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Analysis on the Problems Induced by the Exploration of Geothermal Power Generation in Tianjin

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ABSTRACT

Rich in geothermal resources, Tianjin has remarkable potential in exploring and using these natural resource. Tianjin is one of the most competent cities in geothermal usage and development in China and has built 8 geothermal fields with a combined heating area of up to 19,000,000 m^2. Moreover, the area covered by shallow geothermal has climbed up to 12,000,000 m^2 which account for approximately 50% of the gross area exploited in China. However, the further use of geothermal resources in power generation has been limited with different kinds of constraints. By making a comparison of the usage and development of geothermal resources between Tianjin and other regions, we propose some counter measures to problems about environment, technology, economic, and we complete the corresponding analysis aimed at having a positive effect on the atmospheric environment and hence avoiding the occurrence of hazy weather from other energy sources, eventually being beneficial for the construction of an ecological economic zone in the Bohai Rim area.

1. INTRODUCTION

Since the first energy generation from geothermal in Italy in 1913, geothermal power generation has been greatly focused and has achieved magnificent progress. According to data from the World Geothermal Congress in 2010, there were 24 countries involved in the application of geothermal power generation whose total installed capacity was up to 10716 MW_e. Among them, America and the Philippines, accounting for 28.9% and 17.8%, first and second place respectively, the following countries were Mexico, Indonesia and Italy. Nevertheless, New Zealand, accounting for 5.9%, replaced Japan and stood in sixth place. Detailed information can be referred from Table 1.

From Table 1, one could find that most of the countries are located at the convergent zone of the crustal plate or the rift valley on the plate interiors; as a result of these countries being rich in high temperature geothermal resources. The usage of geothermal resources in developed countries accounts for a relatively larger proportion. While some developing countries, especially for the countries near the equator, possess abundant high temperature geothermal resources which promotes the development of geothermal power generation, few countries make extensive direct use of lower temperature geothermal resources. Interestingly, some developed countries such as Germany, Austria and France, not rich in high temperature geothermal resources are exploring direct usage of lower temperature and EGS geothermal resources and their application of geothermal power generation.

2. DEVELOPMENT OF GEOTHERMAL POWER GENERATION IN CHINA

Considering the ability of the direct usage of geothermal resources, China, following the USA, is ranked second among the 65 countries. Whereas for geothermal power generation, China is in 18th place among the 24 countries capable of generating power by geothermal resources. Presently, only Yangbajing geothermal plant in Tibet is still in operation. In the 1970s, there were 7 medium-low temperature geothermal power plants adopting double working medium (binary plant or hot water heat exchangers), namely, in: Dengwu Fengshun Guangdong (92 ℃, 300 kW), Huitang Ningxiang Hunan (98 ℃, 300 kW), Houheyao Huailai Hebei (87 ℃, 200 kW), Tangdong Zhaoyuan Shandong (98 ℃, 300 kW), Xiongyue Gai Liaoning (90 ℃, 200 kW), Reshui Xiangzhou Guangxi (79 ℃, 200 kW) and Wentang Yichun Jiangxi (67 ℃, 100 kW). The last five stopped running at the end of 1970s whereas the first two could not persist due to the aging of equipment.

3. DEVELOPMENT PROSPECT OF GEOTHERMAL POWER GENERATION IN TIANJIN

Gifted with a large amount of low temperature geothermal resources, Tianjin has huge potential in exploring and utilizing these resources. Specifically, 9 state of the art heat exchange systems have been built to meet the heat supply needs of more than 300 departments in Tianjin, which gives rise to a heating area of 19 million m^2 and shallow geothermal cover area of approximately 12 million m^2, accounting for more than 50% of the total in China. But from the view of technique and cost prospects, Tianjin, even for China, has always been hesitating to move a further step in geothermal power generation.

Given the predominant place of medium-low temperature resources and limited corresponding techniques available in China, Tianjin has developed extensive and profound cooperation with Iceland, New Zealand, Japan etc. over the years, to acquaint the advanced techniques and pave the way for the better development of low temperature geothermal fields giving confidence to the options for doing large contributions to the development of geothermal power generation in Tianjin.

It has been said that it is better to replace geothermal power generation by other forms of clean energy from the view point of technical complexity. Hydroelectric generation and wind power generation account for a large part of new energy power generation, no matter the absolute energy production or growth rate. Moreover, the rate of development of solar energy and nuclear energy is also faster than that of geothermal energy. However, according to the statistical data from the International Energy Agency (IEA), among all the renewable energy resources geothermal energy has the most abundant storage volume, see Table 2, and is also of a higher consistency compared to most of other forms of clean energy. In Tianjin, there is not enough space and

natural conditions for hydroelectric generation and wind power generation to be used in practice, therefore, geothermal energy would be the best choice to substitute the conventional energy resources in the future.

Table 1. Information on geothermal power generation and direct usage of geothermal resources of 24 countries in 2010.

Countries	Geothermal power generation		Direct usage of geothermal resources	
	Installed capacity/ MWe	Productivity/ GWh	Capacity of equipment/ MWt	Productivity/ GWh·a^{-1}
America	3093	16603	12611.46	15711.1
Philippines	1904	10311	3.3	11
Indonesia	1197	9600	2.3	11.8
Mexico	958	7047	155.82	1117.5
Italy	843	5520	867	2761.6
New Zealand	628	4055	393.22	2653.5
Iceland	575	4597	1826	6767.5
Japan	536	3064	2099.53	7138.9
Salvador	204	1422	2	11.1
Kenya	167	1420	16	35.2
Costa Rica	166	1131	1	5.8
Nicaragua	88	310		
Russia	82	441	308.2	1706.7
Turkey	82	490	2084	10246.9
Papua New Guinea	56	450	0.1	1
Guatemala	52	289	2.31	15.7
Portugal	29	175	28.1	107.3
China	24	150	8898	20931.8
France	16	95	1345	3591.7
Ethiopia	7.3	10	2.2	11.6
Germany	6.6	50	2485.4	3546
Austria	1.4	3.8	662.85	1035.6
Australia	1.1	0.5	33.33	65.3
Thailand	0.3	2	2.54	22
Total	10716	67236	33829.66	77506.6

Table 2. Application potential of different kinds of renewable energy sources.

Category of energy	Power/EJ·a^{-1}
Geothermal energy	5000
Solar energy	1575
Wind energy	640
Biomass energy	276
Hydroenergy	50
Total	7541

4. PROBLEMS ACCOMPANIED BY GEOTHERMAL POWER GENERATION IN TIANJIN

4.1 Environmental Issues

It would be inevitable that the development of geothermal power generation will lead to some environmental issues, mainly including discharge water, resource consumption and air pollution.

Discharging high temperature discharge water arbitrarily would cause damage to the balance of the subsurface temperature field and to the ecological environment of surface water. Fluorine, arsenic, chromium and lead embedded in discharge water may pollute the soil and further have a negative side-effect on human health.

In addition, if geothermal power generation is in a predominant place in the future, it may cause the over-exploitation of geothermal resources which would induce geothermal resource exhaustion and a series of secondary geological disasters.

As is well known, low concentration of H_2S may paralyze the olfaction nerve of human beings and relatively high concentrations of H_2S can cause respiratory paralysis and be fatal. Additionally, discharging CO_2 arbitrarily may intensify the greenhouse effect. There are comparatively low levels of H_2S and CO_2 etc. which may have adverse effects on the surroundings. Moreover, the dust originating from land formation, pile-driving, earthwork, building construction, etc., in the working process of geothermal

engineering, might have a temporary influence on the atmospheric environment and could lead to a dramatic increase of total suspended particulates.

4.2 Cost Issues

As a whole, the cost relating to geothermal power generation consists of the initial capital investment and the subsequent operating cost. Now that there is no medium-low temperature geothermal power plant in operation in China, it would be reasonable to give an estimation of initial capital input for each 1 kW install to be about 15 thousand RMB by referring to the foreign cases. Such a high input, as compared to that of the conventional energy resources, reduces the feasibility of implementing this technology. As for the operating cost, the residential electricity cost is 0.49 yuan per kW·h in Tianjin, by comparison, the average generation cost of Yangbajing geothermal plant in Tibet is 0.95 yuan per kW·h. almost twice the usage cost of conventional energy resources. It should be noted that Yangbajing geothermal plant, a typical application of high temperature geothermal power generation, is characterized by a relatively low cost input which is far more than the current usage fee.

4.3 Policy Problems

As mentioned above, the geothermal power generation could not arouse any interest of business investment within the framework of the market economy because of the high investment and slow return. Currently, Tianjin municipal government hold the viewpoint of supporting the development of geothermal power generation but only limited actions have been taken to support the popularization and application of this technology, which is far behind the extension of the support to directly utilize geothermal resources.

5 COUNTER MEASURES

5.1 Targeting Environmental Issues

The government should take some measures to minimize the negative impact on the environment with new initiatives. Specifically, relevant departments should: intensify the supervision and management, strictly execute the examination and approval system of geothermal engineering, attach great importance on the construction of monitoring network and recharge systems so as to utilize geothermal resources reasonably and orderly and to reduce the waste of geothermal resources and to prevent a geological disaster from happening resulting from unsustainable exploration. . At the meantime, research institutions should focus their attentions on the key technologies of field surveys, exploration and protection of geothermal resources, e.g. research on recharge and treatment of geothermal waste water, the study of improving utilization efficiency of geothermal resources such as better heat isolation of heat transmission piping and minimizing the temperature of waste water, studies on the improvement of well drilling, anticorrosion and comprehensive development and utilization of geothermal energy.

As for the pollution from waste water induced by the utilization of geothermal resources, stepwise and recycling and reusing of waste water would be effective in reducing this pollution, specifically in aquaculture, bathing, planting in green houses and recharge. It is feasible to get rid of the atmospheric pollution with the help of physical and chemical methods, such as steam reforming, combustion methods and commercial sulfur production. In addition, planning and control of construction schemes and complete implementation would be useful in reducing fugitive dust accompanying the construction work.

5.2 Pertinent to Cost Problems

Lacking advanced technology and management experiences is one of the root causes of high costs in China, which is primarily dependent on the training of technical staff who are providing the key technologies by communicating with and learning from foreign experts. When necessary, it is helpful to introduce a variety of professional staff so as to accelerate the development of the geothermal industry of Tianjin.

Policy-type subsidies are recommended to reduce and remove any kind of concerns on financial obstacles. Meanwhile, as an administrator and coordinator, the government could also formulate some regulations relevant to geothermal power generation and set up projects to demonstrate the best ways to control the operating cost and optimize the management procedures.

5.3 Relevance to Policy Problems

Considering the practical situation of Tianjin as mentioned above, it is acceptable to formulate some preferential policies and put them into practice so as to make people attach more importance on environmental protection and be more aware of the advantages of clean energy compared to that of conventional energy. On the contrary to the price ascending and purchase restrictions, any policy from which the people could get tangible benefits would support the development of geothermal power generation.

6. CONCLUSION

Tianjin has untapped potential and broad prospects in developing mediate-low temperature geothermal power generation, yet it also encounters different kinds of difficulties, e.g. environmental issues, financial barriers and technical problems. The undesirable consecutive haze weather, invading most parts of China in the past years, has proven it is imperative to develop new types of clean energy. As a pioneer of the geothermal industry in China, Tianjin should break through any obstacles encountered in the process of developing the geothermal industry so as to pave the way for the improvement of quality of life.

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