GROUND SOURCE HEAT PUMP APPLICATION IN TROPICAL COUNTRIES

Arif Widiatmojo[1], Yohei Uchida[1], Isao Takashima[2] Kasumi Yasukawa[1], Punya Charusiri[3], Srilert Chotpantarat[3], Sasimook Chokchai[3], Trong Thang Tran[4], Tien Quang[4]

[1]Renewable Research Center, National Institute of Advanced Industrial Science and Technology, 963-0298 Japan

[2]Akita University, 1-1 Tegatagakuenmachi, Akita, 010-8502 Japan

[3]Department of Geology, Chulalongkorn University, 10330 Thailand

[4]Vietnam Institute of Geosciences and Mineral Resources, Hanoi, Vietnam

e-mail: arif.widiatmojo@aist.go.jp

ABSTRACT

In this paper we discuss the performance data of Ground Source Heat Pumps (GSHPs) installed in Tropical countries, in this case South East Asia (Thailand and Vietnam). Unlike the application of GSHP in four-seasons countries in which rejection (cooling) and heat uptake (heating) are balance, the use of GSHP in tropical country is mostly for cooling only (heat rejection). Also, the difference between ground and atmospheric temperature is essentially low. The ground water flow, on the other hand, can potentially increase the heat exchange rate by mean of natural convective heat transfer. Moreover, the groundwater temperature in recharge zone is generally lower than that of the other zone, allowing greater difference with the atmosphere temperature. The results of test data show the significant advantages in energy saving compared to those normal Air Source Heat Pump (ASHP). Moreover, in Hanoi, the GSHP can be used for heating purpose during low temperature season (December-January).

Keywords: Ground Source Heat Pump (GSHP), Groundwater, Tropical Countries

1. INTRODUCTION

Ground Source Heat Pump (GSHP) has been widely used in many subtropical countries in which seasonal heating and cooling are required. The GSHP system takes advantage of the relatively constant ground temperature against seasonal temperature variations. The tropical countries, however, have less seasonal temperature variations, besides, the underground temperatures in some location may significantly high to the extend the use of GSHP may not provide better efficiency compared to normal ASHP. Moreover, the intensive use of GSHP merely for heat rejection may create underground heat island problem. Figure 1 shows the average ground temperature in comparison with atmospheric temperature.

The presence of groundwater flow in other hand, has several benefits. Shallow groundwater recharge area generally has lower temperature. Also, the groundwater flow provides convective heat transfer which increase the heat exchange rate and dispersing the heat away from heat exchanger.

2. GSHP INSTALLATION IN THAILAND AND VIETNAM

Yasukawa et al. (2009) presented meaningful data on general groundwater condition and temperatures in Chao-Phraya plain, Thailand and Red river plain, Vietnam by conducting ground water temperature surveys. The study identified several locations in Thailand where the use of GSHP as cooling may have greater advantages. In Hanoi, Vietnam, on the other hand, where the climate is humid subtropical, characterized by humid and hot summers and mild winters, the heating may also be applied.

Southeast Asian countries are experiencing rapid economic growth in an average of 5.2% per year since 2000. The rapid growth is followed by the significant increase of energy demand. In 2015, the region's total primary energy consumption reached 621 Mtoe. The total electricity generation of the region has increased from 370TWh to 868TWh from 2000 to 2015. By 2015, 83.4% of electricity was generated by burning the fossil fuel (coal, natural gas, oil). While Southeast Asian countries may not be considered as major global CO2 contributor, however, the data trend shows significant increment of CO2 emission from 711Mt in 2000 to 1288Mt in 2015.

Based on the report World Air Conditioner Demand by Region, published by The Japan Refrigeration and Air Conditioning Industry Association (JRAIA), national total air conditioner demand in 2016 was 1.56million units, the third largest in southeast Asia after Indonesia and Vietnam JRAIA. (2017).

South east Asian countries, as one of the region with the fastest economic growth rate where most of its countries are in tropical regions, are among the major contributor to global (Green House Gasses) GHG emissions. At the 2015 United Nations Climate Change Conference (COP21) held in Paris, the panel of 190 countries agreed upon a framework for global warming countermeasures from 2020 onward. It implies that, reducing the emission of CO2 into the atmosphere become the main issue that requires immediate action.

The application of GSHP in the tropical countries can potentially be applied to reduces GHG emission reduction.

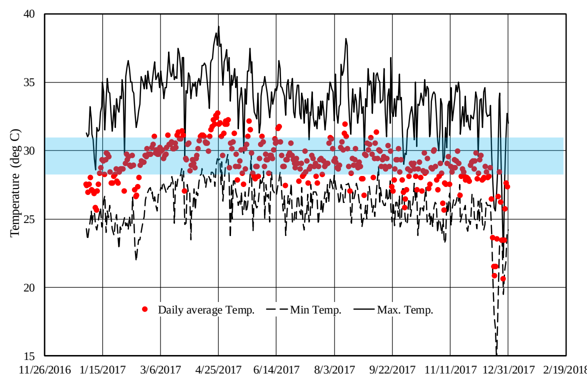

Figure 1. Average atmospheric temperature and average underground temperature in Bangkok.

3. GSHP INSTALLATION SITE

We have installed four GSHP sites, three of which in Thailand and one in Hanoi, Vietnam.

4.1 Thailand Sites

Currently, we have three installed GSHP systems in Thailand. The Chulalongkorn University GSHP at Bangkok campus has two vertical boreholes with single u-tube arrangement. Both boreholes were supposed to have 50m depth, however, due to one of the borehole collapsed, only one can be installed as planned while the other one has only 20m depth. The Fan Coil Unit (FCU) of the system is used for cooling purpose in one of the room of Parot Racha building. For the comparison, a normal ASHP (rated output 3.5kW) was installed and the electricity consumption is recorded.

The Department of Mineral Resources (DMR) GSHP at Pathum Thani Province has two vertical 50m boreholes with double u-tube arrangement. The FCU is used for room cooling of the museum's souvenir shop.

The Saraburi systems installed at Chulalongkorn University Saraburi campus is using horizontal ground heat exchangers (carpet type and slinky coils). The systems are used for room cooling in one of the laboratory offices. Two GSHP systems were installed and connected in series to the ground heat exchangers. One GSHP system has 4kW equipped with inverter while another one is a modified normal ASHP (originaly rated 3.6kW), by changing the refrigerant-air heat exchanger to refrigerant-fluid plate type heat exchanger. A normal ASHP, 3.5kW was also installed and the power consumption is recorded.

4.2 Vietnam Site

The system was installed in the Director room of the Vietnam Institute of Geosciences and Mineral Resources, Hanoi. The two double u-tube heat exchanger were installed into two 50m boreholes.

4. RESULTS

Figure 2 shows one of the observation data and calculated System-CoP of Thai DMR museum from March to September 2017. The recorded temperatures were outside, room, heat exchange fluid inlet and outlet temperature. The electrical consumption and heat exchanger fluid flowrate were also recorded. The average temperature difference between outside and room temperature were 9.7^0C while average temperature difference between outlet and inlet were 4.5^0C.

On December 2017 heating test for Vietnam GSHP was carried out. The minimum atmospheric temperature was 130C and the setting temperature was 23. The obtained average system CoP was 3.7

Figure 3 shows the Vietnam GSHP system performance during cooling and heating respectively. The average S-CoP is 3.1 and 3.6 respectively.

The accuracy of the recorded data has been one of the major issues in the experiment. It includes the use of standard thermocouples, sensors and proper installations. The standard power logger was just installed this year to ensure the precision of the power consumption.

5. CONCLUSIONS

- The data obtained from GSHp sites in Thailand and Vietnam showing potential advantage for GSHP application in tropical countries
- In Hanoi, where the temperature during January-February are low, GSHp can be potentially used for room heating with good Coefficient of Performance.
- The GSHP systems installed in Thailand and Vietnam may also be used to introduce GSHP

technology and its potential advantages to local people.

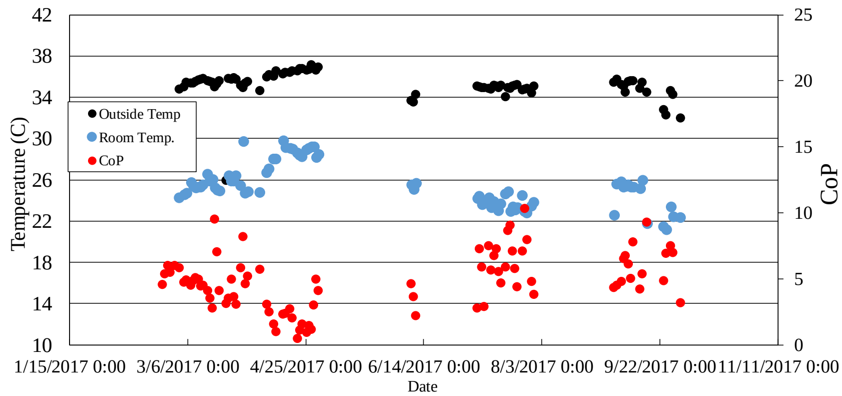

Figure 2. Cooling performances of GSHP system installed at DMR museum

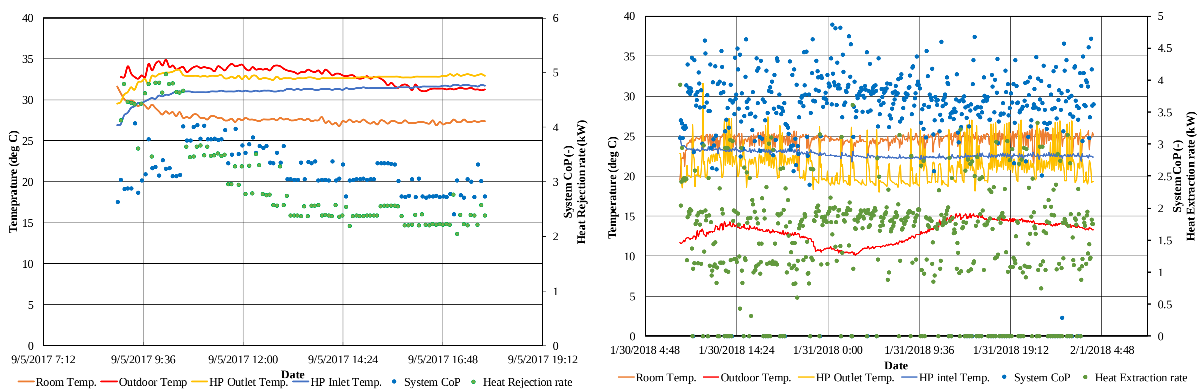

Figure 3. Performance of GSHP systems, cooling and heating respectively

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