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ANALYSIS OF LAKE WATER FOR AIR CONDITIONING: A CASE STUDY IN FACULTY OF ENGINEERING, UNIVERSITI PUTRA MALAYSIA

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Abstract

This report includes a detailed and simple explanation of the general introduction to Ground Sources Heat Pumps and several types of Ground Sources Heat Pump which is Surface Water Heat Pump as one of the parts of renewable energy technology. The surface Water Heat Pump focused on the deepest depth to get constant heat sources which can be used as chilled water supply to air conditioning for Auditorium Jurutera Building. The main purpose of this report is to analyze lake water for air conditioning: A case study in the Faculty of Engineering, UPM to obtain, a lake profile, the depth of the lake, and the deepest depth temperature in the lake. In achieving the objectives, there are some methods that need to be done which have been presented in the Methodology. All data resulting from the analysis of water lake depth temperature had shown some factors that can be considered as the influence to use available ground sources heat. The lake area and distance of the deepest point have also been calculated and provided information in this report. In conclusion and recommendation, even the water's deepest temperature cannot be used to supply chilled water to the cooling coil inside the Auditorium Jurutera building. The recommendation is also provided for the improvement of this project. In addition, this report also contains other types of Ground Sources Heat Pump with different applications that have been used nowadays. This report also will help anyone seeking to know the profile of the Lake Faculty of Engineering and intends to study the surface water source heat pump as the cooling system.

Keywords: Renewable Technology, Ground Sources Heat Pump, Cooling load
JEL Classification: Q42, Q56, O30

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1. INTRODUCTION

Nowadays, all building applications have been using conventional air conditioning to provide a cooling comfort zone. Year by year the temperature on the surrounding area increasing due to one of the several factor with use non-friendly refrigerants, which affected to ozone depletion. Conventional air conditioning also is a part of the main contribution electricity cost in the building operation. To use of renewable energy sources is the fundamental of the improvement energy efficiency and the reduction of the demand. Ground source heat pump (GSHP) is one of great importance due to less seasonal temperature changes with respect to the supply air and the possibility to achieve high energy efficiency. GSHPs are mainly divided into three categories with ASHRAE based on the use of groundwater from wells, surface or ground water directly coupled to the heat exchanger, as a heat source or sink. Water consumption generally allows advantages such as low initial cost and no surface area is required. Surface water heat pump (SWHP) can be valid as alternative for the building sited important proximity of surface water bodies such as rivers, lakes or the ocean. The SWHP is very popular in coastal cities which the temperature sea water was influences by outdoor air and by sea current sometime unfavorable. For this project, the consideration of use Surface water heat pump as a renewable energy technology will apply for Auditorium Jurutera building.

Surface Water Heat Pump (SWHPs) has been included in the subset of Ground Sources Heat Pump (GSHP) because of the more likely in application and installation methods. This method also can be either closed loop which similar to GCHPs or open loop systems similar to GWHPs. However, the thermal characteristics of surface water bodies are different than those of the ground or groundwater. SWHPs consist of water to air or water to water heat pump connected to the piping network, which placed in a lake, river, or other place touched with open water. A pump circulates water or a secondary fluid (antifreeze solution) through to heat pump water to refrigerant shell and tube heat exchange which to transfer heat from a body of water. The piping material suggested to be used is thermally fused high-density PE tubing with Ultraviolet (UV) radiation protection to ensure heat can be transferred as well. The advantages of SWHPs are relatively low cost compared to GCHPs due to reduced excavation costs, low pumping energy requirement, low maintenance requirement and low operating cost. Beside the advantages SWHPs, there also have the disadvantages which are the possibility the coil damage in public lakes and wide vibration water temperature with an outdoor condition if a lake is small and shallow. Faculty of Engineering, UPM has built by architecture cooling structure concept which evaporates / reduce heat from the floor / earth surface with water. Theoretically, if deeper a lake, more cooling can achieve because of low pressure and not exposed to the atmosphere. In this project, the main concern is to analyze sources of water lake depth, temperature whether suitable for use as cooling/chilled water for uses Auditorium Jurutera building.

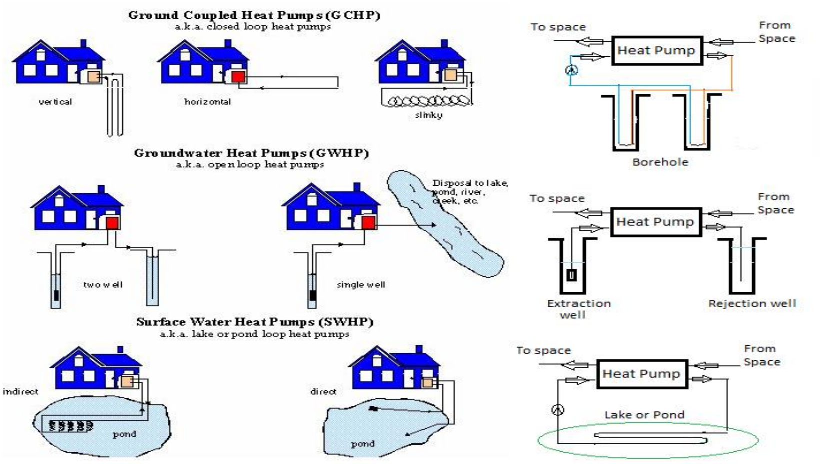
Mainly air conditioning systems work at their design loads for only a small part of their life and it follows, therefore, that the designer should be concerned not only with the highest temperature gains and cooling loads but also with the means these changes during the day and over the year. Establishing the mock-up of such variations will be of help in choosing the right system and in selecting the greatest form of regular control. Applications recline in the marketable, industrial, institutional and domestic sectors for the climates of over the world. It must, thus, be estimated that the size of the input made by each of the key elements in the temperature gain will not be constant but, nevertheless, the come within reach of to the calculation will be basically the same in all instances while the same importance will not be attached to each constituent. The conventional air conditioning system consists of four main components to provide cooling solution inside the room or building, which is the compressor, condenser, expansion valve, and evaporator. All components have their own function to transfer heat in one refrigeration circuit such the compressor, to compress gas from low pressure and low temperature to high pressure and high temperature.

All the main components must be installed to follow the sequence and functioning of the component. The first component is the compressor which we call a heart of refrigeration cycle. The compressor pumps the refrigerant and distributes it to the second component which is the condenser. The condenser will reject heat inside the condenser coil with helping motor and direct flow fan to surface fins and condenser coil before distributing liquid high temperature to the expansion valve. The expansion valve will expand the high-temperature liquid refrigerant to low temperature liquid depend on the demand of evaporator. The evaporator structure design almost same with the condensing coil which has coil and fins to increase heat exchange, but evaporator will absorb heat from surrounding room and provide comfort zone with helping blower fan to distribute and suck air the room. Each component requires electric power to make it function in the system application, and the higher uses electric power is compressor which needs to run the motor compressor and followed by the motor fan and blower fan. The objectives for the paper are to review building criteria and cooling load selection, to measure lake water profile and depth for air conditioning data requirement, and to analyses the data of lake water for use as Ground Sources Heat Pump (GSHP).

2.LITERATURE REVIEW

Figure 1 shows the Ground Water Heat Pump, which utilizes ground water as heat sources or heat sink, has some marked advantages including low initial cost and minimal requirement for the ground surface area over the Ground Source Heat Pump systems.

Figure 1. Schematic of different ground sources heat pumps



Source: A Ground Coupled Heat Pump system (Ball, 1983).

However, several factors seriously control the wide application of the Ground Water Heat Pump system, such as the limited availability of ground water and the high maintenance cost due to fouling corrosion in pipelines and equipment. In addition, many legal issues have arisen over ground water withdrawal and reinjection in some regions, which also restrict the Ground Water Heat Pump applications to a large extent. In an SWHP system, heat rejection extraction is accomplished by the circulating working fluid through high-density polyethylene (HDPE) pipes positioned at an adequate depth within a lake, pond, reservoir, or other suitable open channels. Natural convection becomes the primary role in the heat exchangers of the Surface Water Heat Pump (SWHP) system rather than heat transfer process in a Ground Coupled Heat Pump (GCHP) system, which tends to have higher heat exchange capability than a Ground Coupled Heat Pump system (D.A. Ball, 1983).

3.METHODOLOGY

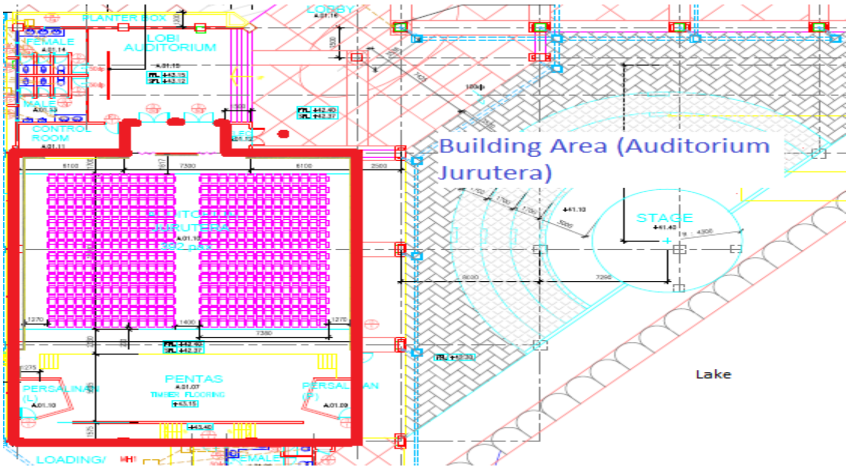
3.1. Decide Location for the Project

A location for the project must be selected based on a few criteria such as space availability, the size of project plans, ease of project developments and the building for the project itself. Auditorium faculty of engineering building as shown in Figure 2 has been selected as it has suitable for as a reference for this project. Figure 3 shows the location and picture of Auditorium Jurutera and Water Lake in Faculty of Engineering, Universiti Putra Malaysia in several zone views.

Figure 2. Location Auditorium Jurutera and Water Lake from top view

Figure 3. Auditorium Faculty of Engineering UPM

Figure 4. Auditorium Jurutera Building As-Built Drawing.



3.2. Proposed Type of Ground Sources Heat Pump

GSHPs has several types and operation strategies, depending on the design and applications for the building. The types are Ground Water Heat Pump, Surface Water Heat Pump, and Ground Coupled Heat Pump. For this project, the type of Ground Source Heat Pump will be used is Surface Water Heat Pump. The factors of selected that type / method is because of building location near with a lake, low initial cost, less public activity in the lake, and natural convection in primary role heat exchangers.

3.3. Data Collection

Some data are required before conducting this project. The data includes building structure / plan and characteristic, and sources of Water Lake profile data or geographic information system (GIS) from civil engineering. Building structure or architecture need to have for calculating heat load. Heat load are a concern of wall surface, window, door, floor, roof, and etc which is exposed to the sun. The operation inside the building, people, and items which generate heat are also a part of heat load.

By using special tools or software to generate analysis building cooling or heating load, Carrier's Hourly Analysis Program (HAP) will be used. HAP is a computer tool which assists engineers in designing HVAC systems for commercial buildings. HAP is two tools in one. First it is a tool for estimating loads and designing systems. Second, it is a tool for simulating building energy use and calculating energy costs. HAP uses the ASHRAE endorsed transfer function method for load calculations and detailed 8,760 hour by hour simulation techniques for the energy analysis. Specifically, HAP performs the following tasks during an energy analysis:

-Simulates hour by hour operation of all heating and air conditioning systems in the building.

-Simulates hour by hour operation of all plant equipment in the building.

-Simulates hour by hour operation of non-HVAC systems including lighting and appliances.

-Uses results of the hour-by-hour simulations to calculate total annual energy use and energy costs.

-Costs are calculated using actual utility rate features such as stepped, time of day and demand charges if specified.

-Generates tabular and graphical reports of hourly, daily, monthly, and annual data.

4.RESULTS AND DISCUSSION

4.1. Measurement Area Building Project.

Before commencing calculate building heat load calculation. The building's criteria or structure must be reviewed first to determine the structure's actual condition. A portion of the procedure must also specifically address room zoning. When calculating the refrigeration capacity requirement for a structure with multiple partitions, the calculations must be performed separately and added. After reviewing the area of the building that requires a comfort zone, it was discovered that the auditorium has only a single zone, resulting in a space area of 5,568 square feet and an average ceiling height of 19 feet.

4.2. Cooling Load.

Carrier's Hourly Analysis Programme (HAP) is utilised to generate analysis of building cooling or heating load by employing special tools or software. The HAP is a computer programme that aids engineers in the design of HVAC systems for commercial buildings. HAP is a two in one tool. It is first and foremost a tool for predicting loads and designing systems. Second, it is a tool for calculating energy expenses and simulating building energy use. HAP calculates load using the ASHRAE endorsed transfer function method and analyses energy using sophisticated 8,760 hour by hour simulation techniques. The focus of this work is on load estimation and system design. When data is entered into the E20 / HAP, the results show, among other things, air system sizing, air zone sizing, ventilation sizing, system load, zone load, space load, hourly air system, hourly zone, and system psychometrics.

Table 1. Table 1. Air System Sizing Summary for Cooling Ventilation

Description		**Data**	**Unit**
Air System Information	Air System Name	Cooling Ventilation	
	Equipment Class	UNDEF	
	Floor Area	5568	ft^2
	Location	Kuala Lumpur, Malaysia	
Sizing Calculation Information	Zone CFM	Sum of space airflow rate	
	Space CFM	Individual peak space load	
Central Cooling Coil Sizing Data	Total coil load	27.1	Tons
	Sensible coil load	325.2	MBH
	Coil CFM	8704	CFM
	Sensible heat ratio	0.597	
	ft^2/Ton	205.5	
	Water flow @ 10 °F	65.1	gpm

	rise		
	OA DB / WB	92.4 / 77.6	°F
	Entering DB / WB	80.6 / 70.3	°F
	Leaving DB / WB	59.8 / 58.9	°F
	Coil ADP	57.6	°F
	Resulting RH	54	%
	Design Supply Temperature	68	°F
Supply Fan Sizing Data	Actual max CFM	8704	CFM
	Standard CFM	8682	CFM
	Actual max CFM/ft²	1.58	CFM/ft²
Outdoor Ventilation Air Data	Design airflow CFM	2294	CFM
	CFM/ft²	0.41	CFM/ft²
	CFM/person	5.86	CFM/person

Table 1 shows the auditorium building required cooling capacity 27.1 Ton refrigerants, and entering air dry bulb, wet bulb respective 26.9 °C / 21.3 °C with relative humidity 64%. The data result much helpful for engineer to design air cooling ventilation system for this auditorium.

Table 2. Air zone sizing

Description		Data	Unit
Zone and Space Sizing Method	Zone CFM	Sum of space airflow rates	
	Space CFM	Individual peak space load	
	Calculation Months	Jan to Dec	
Zone Sizing	Zone	1	
	Max. Cooling Sensible	159.4	MBH
	Design Airflow	8704	CFM
	Min. air flow	8704	CFM
	Zone floor area	5568	ft²
	Zone CFM/ft²	1.56	CFM/ft²

Space Load and Airflow	Zone 1	AUDITORIUM JURUTERA	
	Mult.	1	
	Cooling sensible	159.4	MBH
	Airflow	8704	CFM
	Floor area	5568	ft²

Table 2 depicts the results of air zone sizing calculations for Auditorium Jurutera from January to December. If multiple zones require conformity, zone terminal sizing is required for this system in order to separate the ventilation and cooling requirements for each zone. For this project, only a single zone is required because no partitions or rooms necessitate a comfort zone within the building. Auditorium zone required designing airflow of 8704 cfm, Individual space airflow per area of 1.56 cfm/ft2, and cooling sensible energy is 159.4 MBH, according to the results data. The characteristics or operations of a building can refer to the actual construction site, how the building operates, and the energy consumed by the activities within the building. For the purposes of this paper, only the heating or cooling burden of the building is considered. As a result, the sensible capacity load for this building's cooling zone is 159.3 MBH and the latent capacity load is 803.6 MBH. The ventilation sizing data for the interior of the Auditorium Jurutera building is shown in Table 3. The method for calculating the required fresh air intake for ventilation is to determine the building's comfort level, the maximum number of occupants, the maximum supply air (CFM), and the required fresh air in the building space area. For this paper, the ventilation airflow rate specified for the Auditorium Jurutera building is 2,294.1 CFM.

Table 3. Ventilation Sizing

Description		**Data**	**Unit**
Summary	Ventilation sizing method	Sum of Space OA Airflow	
	Design Ventilation Airflow Rate	2294	CFM
Space Ventilation Analysis Table	Zone	AUDITORIUM JURUTERA	
	Mult.	1	MBH
	Floor area	5568	ft²
	Max. Occupants	392	person
	Max. Supply Air	8704.4	CFM
	Required Outdoor Air	5	CFM/person
	Required Outdoor Air	0.06	CFM/ft²
	Uncorrected Outdoor air	2294.4	CFM

Building characteristics or operation may refer to the actual job site, including how the building functions and the energy consumed to support internal activities. Concern for this paper's aims is limited to the building heating and cooling loads. As a result, the sensible capacity load for this building's cooling zone is 159.3 MBH, while the latent capacity load is 803.6 MBH.

CONCLUSION

Based on the results of the many tasks that were carried out to achieve the goals, it was determined that the Auditorium Jurutera Building needed 27.1 Tonnes of cooling capacity to create a comfortable environment. Packaged chillers can be utilised as air conditioning systems when employing the traditional approach. Conventional air conditioning is now the main cause of a building's high electricity costs. To use less electricity and to safeguard the environment from pollution and the possible effects of global warming, several academics are working to create new designs or find new solutions that utilise natural heat and cooling. One of the approaches used for this project was to introduce SWHP to replace the traditional air conditioning system. But regrettably, in the Faculty of Engineering's lake, UPM can only be achieved with a water depth temperature of 30.2°C (86.4°F) and a minimum depth of 447 cm (14.66ft).

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