Effect Of Geothermal Heat Pump On Carbon Dioxide Emissions

Ahmed F. Atwan, Naseer K. Kasim, Waqar A. khudhair

Abstract: In this research the calculations of carbon dioxide emissions CO_2 in summer (May to September, 150 day) and winter seasons (December to February, 90 day) were performed by using the coefficient of performance for each air and ground source heat pump. The place of study case take relative to solar path in to account and the study case was three halls (men, women, and surgery halls) in Al-Musayyib hospital in Babylon.

Index Terms: Ground source heat pump, Al-Musayyib hospital, Caron dioxide emissions, Coefficient of performance, Consumption power, Air conditioning, Thermal load.

1 Introduction

Energy is considered as the backbone of economic development. The major sources of used energy are the fossil fuel which are petrol, gas, and cook. The combustion products of these sources are responsible of the high percentage of environmental pollution [1]. In particular, Carbon dioxide emissions from the combustion of fossil fuels have significantly raised in the Atmosphere. The balance of scientific opinion is that if this continues, it will enhance the greenhouse effect and lead to significant climate change within a century or less, which could have major adverse impact on food production and water supply [2]. Geothermal energy is one of the most important of renewable energy resources which is energy stored in the form of heat beneath the surface of the earth. It is known based on heat capacity or/and temperature or/and depth threshold of the underground or on the associated use (heating and cooling). Shallow geothermal energy (SGE) refers to depths less than 500m, which represents a renewable energy source with a large potential of energy savings and greenhouse gas emissions reduction. Hence, it will be a key technology to achieving all major objectives like air conditioning; for example the space cooling for hot countries and space heating for cold countries and the two objectives (cooling in summer and heating in winter) for several countries like middle east and north Africa regions [3]. In many countries the surface of the earth acts as a very large collector of solar energy, where the energy radiated from the sun is stored below the earth's surface. The efficient method of harnessing this renewable energy is called ground source heat pumps (GSHPs) or sallow geothermal heat pump [4]. The need for alternative low-cost energy resources has given rise to the development of GSHP systems for space cooling and heating in residential and commercial buildings. GSHP systems work with the environment to provide clean, efficient, and energy-saving heating and cooling the year round. GSHP systems use less energy than conventional heating and cooling systems, helping to conserve our natural resources. GSHP systems do not need large cooling towers and their running costs are lower than conventional heating and air-conditioning systems. GSHP system consists of three parts: ground heat exchanger, heat pump, and heat dissipater or heat absorber. GSHP system can be used to provide space and domestic water heating and space cooling to buildings [5,6].

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2 Case of Study

Ground source heat pumps (GSHPs) are well-established systems that can economically heat and cool buildings. Hospitals are promising settings for GSHPs because of their year-round and often round the clock heating and cooling requirements. GSHPs utilize a ground or groundwater heat exchanger, taking advantage of the relatively constant temperature of the earth just a few meters below the surface. This approach makes GSHPs far more energy efficient than conventional heat pumps (ASHP), which use the outside air as the heat exchange medium and must compensate for wide seasonal variations in air temperature. In the present work an open loop ground source heat pump system was used to cast the water from depth 20m and applied on Al-Musayyib hospital. The three main halls, which are men, women, and surgery halls, were the cases of the present study. The characteristics of these halls are listed in Table 1.

TABLE 1

Characteristics of halls (case study) in Al-Musayyib hospital.

Hall name	Design Temperature (°C)	Space Volume (m^3)
Men Hall	22	260.1
Women Hall	22	226.0
Surgery Hall	22	227.1

3 Emmesion of Carbon Dioxide

According to thermodynamics, the coefficient of performance (COP) of a heat pump cycle is influenced by the operating conditions (condensation and evaporation temperatures). The highest (COP) occurs when the cycle is operating at the Carnot limit, i.e. compression and expansion processes are isotropic, and heat exchange processes are isothermal,

$$COP_C = \frac{T_e}{T_c - T_e} \qquad (1)$$

$$COP_H = \frac{T_c}{T_c - T_e} \qquad (2)$$

Here, T_e represents the evaporation temperature, which is lower but follows the indoor temperature. T_c represents the condensation temperature, which is higher but follows the temperature of the heat sink (air/ground). Given that the indoor temperature is stable, COP_C is a function of Thigh, i.e. COP_C increases with decreasing Thigh, i.e. the temperature of the heat sink (air/ground). while, the COP_H is a function of lower and decreases with it, i.e. the temperature of the cool sink (air/ground). Since the air temperature is a variable the COP of ASHP system will be change while it is constant for GSHP system due to stability of underground temperature. The air temperature of Babylon city with the solar time in summer and winter months are shown in Figure 1 and 2 respectively. These data are from laboratory of atmospheric in Department of Physics, College of education for pure sciences, University of Babylon.

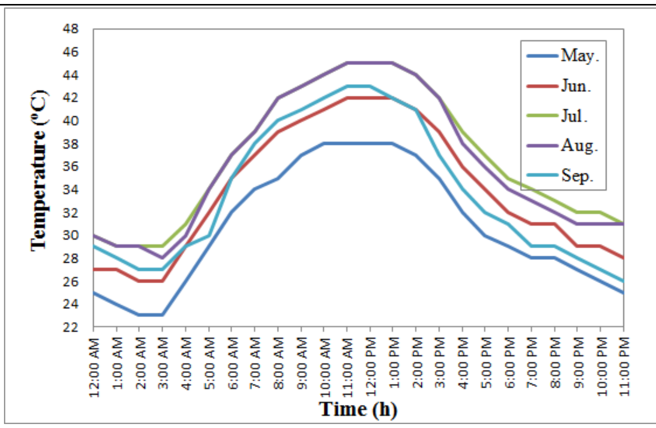

Fig. 1. *Temperature air in the Babylon city during day time and along summer months.*

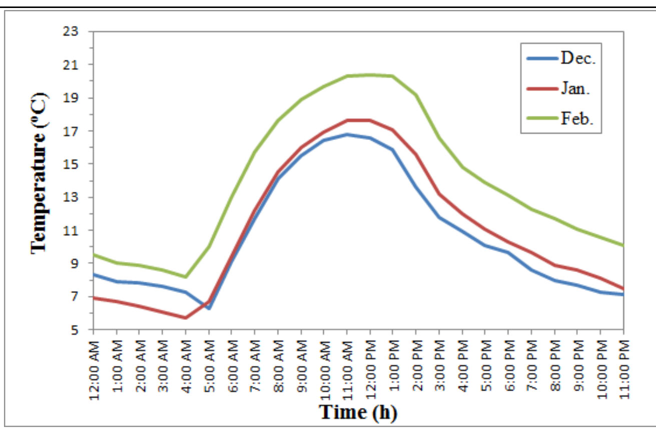

Fig. 2. *Temperature air in the Babylon city during day time and along summer months.*

The underground temperature for $20\,m$ depth is relatively constant throughout the year. The properties of ground that determine its response to temperature changes at the surface are volumetric heat capacity, thermal conductivity, and water content (see Figure 3) [7].

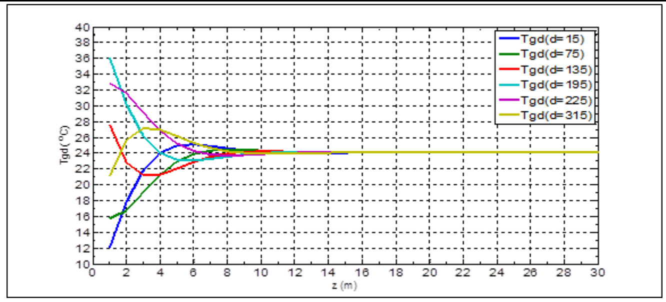

Fig. 3. *Distribution of underground temperature with depth for particular days from year in Iraq.*

The calculations of consumption electrical energy performed by using the first low in thermodynamic and equation of coefficient of performance,

$$\dot{Q}_H = W_{con.} + \dot{Q}_L \qquad (3)$$

$$COP_c = \frac{\dot{Q}_L}{W_{con.}} \qquad (4)$$

$$COP_H = \frac{\dot{Q}_H}{W_{con.}} \qquad (5)$$

where $\dot{Q}_H$, $\dot{Q}_L$, and $W_{con.}$ are heating, cooling, and compressor capacity respectively. The functionality of air-conditioner is decreasing the heat in hall from Q_H to Q_L. The relationship between compressor capacity, the consumption power $P_{con.}$ is given by,

$$P_{con.} = W_{con.} \qquad (6)$$

The emission of carbon dioxide CO_2 has important relation with the consumption electrical energy because the petrol was used in the electric generators, when petrol burn, it was emitted carbon dioxide CO_2 as 0.83 Kg for all KWh, approximately [8],

$$Emission_{CO_2} = 0.83\, P_{con.}\,(Kg) \qquad (7)$$

4 Results and Discussion

The carbon dioxide (CO_2) gas and other gases are emitted as a result of burning the fossil fuel to generate heat or electricity. The emission of these gases cause an environmental defects such as global warming. The amount of emitted CO_2 by ASHP and GSHP per month is shown in Figures 4, 5, 6 and 7. In these figures it can be noted that the GSHP cooling and heating systems contributes in CO_2 reduction in both Summer and Winter seasons.

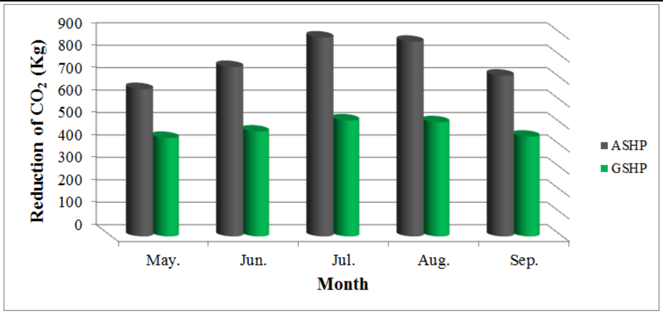

***Fig. 4**. Monthly emission of CO_2 by using ASHP and GSHP for hall of men in the Summer months.*

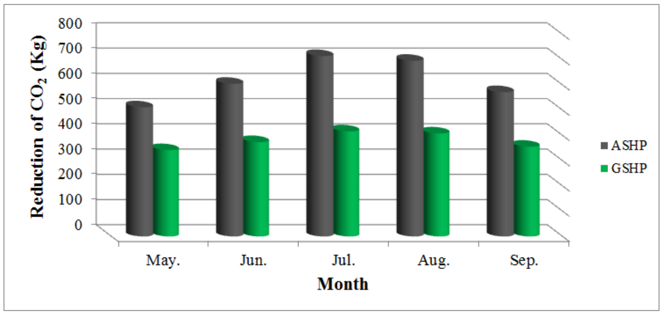

***Fig. 5.** Monthly emission of CO_2 by using ASHP and GSHP for hall of surgery or women in the Summer months.*

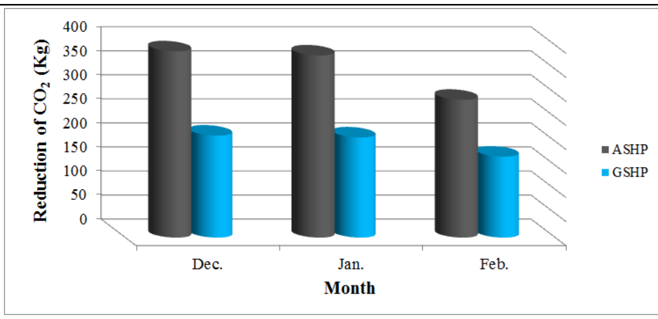

***Fig. 6.** Monthly emission of CO_2 by using ASHP and GSHP for hall of men in the Winter months.*

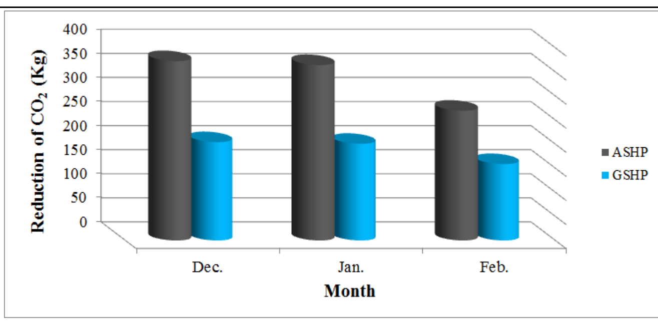

***Fig. 7.** Monthly emission of CO_2 by using ASHP and GSHP for hall of surgery or women in the Winter months.*

The total amount of emitted CO_2 in Summer months by ASHP is 10.11977 ton per month, while it was 6.235225 ton per month by GSHP as demonstrated in Figure 8. Thus the GSHP cooling system reduced about 3.964545 ton per 150 day (summer season) of emitted CO_2.

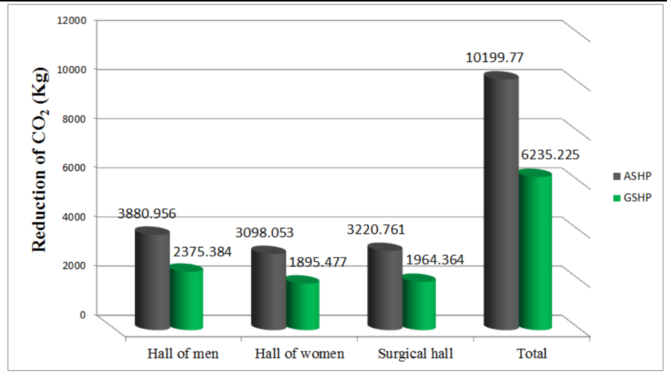

***Fig. 8.** Emission of CO_2 by using ASHP and GSHP for all halls in the Summer months.*

In Winter, The total emission of CO_2 by ASHP is 3.033599 ton per month, while it was 1.697976 ton per month by GSHP as demonstrated in Figure 9. Thus the GSHP heating system reduced about 1.335623 ton per 90 day (winter season) of emitted CO_2.

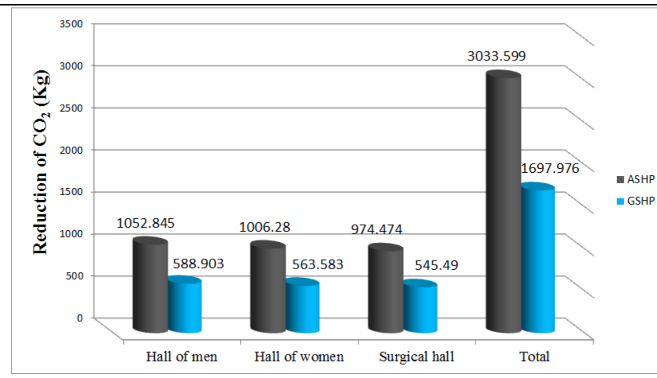

***Fig. 9.** Emission of CO_2 by using ASHP and GSHP for all halls in the Winter months.*

5 Conclusion

It can be concluded that the GSHP can offer the benefits of reduced energy bills, carbon savings and reduced maintenance costs.

6 Acknowledgments

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