A GEOTHERMAL HEAT PUMP SYSTEM IN BANGKOK, THAILAND

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ABSTRACT

First trial on Geo-heat pump application for tropical land was carried out at Kamphamgpet (Central Thailand) in 2006 and moved to Bangkok in 2010. Underground temperature of Thailand is 5-10^{o}C lower than atmospheric one. Even though, we get 20-40% energy shortage than normal electric air condition. Bangkok system is designed for space cooling by using 1m depth horizontal piping line. Our experiment is less than one year but the system is working well. The COP (coefficient of performance) is 3-4 and underground temperature is recovered quickly. Shallow horizontal system is the best for tropical countries because temperature is the lowest and construction cost is low. We continue to operate more longer term and finding best system and operation method of GHP in tropical land.

Keywords: Geo-heat pump, tropical land, Thailand, horizontal piping, space cooling

1. INTRODUCTION

Geo-heat pump (GHP) or ground coupled heat pump system is an application of sallow geothermal energy use and widely installed many countries, as Sweden, Switzerland, USA, Canada, etc. System is very simple and getting normal heat from shallow ground. Underground heat is put into heat pump to use space heating/cooling, and hot water supply and snow melting in some case. The underground is good and big heat sink and stable temperature. Advantages for GHP introduction are as follows;

(1) High efficiency that reduces of energy consumption, CO_2 emission and operation cost
(2) No heat output to atmosphere that reduces “Heat Island” phenomena
(3) Reduce peak electricity consumption by use of water storage tank
(4) Long life and good LCA (Life Cycle Assessment) value in energy use
(5) Can use everywhere
(6) No need to use antifreeze liquid (tropical land)

The GHP system is considered to be un-adaptable for tropical lands because of high underground temperature and only cooling operation. Recently, actual survey was carried out to search for underground conditions in Thailand and Vietnam (Yasukawa et al., 2005). They concluded that the locations where low temperature ground water supply are applicable to GHP cooling system. Based on such data, actual experiment was started at Kampheng Phet, central Thailand (Yasukawa et al., 2006). Operation was carried out from October 2006 to March 2008 and the first evaluation is very good (Yasukawa et al., 2009). The system was moved to Kasetsart University (KU), Bangkok, capital of Thailand. Newly constructed system have a horizontal piping system which is the best for tropical land. We introduce the system design and operation record for this new system.

2. WHAT IS GEO-HEAT PUMP SYSTEM?

Energy source of heat pump is not limited shallow underground but lake, liver water, ground water, etc (Fig. 1). However, system using of shallow underground is the most common. Underground heat gathering systems have many varieties. Horizontal or slinky type is low cost and widely used in USA because an average land area is wide. The Most popular type is install pipe in bore hole with the depth about 50-100m. Single or double tubing is set in bore hole to make a closed loupe by PE pipe. Best efficient one is coaxial type using inner thermal insulation pipe which developed for high temperature dry geothermal resources (Morita et al., 1985) and then applied to low temperature “Gaia System” (Morita and Tago, 2000). All system are completely closed water (or anti-frozen liquid) circulation line. There is no pollution to underground water.

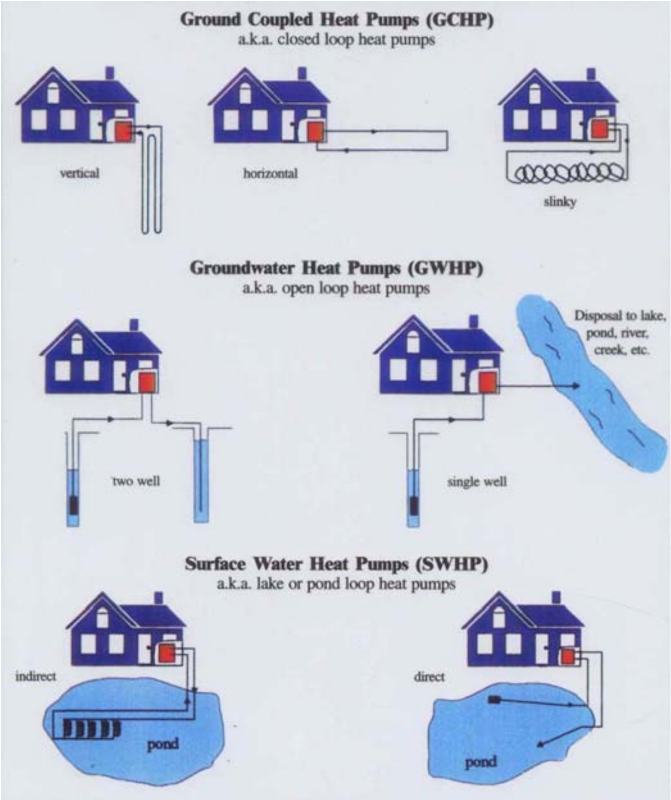

Fig. 1 Many verity heat source for heat pump system (After Geo-Heat Center Bulletin, 1997).

Recently, civil engineering method is introduced to make relatively shallow (normally up to 30m but more than 60m when deep weak formation) holes. Typical ways are shallow pipe foundation for building or house and electric transmission pole driller. Shallow system is reducing cost drastically and suitable for tropical country because the temperature around 10m depth is lower than deep part. Horizontal system is the best way to reduce cost. Two meter is the critical depth for constructing good GHP system.

Underground temperature is neutralized in temperate countries because of cooling in winter and heating in summer. However, heat pump output water temperature into underground is always high in tropical countries. The situation is opposite in cool country where underground temperature is always cool down. Even in such case at Switzerland, underground temperature become table only 1-2˚C drop in 2-3 years operation, which indicates big buffering character of the ground (Eugster and Rybach, 2000). We expect that the underground temperature must be stabilized even cooling operation only. However it is better to get high efficiency and use hot water for shower and bath. We propose new attachment of adsorption cooler system. Such tropical oriented GHP based cooling system will be explained in later chapter.

Underground temperature is normally only 5-10˚C lower than atmospheric one in tropical land. Even though, it saves

21-45% energy than normal electric air condition. Such saving rate is evaluated by COP (coefficient of performance) diagram (Fig. 2). We assumed cooled water and underground temperatures are 7˚C and 30˚C , respectively. Then the temperature differences are 5˚C and 10˚C, respectively when the atmospheric temperatures are 35˚C and 40˚C. The efficiency rates are 0.21 and 0.45 ((5.8-4.8)/4.8=0.21 and (5.8-4.0)/4.0=0.45)). The basic condition may apply for many tropical lands.

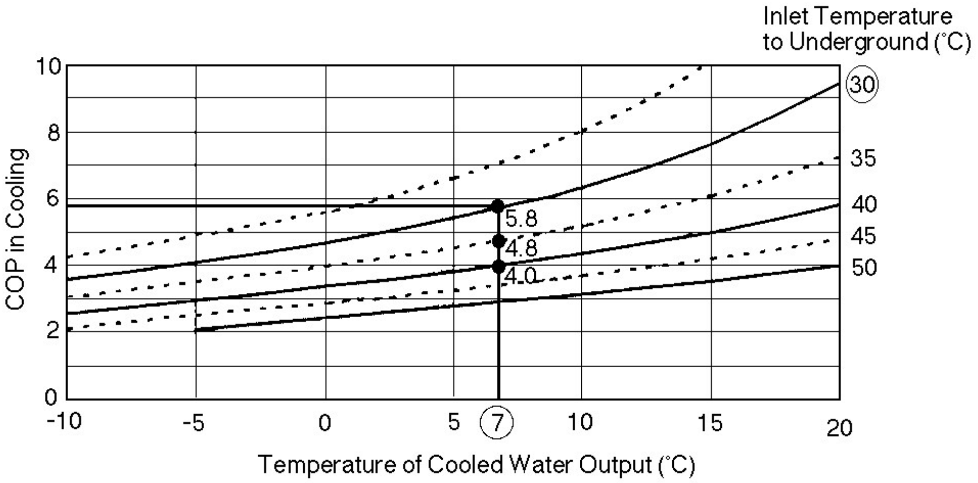

Fig. 2 COP diagram of heat pump showing efficiency calculation in different temperature (Modified from Shiba, 2005)

3. GEO-HEAT PUMP SYSTEM AT KASETSART UNIVERSITY AND OPERATION DATA ANALYSES

The system constructed in Kasetsart University (KU) is shown in Fig. 3. Most important feature is using horizontal piping system. We made a 1m depth trench along the building of north side by using back hopper. The total length is 300m. At present, only 200m of pipe is used for operation (damage of Pipe C at construction time). Heat pump and other facilities are set outside of the cooling room. It reduces the efficiency of cooling by more than 10m long cooling pipe. Water flow rate of underground and secondary cooling waters are 15L/min. and 10L/min., respectively. Fun and circulation pumps are 100V type and need transformer for operation. Temperature monitoring sites are 7 points as shown in Fig. (red circles except GP2 point). Underground temperatures at 1m depth are measuring monthly for 5 points (T1-T5 in Fig. 3). Power consumption is also monitoring. Room for experiment is equipped normal type air conditions. We need to count the effect of such air condition running.

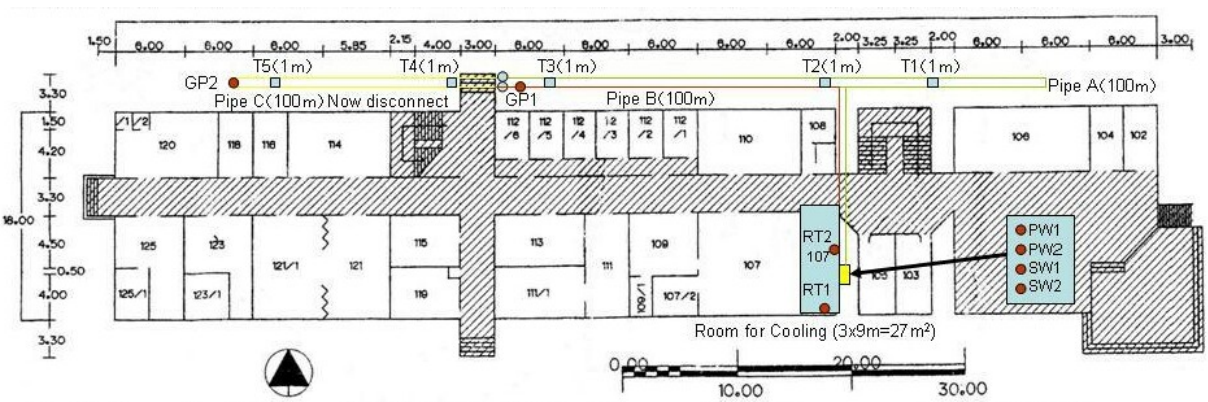

Fig. 3 System outline of GHP system at Kasetsart University (KU), Bangkok, Thailand.

System was started operation on 10 December 2010. Condition of run are manual start around 9am and stop around 5pm in weekdays. Temperature setting of output (cooling) is automatic control from 12^{o}C (start) to 18^{o}C (stop). Figure is one day date of 3 May, 2011. It is the hottest season in Bangkok and maximum atmospheric temperature reaches 40^{o}C. It shows only 4 temperatures for clear understanding.

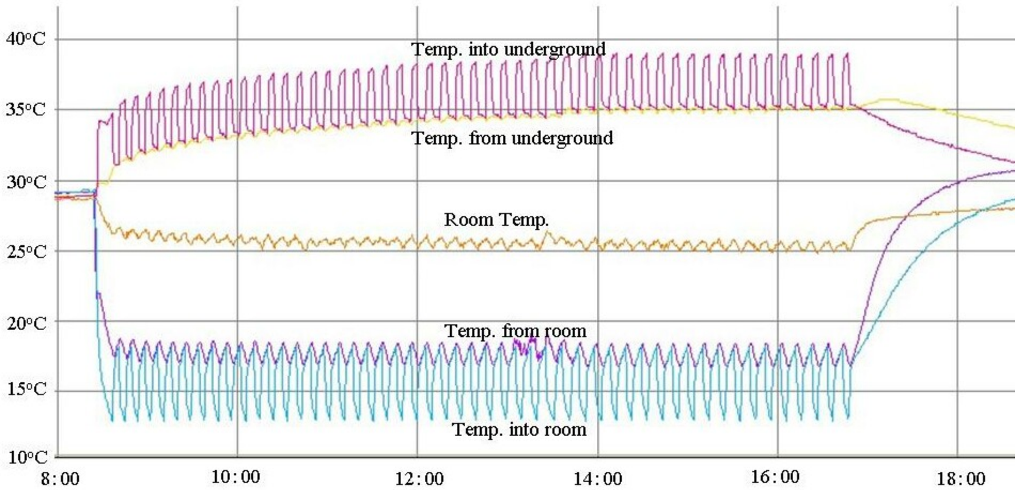

Fig. 4 One day operation of GHP on 3 May 2011 of KU system.

Temperature of water used heat pump is 35-39^{o}C (into underground) and return back to 32-35^{o}C for heat pump inlet. Cooled water by heat pump is around 13^{o}C and back to heat pump around 18^{o}C. During operation, room temperature was kept around 25^{o}C. Electric power consumption of this operation is around 600W/h. Roughly estimated COP is around 3-4. It will be improved if the system is designed for short cooling piping and use 200V pumping system.

Underground temperatures are also monitored. Figure 5 is the long term 1m depth temperature. Pipeline temperature is increased until about 36^{o}C during operation but rapidly back to background temperature. We need more longer term observation but underground heat capacity is quite big.

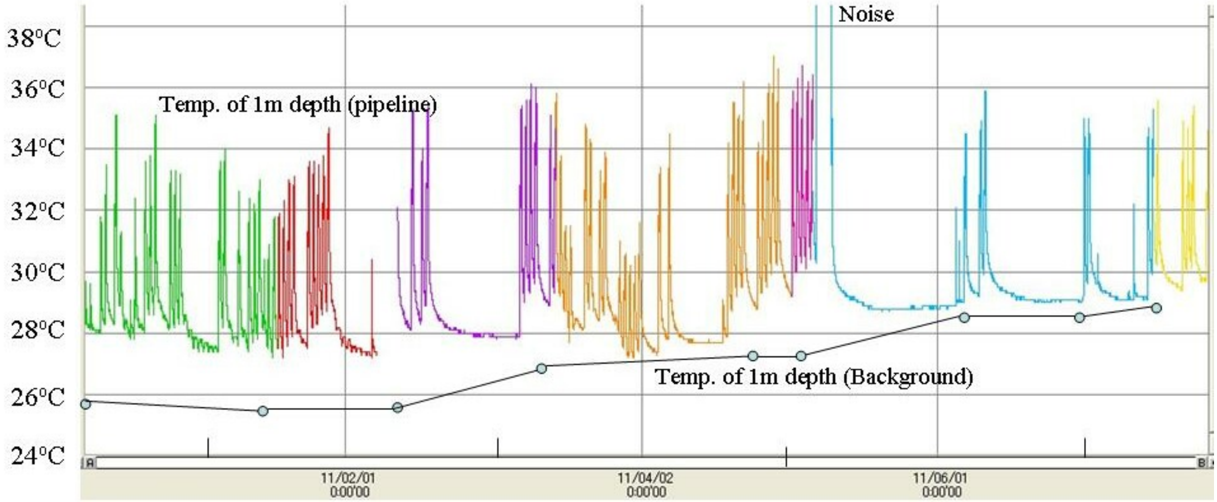

Fig. 5 Long term 1m depth temperature (10 Dec., 2010 to 20 July, 2011) of KU system.

4. CONCLUSIONS

Tropical land is not best for GHP system but still gain 21-45% energy saving. We installed horizontal piping system at Kasetsart University, Bangkok and obtained good result as high COP of 3-4 and stable underground temperature. Shallow (1-2m) depth is the lowest temperature zone in tropical land and easy to construct by low cost. It is the first trial for tropical land and need more data for going to next step.

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