AIR-CONDITIONING SYSTEM
BY USING DISTRICT COOLING SYSTEM (DCS):
THERMAL ENERGY STORAGE (TES) TECHNOLOGY

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"I verify that this report is my own word except summary and extract that every one of it I have clarify the resource"

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For my beloved parents, siblings and friends

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ABSTRACT

This study is about the air conditioning system by using District Cooling System (DCS) with the Thermal Energy Storage (TES) technology. DCS is a system where a central chiller plant provides chilled water for air-conditioning purposes for multiple buildings. Whereas TES is the storage of cooling energy during low air-conditioning loads period and used later to meet the air-conditioning loads. TES can be further broken down into ice harvesting, ice-on-coil, ice slurry, and encapsulated ice options. Ice-on-coil systems may be internal-melt or external-melt and may be charged and discharged with refrigerant or a single-phase coolant (typically a water/glycol mixture). Ice-on-coil systems come in several variations. In all variations, ice is formed on a heat transfer surface (generically referred to as a "coil") without being released during the charging mode and melted away during the discharge mode. Ice-harvesting systems form ice on coils or other refrigerant evaporating surfaces and periodically release the ice into a storage tank that contains a mixture of ice and water. Ice slurry systems produce small particles of ice within a solution of glycol and water, resulting in a slushy mixture that can be pumped. Encapsulated ice systems consist of water contained in plastic containers surrounded by coolant, all contained within a tank or other storage vessel. Within this report, all of these systems will differentiate by the storage system technologies, the mechanism, design and operating systems. Considering the pros and cons, the most suitable system will choose. The reasons of choosing that system as the best option will briefly explain. Moreover, the cooling load of FKM blocks in Durian Tunggal will calculate by using Carmel software. The overview of the software is preview, also the data insertion, check and end result. There are two types of outcomes of the program which consisting of result output and graph output. The most appropriate

capacity/types of equipments that could go well with the system would be selected in order to ensure the system can operate efficiently. These equipments comprise of STL tank, chiller, cooling tower, heat exchanger and air-handling unit (AHU).
The end part of this report will gives general conclusion on this study. It also include a suggestion to continue the research on this topic for better understanding on the refrigeration system and more to the point of obtaining the most competent cooling system in order to reduce its monthly expenses but with higher efficiency and give much benefits to the consumers.

ABSTRAK

Kajian ini adalah mengenai sistem penyejukan udara menggunakan Sistem Pendingin Lingkungan (District Cooling System-DCS) dengan teknologi Tenaga Pendam Lakuran (Thermal Energy Storage-TES). DCS ialah sistem di mana pusat *chiller plant* membekalkan air sejuk untuk tujuan penyejukan bagi beberapa bangunan sekitar. Manakala TES adalah penyimpanan tenaga penyejukan pada waktu beban penyejukan rendah dan akan digunakan kemudian ketika tenaga penyejukan itu diperlukan. TES terbahagi kepada beberapa jenis iaitu *ice harvesting, ice-on-coil, ice slurry* dan *encapsulated ice* Sistem *Ice-on-coil* terbahagi kepada dua iaitu pencairan dalam (internal-melt) dan pencairan luar (external-melt) di mana ia akan dicaj dan nyahcaj menggunakan bahan penyejuk atau cecair penyejuk satu fasa (biasanya campuran air/glikol). Terdapat pelbagai variasi di dalam sistem *ice-on-coil* di mana di dalam semua variasi, ais terbentuk pada permukaan haba dipindahkan (disebut sebagai "coil") tanpa dibebaskan semasa pengecasan dan ais mencair semasa penyahcasan. Sistem *ice harvesting* membentuk *ice-on-coil* atau permukaan sejatan bahan penyejuk lain dan menyalurkan ais secara berperingkat ke dalam tangki yang mengandungi campuran ais dan air. Sistem *ice slurry* menghasilkan ais yang kecil di dalam larutan glikol dan air menjadikan ia sebagai larutan separa cair yang boleh dipam. Sistem kapsul ais (*encapsulated ice*) adalah kapsul plastik yang mengandungi air dan dikelilingi oleh cecair penyejuk di dalam sebuah tangki atau bekas penyimpanan lain. Di dalam laporan ini, sistem-sistem ini akan dibezakan melalui teknologi sistem penyimpanan, mekanisma, rekabentuk serta sistem operasi setiap satunya. Selepas mengambil kira kelebihan dan kekurangan, system yang paling sesuai akan dipilih dan sebab-sebab sistem ini dipilih akan dijelaskan. Beban penyejukan bagi blok FKM di durian tunggal akan dikira menggunakan perisian Carmel. Sedikit gambaran tantang program perisian akan diterangkan beserta

cara memasukkan data, penyemakan dan hasil akhir. Terdapat dua jenis hasil iaitu keputusan teks dan graf. Kelengkapan lain berkaitan sistem ini seperti tagki STL, *chiller,* menara penyejuk, penukar haba dan *air handling unit (AHU)* akan dipilih berdasarkan kapasiti/jenis yang terbaik yang dapat memaksimakan kecekapan sistem. Kesimpulan mengenai kajian disertakan di akhir laporan yang juga merangkumi cadangan untuk meneruskan kajian berkenaan topik ini dengan tujuan untuk lebih memahami tentang sistem penyejukan dan lebih menjurus kepada menghasilkan sistem yang kompeten untuk mengurangkan kos bulanan dan dalam masa yang sama merupakan sistem yang efisien serta memberi banyak kelebihan kepada pengguna.

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LIST OF SYMBOLS

BTU	=	British Thermal Unit
C	=	Celsius
CFM	=	Cubic Feet Meter
F	=	Fahrenheit
hr	=	Hour
J	=	Joule
J/kg	=	Joule per kilogram
K	=	Kelvin
kg	=	Kilogram
KJ	=	Kilojoules
kPA	=	Kilopascal
kW	=	Kilowatt
kW/h	=	Kilowatt per Hour
kWh	=	Kilowatt hour
m^3	=	Cubic meters
m^3/hr	=	Cubic meters per Hour
mm	=	Millimeter
RT	=	Refrigerant ton
RTHr	=	Refrigerant ton hour
SqFt	=	Square feet
SqM	=	Square meter
Ton-Hr	=	Ton hour

LIST OF ABBREVIATION

ASHRAE	=	American Society of Heating, Refrigerating and Air-Conditioning Engineers
CMA	=	Calcium Magnesium Acetate
COP	=	Coefficient of Performance
CTS	=	Conduction Time Series
DCS	=	District Cooling System
DX	=	Direct Expansion
FKM	=	*Fakulti Kejuruteraan Mekanikal* (Faculty of Mechanical Engineering)
HCFC	=	Hydrochlorofluorocarbons
HFC	=	Hydrofluorocarbon
HVAC	=	Heating, Ventilating and Air-Conditioning
HW	=	Heavy Weight
IP	=	Inch-Pound
L/s	=	Litres per second
O&M	=	Operation and Maintenance
PSM	=	*Projek Sarjana Muda*
RTS	=	Radiant Time Series
SHGC	=	Solar Heat Gain Coefficient
SI	=	System International
STL	=	Storage Thermal Latent
TES	=	Thermal Energy Storage
TNB	=	Tenaga Nasioanal Berhad
TNEC	=	TNB Engineering Corporation
UTeM	=	Universiti Teknikal Malaysia Melaka
VAV	=	Variable Air Volume

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CHAPTER I

INTRODUCTION

1.1 Background

Referred to Robert (2003), there are two types of HVAC systems designed to satisfied building cooling requirements; direct expansion (DX) systems, in which there is direct heat exchange between the building air and the refrigerant, and secondary refrigerant systems that utilize chilled water as an intermediate heat exchange medium to transfer heat from the building air to the refrigerant which we called it centralized cooling system or commercially named Direct Cooling System (DCS).

Basically, a DCS distributes thermal energy in the form of chilled water or other media from a central source to multiple buildings through a network of underground pipes for use in space and process cooling. The cooling or heat rejection is usually provided from a central cooling plant, thus eliminating the need for separate systems in individual buildings. In DCS there is one new technology which called Thermal Energy Storage (TES). This type of system has been use widely in overseas but only introduced in Malaysia for about few years.

Thermal Energy Storage capitalizes on the cheaper off-peak tariff offered by the electric utility company. The system produces cooling energy at night when the electricity tariff is low. During the day, when the air-conditioning demand is high, the stored cooling energy is released by circulating chilled water through the storage system and onto the buildings. Only a limited amount of chiller capacity needs to operate during this period. By adopting this concept, the plant consumes less electricity during the day, when electricity tariff is high. This leads to significant savings in operating costs. As the electrical power demand for this plant is also low during the day, further cost saving is achieved through reduced maximum demand charges.

There are many different types of thermal storage systems representing different combinations of storage media, charging mechanisms, and discharging mechanisms. The basic media options are water, ice, and eutectic salts. This system can be further broken down into ice harvesting, ice-on-coil, ice slurry, and encapsulated ice options.

1.2 Problem Statement

The purpose of the study is to find an approach in order to get lower cost and high efficiency for air-conditioning system. Almost every commercial buildings and offices have an air conditioning unit. It has become necessity of modern life. There are two major options to distribute cooling energy to building which are direct expansion system and centralized system. For the average sized of office and home, the trend is to use building-specific cooling that is a split air conditioning unit. For large and/or multiple buildings, it make use of central air conditioning unit which also called District Cooling System (DCS). District cooling means the centralized production and distribution of cooling energy. Commonly, many building which applied this DCS system would use water as a refrigerant. This system will cost high monthly expenses of the electricity consumption of the system also for the maintenance and services. This is because the water chillers will be operated all the time as required to supply cooling energy into buildings and normally the demand is during peak hours. In order to solve this problem, there is new development of refrigeration technology called Thermal Energy Storage (TES). TES can reduce cost by shifting the electricity consumption from day to night. With this system, the