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CONSULATE-GENERAL

WARMING UP CHINA'S GEOTHERMAL SECTOR – SOUTHWEST CHINA WARMEST?

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SUMMARY

- China's potential geothermal resource accounts for almost 8% of global resource.
- Until now it has not been highly prioritised across China as a source of renewable energy, but interest is hotting up.
- Almost half of Lhasa's municipal electricity grid demand is met by geothermal energy.
- Under its newest Five Year Plan on Geothermal Resources (2016-2020) China aims to add 500MW of new geothermal capacity by 2020 – an almost 17-fold increase. Most of this new capacity will be in Tibet and elsewhere in SW China.
- But industry experts believe government subsidies will also be needed if geothermal energy is to take off.
- And it is unclear if China can implement its very ambitious expansion plan with under three years remaining.
- Geothermal heating is increasingly popular as a clean heating solution in northern China.

REPORT

By the end of 2016, China still relied on coal for 62% of its energy production. But China is making great efforts to reduce use of coal and increase the use of clean and low-carbon energies. From 2010 to 2015, China's consumption of non-fossil energy increased from 9.4% to 12%. In the national 13th Five Year Energy Development Plan (2016-2020) the consumption of non-fossil energy is targeted to reach over 15%, and 20% by 2030. For geothermal energy, as one type of renewable energy, the national heating/refrigeration area is planned to reach 1.6 billion m^2, and installed power-generating capacity to reach 530MW by 2020. Total utilisation of geothermal energy is planned to equal 70 million tons of standard coal in 2020, including the equivalent of 40 million tons of standard coal energy for heating. However, the amount of geothermal energy utilisation in China's 13th Five Year Plan on Renewable Energy Development is still small compared to other renewable energies:

Major Index of Renewable Energy Utilization by 2020 of China [1]		
Item	***Utilization (million KW)***	***Equal Standard Coal (million ton/year)***
Electricity Generation		
Hydropower	340	368.75
Grid-connected wind power	210	123.90
Photovoltaic	105	36.73
Biomass power	15	26.6
Solar thermal power	5	5.9
Geothermal energy	**0.53**	**30**
Heating	***(m^2)***	
Solar water heater	80	96
Geothermal energy	**1600**	**40**
Biomass energy		15

[1] *Five Year Plan on Renewable Energy Development*, Dec 2016

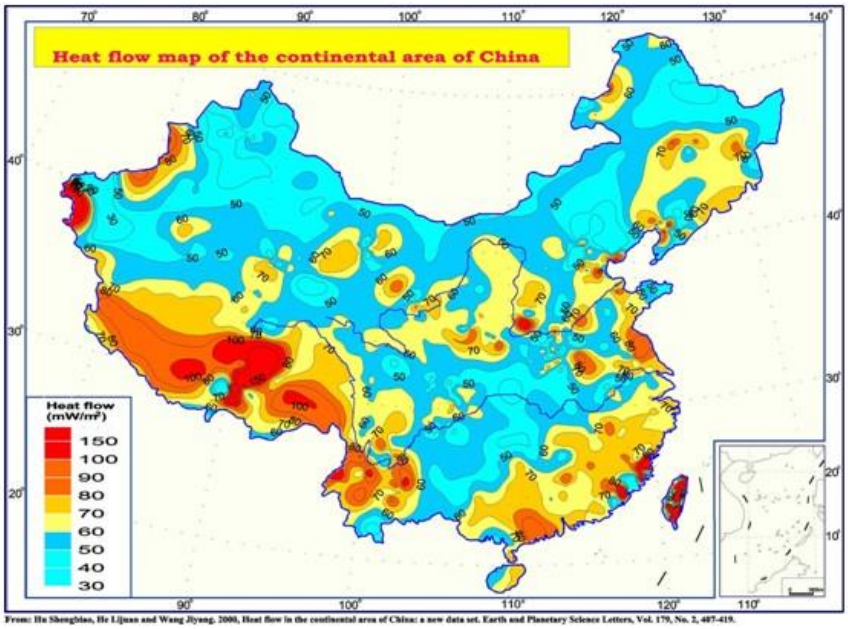
China's general geothermal resources situation

2 China's geothermal resource takes up about 7.9% of the world's total resource. According to the China Geological Survey of Ministry of Land and Resources, China's geothermal energy is categorized into three types: shallow geothermal energy, hydrothermal geothermal energy and hot dry rock geothermal energy. The total reserve of hydrothermal geothermal energy is said to equal 1.25 trillion tons of standard coal, which equals 50% of China's 2015 coal consumption[2]. The reserve of hot dry rock geothermal energy at 3,000 – 10,000 m depth equals 856 trillion tons of standard coal, and 2% of its exploitable energy equals 4,000 times of China's 2015 energy consumption. The annual amount of exploitable geothermal energy in China equals 2.6 billion tons of standard coal, including shallow geothermal energy (0.7 billion tons of standard coal) in 336 cities and hydrothermal geothermal energy (1.9 billion tons of standard coal).

3 However, the actual annual exploited amount for heating was equivalent to only 20 million tons of standard coal by the end of 2015, showing the great potential for future geothermal resource development.

4 Shallow and hydrothermal geothermal energy is mainly used for heating/refrigeration, using hot pump technology, and 80% of its application is in the areas of Beijing, Tianjin, and Hebei, Liaoning, Henan and Shandong provinces. Geothermal energy is also used for some power generation in China. Again, although the reserve of hot dry rock geothermal energy is huge, the development of it is still largely at a research stage.

Heat Flow Map of the Continental Area of China



From: Hu Shengbiao, He Lijuan and Wang Jiyang, 2000, Heat flow in the continental area of China: a new data set. Earth and Planetary Science Letters, Vol. 179, No. 2, 407-419.

5 Regionally speaking, according to Zhiyan Consulting Group, Southwest China has a proved exploitable energy of 2204.45MW, taking up 51% of China's proved geothermal resources:

Proved Exploitable Geothermal Resources in China					
Region	***Hot Fields***	***Exploitable Water Amount (m^3/d)***	***Energy Amount (MW)***	***Equals standard coal (t)***	***Percentage (%)***
North China	56	447.734	745.33	800,900	17.27
Northeast China	43	74.390	109.25	117,600	2.53

[2] *Acta Geoscientica Sinica*, 2017, 38 (4)

East China	182	304.642	427.81	460,500	9.92
Mid-South China	165	696.295	687.75	737,900	15.89
Southwest China	218	701.482	2204.45	2,370,800	51.05
Northwest China	74	245.619	144.37	155,300	3.34
Total	**738**	**2470.162**	**4318.96**	**4,644,000**	**100**

Power Generation

6 China's high temperature (above 150℃) geothermal resources which are suitable for power generation are mainly located in the south part of Tibet Autonomous Region, western Yunnan Province and western Sichuan Province. According to *Statistical Review World Energy*, until 2015 only Tibet Autonomous Region (TAR), Hebei Province and Guangdong Province had geothermal power plants, with a total installed power-generating capacity of 27.28MW, ranking no. 18 globally. The TAR itself takes up 97% of China's power generation by geothermal power, given its abundant high-temperature geothermal resources. China's first power generation plant (24MW) using geothermal resources was the Yangbajing geothermal well in the TAR, first put in to operation in September 1977. The installed capacity of the plant has now reached 25.15MW, supplying 41.5% of the installed capacity of the power grid in Lhasa. Over water-short winters, Yangbajing contributes 60% of Lhasa's power. Also, China constructed low-middle temperature geothermal power plants in the 1970s in Guangdong, Hebei and Jiangxi provinces. The most matured technology for geothermal power generation is high temperature dry steam technology. Middle-low temperature geothermal power generation technology still need improvements.

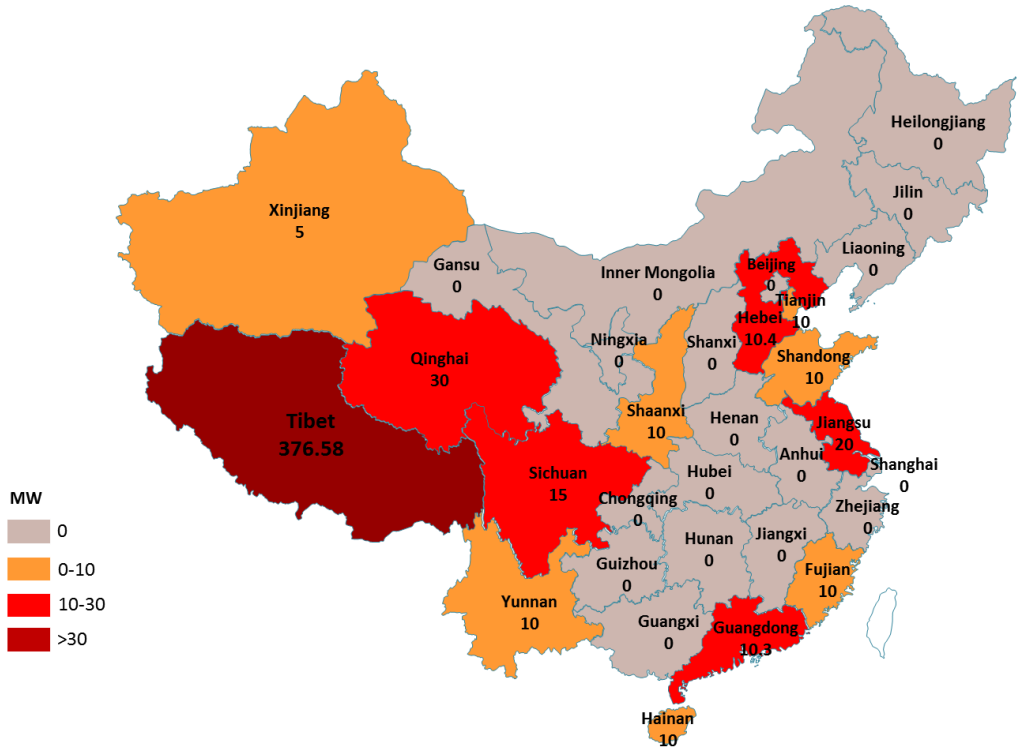
Installed Power-generating Capacity by Geothermal Resources by 2015 (MW)

7 China aims to add 500MW of newly-added installed power-generating capacity in its 13th Five Year Plan on Geothermal Resources by 2020 – in other words a 17-fold increase over 2015 levels. According to one player in the sector, Chen Zeming, "in fact, the 500MW objective is not very big. But given the lack of policy support for geothermal electricity price subsidies, geothermal power generation is hard to develop – this subsidy is considered to be the key to any future success…. Now we only lack government policy, once there is

certain helpful policy, power-generation by geothermal resources will flourish."[3] (Chen is President of Zhengzhou Dimeite New Energy Technology Co., Ltd, and is also the president and founder of Sanquan Group, the largest quick-frozen food company in China. Dimeite has constructed a geothermal power plant in Ruili, Yunnan Province. The first power generation (1MW) of the first phase of the plant (4MW) was connected to the local power grid in July 2017.)

8 350MW of the 500MW planned new capacity is planned to be constructed in the TAR. According to Duo Ji, a senior engineer at Bureau of Geology and Mineral Exploration of Tibet Autonomous Region, currently Sinopec, China National Nuclear Group and some private businesses are working on further assessment of geothermal resources in Tibet, and about 16MW capacity will be constructed in 2017, but it will be very difficult to fulfil the tasks of 350MW in the period of 13th five year (2016-2020).[4] "As a matter of fact, the Yangbajing power generation plant has been given a subsidy on the electricity price after application and approval. The current on-grid price for the second phase of Yangbajing is 0.93RMB/kW·h. But the whole Yangbajing project was invested by the national government and the old technology doesn't allow unmanned operation, therefore the Yangbajing project itself is not economic" said Duo Ji.

Installed Power-generating Capacity by Geothermal Resources by 2020 (MW)



9 For middle-low temperature geothermal power generation, the five-year plan lists Tianjin and Hebei, Jiangsu, Fujian and Guangdong provinces as key areas. China also plans to further explore dry hot rock geothermal resources within 10,000 m depth and to construct 2-3 pilot/experimental dry hot rock power plants, with locations selected between south part of Tibet Autonomous Region, western Sichuan Province, western Yunnan Province, Fujian Province, the North China Plain and Changbai Mountain.

Heating

[3] *Energy* magazine, 15 Jan 2018
[4] *Energy* magazine, 15 Jan 2018

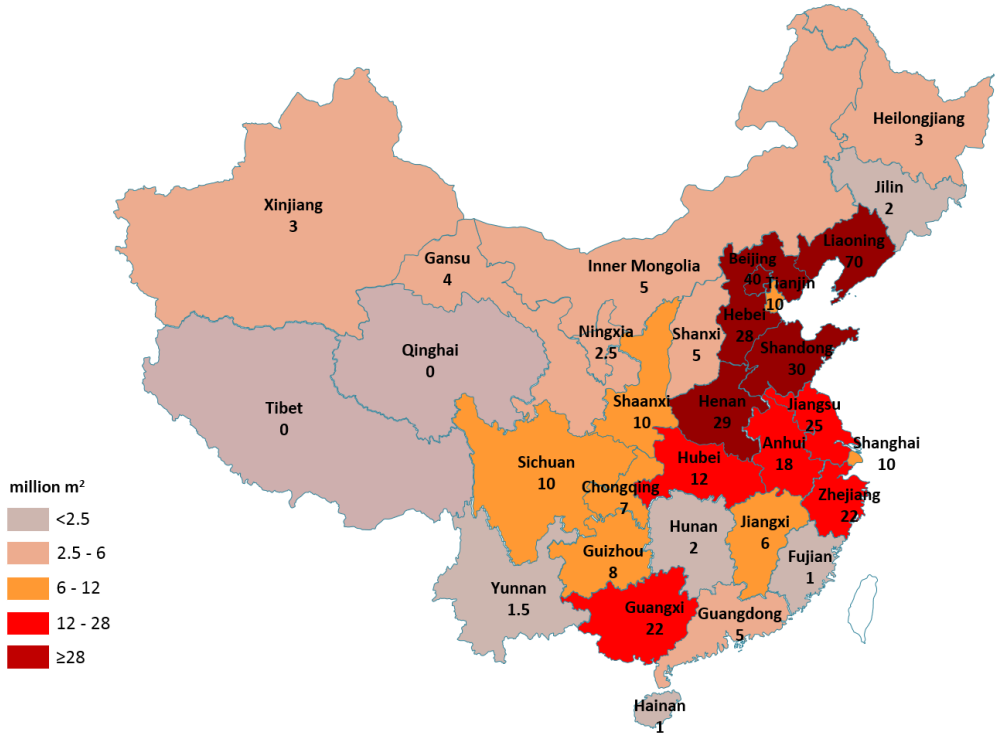
10 China ranges from latitude 53°N in the north to 5°N in the south, resulting in some very cold provinces up in the north in winter. Historically, China's heat-supply dividing line is the Qingling Mountains and Huai River. To the north of the line there are heat-supply systems in most areas. By the end of 2016, the heat-supply area in China was about 7 billion m^2. However, in many of the remote areas in the north the government hasn't extended heat-supply systems, with communities relying on self-generated heat supply. Currently the heat-supply system in China is still largely dependent on coal, which also causes dispute and urgency of transferring to clean energy, under the pressure of the recent focus on the environmental problems (smog) of China.

11 Geothermal heat supply counts for about 7% of the heat-supply system in China, with an area of 392 million m^2 heated/refrigeration by shallow geothermal energy, and 102 million m^2 by hydrothermal geothermal energy, with an annual utilization amount of geothermal energy equalling 20 million tons of standard coal, by the end of 2015. The technologies of heat supply/refrigeration for shallow geothermal and hydrothermal type geothermal energies are basically mature in China. Heat pump technology is mainly used for utilising shallow geothermal energy. Around 80% of shallow geothermal energy is used in northern China and the southern part of northeast China.

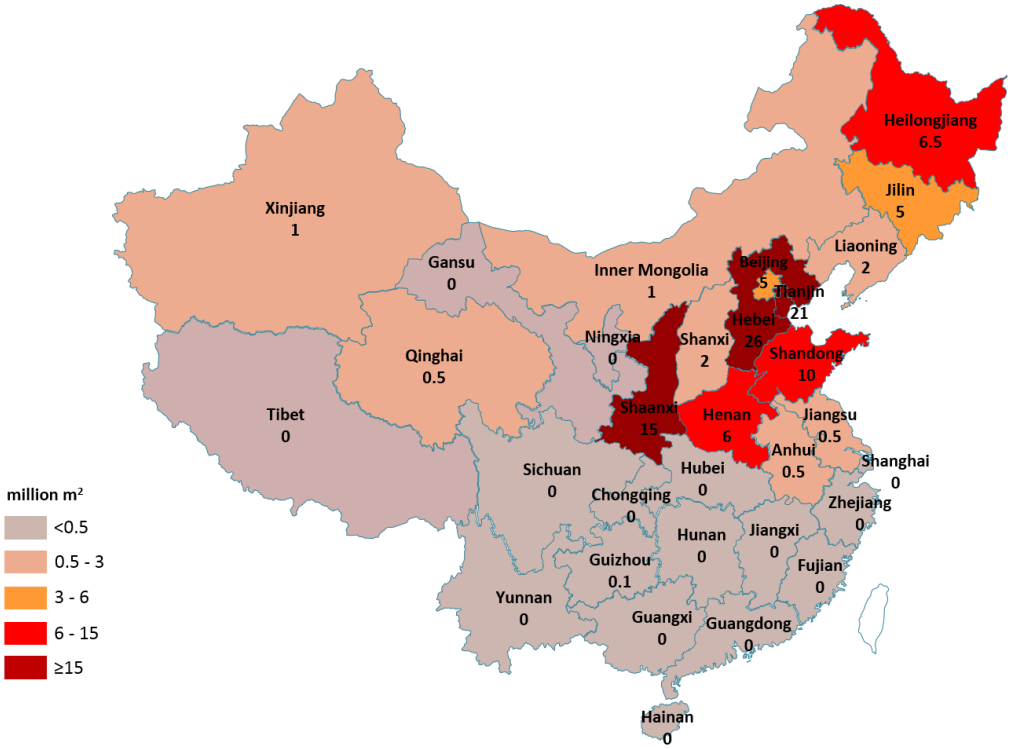
12 When the heat-supply system of China was built in the beginning, the south part to Qingling Mountains and Huai River did not enjoy a heat supply in winter, mainly due to the poor economy of China just after the People's Republic of China was founded. Now, the heating demand of many cities just south of the heat-supply dividing line is getting bigger and bigger, for the weather there in winter is still very cold and sometimes unbearable without a heating system. Some people in Sichuan Province and Chongqing City installed natural gas water-heating systems in their houses to get through the cold winters. The Geothermal Five Year Plan also has a targeted utilisation of geothermal power mostly for heating equalling 20 million tons of standard coal, and 310 million m^2 of new heating areas by 2020 in the area of Beijing, Tianjin and Hebei Province, which will account for 28% of the total new heating area by 2020 in China. Other provinces also plan new heating areas using geothermal power, such as Shandong (100 million m^2), Jiangsu (62 million m^2), Henan (82 million m^2), Hubei (62 million m^2), Shanxi (60 million m^2) and Shaanxi (50 million m^2).

Heat Supply Map of China

Utilization of Shallow Geothermal Energy of China (by 2015)



Utilization of Hydrothermal Type of Geothermal Energy of China (by 2015)



Southwest China's geothermal energy resources

13 The Tibet Autonomous Region has the most abundant geothermal resources in China. According to Zhiyan Consulting Group, the TAR has a proved exploitable energy of 1732.2MW, followed by Yunnan Province, Guangdong Province, Hebei Province and Tianjin, with a combined proved exploitable energy of 3157.1MW, accounting for 75% of the total in China. The TAR has more than 600 geothermal areas (points). The high-temperature geothermal reserve also ranks first in China, taking up 80% of the high temperature reserve, with a potential power generating capacity of 3000MW, especially in the south of the Bangongcuo – Nujiang River active tectonic zone, which is a concentrated area for middle and high temperature geothermal resources, with concentrated population and high demand for energy. According to China's 13th Five Year Plan on Geothermal Resources Development, 11 high-temperature geothermal fields (Yangbajing, Yangyi, Ningzhong, Gulu, Gudui, Langjiu, Qupu, Chabu, Quzhuomu, Kawu and Kuma) in 9 counties (Dangxiong county, Naqu county, Cuomei county, Ge'er county, Pulan county, Xietongmen county, Cuona county, Sajia county and Gangba county) in Tibet are the targeted area for geothermal power generation. A total potential power generation of these 11 fields is 830MW.

14 Sichuan Province's main geothermal resource is underground hot water. There are 244 hot springs and 82 geothermal wells in Sichuan and the annual exploitable geothermal resource of underground hot water equals 550 million tons of standard coal, taking up 29% of the national hot water resource. The basin and its surrounding area of Sichuan have a relatively higher utilization of geothermal energy, mainly in the form of hot springs resorts. The highland area of east Sichuan has a good resource of middle and high temperature (90-150 ℃ and above) geothermal resources, suitable for power generation, heat supply and gradient utilization. However, the area does not have a developed economy and convenient transport system, and the utilization rate of geothermal resources is still very low. In Ganzi Prefecture of Sichuan Province, Swedish company OPCON has conducted field visits for a project to develop 10,000 KW of geothermal power. This project will be the first geothermal power generation project in Southwest China (outside the TAR) after completion. Sichuan Kangsheng Geothermal Energy has signed development agreements on geothermal resources with the governments of Sichuan, Hebei, Henan, Shandong, Tianjin, Guizhou and Tibet, and it also owns exploration rights for four high-temperature geothermal resources, one of which is the site of the OPCON power generation project. The local businesses engaged in the geothermal resource sector are mostly geological exploration companies, and tourism and real estate developers. In the national 13th five year (2016 - 2020) geothermal energy development plan, 15MW of new installed geothermal power-generating capacity is planned in Sichuan, following 30MW in Qinghai Province and 20MW in Jiangsu province. Also in the plan there is 30 million m^2 of newly-added heat-supply/refrigeration area in Sichuan.

15 Yunnan Province is abundant in geothermal resources, with over 800 hot springs (over 25 ℃), equalling 6 billion tons of standard coal, with an annual exploitable amount of energy equalling 1.46 million tons of standard coal. The high temperature (over 150℃) water resources are located in the west and middle of Yunnan, with over 600 hot springs, accounting for 77% of the province's total number. Another 200 hot springs are mainly located in the east part of Yunnan, mostly low-middle temperature and a few middle-high temperature. The geothermal resources are used for tourism (hot spring resort) and entertainment. Yunnan also plans 10MW of installed power-generating capacity of geothermal use and 1 million m^2 area of heat supply by 2020. The weather is relatively warm in winter in Yunnan, so it is not in urgent need of a heat-supply system.

16 Guizhou Province has 91 natural hot springs and 149 geothermal wells. Its geothermal resources are mostly less than 90 ℃, and are of middle and low temperature hydrothermal type. Most hot water resources are of 40-60 ℃, and the rest are of 60-90℃. The water discharge for the 91 hot springs is 28.7 million m^3/year, and the water discharge of the 149 geothermal wells is 48.4 million m^3/year. Of the 91 hot springs, 20 have been utilized, counting 22% of the total number; out of the 149 geothermal wells, 43 have been utilized, counting 29% of the total number. The main utilization of geothermal energy are for hot spring resorts and physiotherapy, and then potable mineral water and aquaculture. The resource hasn't been used for heating,

greenhouse or agriculture. A 20 million m^2 area of heat-supply/refrigeration by geothermal energy is also on Guizhou's agenda to achieve by 2020.

17 Chongqing Municipality has 116 hot springs, with a reserve of 260,000 m^3/d, and temperature between 25-62℃. The water discharge of geothermal resources could rank in the top 5 nationally, probably after Hainan, Tibet, Yunnan and Sichuan. According to Chongqing authorities, 49 hot springs have been utilized for tourism (hot spring resort) and ecological agriculture. The main local businesses that engage in geothermal energy development are tourism and real estate developers. Chongqing is planning to add 3.7 million m^2 of heat-supply/refrigeration area by 2020, mainly in the Liangjiang New Area. Also, by the year 2020, the area used with shallow geothermal energy should reach 50% of the construction area of new buildings and constructions.

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