Energy Saving Analysis of Free Cooling System in Meditranian Building

Samar J. Jaber and Akram W. Izzat

***Abstract*—— Mediterranean climate receives its name from the Mediterranean Sea. It is characterized by rainy winter and dry, warm to hot summer. It has a variation in temperature between day and night during summer time. Therefore, a good natural climate conditions for natural cooling technology for air conditioning is a great opportunity in such climate. On the other hand, the energy consumed for cooling purposes contributes a large portion of the total energy consumption in commercial buildings. In this paper, a critical analysis for building cooled partially by fresh air circulation system for obtaining an efficient building is performed. Partial cooling by fresh air circulation system aims to improve the efficiency of the conventional cooling unit, reduce its usage time, and improve the cooling unit service life.**

***Keywords*— Building, HVAC, Ventilation, Free Cooling, Mediterranean .**

I. Introduction

Jordan is one of many countries where energy consumption is considered an issue. Due to fuel is imported and not extracted. Jordan depends on the importation of fuel from the nearby countries such as the Golf region. Accordingly, Jordan is trying to reduce the GDP and the primary energy cost by utilizing the renewable energy in an effective way, despite the increase in population, and the increase of the fuel cost, by developing new plans and restrictions of energy consumption [1].

Partial cooling by fresh air circulation system is a promising technology during recent years. It is based on the use of the outside fresh air when the outside air is cooler than the indoor temperature. This will decrease the electrical load of the traditional cooling system and save cooling energy consumption accordingly [2]. Once the outside air can't provide a sufficient cooling energy the mechanical cooling makes up the difference.

There are several schemes of natural cooling; direct air free cooling, direct cold water to cool naturally, indirect air to cool naturally, and free cooling water systems [3]. Breesch studied the impact of different free cooling techniques and presented that free cooling can take part in buildings cooling process in the summer [4]. Lee and Chen investigated the energy saving generated by the use of free cooling. The results show that for every 2˚C decrease in indoor temperature the energy consumption reduces by 2.8-8.5%, depending on the climate zone [5].

In this study, a commercial building has been selected. It has 12 floors and occupies an area of around 1,890 square meters. The indoor temperature is kept (22 ± 2) ˚C and humidity (50 ± 5) %. The breakdown of the energy consumption in the building is shown in Fig. 1. The lighting system is the main consumer followed by the cooling system.

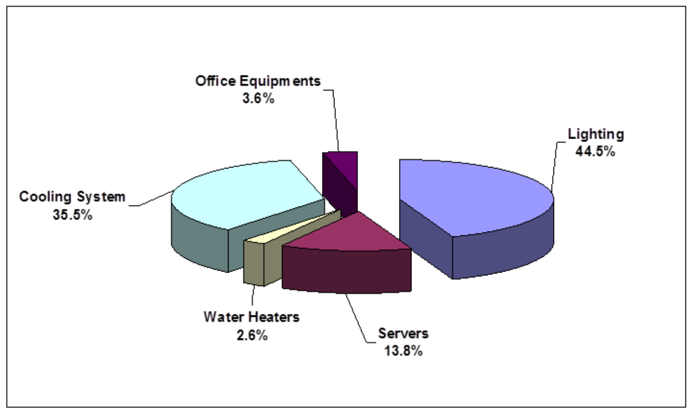

Fig. 1: Energy Consumption Breakdown

The cooling system consists of two air-cooled chillers. It serves floor cabinet fan coil units, which is used to cover the cooling load in summer as well as for the heating load in winter for offices and corridors. Fig. 2 shows a schematic diagram of the cooling system.

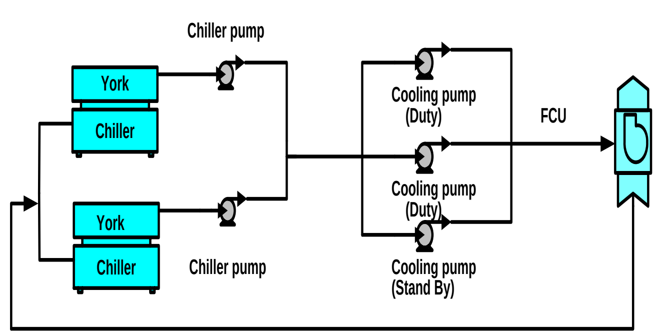

Fig. 2: A Schematic diagram for the cooling system

In order for an outside fresh air to work properly, the chilled water system must be able to control the amount of outside air intake accurately. In addition, the air intake and relief passage must be large enough to allow large volumes of air to be brought into the building. In new construction, these features can be

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included at modest cost. On the other hand, in existing buildings, the outside air intake capacity is ample and the necessary dampers are easily installed in the system. In this study the existing ductwork will be used for the proposed partial fresh air circulation cooling as shown in Fig.3.

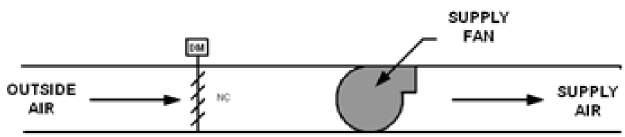

Fig. 3: Schematic of Ventilation System

II. ASSUMPTIONS FOR MODELLING

Estimation of power saving using partial cooling by fresh air circulation system is based on some assumptions derived from the design criteria of the system that simplify calculations and ensure reasonable accuracy for their results. The design criteria of the circulation system is based on continuous controlling of air intake and exhaust based on building thermal load taking into account the heat capacity of building structural material. Thermal load calculation is based on daily maximum and minimum temperature values per each month. The required air volume to be exchanged per day could be calculated based on these temperatures. Rough estimation for power saving could be ensured per each month with reasonable accuracy based on the maximum outside day temperature in every month and the night temperature at that day as the fluctuated temperature values with reference to their monthly average values will have minor effect on these calculations.

III. RESULTS AND ANALYSIS

A natural outside fresh air saves cooling energy only if the outside air temperature is less than the indoor temperature. Therefore, a critical issue is the number of hours each year that the ambient air is cool and dry enough to be used for cooling during operation. Saving potential of a natural outside fresh air is determined by the climate, the net internal cooling load in the spaces, and the chilled water system capacity.

By plotting the hourly climatic data of ambient temperature, it was found that the hourly ambient temperature during summer days (from mid-April to the mid of October) varies between 7˚C and 37˚C. During the study, it was found that the interior temperature was 23˚C in the offices. Thus, any external air temperature of less than or equal to 21˚C is assumed a comfortable temperature.

Hourly air temperature distribution outside building is plotted during chillers running period (15 April, 15 October) in Fig. 4-10.

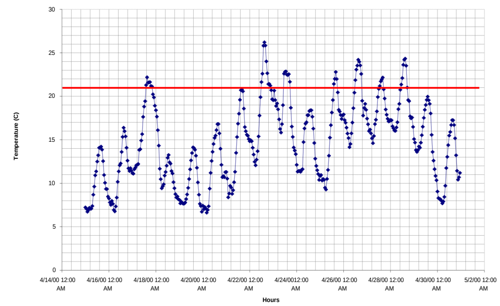

Fig. 4 : Hourly ambient air temperature for April

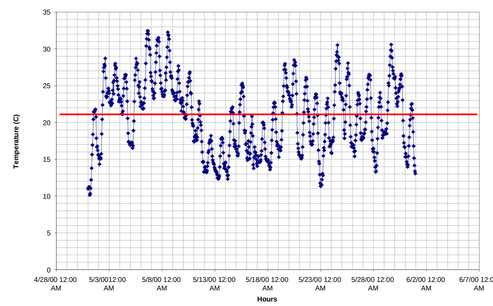

Fig. 5: Hourly ambient air temperature for May

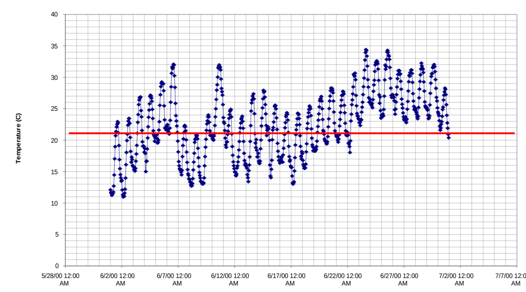

Fig. 6: Hourly ambient air temperature for June

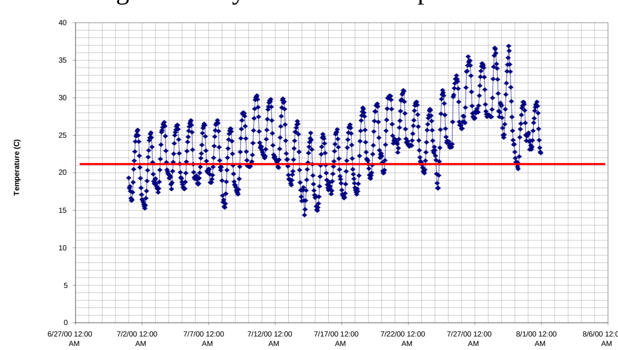

Fig. 7: Hourly ambient air temperature for July

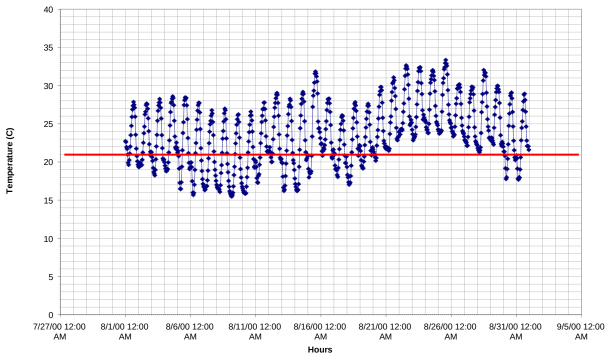

Fig. 8: Hourly ambient air temperature for August

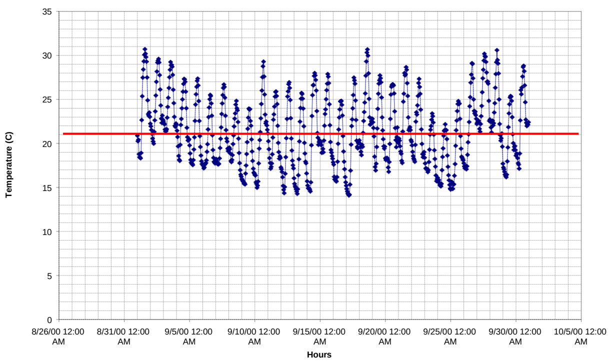

Fig. 9: Hourly ambient air temperature for September

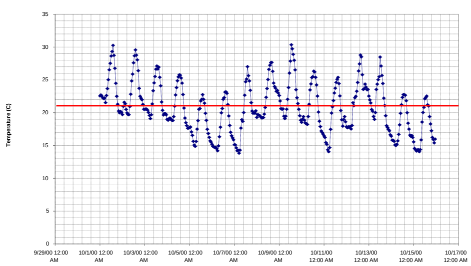

Fig. 10: Hourly ambient air temperature for October

The analysis showed that the ambient temperature is less than 21˚ C by about 80% of total hours during April. 50% and 33% of total hours is less than the comfort temperature during May and June, respectively. About 20% of total hours for July and August, around 50% of total hours for September and October. Thus, an acceptable amount of saving will be gained through introducing fresh air.

IV. Conclusion

In this paper a reliable energy saving could be obtained buildings constructed in Mediterranean region by using partial cooling based on fresh air circulation system during summer time. A proper combination of cooling system and free cooling technology will further improve the energy efficiency of the system.

The outcomes showed an interesting result. If ambient temperature drops below 21˚ C at night, a night flushing can used to remove the interior hot air by using supply and exhaust fans and controlling the exchange rates of air based on their desired temperature value, 21oC. Therefore; the building structures will cool down and store cooling for the next day.

Appendix

Appendixes, if needed, appear before the acknowledgment.

Acknowledgment

The preferred spelling of the word “acknowledgment” in American English is without an “e” after the “g.” Use the singular heading even if you have many acknowledgments..

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(Periodical style)

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