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Geothermal Heat Pump in Iran

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ABSTRACT

Iran is a country that is blessed with an abundance of fossil fuel in the form of oil and gas. It has the second largest gas reservoir and also huge oil reservoirs. However, Iran has also a good potential for renewable energy such as geothermal, wind, and solar that it wants to use for the benefit of its people. There are many different types of climates in Iran. In summer, most of the cities and villages have high temperature (35-50`C) for 4-6 months. In the north of Persian Gulf and Oman Sea , as well as in the south of Caspian Sea, many people use air conditions due to the high humidity. In winter, especially in mountainous regions, the weather is very cold (-15 to -5`C) for 4-6 months, causing many people to use gas heaters (see Fig. 1).

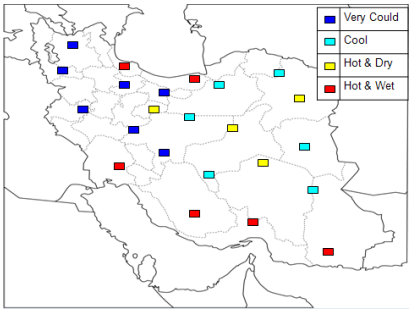

Figure 1. Heating and cooling map of Iran.

The electricity network had been developed in most cities and villages, also the gas network had been installed in most cities. However, there are many villages (near 5000 villages) that are too far from gas network, and there is no economic justification for developing the gas network in these areas. According to this information, the government tries to prepare some plans for using geothermal heat pumps (GHP) as a cooling and heating system for decreasing the energy consumption. Installing 110 kWt pilot and sample geothermal heat pumps for presenting the GHP cooling and heating systems is one of the important parts of plan. In this report, the history of the use of geothermal heat pumps in Iran and technical and economical possibility of geothermal heat pumps as cooling and heating system is discussed.

1. INTRODUCTION

Iran is a country found in the Middle East. Its coordinates are 35 °41 N 51 °25 E. Iran has a variable climate. In the northwest and mountainous places, winters are cold with heavy snowfall and subfreezing temperatures (-15 to -20°C) during October to March. Spring and fall are relatively mild, while summers are dry and hot. In the south, winters are mild and the summers are very hot, having average daily temperatures exceeding 45-50 °C from April through September. The heat is often accompanied by high humidity. In the south of the Caspian Sea the weather is cold in winter and hot with high humidity in summer. Because Iran has the second largest gas reservoir in the world, the gas pipeline network has been installed at a very high price and the gas has been burned for heating. In summer in north of Persian Gulf, Oman Sea, and south of Caspian Sea, air to air cooling systems have been used for cooling due to the high temperature and humidity. Most of gas heaters and air to air cooling systems have very low efficiency and very high energy demand. According to this information, some geothermal heat pump pilot projects have been introduced by the Renewable Energy Organization of Iran on behalf of power ministry in order to reduce the power load. Also some geothermal heat pump pilot projects have been introduced by the National Iranian Gas Company (NIGC) on behalf of the Petroleum Ministry for heating the houses that are located in villages or cities that are far from the gas network.

2. ENERGY CONSUMPTION FOR HEATING AND COOLING IN IRAN

A gas pipe line network has been installed for the most high population cities and villages for heating. The gas consumption has been increasing each year. Figure 2 shows the gas consumption from 2005 to 2011 in Iran. More than 75% of the gas consumption has been used for heating buildings.

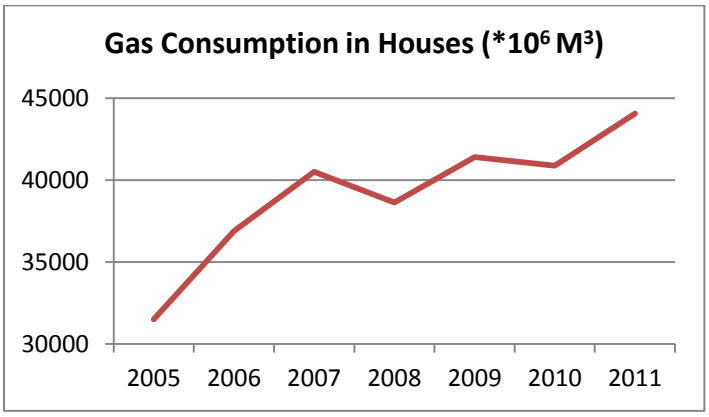

Figure 2. Gas consumption curve in houses for heating.

Electricity is used for cooling buildings. For this aim, gas, oil and other fossil fuel had been used to produce electricity in power plants. The most common form of electricity generation is from gas-fired power plants. This has caused the gas consumption rate to rise during the summer months. Figure 3 shows the gas consumption by power plants from 2005 to 2011 in Iran. From 2010 to 2011, the government changed the style of subsidizing the energy and the electricity consumption had been decreased in power plants.

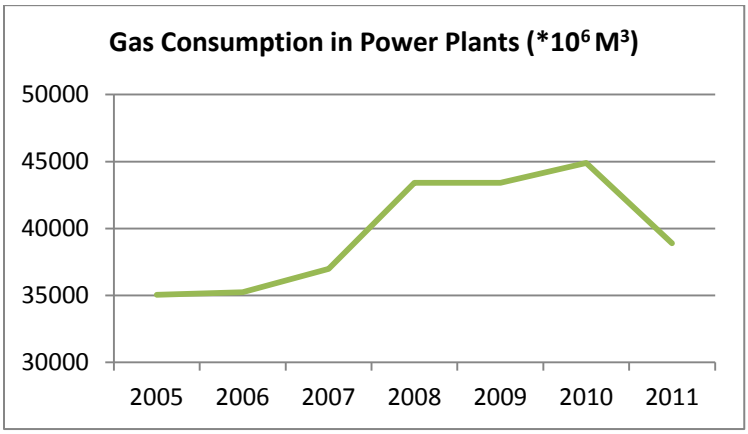

Figure 3. gas consumption in power plants for producing electricity for cooling.

About 33% of the electricity has been used in houses and most of it has been used for cooling. Figure 4 shows the electricity consumption for cooling in houses from 2005 to 2011. From 2010 to 2011, the government changed the style of subsidizing the energy, reducing the electricity consumption from houses.

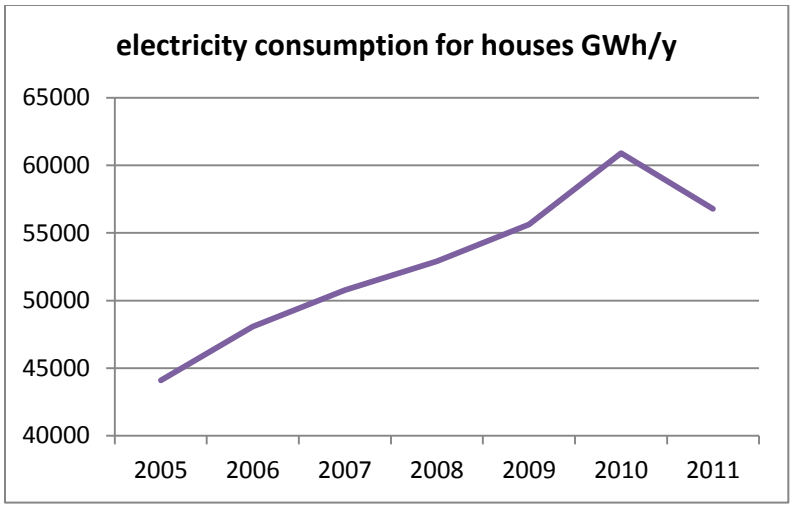

Figure 4. Electricity consumption for cooling in houses.

Decreasing the energy consumption is one of the most important problems for the government. In Iran, one of the biggest energy consumption sections is cooling and heating in buildings. So replacing the low efficiency coolers and heaters with geothermal heat pumps is a very good way for decreasing the energy consumption. So the first plan had been explained in Renewable Energy Organization of Iran (SUNA) on behalf of Power Ministry and the second plan had been explained in National Iranian Gas Company (NIGC) for heating. In both plans, installing some pilot geothermal heat pump projects has been implemented and the important data in all geothermal heat pump projects has been collected. The important data includes: inlet and outlet air temperature, inlet and outlet water temperature, humidity and temperature of the inside and outside of the rooms, mass flow of the coil water and electrical parameters (watts, volts, amperes, etc.).

3. GHP FOR HEATING

Iran has 31 provinces and 30 of them have one gas company on behalf of National Iranian Gas Company (NIGC). There are more than 38000 villages that the people use petroleum, gasoline or wood. These methods are not economical and have high air pollution. Installing gas pipeline and developing the gas network may be good for some of the villages, but many of them are located in mountainous places where the gas pipeline is not available.

In NIGC, the Qom Province Gas Company had been selected for deputy of renewable energy in petroleum ministry. Qom province is located in a desert and mountainous region with hot and dry climate in summer and cold in winter. Installing the gas network and obtaining the gas for some villages that are far from the gas network may not be available or economical. So it may be possible to use GHP for heating in village houses.

3.1 GHP pilot projects for heating

In Qom Province Gas Company there are 17 villages that are far from gas network and developing the gas network for sending gas to the houses is not economical. For the first step, choosing a village had been done by Atec Renewable Energy Consultant Company and for the next step, installing 3 GHPs had been done by Asad Sanat Company in three houses. The area of these houses is 60, 80 and 100 square meters. One of the GHP pilot projects is open loop and two of them are closed loops. The capacity of these 3 GHPs is 10 kWt (36000 Btu/h).

For getting more experience, especially in lager buildings, a new pilot project has been implemented by one of the administrative Qom Province Gas Company. The area of the building is 250 square meters and the heating load is 40kWt. In the first step, a thermal response test (TRT) has been done using two wells drilled to 170 meters depth. Due to the failure of the integrity of the bottom section of the wells, U shape pipe was installed in the wells with 110 meters length. The result of TRT shows that each well has 6kWt potential. So in second step, two wells have been drilled with 200 meters depth.

Another pilot project has been implemented for combining geothermal heat pump with solar hot water. One room in Qom Province Gas Company region has an area that is 60 square meters and a 6.6kWt heating load. The coil of this project is slinky and the length of the trench is 30 meters, depth of trench is 2 meters, numbers of solar hot water plate are 15. More technical information of these pilot projects has been collected in Table 1.

3.2 GHP plan for heating

After these pilot projects, the petroleum ministry and National Iranian Gas Company (NIGC) accepted to compare geothermal heat pump with gas and other kinds of resources for heating the houses in villages. The price of installing gas pipeline for the

houses depends on the distance between the village and gas pipeline and also the number of houses. According to the survey of NIGC if the distance of the village from the gas pipeline is less than 5 kilometers it will be economical to install pipeline but more than 15 kilometers has no economic justification. The result of comparing these methods shows that it will be economical to use geothermal heat pump for heating in villages that are far from the gas network. So in 2014, installation of the geothermal heat pumps has commenced to heat the houses in five villages. There are 1500 homes in these villages, and it has been estimated that the total capacity of the houses is more than 7500 KWt.

Table 1. Technical information of geothermal heat pump pilot projects in National Iranian Gas Company.

Name of Project	Year	Location	Area (M^2)	Capacity (KWt)	COP	Coil
Ghahan-Jemezghan	2012	Qom	100	10	4-4.2	Open
Ghahan-Jemezghan	2012	Qom	60	10	3.8-4	Vertical
Ghahan-Jemezghan	2012	Qom	70	10	3.8-4	Vertical
Ghanavat	2013	Qom	300	33	3.9-4.2	Vertical
Edaray Gaz Qom	2013	Qom	50	6.67	4-4.2	Slinky

4. GHP FOR COOLING

Most of the Iranian use electricity for cooling in hot months and the most of the electricity has been generated in fossil fuel power plant and hydroelectric power plant. A small portion of electricity has been generated with wind turbine or photovoltaic. In some places that have hot and dry climate, water cooler has been used but because of high humidity, water cooler system cannot be used in hot and wet places. In these areas, everyone must use air to air coolers. The power consumption of the air to air cooler is higher (2 or 3 times more) than the power consumption of water cooler. The efficiency of the geothermal heat pump is 2 or 3 times more than the efficiency of the air to air cooler. So if the government has a program for developing the GHP as a cooling system, the electricity load will decrease.

4.1 GHP pilot projects for cooling

Renewable Energy Organization of Iran (SUNA) on behalf of Power Ministry has implemented five geothermal heat pump pilot projects in different places with different climate. The first was a 5KWt GHP in Meshkin-Shahr with mountainous and very could climate for heating with horizontal coil. The second GHP had been installed in Taleghan that has a climate that is warm and dry in summer and cool in winter with vertical coil. The third GHP was installed in Rasht with high temperature and high humidity in summer and cool in winter with slinky and horizontal-vertical coil. The fourth and fifth GHPs were installed in Ahvaz and Bandar-Abbas, where the temperature and humidity are very high in summer and the climate is slightly cooler in winter especially at night. Both of these two GHPs have slinky coil. All of these geothermal heat pumps have 5KWt (18000 Btu/h) capacity. After these GHP projects, three geothermal heat pumps with 3.5KWt (12000 Btu/h) capacity and one geothermal heat pump with 5KWt (18000 Btu/h) capacity had been installed in Taleghan in administrative building. The technical information of these pilot projects has been collected in Table 2.

4.2 GHP plan for cooling

Some big geothermal heat pump projects have been considered by the power ministry for developing and showing the GHP quality. Bandar-Abbas city have been located in north of Persian Gulf with hot and wet climate that people use air to air cooling systems. So the first geothermal heat pump project had been designed in Bandar-Abbas for cooling a basketball gym with 272 KWt capacities. Also the second geothermal heat pump had been designed for a power substation near Tehran with 171KWt capacities. The third geothermal heat pump project had been implemented in Masouleh. Masouleh is an old touristy city that is located in north of Iran with mountainous climate where installation of the gas pipeline is not available. Secure the heat for the buildings with the electrical heater has not met economic justifications, but geothermal heat pumps will be economic projects. The total GHP capacity for Masouleh is about 4200KWt. The last geothermal heat pump project had been installed in Mashhad city for a library with 100KWt capacities. These four geothermal heat pump projects have been started in 2014.

Table 2. Technical information of geothermal heat pump pilot projects in SUNA.

Name of Project	Year	Location	Area (M^2)	Capacity (KWt)	COP	Coil
Ahvaz	2006	Khozestan	45	5	3.5-3.8	Slinky
Taleghan 1	2006	Ghazvin	45	5	3.9-4	Vertical
Rasht	2006	Gilan	50	5	4-4.1	Slinky- Vertical
Bandar-Abbas	2006	Hormozgan	50	5	3.6-3.8	Slinky
Taleghan 2	2010	Ghazvin	50	7	4-4.1	Vertical
Taleghan 2	2010	Ghazvin	40	5	3.9-4	Slinky
Taleghan 2	2010	Ghazvin	30	3.5	3.8-4.1	Slinky

5. CONCULUSION

Iran has the second largest gas reservoir in the world. Natural gas have been used for heating and also for generating electricity in power plants. Gas heaters use lots of energy and have low efficiency. Therefore, several big projects for replacing the gas heaters with geothermal heat pumps have been started by the National Iranian Gas Company (NIGC). The capacity of these projects is 7500KWt. Geothermal heat pump projects as a cooling system have also been started by the Renewable Energy Organization of Iran (SUNA). The total capacity of these projects is more than 4800KWt.

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