parameter grid units of Tertiary Minghuazhen Group Reservoir



Name of geothermal field	Area(km²)	Sum of grid unit
Rongcheng geothermal field	31	31
Niutuo geothermal field	205	205
Gaoyang geothermal field	2066	2066
Liushi geothermal field	652	652
Total	2954	2954

Figure 6: Parameter grid units of Tertiary Guantao Group Reservoir



Name of geothermal field	Area(km²)	Sum of grid unit
Rongcheng geothermal field	330	330
Niutuo geothermal field	482	482
Gaoyang geothermal field	1101	1101
Liushi geothermal field	298	298
Total	2211	2211

Figure 7: Parameter grid units of Rock Reservoir

Table3: Reserves of Geothermal Fluids in Baoding Area

Name of geothermal field	Era of reservoir	Total reserves 10^6m^3	Reserves of geothermal fluids		
			Heat reserves $10^{16}J$	Equal to coal（10^6t）	Heat energy（Mw）
Rongcheng field	Ng	434.25	6.41	2.19	20.33
	Ch-Jx	6520.44	129.37	44.14	410.23
	Total	6954.69	135.77	46.33	430.52
Niutuo field	Nm	19188.16	271.39	92.60	860.57
	Ng	4965.43	84.35	28.78	267.47
	Ch-Jx	6148.82	172.61	58.90	547.34
	Total	30302.41	528.36	180.28	1675.42
Gaoyang field	Nm	72568.56	941.07	321.10	2984.11
	Ng	72084.70	1394.95	475.97	4423.36
	Ch-Jx	2427.02	119.05	40.62	377.51
	∈-O	2148.57	89.49	30.53	283.77
	Total	149228.85	2544.56	868.23	8068.75
Liushi field	Nm	52959.71	737.56	251.66	2338.79
	Ng	30132.84	634.89	216.63	2013.22
	∈-O	653.47	28.82	9.83	91.39
	Total	83746.02	1401.27	478.13	4443.40
Amount	Nm	144716.43	1950.02	665.36	6183.47
	Ng	107617.22	2120.61	723.57	6724.41
	∈-O	2802.04	118.31	40.37	375.16
	Ch-Jx	15096.28	421.03	143.66	1335.08
Total		270231.97	4609.97	1572.96	14618.12
Remarks		1ton coal=heat2.93076×10^{10}J,10^{16}Jheat distribute to 100years=heat energy(1/0.31536)MW			

Table4: Minable Quantity of Geothermal Fluids in Baoding Area

Name of geothermal field	Era of reservoir	Total reserves 10^6m^3	Minable Quantity 10^6m^3	Minable reserves of geothermal fluids		
				Heat reserves $10^{16}J$	Equal to coal（10^6t）	Heat energy（Mw）
Rongcheng field	Ng	434.25	17.36	0.26	0.09	0.82
	Ch-Jx	6520.44	260.82	5.17	1.76	16.39
	Total	6954.68	278.18	5.43	1.85	17.21
Niutuo field	Nm	19188.16	767.52	10.86	3.71	34.44
	Ng	4965.43	198.62	3.38	1.15	10.72
	Ch-Jx	6148.82	245.95	6.9	2.35	21.88
	Total	30302.41	1212.09	21.14	7.21	67.04
Gaoyang field	Nm	72568.56	2902.74	37.64	12.84	119.36
	Ng	72084.70	2883.38	55.8	19.04	176.94
	Ch-Jx	2427.02	97.08	4.76	1.62	15.09
	∈-O	2148.57	85.94	3.58	1.22	11.35
	Total	149228.84	5969.14	101.78	34.72	322.74
Liushi field	Nm	52959.71	2118.38	29.5	10.07	93.54
	Ng	30132.84	1205.32	25.4	8.67	80.54
	∈-O	653.47	26.14	1.15	0.39	3.65
	Total	83746.02	3349.84	56.05	19.13	177.73
Amount	Nm	144716.43	5788.64	78	26.61	247.34

	Ng	107617.22	4304.68	84.84	28.95	269.02
	∈-O	2802.04	112.08	4.73	1.61	15
	Ch-Jx	15096.28	603.85	16.83	5.74	53.36
Total		270231.97	10809.25	184.4	62.92	584.72
Remarks		1ton coal=heat2.93076×10^{10}J,10^{16}Jheat distribute to 100years=heat energy(1/0.31536)MW				

Table 5: Scale Division of Geothermal Resources in Baoding Area

Name of geothermal field	Era of reservoir	Area ($10^6m^{2)}$	Minable quanity 10^6m^3	Minable reserves of geothermal fluids			Scale of geothermal field
				Heat reserves 10^{16}J	Equal to coal（10^6t）	Heat energy（Mw）	
Rongcheng field	Ng	31	17.36	0.26	0.09	0.82	Medium
	Ch-Jx	330	260.82	5.17	1.76	16.39	
	Total		278.18	5.43	1.85	17.21	
Niutuo field	Nm	324	767.52	10.86	3.71	34.44	Large
	Ng	205	198.62	3.38	1.15	10.72	
	Ch-Jx	482	245.95	6.9	2.35	21.88	
	Total		1212.09	21.14	7.21	67.04	
Gaoyang field	Nm	1080	2902.74	37.64	12.84	119.36	Large
	Ng	2066	2883.38	55.8	19.04	176.94	
	∈-O	469	97.08	4.76	1.62	15.09	
	Ch-Jx	632	85.94	3.58	1.22	11.35	
	Total		5969.14	101.78	34.72	322.74	
Liushi field	Nm	652	2118.38	29.5	10.07	93.54	Large
	Ng	652	1205.32	25.4	8.67	80.54	
	∈-O	298	26.14	1.15	0.39	3.65	
	Total		3349.84	56.05	19.13	177.73	
Remarks	Scale division：large：>50MW，medium：10-50MW，small：<10MW。						

2.3 Status of Geothermal Exploitation and Utilization

Geothermal exploitation and utilization in flatlands was started in 1970s. Geothermal abnormity appeared in oil drilling wells in Xiongxian County when large scale oil exploitation was conducted by Huabei Oil Field Company. In these artesian wells temperature of hot water was up to 86℃. The discovery of geothermal resources attracted great public attention. Then geothermal was continually discovered in Gaoyang County, Anxin County, and other places. Various utilizations such as house heating, bathing, kitchen hatching and green house were widely applied in rural and urban areas. Especially in recent years, construction of Low Carbon Model City conducted by Baoding Municipal Government enhanced geothermal resources development greatly as one of the new energy resources (figure 8).

By the end of 2012, 186 geothermal wells and natural springs were counted, including 127 being used. Among them 166 wells were from 4 geothermal fields, 116 being used, including 13 reinjection wells. Annual production of hot water is $1300\times10^4m^3$ for $600\times10^4m^2$ house heating. Till April, 2014, 52 newly added wells including 7 reinjection wells have made house heating area reach $800\times10^4m^2$. Another 50 wells are planned to be drilled by the end of 2015. At present 29 water-source heat-pump systems were severed $32\times10^4m^2$ building heating and cooling in urban area of Baoding. The typical and representative "Xiongxian Model" has already been the proud and symbol of Baoding's geothermal development.

2.4 Xiongxian Model

Xiongxian County is located in east flatland of Baoding City. It is 54km southwest to Baoding, 108km north to Beijing, 100km east to Tianjin. The total land area is 524 km^2, and the population is 338,000. It is the main part of the large Niu Tuo Town geothermal field with 320 km^2 area and one of the most abundant geothermal field in north China and even in whole nation. The fluid reserves are 82.17 billion m^3. The annual minable fluid is 8.165 million m^3. Professor Pang Zhonghe, researcher of Institute of Geology and Geophysics, Chinese Academy of Sciences, IGA member, named it "large karst geothermal reservoir of northchina". It also has a

name “China Geothermal Town” which was co-awarded by Ministry of Land & Resources and China Mining Association in 2006. Geothermal utilization model has great leading and pioneering meaning in this county.

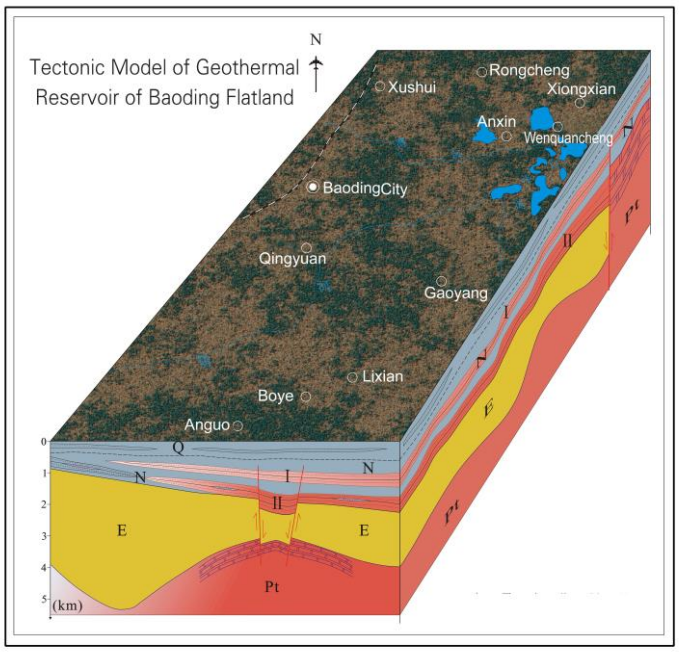


Figure8: Tectonic Model of Geothermal Reservoir of Baoding Flatland

The model is described as: the local government formulated high standard scheme on geothermal development, imported Sinopec Green Source Geothermal Company (joint venture between Sinopec and Icelandic Orkar Company) invested 250 million Yuan to develop geothermal on district heating in urban area with the help of high technology such as heat exchange and reinjection and monitoring. From 2008 to 2013, the old less than 600,000m^2 heating building area has been enlarged to 2.4 million m^2, which means 80% of total building of urban area has been occupied. 40 geothermal wells including 30 production wells and 10 reinjection wells were used in the system, among which 7 were purchased and reformed old wells. 20 heat exchange stations were built for geothermal heating pipelines tap water as heaters. The waste heating geothermal water was reinjected back to the same layer through reinjection wells at 35℃± to keep reservoir balance. Now production is 3.8 million m^3/a and reinjection is 3.0 million m^3/a, the rest is used for life (wash and bath) use. The pipeline grid and geothermal wells are all using automatic monitoring. Some key technological studies such as trace test are being conducted by institutes.

This utilizing model of “only get thermal through the hot water” has achieved the sustainable aim of taking full advantage of heat energy, keeping reservoir balance and protecting ecological environment and has been popularized to other counties in Baoding. The green Source Geothermal Company has drilled 14 geothermal wells including 7 production and 7 reinjection wells in the urban area of Rongcheng County, all pipelines grid and some exchange stations have been finished, which can fulfill 1.2 million m^2 building heating. Now 20×10^4m^2 has been heated in this county, a place that used only traditional coal boilers with no geothermal heating. In Boye County, the company has finished geothermal development scheme on the government guideline, planed to purchase all 10 old geothermal production wells and transform to exchange system to fulfill district heating building of 1.2 million m^2 in the urban area. A new 3500m depth prospecting rock well is planned to be drilled for low-moderate temperature geothermal power generation test due to its geothermal condition. Other cooperation is being discussed by the company and local governments.

2.5 Government Management

Baoding Municipal Government puts great emphasis on the potential of geothermal development. Exploitation and utilization management work was disposed from 2010: more than ten top national experts were invited to discuss geothermal utilization for the whole area; a work leading group was formed by the municipal government whose leader was the present deputy mayor in 2011; “Geothermal Resources Management Measures of Baoding City” was promulgated in 2011; “Geothermal Development Strategic Cooperation Framework Agreement of Baoding City” was signed between Baoding Municipal Government and Sinopec New Star Petroleum Company in Oct 2011; “Geothermal Resource Evaluation of Baoding” was finished in 2012; “Scheme of Geothermal Resource Prospecting, Exploitation and Utilization of Baoding City” was published in 2013; Baoding Geothermal Association was set up in 2012;… These works got exciting achievements nationwide: The CCTV-4 propagated program “Magic Geothermal” gave comparison between Baoding and Reykjavik, Iceland, one of the most advanced countries worldwide in geothermal utilization technology in 2012; Premier Wen Jiabao introduced “Xiongxian model” on Rio+20, UN Conference on Sustainable Development in 2012; National Geothermal Development Workshop was held by National Administrative Bureau of Energy at Xiongxian County to exchange and spread “Xiongxian model” experience in Feb 2014; a geothermal development framework agreement between Hebei Province and Sinopec will be signed in Jun 2014, promising that 16 billion Yuan will be invested by Sinopec to develop geothermal in the entire Hebei Province.

2.6 Scheme of Geothermal Exploitation and Utilization

As unique geographic and environmental energy, geothermal resource has an important role of strategic development in Baoding. Ministry of Land & Resources named Baoding City "China Geothermal City" in 2012. The requirement is being enlarged rapidly on a variety of utilizations such as building heating, spring physiotherapy, tourism, agricultural planting, fish farming, etc. According to 100 years mining period, minable reserves of geothermal fluids in flatland is $1.08\times10^8m^3/a$, at present the mining figure is only $13\times10^6m^3/a$. Total production of geothermal fluid is predicted to be $22\times10^6m^3/a$ and reinjection amount will be $4\times10^6m^3/a$ by 2015, production will be $30\times10^6m^3/a$ and reinjection will be $8\times10^6m^3/a$ by 2020.

The overall objective of the geothermal exploitation and utilization scheme of Baoding is: on the basis of $6\times10^6m^2$ building heating area in 2011, increase heating area to $10\times10^6m^2$ (including $1.6\times10^6m^2$ heat pump) by 2015, which can save 11.8×10^4t of coal, and reduce CO_2 emission by 28.1×10^4t; increase heating area to $30\times10^6m^2$ (including $2.6\times10^6m^2$ heat pump) by 2020, which can save 36.8×10^4t of coal, and reduce CO_2 emission by 87.6×10^4t, and power generation is expected to reach 15MW.

The above government work can be summarized as "12345" in the first 5 years and "54321" in the last 5 years in the scheme: from 2011-2015, to construct 1 "China Geothermal City", try for 2 provincial model areas, hold 3 provincial projects, bring up 4 1000mu ecological farms, focus on 5 important geothermal counties; from 2016-2020, to construct 5 model villages and towns whose renewable energy consumption is over 50% of total everyday energy consumption, hold 4 provincial projects, enlarge 3 geothermal counties, try for 2 national model areas, and build 1 comprehensive cascading integration model of low-moderate temperature geothermal power generation-district heating-green house- reinjection use.

CONCLUSION

1. Air quality monitoring results in 74 cities in 2013 shows that Beijing-Tianjin-Hebei region is seriously polluted, Baoding City of Hebei Province is one of the top ten. To effectively improve air quality, Baoding Government published "The overall work plan for air pollution control of Baoding City". Ten key measures have been determined, which mainly include strengthening clean energy supply, eliminating scattered coal-fired boiler, controlling coal burning pollution and others.

2. Geothermal is quite abundant in Baoding area. Geothermal reserves reach $22006.22\times10^{16}J$, hot water reserves reach $2702\times10^8m^3$, minable geothermal fluid is $1.08\times10^8m^3/a$, suitable heat energy is 584.72MW in 4 large and medium scale geothermal fields in flatland. It is equivalent to 6292×10^4t of coal and can reduce 15170×10^4t of emission of CO_2, SO_2 and dust. Statistic building area suitable for heat-pump is $19.85\times10^4m^2$ in urban area, which equivalent to 35.11×10^4t of coal and can reduce 84.66×10^4t of emission of CO_2, SO_2 and dust.

3. Till April, 2014, a total number of 240 wells including 20 reinjection wells reached a house heating area of $800\times10^4m^2$ in Baoding City. Production of hot water was $13\times10^6m^3$ and reinjection was $3\times10^6m^3$ within 2013 heating period. This can save 9.44×10^4t of coal and reduce CO_2 emission by 22.48×10^4t. By 2015, building heating area will be $10\times10^6m^2$, total production of geothermal fluid will be $22\times10^6m^3/a$ and reinjection amount will be $4\times10^6m^3/a$, the energy can save 11.8×10^4t of coal, and reduce CO_2 emission by 28.1×10^4t; By 2020, building heating area will be $30\times10^6m^2$, total production of geothermal fluid will be $30\times10^6m^3/a$ and reinjection amount will be $8\times10^6m^3/a$, the energy can save 36.8×10^4t of coal, and reduce CO_2 emission by 87.6×10^4t. Power generation is expected to reach 15MW.

4. Baoding Municipal Government puts great emphasis on geothermal development. Sinopec New Star Green Source Geothermal Company achieved great success in conducting district geothermal heating project, leading the heat-exchange and reinjection technology in Xiongxian County. 40 geothermal wells including 10 reinjection wells severed to $2.4\times10^6m^2$ geothermal heating area which occupied 80% of building area in urban district of the county. Total production is $3.8\times10^6m^3/a$ and reinjection is $3.0\times10^6m^3/a$. The utilizing model of "only get thermal through hot water" has achieved the sustainable aim of taking full advantage of heat energy, keeping reservoir balance and protecting ecological environment. It has been emphasized nationally and carried out to the whole country. Sinopec will sign strategic geothermal development framework agreement with Hebei Provincial Government in 2014 to invest 16 billion Yuan for developing geothermal resource in Hebei Province.

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