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Geothermal Heat Pumps in Iran

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ABSTRACT

It is recommended that the Iranian Ministry of Energy install more power plants or apply new policies for use of newer technology with higher efficiency and lower consumption. This would stimulate industrial development and help solve the problem caused by varying climatic conditions across the country. In north and south parts of Iran air to air heat pumps have been used for cooling in 6-7 months per year, because temperatures are about 40-50°C with very high humidity (80-90%). Gas heaters are also used during the 4-5 month heating season.

The Renewable Energy Organization of Iran (SUNA) has unveiled a new project to install 5 geothermal heat pumps (GHP) in 5 different climates in order to determine the technical and economical effects of the climate on geothermal heat pump operation. Electricity consumption was reduced by 50 – 70% due to the use of GHP systems, which can be tailored to fit a given climate.

1. INTRODUCTION

The Iranian Ministry of Energy should install more power plants or apply new policies for use of new technology with higher efficiency and less electrical consumption. In the northern and southern parts of Iran, air to air heat pumps have been used for cooling for 6-7 months per year because the temperature is about 40-50°C with very high humidity (80-90%). Thus, the Renewable Energy Organization of Iran (SUNA) has unveiled a new project for the installation of 5 geothermal heat pumps (GHP) in 5 different climates to determine the technical and economical effects of climate on the operation of geothermal heat pumps. The proposed locations of these GHPs are shown in Figure 1.

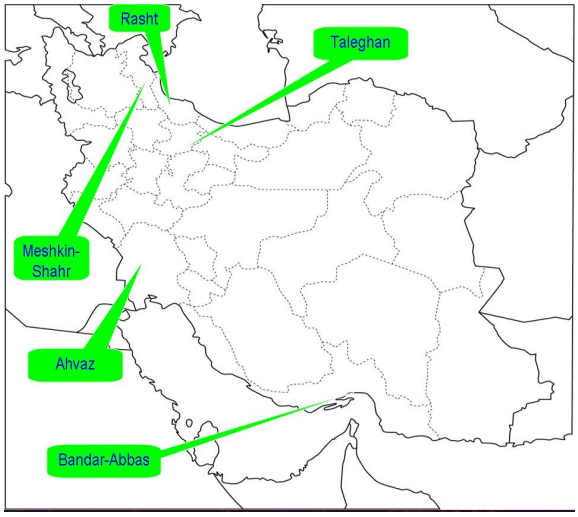

Figure 1: Positions of GHPs in Iran

The first geothermal heat pump was installed in Meshkin-Shaher city near the geothermal field in Sabalan Mountain. This GHP has been used for heating for 8 months heating and cooling for 2 months. The second GHP was installed in Taleghan and has been used for 3 months of cooling and 5 months of heating. The third GHP was installed in Rasht city for 4 months of cooling and 5 of months heating. The fourth GHP was installed in Ahvaz (in southern part of Iran, far from the Persian Gulf) for 7 months of cooling and 2 months of heating. Finally, the fifth GHP was installed in Bandar-Abbas city (in southern part of Iran close to Persian Gulf) for 8 months of cooling. This project was undertaken to determine the feasibility of GHP application in 5 different climate conditions and includes the characteristics of the climate, GHPs, and GHP coils.

2. GHP IN MESHKIN-SHAHR

The first GHP was installed in northwestern Iran near the Sabalan geothermal field. This region is subject to cold weather. The heat pump installed here was the first to be installed in Iran. An air to air heat pump system was converted to a ground source heat pump and coupled with a horizontal coil. As shown in Figure 2, the GHP coil consists of 400 m of polyethylene pipe, but the length of coil could be changed to 300 m. The GHP can be used to heat or cool an area of 27 m^2. Energy use was reduced by 30% at this site.

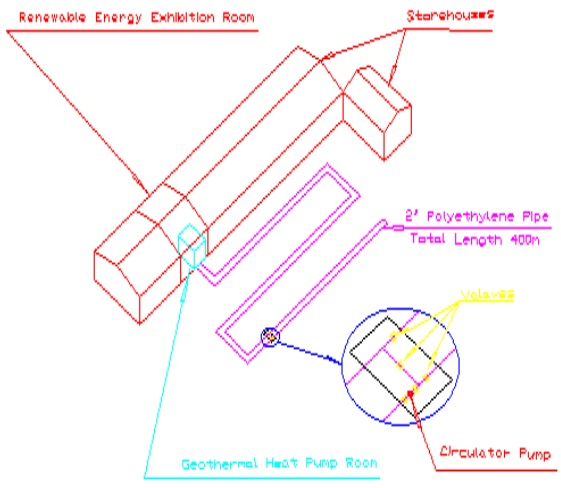

Figure 2: Layout of GHP in Meshkin-Shahr

3. TEST GHP IN AIR TO AIR LABORATORY

Before importing new air to air heat pumps to Iran from other countries, they must be evaluated by the National Energy Conservation laboratory (NECL)A GHP was installed at NECL and tested using the necessary equipment

and standards. A photograph showing the equipment layout is displayed in Figure 3.

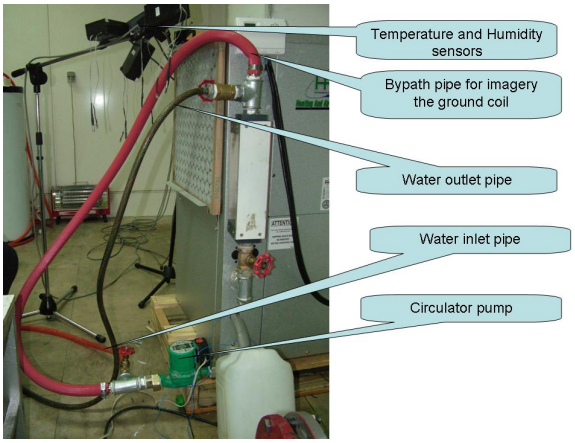

Figure 3: Equipment used for GHP testing in NECA

The humidity and temperature of the room, the inlet and outlet water temperatures, and the amount of the power used by the GHP were measured over time. The resulting of inlet and outlet water temperature and power capacity curves are shown in Figure 4.

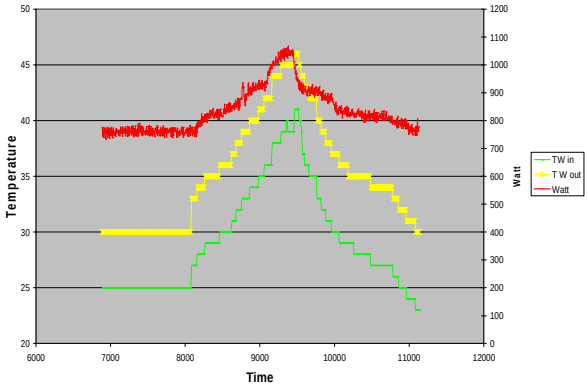

Figure 4: Inlet and outlet water temperature and power capacity plotted over time

According to these curves, the temperature difference between the water inlet and outlet is about 5°C. When the inlet water temperature is about 20°C, 770 W of power can be produced, but if the temperature is raised to 40°C, capacity increases to 1050 W. This means that inlet water temperature is the main parameter affecting power capacity.

4. GHP IN TALEGHAN

Taleghan is located 120 km west of Tehran. A water cooler was used there for cooling from June to September, and gas heaters were used for heating from November to April.

To determine the best layout, the shortest length of pipe, and the most economically feasible coil in Taleghan, a coil with the 9 wells was designed. With this coil, it is possible to choose several different sets of conditions. A 3-D model of the GHP coil layout in Taleghan is shown in Figure 5.

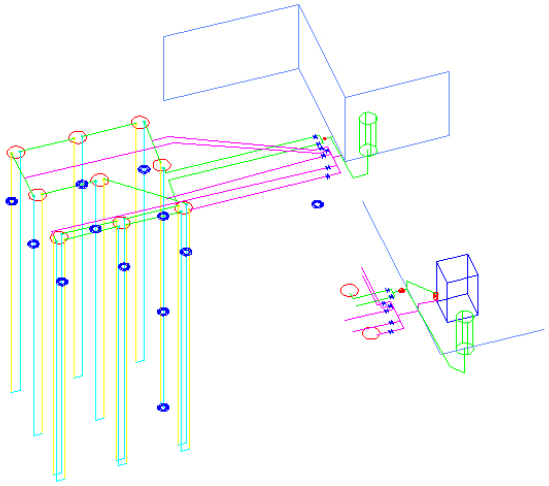

Figure 5: 3-D model of GHP coil layout in Taleghan

Nine wells were excavated, each with a 15 m depth and a 1 m diameter. The distance between the wells is 3 m. Data collection began in February 2007 (in heating mode) and has continued until now. The results of this data collection show that the use of GHP systems reduces power consumption by 60% compared to air to air heat pumps. The outside and inside temperatures and the power consumption of the GHP for heating are plotted in Figure 6.

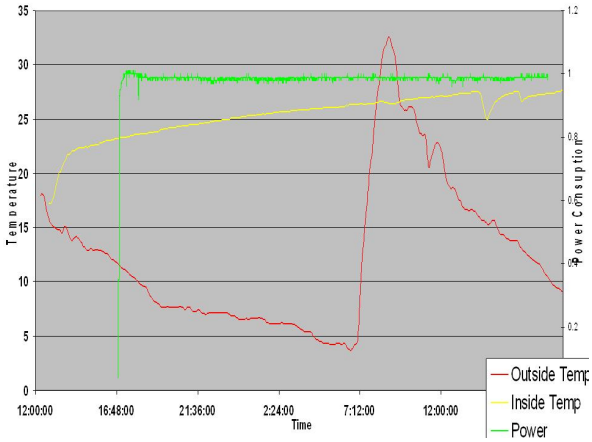

Figure 6: Inside and outside temperatures and power consumption for GHP heating mode in Taleghan

5. GHP IN RASHT

The temperature and humidity in the southern Caspian Sea are very high, so air to air heat pumps have been used widely for cooling in this area. Rasht is capital city of the Gelan province, which is located near the southern part of the Caspian Sea. A GHP with ground coils of 4 different length and different layouts were designed, and a room with a 45 m^2 area was chosen for GHP application. A diagram of this coil is shown in Figure 7.

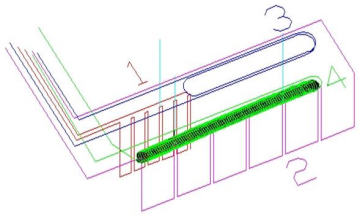

Figure 7: Ground loop coil in Rasht

The characteristic heating and cooling parameters of the GHP in Rasht are shown in Figures 8 and 9, respectively.

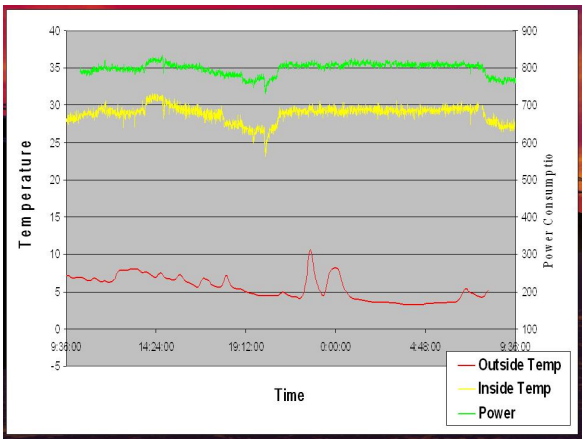

Figure 8: GHP heating mode in Rasht

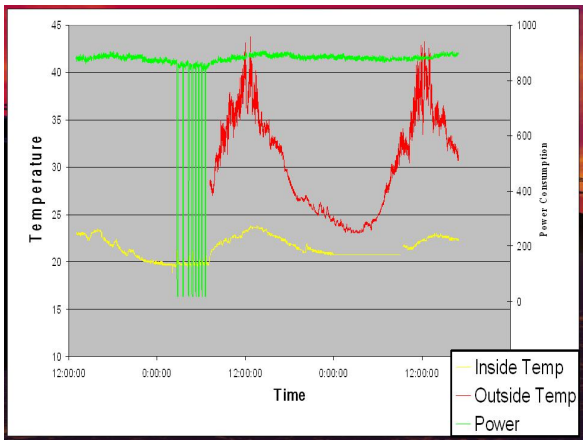

Figure 9: GHP cooling mode in Rasht

6. GHP IN AHVAZ

Ahvaz is the capital city of the Khozestan province. During the summer in Ahvaz, the maximum temperature is 50°C, and the minimum temperature is 10°C. Because of high temperatures and humidity, air to air heat pumps are very popular for cooling and to decrease the humidity. Most air to air heat pumps have loads of 18,000, 24,000, or 36,000 Btu/hr with respective energy consumptions of 2500, 3000, and 3500 W. In August 2007, a geothermal heat pump was installed in Ahvaz to determine important parameters, such as the amount of energy savings and GHP efficiency. The slinky coil was designed for this GHP, and it was installed in a trench. The GHP was used for cooling and heating a room with an area of 40 m^2. Plots of the important heating and cooling parameters are shown in Figures 10 and 11, respectively. These figures show that the energy use is reduced by 50 – 70% when using geothermal heat pumps.

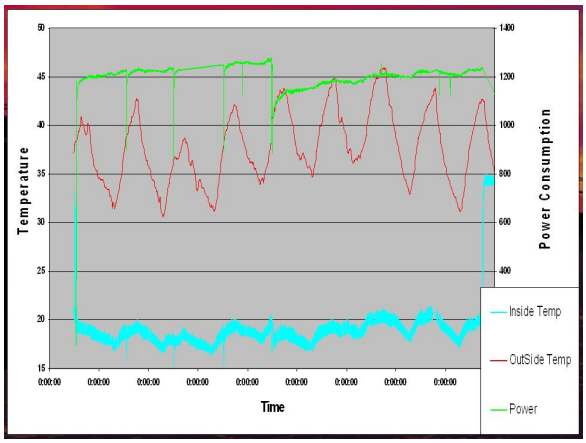

Figure 10: GHP cooling mode in Ahvez

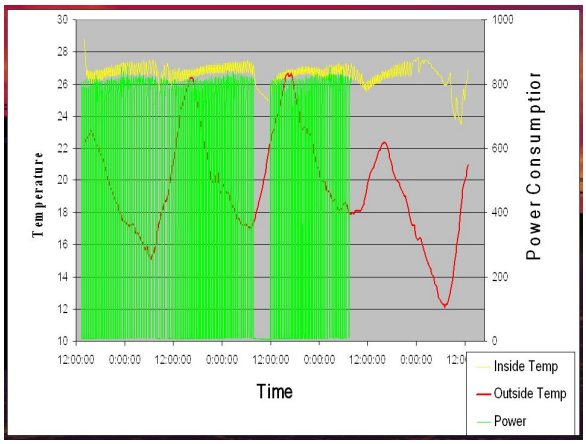

Figure 11: GHP heating mode in Ahvez

7. GHP IN BANDAR-ABBAS

In Bandar-Abbas, the capital city of Hormozgan province, the maximum temperature in summer is 45°C and minimum temperature in summer is 18°C. Humidity is also high here in whole of the year, so air to air heat pumps are used for cooling and to decrease the humidity. The weather is cool for only 140 hours per year, so there are not many heating systems in Bandar-Abbas, but air to air systems are sometimes used in winter to decrease the humidity. The last GHP was installed in a library with an area 45 m^2 and used a slinky coil. Before installing the GHP in the library, two air to air heat pumps with 24000 BTU/hr capacities and 6000 W energy consumptions were used for cooling. By using a GHP with 1300 W energy consumption, energy use was

reduced by more than 70%. A plot of the important cooling parameters is shown in Figure 12.

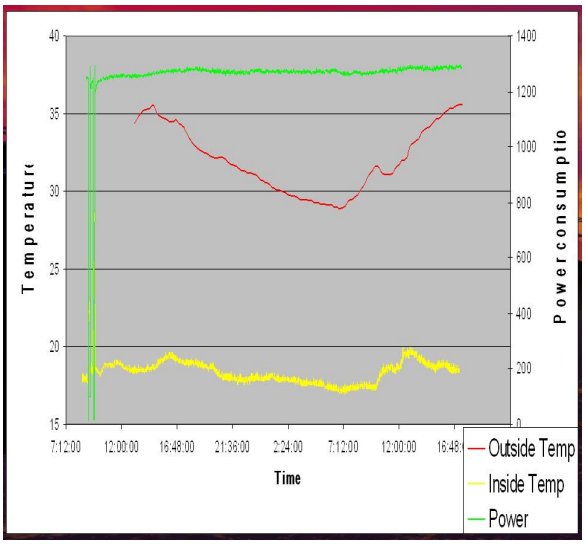

Figure 12: GHP cooling mode in Bandar-Abbas

8. CONCLUSIONS

Because of high humidity temperature in northern and southern Iran, air to air heat pumps have been used for cooling and heating. These cooling systems require 2500-3000 W of energy consumption. According to this analysis of existing GHP systems, it is possible to reduce energy use by 50-70% by replacing the air to air cooling systems with GHP systems.

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Geo heat exchange web site: www.geoexchange.org.