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Geothermal Is the Best Choice of Cleaning Energy for Winter District Heating in Northern China

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ABSTRACT

The Chairman of the Communist Party of China and the People's Republic of China XI Jinping emphasized that carries forward cleaning winter district heating in northern China, e.g., as far as possible to use clean energy. The cleaning energy should have a selection principle: energy technology feasibility, energy economy feasibility, and energy source sustainable supply. Selectable cleaning energies could involve natural gas, solar energy, electric heating, thermal storage electric space heating, air source heat pump (ASHP), ground source heat pump (GSHP) and geothermal space heat. In this paper, the energy was compared with the selection principle. Then the results showed their advantage and disadvantage respectively. Thus, we can know that natural gas still has inevitable pollution, its price is high, and sometimes its demand exceeds supply. The technique for solar energy space heating is not mature, especially for high buildings. There is low efficiency for electric heating. The thermal storage electric space heating is better than electric heat, but its efficiency is still lower. Air source heat pump has an equipment COP (coefficient of performance) about 2, but its system COP is just about 1.5. However, the ground source heat pump has the highest COP. It is usually the system COP could be 3.5. Therefore, it is better for energy saving and CO_2 reduction. It used shallow geothermal energy is suitable for anyone and anywhere. Myriad examples and applications have explained the facts in the world. Finally, if there is geothermal resource somewhere then the geothermal district heating is most suitable choice. A single geothermal well with medium-low temperature could solve district heating for 50-100 $\times 10^3$ m^2 even 200 $\times 10^3$ m^2 in northern China. However, although Beijing municipality has "2013-2017 Action Plan for Clean Air", but its implement result in Beijing rural areas is not currently satisfied. The 12% of natural gas and 67% of air source heat pump would not be a good choice, because there is only 1% of ground source heat pump and none of geothermal district heating. Policy implementation should be treated fairly. A communal effort is required to improve future implementation and results.

1. INTRODUCTION

It is necessary for winter space heating in northern China with a period of 4 to 6 months per year. Past heating used coal boilers or heating power as a byproduct from thermoelectric coal plants. In order to protect the environment and reduce pollution, coal burning has been restricted in recent years. Coal was replaced by natural gas progressively. New district heating by using clean energy is currently in production. The Chairman of the Communist Party of China and the People's Republic of China XI Jinping emphasized that carries forward cleaning winter district heating in northern China, e.g. to use clean energy. However, clean energy district heating is a significant proposition. There are concerns in energy choice; e.g., particularly technical and economic aspects in programming and implementation. The government's authority is essential in policy orientation and leadership's decision making in the implementation of using clean energy sources.

2. ENERGY SELECTION PRINCIPLE FOR CLEAN HEATING

In the previous planned economic period, the major project did not consider the cost of development because politics seemed always to have come first. Currently, in the market economic period; energy selection is a significant project, according to corresponding technical and economic feasibility assessment. It suggests that development must follow the selection principle in the energy selection process.

2.1 Feasibility of energy technology

There are various clean energies possible for winter space heating, e.g., natural gas, solar energy, electric heating, thermal storage electric space heating, air source heat pump (ASHP), ground source heat pump (GSHP) and geothermal space heat. Studies can compare their technical feasibility, including technical maturity, applied efficiency, and service life.

2.2 Feasibility of energy economy

There is a cost problem for overall energy use; long term cost should be considered in development. Cost payment should be acceptable by business companies and users.

2.3 Sustainable supply of energy

It is essential to consider the local condition; the energy chosen could be considered to be supplied for an extended period, at least for several decades or more.

3. SELECTABLE CLEAN ENERGIES FOR WINTER HEATING

A comparison for each of selectable clean energies for winter heating; comparing their advantage and disadvantage to each other.

3.1 Natural gas

Natural gas seems to be the most straightforward selection if there are local natural gas station and supply source. It is easy to lay pipelines plus terminal heating facilities. This would solve the problem in the district for the winter district heating. However, it concerns three aspects of problems; first problem is its high price; long-time consumption will have high cost. The second is that significant progress perhaps leads to demand exceeds supply. Third, natural gas still has unavoidable pollution. The CO_2 emission of natural gas is about half of emission from coal or oil burning. However, it is several decades times higher than other clean energies (Fig 1).

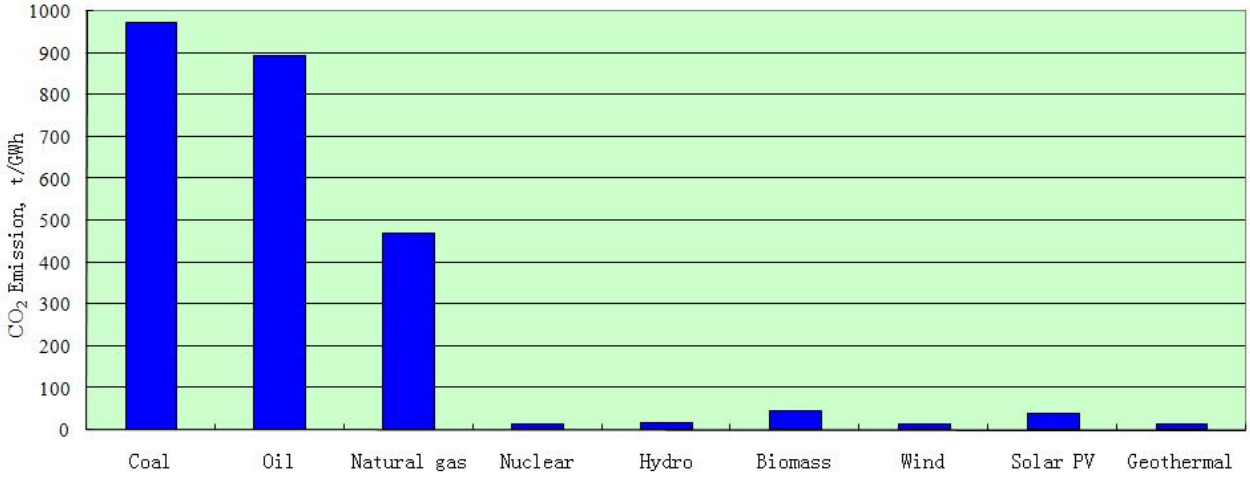

Figure 1: CO2 emission comparison for various energies

3.2 Solar energy

Collecting solar energy does not need to pay for resource cost. There is a kind of passive heating, just like resident house at Tibet which with a very thick wall of soil. It absorbs solar heat during day time and releases heat at night. A few tests using circulated hot water from solar water heater for space heating. However, the technique of solar space heating is in the early stage of research. It is problematic, especially for high buildings in downtown.

3.3 Electric heating

Electric heating is easy for implementation. It just requires an electric stove or improved quartz tube electric heater. However, its heat efficiency is low. There is a high consumption of electric power for conventional electric heaters. Their coefficient of performance (COP) is just one example. So, users need to pay more for electricity consumption.

3.3 Thermal storage electric space heating

Thermal storage electric space heating uses electric heated hot water for circulation. It increases the heating efficiency. The COP could little higher than one. However, it is still low. Users would need still to pay more for electricity consumption.

3.5 Air Source Heat Pump (ASHP)

Previous southern China low-temperature disaster of freezing rain made domestic air-conditioner not work at all in 2008. Therefore, inland air-conditioner manufactories improved its air-conditioning products. Producing their air-conditioner could work at lower temperature even for an air temperature around -25°C. It is called air source heat pump, installation process is relatively simple, and its price is lower compared to ground source heat pump (GSHP). It has started to become an interest to the public However of its big size, loud noise, higher maintenance cost (because of the world in cold environments outdoors) and lower lifetime; its equipment COP is lower as two, and its system COP is lower about 1.5. So, it will consume more electricity and increase running cost.

3.6 Geothermal Space Heating

Geothermal space heating includes conventional geothermal district heating and burgeoning GSHP. It could be called optimum clean energy for winter heating. This paper will explain this in more detail.

4. GEOTHERMAL IS OPTIMUM CLEAN ENERGY FOR WINTER HEATING

Geothermal district heating has successfully operated for 90 years around the world. GSHP using shallow geothermal energy has experienced more than seven decades of operation. They have been proven that they are optimum clean energy for winter space heating,

4.1 Geothermal district heating

Storing geothermal resources such as; geothermal water produced from geothermal wells could be used for geothermal district heating, creating huge communal benefit. For example, in Beijing, a geothermal well drilled 2,000 m depth could yield geothermal water 2,000 m^3/d with a temperature of 70°C. A couple of production and reinjection wells can provide heat of 3,400 kW using temperature down to 35°C. So, it could supply district heating to around 90,000 m^2 for good insulation buildings. If we use additional heat pump the temperature could use down to 10°C. Then it could supply district heating of about 120,000 m^2, even 150,000 m^2 for good insulation buildings. Similar geothermal geological conditions existed in Northern China, especially in the most substantial part of the North China Plain, as well an in the Song-Nun Plain, Liaohe Plain, Fen-Wei Basin, etc.; which are have an abundance of geothermal resource.

4.2 Ground Source Heat Pump (GSHP)

The ground source heat pump (GSHP) could be used for winter heating and summer cooling both ways. It made its rapid expansion in the world, especially in developed countries. It is easy to extract heat from the ground (or groundwater or surface water) at 10°C of temperature. Its average coefficient of performance (COP) could reach about 3.5. This is uniquely the single technique with highest COP. The disadvantages are needing a longer time due to its complicated installation process, increasing the initial cost. The average heat power from each meter of ground-coupled heat pump is about 150W. A single ground-coupled borehole with 100m depth could provide heat power about 15kW. For winter district heating of 10,000m^2 building needs heat power of 500kW. It would be required to install around 33 ground-coupled boreholes, occupying a larger area of land.

Generalized GSHP involves water source heat pump (WSHP) including use groundwater and surface water. Many cities restricted to use of WSHP, in order to protect the drinking water sources (groundwater or surface water). However, if there are large river or lake located nearby, the abundant surface water will provide massive heat power when reducing to a few degrees of temperature. Nanjing is implementing a surface water WSHP station by Yangtze River; it will supply district heating and cooling for 2.6 million m^2 area of buildings. One million m^2 supplying district heating has been completed.

From the above comparison, it can be summarized as follows:

1) There is high COP for GSHP, three times more than electric heating. It has the best efficiency of energy saving and emission reduction. The disadvantages are the higher initial cost and longer installation time.
2) Geothermal district heating can solve winter district heating for several decades using around 1000 m^2 for production and reinjection wells. However, it is necessary for suitable geothermal geological condition.
3) Available clean energies selection for winter heating needs make overall plans and consider all factors. Considering technical and economic feasibilities is essential. Multi-use methods can be combined. However, the primary method should have the most significant benefit to the community. Geothermal district heating and GSHP is suggested to be the optimum decision.

5. NOT SO ENTIRELY SATISFACTORY

After Xi Jinping's speech, various region's governments issued local winter heating plan to speeding up the remoulding of the coal industry and moving into using more renewable energy sources. Beijing municipal government has had the "2013-2017 Action Plan for Clean Air" already in place. It explains the clean energy system using electricity and natural gas as the principal energy along with geothermal and solar as assistant energy sources. Under the stress of the new target, the Beijing municipal government accelerated the progress of using non-coal sources. The result of 2017 showed the composition of clean energy as following: natural gas 12%, ASHP 67%, thermal storage electric space heating 19%, GSHP 1% and solar 1% respectively (Fig 2).

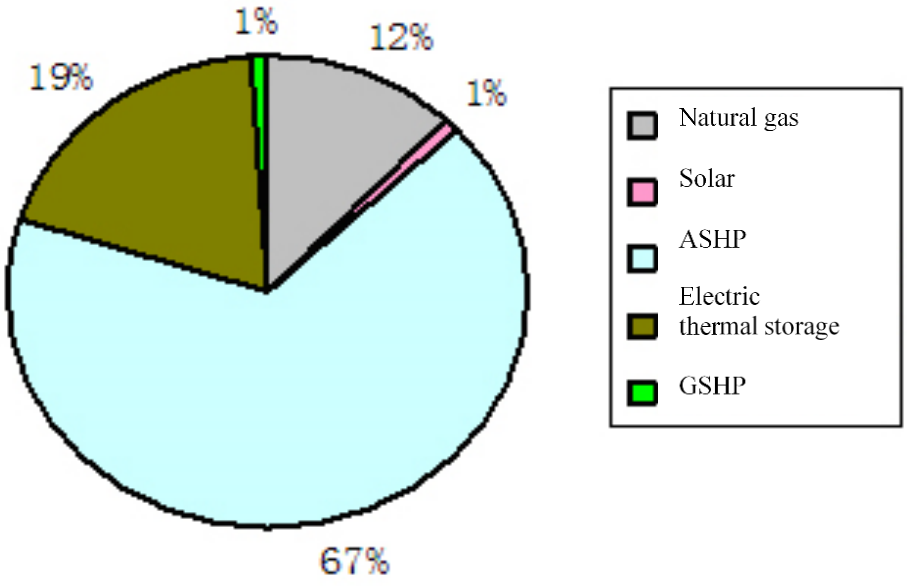

Figure 2: Beijing rural energy remoulding result for winter space heating at 2017

According to the previous description for the various clean energy sources, it was unable to observe the superiority of technical or economic feasibilities from such result.

There are abundant geothermal resources reserved under the Beijing Plain. Geothermal is the best choice of clean energy for winter space heating. However, unfortunately, Beijing did not approve any geothermal well drilling within the past 3 years; the advantages of using geothermal energy as winter heating option is obvious. Some experts from the Environmental Protection Bureau said geothermal would also cause pollution; leading to barriers in development; they did not consider that geothermal fluids could be reinjected back underground. Another person from water bureau said the groundwater had formed a giant "smokestack" in the North China Plain; it was not considered that the geothermal reservoir was at more than 1,000 m depth and was never connected to the cold groundwater due to very thick obstruct between the reservoir and groundwater at over several hundred meters apart. Unfortunately, the growth of geothermal winter district heating was diminished.

Developed countries in the world comply with the superiority of GSHP. However, Beijing chose ASHP actually in 67 times than GSHP. Beijing's subsidy fee for ASHP is 24,000 CNY per family, including facilities and installation. Other electric charge subsidies are at 2,000 CNY per year and for 3 years. Many GSHP business companies said that such subsidy is acceptable to install GSHP, which will have cost-effectiveness benefits than ASHP in the future. Beijing government's decision making was quick and neglected comprehensive comparison of the various advantages between different energy sources. Beijing's implementation in 2018 had little improvement. However, unfortunately the best geothermal district heating still had zero progress.

Hebei province chose natural gas generalization in the same term. Thus, the shortage of natural gas appeared at the period of winter heating. The demand exceeded supply in many regions. So many residents exposed cold at that time.

6. EXPECTATION

"The 13th 5-Year-Plan of Geothermal Energy Development and Utilization in China" has implemented for the first time in 2017. Nationwide there was a growth of enthusiasm for geothermal development and utilization. Delightedly it was witnessed in 2018 that many local governments issued various preferential policies, including supporting the growth of GSHP and for geothermal district heating projects. These embody as an ethical and environmentally-friendly choice of clean energy for winter space heating. It will make significant contribution to energy saving, while also reducing greenhouse emissions.

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