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Geothermal Resource and Development in Tianjin of CHINA

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ABSTRACT

In low carbon economy, new energy, especially the development and utilization of renewable energy and energy saving and emission reduction are very important. Tianjin have favorable conditions to do the work. Geothermal exploration begin in 1970's in Tianjin. 9 geothermal field have been found and It has rich geothermal resources. Low medium temperature geothermal resource potential reserves of $844.62\times10^9 m^3$, equivalent to the total heat resources 6.6×10^9 tons of standard coal. The proven geothermal water recoverable reserves of 68.57×10^6 m^3/a. Geothermal markets have been broadened and made great progresses with the economic rapid developing processes and growing need for geothermal resource in Tianjin. 474 geothermal wells have been drilling and geothermal space heating has reached 20 million m^2 in 2013. almost a 20% increase over the 2010 data, growing at a rate of 5,0% annually. Geothermal reinjection test carried out since 1996. Injection ratio of single well reaches 100% in karst reservoir and 50-80% in porosity reservoir. The total injection ratio reaches 34% of production.

1. INTRODUCTION

China is rich in geothermal resources, which is at the top of countries in direct using of geothermal energy. Particularly in North of China, Tianjin is at the top for China in direct using of geothermal energy. There are two types of geothermal reservoirs, which include sandstone porous reservoir and bedrock fractured geothermal reservoir in Tianjin. Water temperature is to 103 °C. Since the 1980s, the development and utilization of geothermal resources came into a rapid development period. But pressure of reservoir have drop down rapidly. Geothermal reinjection test carried out since 1996. By 2013,The total injection ratio reach 39% of production. Injection ratio in fractured reservoir is 61% and 177% in Ordovician reservoir.

2. GEOTHERMAL EXPLORATION

The exploration of geothermal resources in Tianjin started in early 1970. Ten geothermal anomalies were delineated in an area of 8700 km^2 in the south of Tianjin (figure 1). Geothermal exploration and evaluation were carried out in Wanglanzhuang, Shanlingzi, Wuqing, Binhai, Zhouliangzhuang, Panzhuang, Wanjiamatou , Jinghai and Panshan (Table 1).

Geothermal exploration has been carried out in Tianjin Jixian County Panshan area during 2007 to 2012. Two geothermal well have been drilled successful where is in north part of Tianjin.

At present, there are seven geothermal fields whose reserves have been proven up by national reserve administration department (Table 2).

Figure 1: Geothermal anomalies.

Table 1: Geothermal fields

Geothermal field	Area（km^2）	Geothermal gradient (°C/100m)
Wanglanzhuang	534	8.0
Shanlingzi	315	8.3
Wanjiamatou	235	8.8
Wuqing		
Panzhuang	610	6.9
Zhoiuliangzhuang	180	5.5
Binhai	2000	3.0
Jinghai	190	4.5
Panshan	42	7

Table 2 Geothermal resources reserves（$10^3m^3/a$; P- Proving; C- Controlling; R-Reasoning）

Resource reserves \ Geothermal Field		WLZ	SLZ	BH	ZLZ	WQ	WJMT	PZ	JH	PS
Tertiary	Total reserves	15210	6010	10440	2310	1180	730	3100	3412	
	Reserves class	P	C	P and C	C and R	C and R	C and R	C and R	R	
	Minghuazhen	9887	3907	6786		767	730	3100	1934	
	Guantao	5323	2103	3654		413	-	-	1478	
Bedrock	Total reserves	6260	11780	-	5070	-	2100	-		972
	Reserves class	P	C and R	-	C and R	-	R	-		C
	Ordovician system	1815	3416	-	450	-	-	-		
	Hanwu system	63	118	-	320	-	-	-		
	Jixian system	4382	8246	-	4300	-	2100	-		
	Granite									972

3.GEOTHERMAL RESERVOIRS

The geothermal fields in Tianjin belong to the low-medium temperature geothermal resource. The unique characteristics is regional distribution as resource. The main geothermal field is in the urban and the surrounding areas. The other geothermal fields are distributed out side of the city. They are buried at the depth of 1000m-4000m with good economic features and five reservoirs in two types vertically,which are sandstone porous geothermal reservoir in Tertiary system including Minghuanzhen(Nm) and Guantao(Ng) formation, and limestone fracture reservoir in the bedrock including Ordovician system(O), Cambrium system(Є) and Wumishan formation of Jixian system(Jxw)(Figure 2). It is can be developed and used on the space heating in winter, agricultural greenhouse, aquiculture, bathing and medical care etc. The hot water is of good quality and medium temperature, maximum temperature of hot water is 103℃. The single well discharge ranges from 60-150 m^3/h, maximum is 340 m^3/h. The geothermal resource is about 68574 $10^3m^3/a$.

Figure 2: The geothermal reservoirs

4.GEOTHERMAL DEVELOPMENT

The hot water is characterized by high single-well yield and less impact on environment when it is exploited in Tianjin. Geothermal resources utilization came into a rapid development period since 1980's. Geothermal resources are widely used for space heating, bathing, agriculture and aquaculture and others(figure 3). We have a great increasing in recent years to fit with the need of modern market economy in Tianjin. By the Year 2013, there are total 474 geothermal wells in Tianjin. Hot water production is 32.40×10^6 m^3. About 19.53×10^6 m^2 areas are used geothermal for space heating. There are 100×10^3 families use geothermal hot water in daily life. The geothermal utilization have been served in economical development in Tianjin. Large scale production with the increasing exploited efforts, the geothermal reservoir pressure declining year by year. The deepest static water level of the major reservoir is about 140 meter and the rate of drawdown is about 10 meter in urban city of Tianjin. How to keep its sustainable development, has become an urgent problems which needs to be solved. Generally considered that reinjection is the main method of geothermal resources exploitation and protection, it can effectively solve many problems brought with the development and utilization of geothermal development. We have carried out the geothermal reservoir reinjection technology study since 1996, which is the first one in our country. Through pilot testing a variety of technical methods, has made a series of achievements, and set up three demonstration modes double wells with a layer, tow production wells one reinjection well with a layer and two wells in different layers(figure 3).

With the development strengthening of geothermal resources, geothermal reinjection as an effective way to maintain resource sustainable development is increasing at different layers of geothermal reservoir. Reinjection is significantly important for sustainable development of geothermal resources.

The new well completion technology of reinjection wells were focused on in porous sandstone reservoirs which is very little geothermal water recharge in the latest five years which realizes the new breakthrough of porous reservoir reinjection, and have made some achievements. The reinjections rate are 100-130 m3/h, It also shows that the temperature of the reservoir in reinjection region recovers rapidly to the initial temperature of last year .

Up to last heating season in 2013, there has been totally132.85×106m3 /a geothermal water re-injected into the reservoir.The water level drop has been controlled to be 3-5 meter per year in the compare of 10 meters per year in the past years.

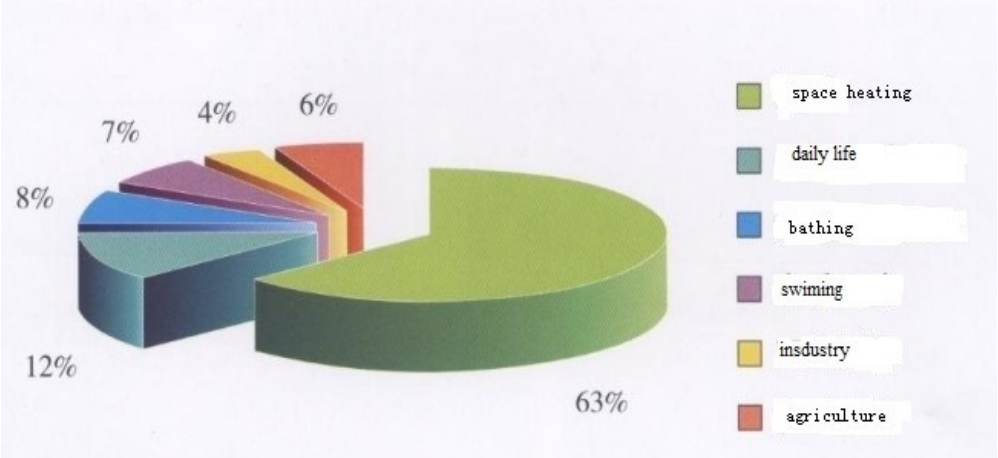

Figure 3: Geothermal resources utilization.

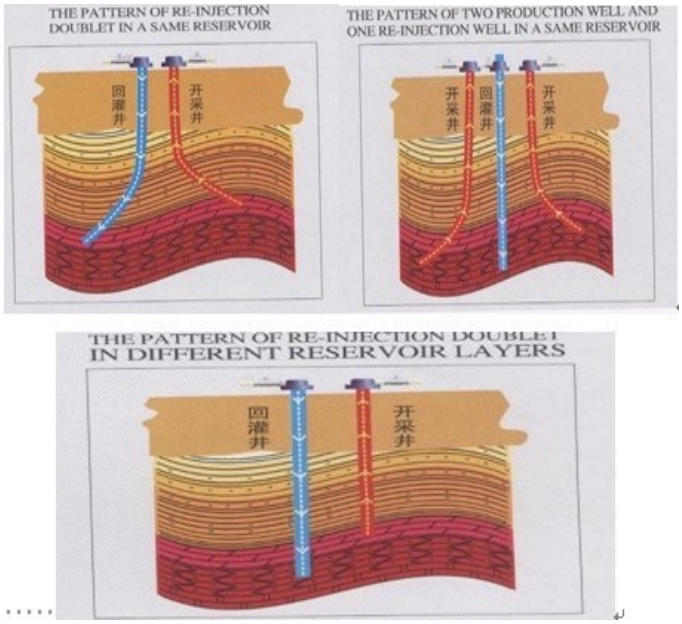

Figure 3: The Pater of rejection in geothermal reservoirs.

Table 3: Production and reinjection in reservoirs.

Reservoirs	Production reinjiection	**2010**	**2011**	**2012**	**2013**
Nm	Production ($\times10^4m^3$)	470.1	442.3	383.38	441.96
	Rejection ($\times10^4m^3$)	0	0.9	8.74	2.85
	Ratio (%)	0	0.2	2.3	0.6
Ng	Production ($\times10^4m^3$)	784.2	608.1	747.66	628.28
	Rejection ($\times10^4m^3$)	20	12.6	26.52	62.17
	Ratio(%)	2.6	2	3.6	10
Ed	Production ($\times10^4m^3$)	25.1	22.7	18.27	17.25
	Rejection ($\times10^4m^3$)	0	0	0	0
	Ratio(%)	0	0	0	0
O	Production ($\times10^4m^3$)	217.73	258.7	246.26	183.11
	Rejection ($\times10^4m^3$)	159.8	276.9	258.35	325.20
	Ratio(%)	73.4	107	104.9	177.6
Є	Production ($\times10^4m^3$)	62	69.77	85.19	114.87
	Rejection ($\times10^4m^3$)	24.1	44.94	36.09	99.85
	Ratio(%)	38.9	64.41	42.36	86.92
Jxw	Production ($\times10^4m^3$)	1362.2	1498.5	1675.91	1768.93
	Rejection ($\times10^4m^3$)	550.4	573.3	757.63	838.39
	Ratio(%)	40.4	38.26	45.21	47.40
	Total(%)	25.8	31.3	34.45	39.98

5. CONCLUSION

Low -medium temperature geothermal resources are directly and comprehensively used as new energy in Tianjin. The geothermal utilization has played an important role in economical development in Tianjin. 10 geothermal anomalies were delineated in an area of 8700 km^2 in the south of Tianjin. Two geothermal well have been drilled successful where is in north part of Tianjin. The geothermal resource is about $68574\times10^3m^3$/a. By the Year 2013, there are total 474 geothermal wells in Tianjin. Hot water production is 32.40×10^6 $m^3$and $132.85\times10^6m^3$ /a geothermal water reinjected. Porous geothermal reservoir of Neogene as an important mining geothermal reservoir, new well completion technology use in reinjection systems, the demonstration of projects is reinjection rate of single well is up to 100-130m^3/h.

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