STUDY OF THE CONVENTIONAL HVAC SYSTEM AND DEVELOPMENT OF AFFORDABLE VENTILATION SYSTEM

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A PROJECT & THESIS

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ABSTRACT

Ice based Cool Thermal Energy Storage (CTES) systems have attracted much attention during last few decades. The reasons are mainly of economic and environmental nature. Compared to conventional refrigeration and air- conditioning systems without cool thermal energy storage, implementation of CTES will increase environmental standards and overall efficiency of the energy systems as it contributes to the phase-out of synthetic refrigerants and reduces peak loads in electricity grids. Our focus is to create a different ventilation system instead of the chiller for a low temperature in the industry's (Textile) working area. The application of a cool thermal energy storages HVAC systems in industry and building sector, it is necessary to have appropriate design tools in order to sufficiently accurately predict their performance we will make ice through an ice plant. We know that when the ambient temperature is 35 - 39 degree Celsius, the working Express's temperature ranges from 43 degrees Celsius to working space. We tried to keep this temperature in between 28 to 30 degree. The aim of the present thesis is to extend the knowledge in the field of ice based CTES (Cool Thermal Energy Storage) systems, there by contributing in the development and wider utilization of those systems.

Contents

List of figures

List of tables

NOMENCLATURE

Symbol	Definition	Unit
TR	Ton	*Kw*
I	Current	*amp*
V	Voltage	*volt*
P	Power	*watt*
T	Time	*Sec*
db	dry bulb temperature	°c
wb	wet bulb temperature	°c
PLR	partial load ratio	

ABBREVIATIONS

Symbol	Description	Symbol	Description
AC	AIR CONDITIONING	HHWR	HEATING HOT WATER RETURN
ACH	AIR CHANGE PER HOUR	HHWS	HEATING HOT WATER SUPPLY
AHU	AIR HANDLING UNIT	HEX	HEAT EXCHANGER
FCU	FAN COIL UNIT	DHE	DEHUNIDIFIER
AP	ACCESS PANEL	LL	LOW LEVEL
B	BLANKET OF	I/O	INPUT/OUTPUT
BMS	BUILDING MANAGEMENT SYSTEM	MA	MACKUP AIR
CBV	CHILLED WATER BUFFER VASELS	MAX	MAXIMUM
CHWP	CHILLED WATER PUMP	MIM	MINIMUM
CHWR	CHILLED WATER RETURN	MOP	MAXIMUM OPERATING PRESSURE
CHWS	CHILLED WATER SUPPLY	HL	HIGH LEVEL
CT	COOLING TOWER	NC	NORMALLY CLOSE
CDU	CHEMICAL DOSING UNIT	NO	NORMALLY OPEN
CMH	CUBIC FEET PER HOUR	NRD	NON-RETURN DAMPER
CWR	CONDENSER WATER RETURN	OA	OUTSIDE AIR
CWS	CONDENSER WATER SUPPLY	OBD	OPPSIDE BLADE DAMPER
D	DRAIN	PDI	ROOM PRESSURE INDICATOR
DC	DAMPER CONTROL	PS	PRESSURE SWITCH
DG	DOOR GRILL	CFM	CUBIC FEET PER MINUTE
SD	SUPPLY DEFFUSER	IAQ	INDDOOR AIR QUALITY
RG	RETURN GRILL	BTU	BRITISH THERMAL UNIT

CHAPTER-01

INTRODUCTION & OBJECTIVE

1.1 Introduction:

In residential and industrial area for per unit electricity consumption we follow the time of day tariff charges which cost is differently in whole day on per hour basis. We are using this concept to replace Air conditioner main part chiller with "ICE BANK" heat exchange process. In which we will produce ice with help of compressor and coolant in that period where the per unit electricity charges are less and then we will use that ice to exchange heat from air and intake heat in the room.

Heating, Ventilation, and Air-Conditioning (HVAC) systems control the indoor environment throughout the year to ensure comfortable conditions in homes, offices, and commercial facilities. Beside the fact that HVAC systems are making human life healthier and more productive but various products could also be produced faster, better, and more economically in an appropriately controlled environment. Almost each residential, institutional, commercial, and industrial building has a year-round controlled environment in the developed countries of the world.

1.2 Objective:

We developed several goals that the design should be able to meet. They are-

- To design & construct a HVAC system without chiller
- To compare the COP of the system with and without chiller
- To reduce space of the technical area
- To reduce maintenance cost
- To investigate the economic potential and benefits by using of an ice bank air conditioning system in commercial and residential buildings.

CHAPTER-02

Literature Review

2.1 HVAC System:

HVAC stands for heating, ventilation, and air conditioning. is the technology of indoor and vehicular environmental comfort. Its goal is to provide thermal comfort and acceptable indoor air quality. HVAC systems control the ambient environment (temperature, humidity, air flow, and air filtering). HVAC is an important part of residential structures which making it safe and habitable.

Heating: Heating is the process of generating heat used to warm the space to be via the following applications (boiler, furnace, electricity or heat pump) to heat water or air in central location.

Ventilation: Ventilation is the process of changing or replacing air in any space to control temperature or remove any combination of moisture, odors, smoke, heat, dust, airborne bacteria, or carbon dioxide, and to replenish oxygen. Ventilation includes both the exchange of air with the outside as well as circulation of air within the building. It is one of the most important factors for maintaining acceptable indoor air quality in buildings

Air conditioning: Air conditioning is controlled in the interior air temperature and movement and humidity and temperature process. Air-cooled when the weather is warm, heated up when the weather is cold. Air conditioning works to get rid of excess moisture from the air or add to it if the need arises. It also works to remove dirt and dust from the air, which makes it a better health. Which makes us more comfortable at work and at play and during sleep.

The initials HVAC stand for Heating, Ventilation and Air Conditioning. They describe the functions of an HVAC system. This mechanical system's design is primarily an attempt to take control of the environmental conditions inside the space you work. An HVAC system is designed to control the environment in which it works. It achieves this by controlling the temperature of a room through heating and cooling. It also controls the humidity level in that environment by controlling the movement and distribution of air inside the room. The system also ensures cleanliness of air inside the said environment.

2.2 Ice Bank (Ice Cell) System:

A thermal energy storage system remove heat from or add heat to a storage medium to meet a system load at another time. Basically, it separates generation of heating or cooling from the use in time. This allows the generation of heating or cooling to be moved to periods when conditions are more favorable.

Thermal energy storage systems are primarily classified according to a temperature level at which the stored energy is being used. If stored energy is used for heating purposes thermal storage is referred to as heat thermal energy storage and if it is used for cooling, thermal storage is referred to as cool thermal energy storage. Implementation of thermal energy storage in HVAC&R systems can offer certain benefits (ASHRAE, 2007):

O Cost savings in energy by reduction of total operating costs in case when the electricity is primary energy source.

O Reduced equipment size.

O Capital cost savings from downsizing the heating or cooling generation equipment.

O Energy savings in case when the generation of cooling is performed during the night resulting in higher efficiency of refrigeration equipment due to lower ambient and therefore condensing temperatures.

O Increased operating flexibility.

O Extending existing systems capacity

O Back-up capacity.

Besides air-conditioning, there are many industrial processes where the temperature of the products should be kept at a temperature slightly above freezing point of water. Naturally for such applications, water-ice as a phase change media is logical by itself. In food processing plants, namely dairy and cheese factories, the temperature of products that is tube reached in a relatively short period of time is approximately +3 °C. In order to provide it, low temperature water from +0.5 to +1.5 °C is supplied from the CTES system to the load. There are many examples of successful operation of static, ice bank CTES systems for cooling of milk in the world as well as in Croatia (dairy “Antun Bohnec)

2.3 Uses of thermal storage:

Thermal storage is a technology that has come of age. It meets today's need for flexible energy management. Whether you're the owner of a large building, a school executive, a hospital administrator or a manufacturer, you realize that energy costs are a major part of your annual budget, and a somewhat uncontrollable one. Today, you can do something about that. You can begin to manage your energy usage. Thermal storage allows you to produce cooling when most convenient or least costly and use it for air conditioning or process cooling when you need it. You'll find that thermal storage is remarkably economical. In many cases, the equipment is no more costly than conventional, inflexible cooling systems. If you're adding cooling capacity to a given building or process, thermal storage can often provide it with no additional refrigeration equipment.

Building air conditioning systems using Ice-Cell thermal storage can be designed which cost little or no more than conventional chiller-only systems. Ice-Cell is a modular ice thermal storage tank. The tank is filled with water, in which is submerged a polyethylene tube heat exchanger. A glycol solution at about 26°F [-3.3°C] flowing inside the tubes causes the surrounding water to freeze. The chilled glycol solution is typically provided by a chiller having about 24 TR [84 kW] of cooling capacity. When fully frozen, the Ice-Cell stores 240 TR-hours [844 kWh] of cooling capacity, so it requires about 10 hours operation of a 24 TR [84 kW] chiller to fully freeze the water in the tank. Then to serve a cooling load, the ice can be melted at a rate dictated by load, ranging from 0 to 50 TR [0 to 176 kW]. For example, the Ice-Cell could serve a steady load of 20 TR [70 kW] for 12 hours. In providing cooling, the glycol solution flows from the Ice-Cell to the load device (such as an air handler) at a temperature of typically 34°F - 38°F [1.1°C - 3.3°C].

How to use it: Ice-Cell is used mainly to store cooling capacity for air conditioning most central air conditioning systems serving big buildings use electrically-driven liquid chillers. Chillers are often idle at night because little if any cooling is required at that time. When Ice-Cell thermal storage tanks are added to the system, the chiller can operate at night to store cooling capacity in the Ice-cell. Then when cooling is needed during the day, it can be supplied by the Ice-cell. This cooling can either supplement or replace the cooling available from daytime operation of the chiller.

2.4 Ventilation System:

Definitions covering ventilation and the flow of air into and out of a space include: Purpose provided (intentional) ventilation: Ventilation is the process by which 'clean' air (normally outdoor air) is intentionally provided to a space and stale air is removed. This may be accomplished by either natural or mechanical means.

Air infiltration and exfiltration: In addition to intentional ventilation, air inevitably enters a building by the process of 'air infiltration'. This is the uncontrolled flow of air into a space through adventitious or unintentional gaps and cracks in the building envelope. The corresponding loss of air from an enclosed space is termed 'exfiltration'. The rate of air infiltration is dependent on the porosity of the building shell and the magnitude of the natural driving forces of wind and temperature. Vents and other openings incorporated into a building as part of ventilation design can also become routes for unintentional air flow when the pressures acting across such openings are dominated by weather conditions rather than intentionally (e.g. mechanically) induced driving forces. Air infiltration not only adds to the quantity of air entering the building but may also distort the intended air flow pattern to the detriment of overall indoor air quality and comfort. Although the magnitude of air infiltration can be considerable, it is frequently ignored by the designer. The consequences are inferior performance, excessive energy consumption, an inability to provide adequate heating (or cooling) and drastically impaired performance from heat recovery devices. Some Countries have introduced air-tightness Standards to limit infiltration losses

Ventilation is the intentional introduction of ambient air into a space and is mainly used to control indoor air quality by diluting and displacing indoor pollutants; it can also be used for purposes of thermal comfort or dehumidification. The correct introduction of ambient air will help to achieve desired indoor comfort levels although the measure of an ideal comfort level varies from individual to individual. The intentional introduction of subaerial air can be categorized as either mechanical ventilation, or natural ventilation.[2] Mechanical ventilation uses fans to drive the flow of subaerial air into a building. This may be accomplished by pressurization (in the case of positively pressurized buildings), or by depressurization (in the case of exhaust ventilation systems). Many mechanically ventilated buildings use a combination of both, with the ventilation being integrated into the HVAC system. Natural ventilation is the intentional passive flow of subaerial air into a building through planned openings (such as louvers, doors, and windows). Natural ventilation does not require mechanical systems to move subaerial air; it relies entirely on passive physical phenomena, such as diffusion, wind pressure, or the stack effect. Mixed mode ventilation systems use both mechanical and natural processes. The mechanical and natural components may be used in.

Conjunction with each other or separately at different times of day or season of the year.[3] Since the natural component can be affected by unpredictable environmental conditions it may not always provide an appropriate amount of ventilation. In this case, mechanical systems may be used to supplement or to regulate the naturally driven flow in many instances, ventilation for indoor air quality is simultaneously beneficial for the control of thermal comfort. At these times, it can be useful to increase the rate of ventilation beyond the minimum required for indoor air quality. Two examples include air-side economizer strategies and ventilation pre-cooling. In other instances, ventilation for indoor air quality contributes to the need for - and energy use by - mechanical heating and cooling equipment. In hot and humid climates, dehumidification of ventilation air can be a particular energy intensive process. Ventilation should be considered for its relationship to "venting" for appliances and combustion equipment such as water heaters, furnaces, boilers, and wood stoves. Most importantly, the design of building ventilation must be careful to avoid the backdraft of combustion products from "naturally vented" appliances into the occupied space. This issue is of greater importance in new buildings with more air tight envelopes. To avoid the hazard, many modern combustion appliances utilize "direct venting" which draws combustion air directly from outdoors, instead of from the indoor environment.

2.5 Types of Air conditioning system:

The three main types of HVAC systems available today are:

1. Split and Window AC
2. Packaged Heating & Air Conditioning System
3. Central AC System

2.5.1 Split Air Conditioner System:

A split air conditioner consists of two main parts: the outdoor unit and the indoor unit. The outdoor unit is installed on or near the wall outside of the room or space that you wish to cool. The unit houses the compressor, condenser coil and the expansion coil or capillary tubing. The sleek-looking indoor unit contains the cooling coil, a long blower and an air filter.

2.5.2 Packaged Heating & Air Conditioning System:

This kind of air conditioner system has many advantages over traditional air conditioners. Perhaps the most obvious benefit is the quiet performance of a split air conditioner system. The parts of an air conditioner that make the most noise are the compressor and the fan that cools the condenser. In a split system, the compressor and fan for the condenser are located outside of the room being cooled and therefore the major sources of noise are removed - unlike with window units.

Another benefit of a split air conditioner system is that you can opt for a multi-split system, where you can have more than one indoor unit connected to a single outdoor unit. This makes it easy to cool multiple rooms or maintain the temperature throughout a large room through the use of two indoor cooling units.

A split air conditioner is an efficient and cost-effective way to cool your home. It should be noted that the initial cost of this kind of air conditioning unit is significantly higher than a window unit and it does require professional installation. However, the amount of money you. Will saves on your energy bills as well as the longevity of the unit will make it worth your while in the end.

2.5.3 Types of Packaged Units:

Packaged Air Conditioners: The compressor, coils, air handler are all housed in a single-boxed cabinet. The packaged air conditioner can also provide limited warmth by using an electrical strip heating. Packaged Heat Pumps: A packaged heat pump uses heat pump technology to cool and heat your home. Packaged Gas-Electric: The packaged gas-electric unit combines an air conditioner with gas-powered furnace performance. Packaged Dual-Fuel: The packaged dual fuel system contains a heat pump, capable of heating and cooling, as well as a gas furnace. This type of packaged system optimizes the heating source for the conditions.

Packaged Heat Pumps: The heat pump transfers heat by reversing the refrigeration cycle used by a typical air conditioner. Through a cycle of evaporation and condensation, the indoor coils are heated, and the air is pushed over the warm coils. From there, the warmed air is blown through the ductwork to increase the temperature in the interior rooms of your home.

Packaged Gas-Electric: The heating component of a packaged gas-electric system is a gas furnace. The heating portion of the system uses natural gas or propane to combust inside the heat exchanger, creating heat. As cool air from the interior spaces is pulled in through the return ducting, the blower motor then blows the air over and through the hot heat exchanger, heating the air. The warm air is then circulated throughout the home through the ductwork.

Packaged Dual-Fuel: Your dual-fuel packaged system has two heating options, a heat pump or a gas furnace. When installed and configured correctly, your dual fuel system can determine whether it’s more economical to heat your home using electricity or gas. When moderate heating is required, the heat pump automatically reverses from the air condition mode to provide warm air. When temperatures fall further, the system uses the gas furnace to provide reliable, consistent heat.

2.5.4 Central Air Conditioning Plants:

Central air conditioning plants require a dedicated room in which the compressor, condenser, thermostatic expansion valve and evaporator are kept. These systems function the same way they do in any other air conditioning unit, except they are much larger in scale and have higher capacities. These massive machines pump out cooled air, which is sent throughout the building with the use of ductwork, resulting in quiet, yet highly efficient air conditioning in every room. To operate and maintain central air conditioning systems you need to have good operators, technicians and engineers. Proper preventative and breakdown maintenance of these plants is vital.

There are two types of central air conditioning plants or systems:

A) Direct expansion or DX central air conditioning plant: In this system the huge compressor and the condenser are housed in the plant room, while the expansion valve and the evaporator or the cooling coil and the air handling unit are housed in separate room. The cooling coil is fixed in the air handling unit, which also has large blower housed in it. The blower sucks the hot return air from the room via ducts and blows it over the cooling coil. The cooled air is then supplied through various ducts and into the spaces which are to be cooled. This type of system is useful for small buildings.

B) Chilled water central air conditioning plant: This type of system is more useful for large buildings comprising of several floors. It has the plant room where all the important units like the compressor, condenser, throttling valve and the evaporator are housed. The evaporator is a shell and tube. On the tube side the Freon fluid passes at extremely low temperature, while on the shell side the brine solution is passed. After passing through the evaporator, the brine solution gets chilled and is pumped to the various air handling units installed at different floors of the building. The air handling units comprise the cooling coil through which the chilled brine flows, and the blower. The blower sucks hot return air from the room via ducts and blows it over the cooling coil. The cool air is then supplied to the space to be cooled through the ducts. The brine solution which has absorbed the room heat comes back to the evaporator, gets chilled and is again pumped back to the air handling unit.

2.6 Deferent type of Ventilation Systems:

There are several ways to bring fresh air into our homes. Ventilation systems can be natural, mechanical or hybrid. There are two ways to ventilate or cool buildings:

Actively or passively. Active ventilation/cooling refer to systems where mechanical components or other energy-consuming components (such as air-conditioning systems) are used. Passive ventilation/cooling is a technology or design feature used to ventilate/ cool buildings with no energy consumption (e.g. natural ventilation by operable windows). Passive cooling is a measure that uses no energy to cool buildings. It involves at least three concepts:

i. Solar shading
ii. Thermal mass
iii. Ventilate cooling

2.6.1 Mechanical ventilation System:

Mechanical ventilation refers to any system that uses mechanical means, such as a fan, to introduce sub aerial air to a space. This includes positive pressure ventilation, exhaust ventilation, and balanced systems that use both supply and exhaust ventilation.

Mechanical ventilation systems use electric fans to direct the airflow in the building. Mechanical ventilation can provide a constant air change rate independently of external weather conditions, but it uses electricity and usually cannot change the ventilation rate as the need changes over the day and year.

Several variations exist, as illustrated. Systems with both supply and extract can be combined with a heat recovery unit, which recovers (reuses) the heat of the extract air that would otherwise be lost. Up to 90% of the energy can be 'reused'. It is becoming a standard solution in many North European countries for new built houses to be provided with mechanical heat recovery ventilation in order to meet current energy requirements. This is a very energy efficient solution for the heating (winter) season. However, in the summer season, electricity for running of fans can be saved by using natural ventilation. Systems shifting between natural ventilation and mechanical ventilation are called hybrid ventilation systems.

2.6.2 Natural ventilation System:

Natural ventilation refers to intentionally designed passive methods of introducing sub aerial to a space without the use of mechanical systems.

Natural ventilation harnesses naturally available forces to supply and remove air in an enclosed space. There are three types of natural ventilation occurring in buildings: wind driven ventilation, pressure-driven flows, and stack ventilation.[24] The pressures generated by 'the stack effect' rely upon the buoyancy of heated or rising air. Wind driven ventilation relies upon the force of the prevailing wind to pull and push air through the enclosed space as well as through breaches in the building's envelope. Seoul University Professor Wonjun Kwon recently discovered a new way to ventilate large area of indoor space. The so-called "air pump" system uses pressure between inside and outside of rooms to push air out of a structure. Almost all historic buildings were ventilated naturally. The technique was generally abandoned in larger US buildings during the late 20th century as the use of air conditioning became more widespread. However, with the advent of advanced Building Performance Simulation (BPS) software, improved Building Automation Systems (BAS), Leadership in Energy and Environmental Design (LEED) design requirements, and improved window manufacturing techniques; natural ventilation has made a resurgence in commercial buildings both globally and throughout the US.

The benefits of natural ventilation include:

- ✓ Improved Indoor air quality (IAQ)
- ✓ Energy savings
- ✓ Reduction of greenhouse gas emissions
- ✓ Occupant control
- ✓ Reduction in occupant illness associated with Sick Building Syndrome
- ✓ Increased worker productivity

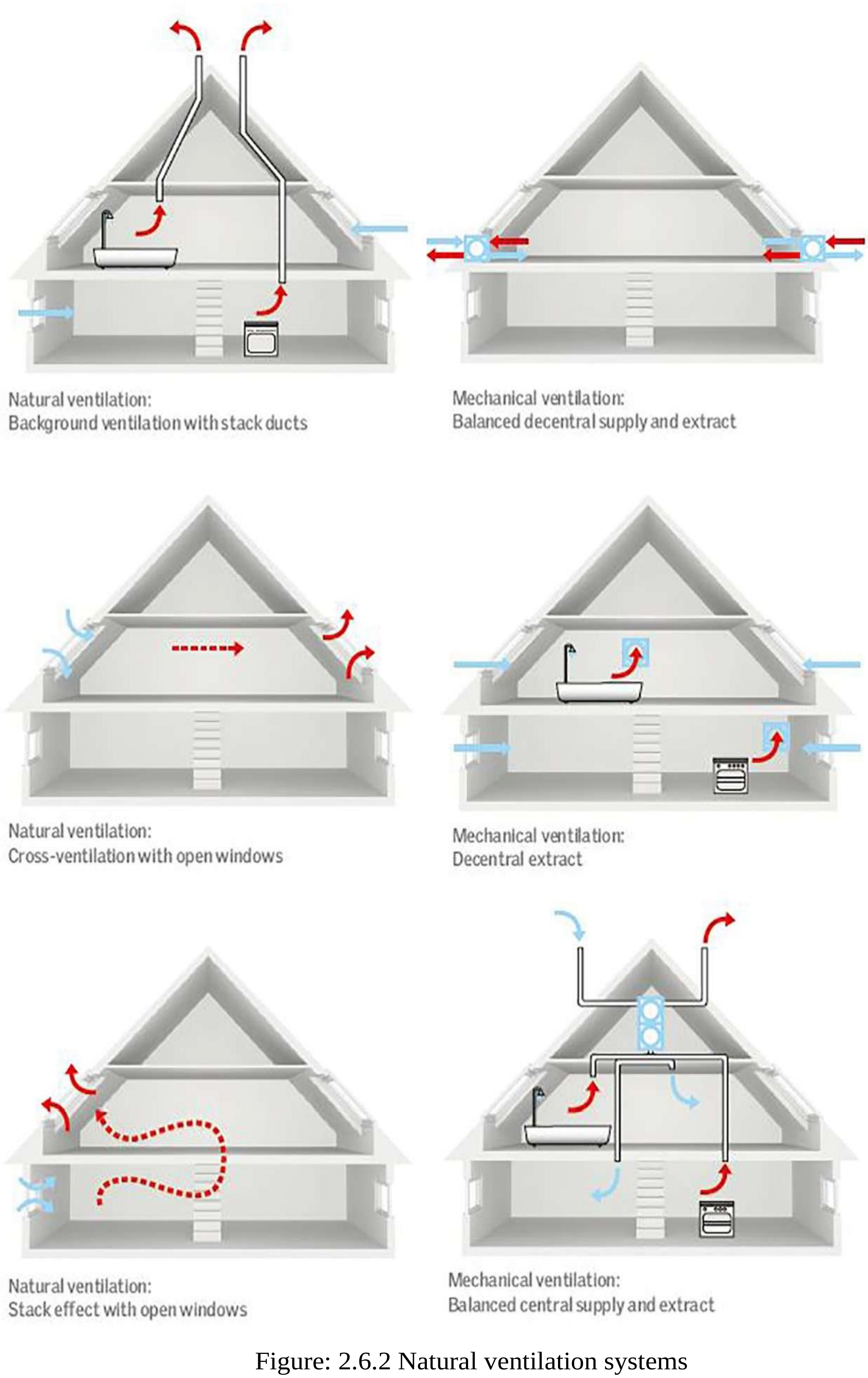


Figure: 2.6.2 Natural ventilation systems

2.6.3 Exhaust Ventilation Systems:

Exhaust ventilation systems work by depressurizing the building. By reducing the inside air pressure below the outdoor air pressure, they extract indoor air from a house while make-up air infiltrates through leaks in the building shell and through intentional, passive vents.

Exhaust ventilation systems are most applicable in cold climates. In climates with warm, humid summers, depressurization can draw moist air into building wall cavities, where it may condense and cause moisture damage. Exhaust ventilation systems are relatively simple and inexpensive to install. Typically, an exhaust ventilation system is composed of a single fan connected to a centrally located, single exhaust point in the house.

A preferable option is to connect the fan to ducts from several rooms (especially rooms where pollutants tend to be generated, such as bathrooms). Adjustable, passive vents through windows or walls can be installed to introduce fresh air rather than rely on leaks in the building envelope. However, passive vents may be ineffective because larger pressure differences than those induced by the ventilation fan may be needed for them to work properly.

Spot ventilation exhaust fans installed in the bathroom but operated continuously represent an exhaust ventilation system in its simplest form.

2.6.4 Supply Ventilation Systems:

Supply ventilation systems work by pressurizing the building. They use a fan to force outside air into the building while air leaks out of the building through holes in the shell, bath- and range-fan ducts, and intentional vents. As with exhaust ventilation systems, supply ventilation systems are relatively simple and inexpensive to install. A typical system has a fan and duct system that introduces fresh air into usually one—but preferably several—rooms that residents occupy most (for example, bedrooms, living room, kitchen). This system may include adjustable window or wall vents in other rooms. Supply ventilation systems allow better control of the air that enters the house than do exhaust ventilation systems. By pressurizing the house, these systems discourage the entry of pollutants from outside and prevent back drafting of combustion gases from fireplaces and appliances. They also allow air introduced into the house to be filtered to remove pollen and dust or to be dehumidified.

Supply ventilation systems work best in hot or mixed climates. Because they pressurize the house, they have the potential to cause moisture problems in cold climates. Like exhaust ventilation systems, supply ventilation systems do not temper or remove moisture from the air before it enters the house. Thus, they may contribute to higher heating and cooling costs compared with energy recovery ventilation systems. Because air is introduced in the house at discrete locations, outdoor air may need to be mixed with indoor air before delivery to avoid cold air drafts in winter. An in-line duct heater is another option, but it will increase operating costs.

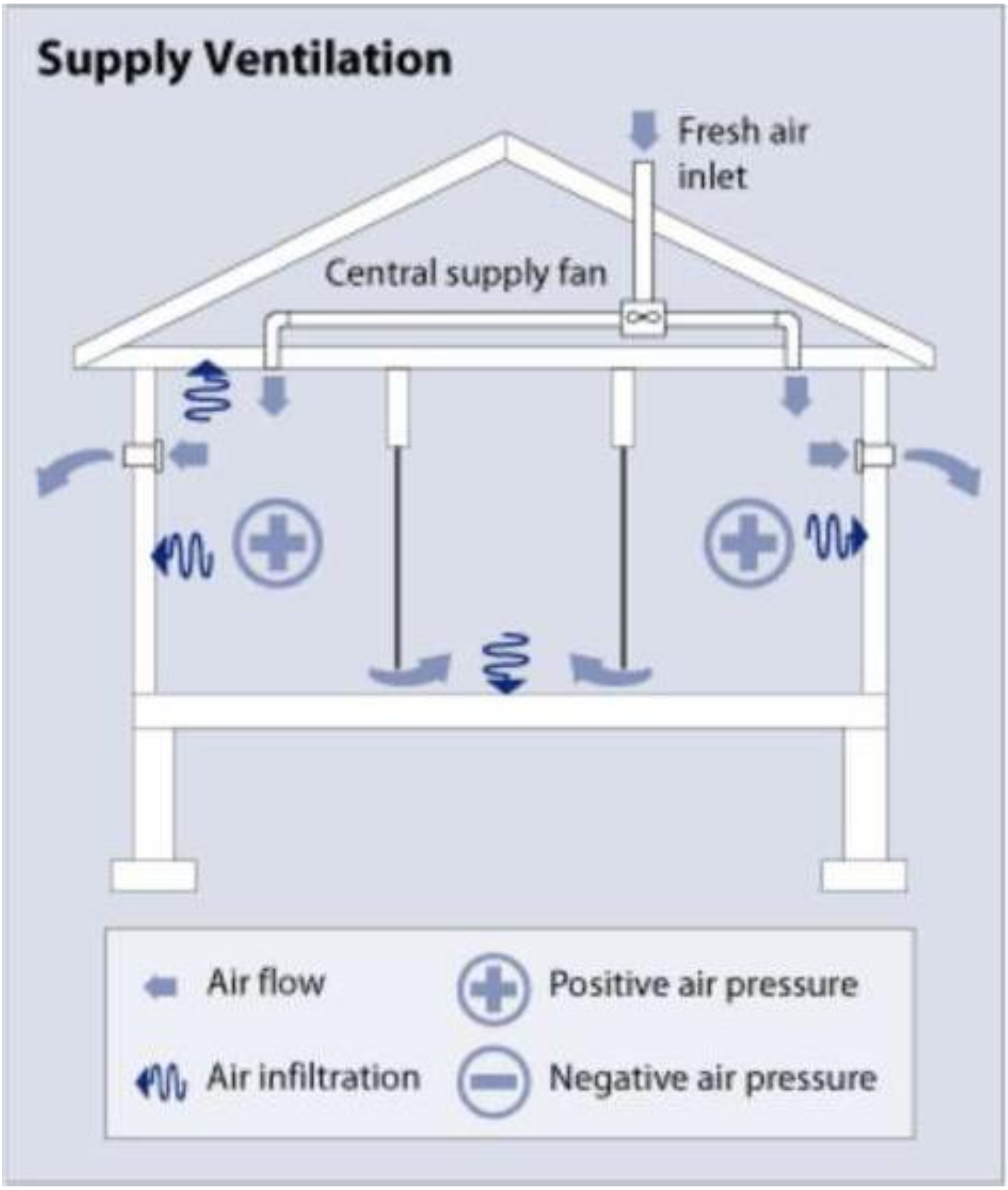


Figure: 2.6.4 Supply ventilation systems

2.6.5 Balanced Ventilation Systems:

Balanced ventilation systems, if properly designed and installed, neither pressurize nor depressurize a house. Rather, they introduce and exhaust approximately equal quantities of fresh outside air and polluted inside air, respectively. A balanced ventilation system usually has two fans and two duct systems. It facilitates good distribution of fresh air by placing supply and exhaust vents in appropriate places.

A typical balanced ventilation system is designed to supply fresh air to bedrooms and common rooms where people spend the most time. It also exhausts air from rooms where moisture and pollutants are most often generated, such as the kitchen, bathrooms, and the laundry room. Like both supply and exhaust systems, balanced ventilation systems do not temper or remove moisture from the air before it enters the house.

They do, however, use filters to remove dust and pollen from outside air before introducing it into the house. Also, like supply ventilation systems, outdoor air may need to be mixed with indoor air before delivery to avoid cold air drafts in the winter. This may contribute to higher heating and cooling costs. Balanced ventilation systems are appropriate for all climates; however, because they require two duct and fan systems, they are usually more expensive to install and operate than supply or exhaust systems.

- ISO ICS 91.140.30: Ventilation and air-conditioning systems
- ASHRAE 62.1 & 62.2: The standards for Ventilation and Indoor Air Quality

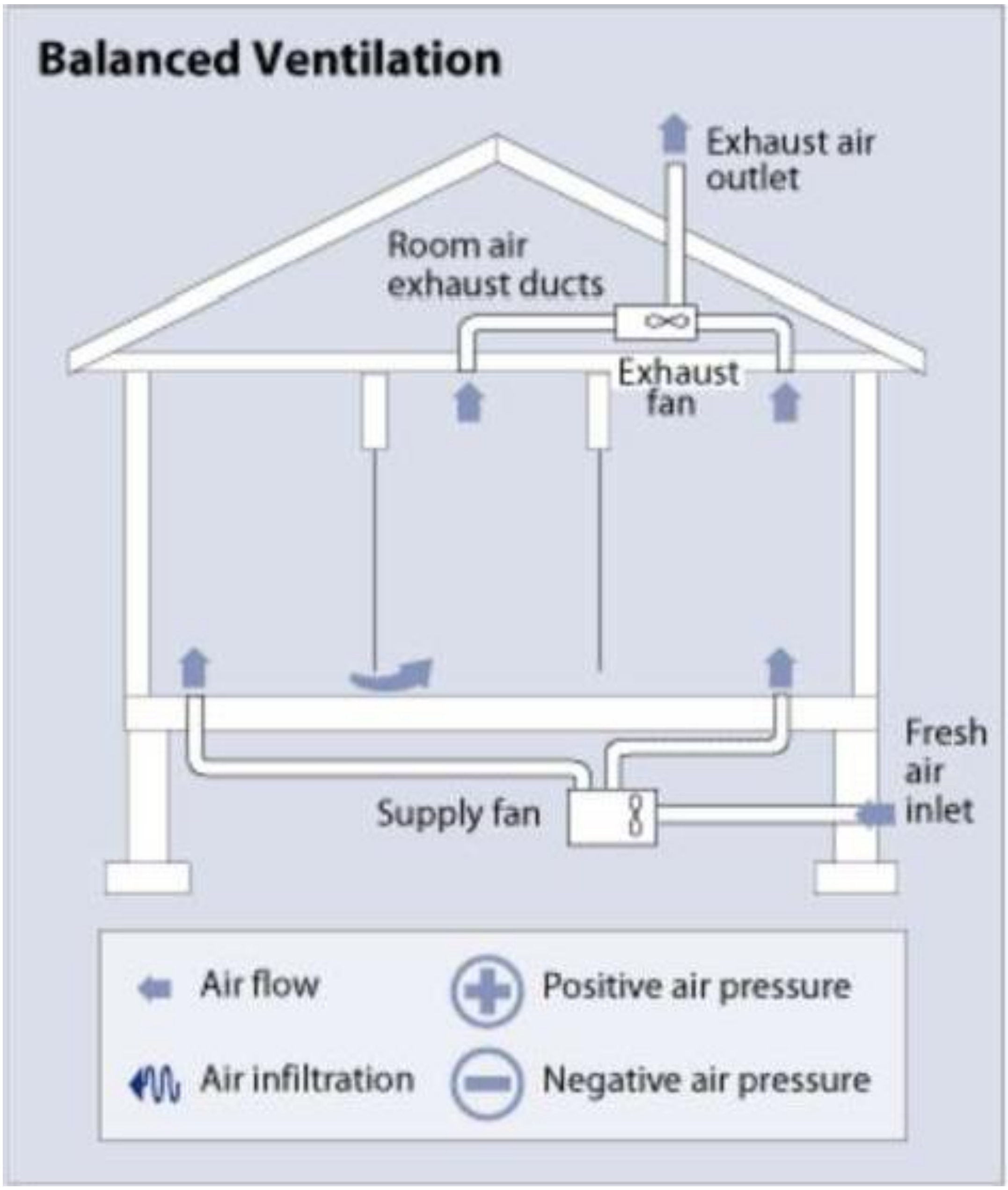


Figure: 2.6.5 Balance ventilation systems

CHAPTER-03

Theory & Methodology

3.1 Working Procedure:

In this thesis ice based cool thermal energy storage technologies are investigated. The investigation methods are of experimental nature. In order to evaluate the performance of a static, indirect, external melt, ice-on-coil cool thermal energy storage system for different design arrangements and under various operating conditions. In the first phase development of a mathematical model that includes components of an ice bank system and their interconnections have been carried out. Due to the high complexity of the system and numerous design and operating parameters that influence its performance a computer application. Was designed. Input of design and operating parameters is enabled through drop down menus while the results are presented via figures, diagrams and pictures.

At first, we try to know about the available ventilation system in our country. I tried to know the advantages and disadvantages of these. Trying to create a system that can get more benefits from these costs. We divided it into two parts. There are indoor and outdoor parts. We used the AHU & fan at indoor site. We used chiller or ice plant at outdoor site. The exception that we have done here is that, to make chilled water here, not using chiller I used the ice plant. To make ice plant power, we using solar panel. At first, we tried to create an ice plant, which contained salt mixed water and there was an ice deposit container in between. To set up this plant ice, set up a Refrigeration Cycle. Where the compressor, condenser, the expansion device and the evaporator inside the plant. And we will use this plant to build chilled water. To send this child water to the floor, we use chilled water pump and condenser water pump.

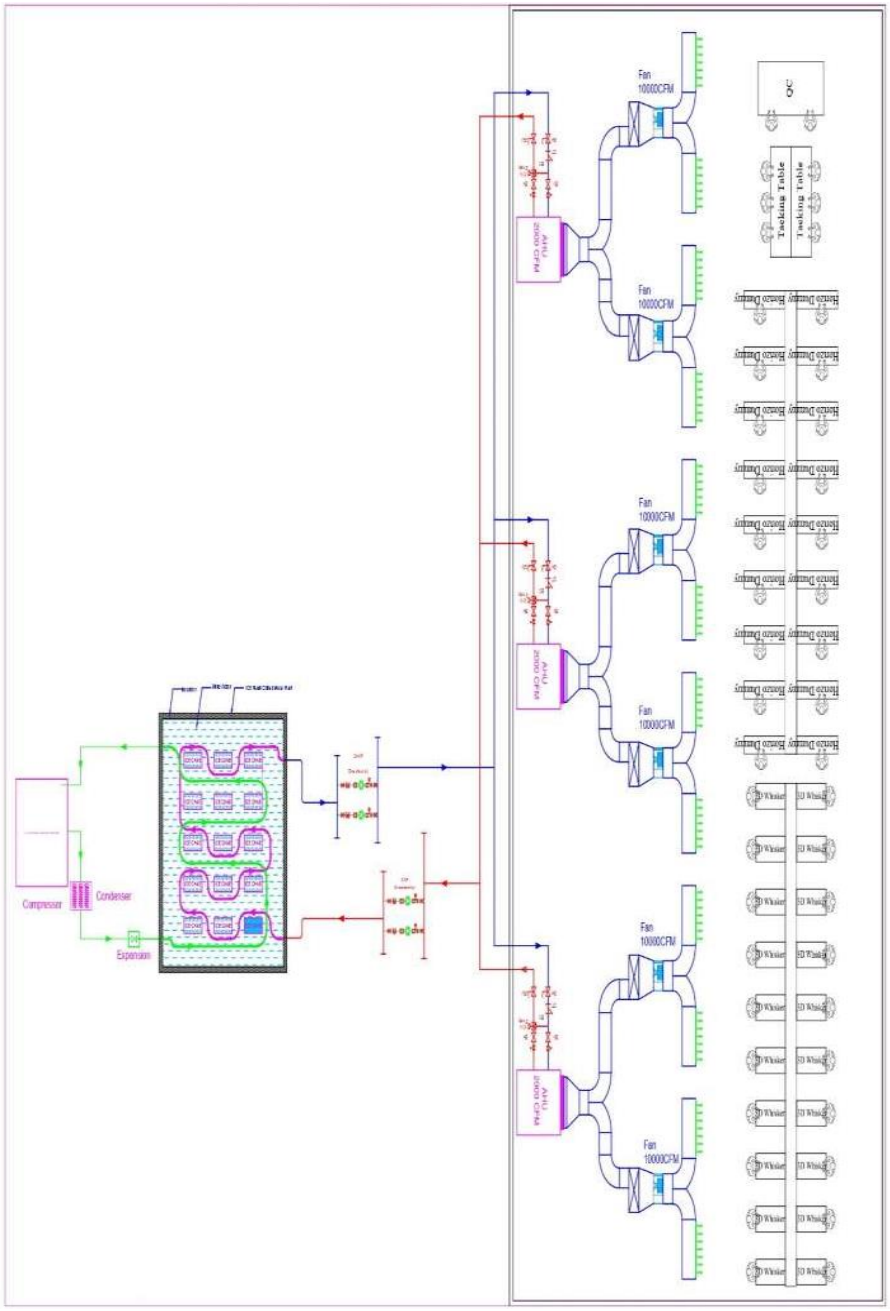


Figure 3.1.1 Thermal Storage & Combined Ventilation Systems

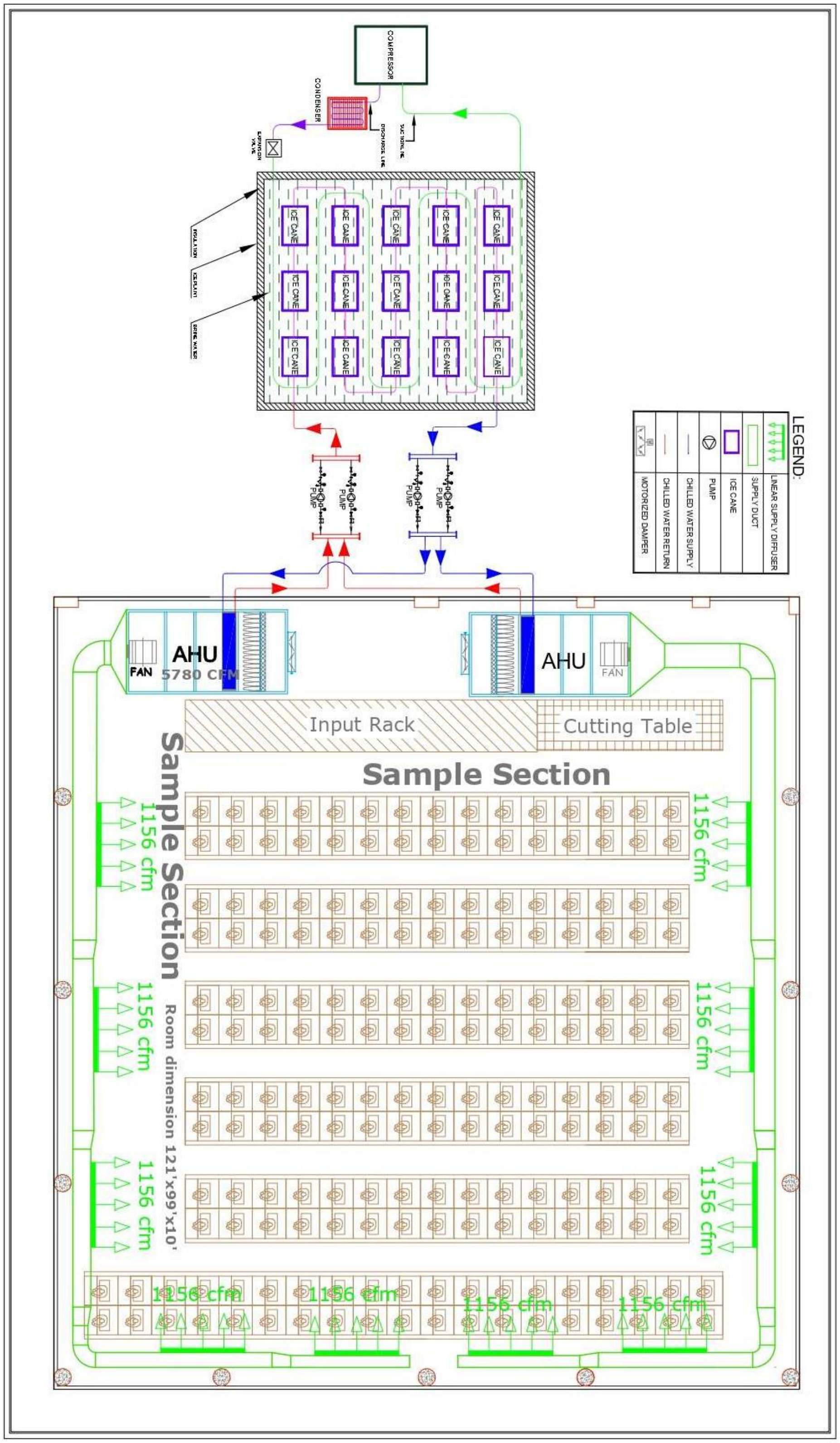


Figure 3.1.2 Thermal Storage & Combined Ventilation Systems

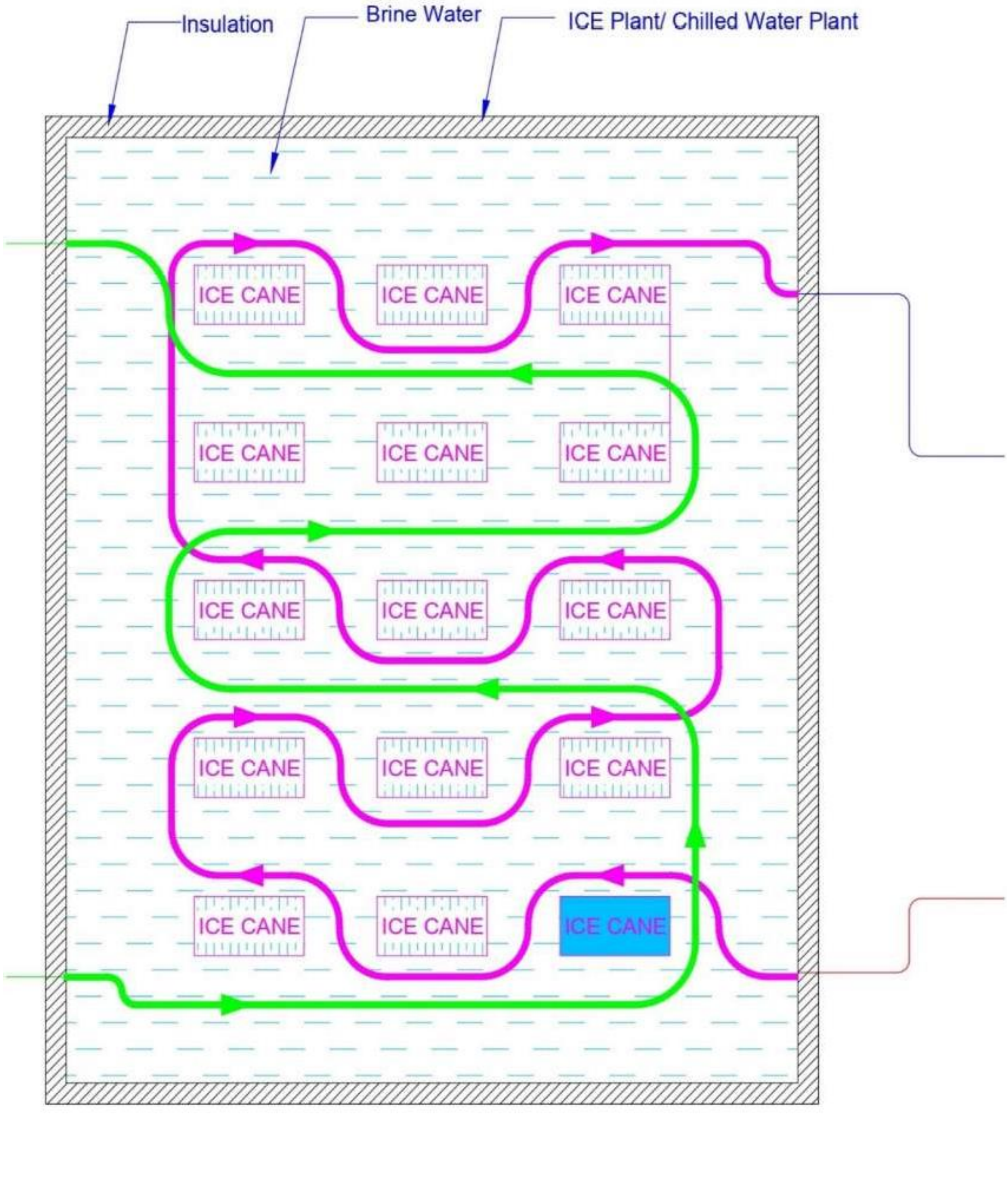


Figure 3.1.3 Thermal Storage Systems

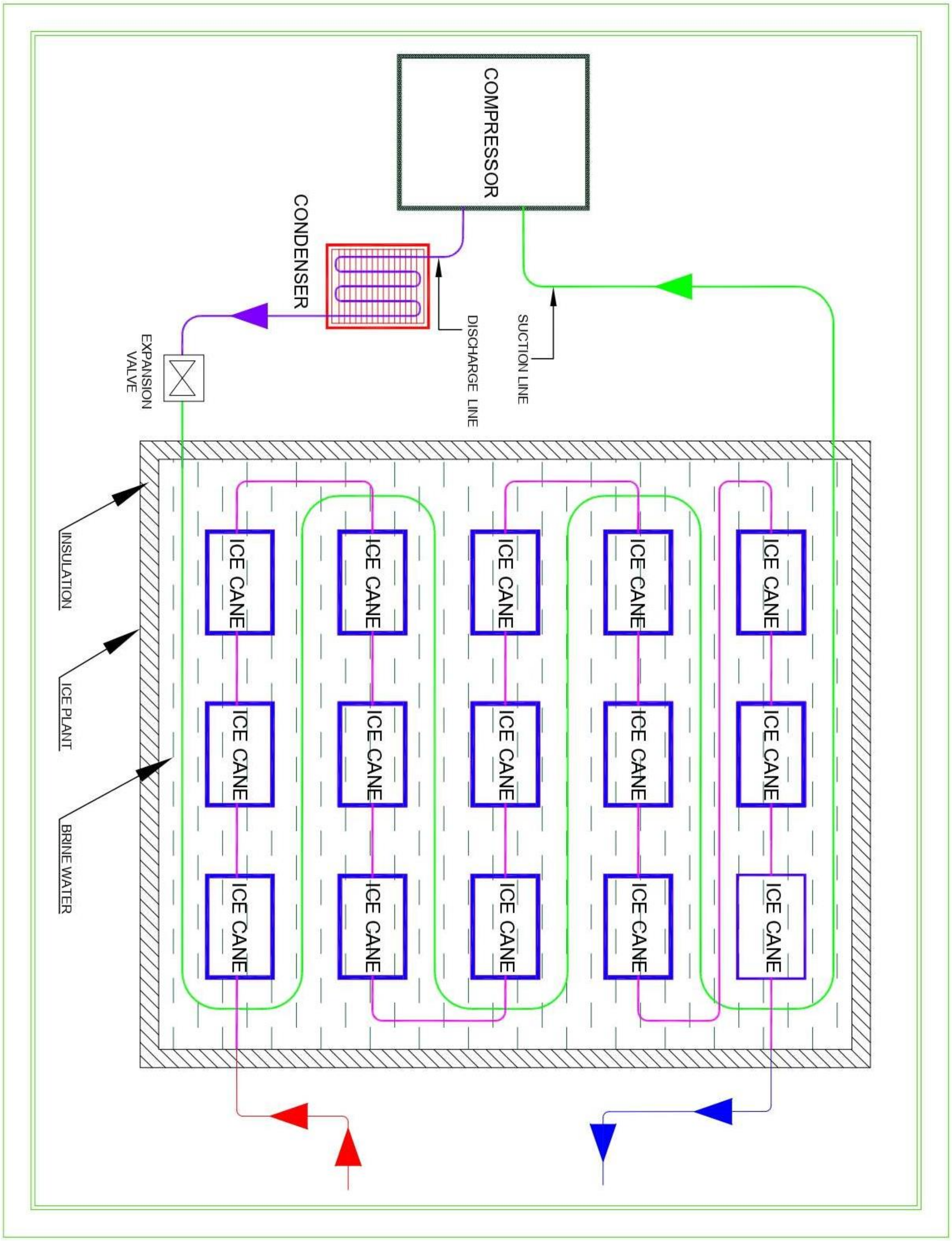


Figure 3.1.4 Thermal Storage Systems

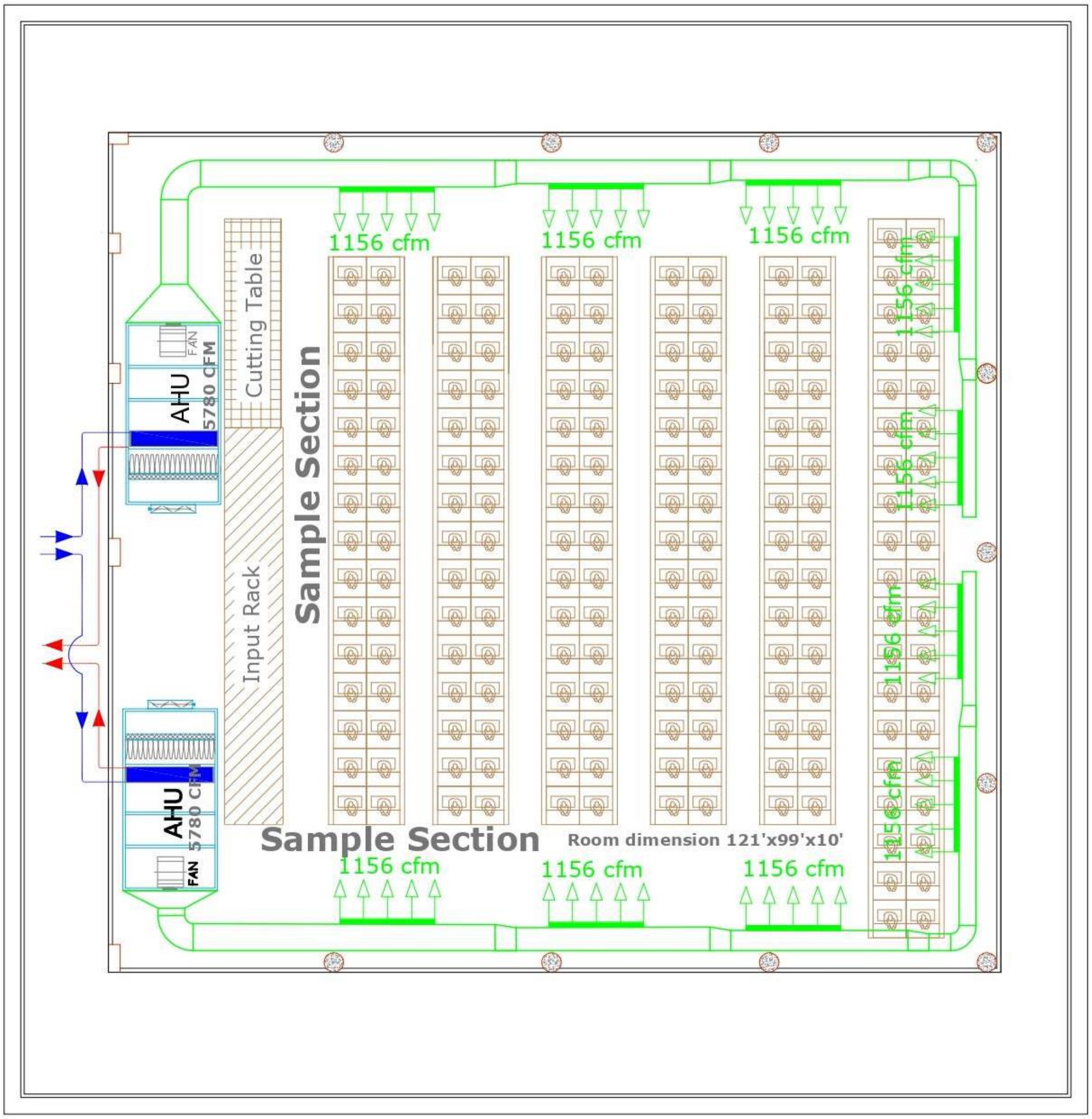


Figure 3.1.5 Combined Ventilation Systems

3.2 Multiple Inverter Compressors:

We use multiple inverter compressors in our outdoor units, depending on size, and that brings all sorts of benefits. By rotating the operating sequence of the outdoor units and individual compressors, we provide a balanced, consistent comfort. The inverter-driven compressors eliminate the under- or over-power usage, putting an end to on/off power surges as the system adjusts to changing demands. This also reduces the risk of compressor failure. Multiple inverter compressors also provide great back-up capability. If one of the compressors fails, the system will continue to operate, maintaining comfort until the faulty compressor is repaired.

Figure: 3.2.1 Multiple Inverter Compressors

3.3 Scroll Compressor:

Bryant's asymmetric design increases energy efficiency and reliability by reducing compression loss. The combination of DC inverter technology and an advanced permanent magnet DC motor makes our scroll compressors remarkably stable and robust. Scroll compressors are positive-displacement devices that work by internal compression. Air (or other gas) is drawn in, trapped, reduced in volume and, finally, discharged at the outlet port. The concept of a scroll compressor has been around for more than a century, but it took more-recent advances in manufacturing technology to make the product viable. The two main components are a stationary scroll and an identical moving scroll. Each is a precisely machined or cast part in the shape of an involute spiral. In a typical design, the second scroll is rotated 180° with respect to the first, which lets the scrolls mesh. They are bounded by a flat base and cove the moving scroll mounts on an eccentric crank offset from the center of the stationary one. The drive motor moves the scroll body in an orbital fashion about the stationary scroll, but the scroll does not rotate.

Movement creates suction that draws gas from the outer inlet openings. Gas gets trapped in crescent-shaped pockets between the two scrolls, and continuous orbiting moves it steadily toward the center, reducing volume and causing compression. Finally, it reaches the center of the assembly where pressurized gas discharges through a port. The design of the discharge port determines the amount of internal compression, similar to that in a screw compressor. However, there are practical limits on the maximum amount of compression, mainly due to the size, shape, wall thickness and strength of the scrolls, and the size and geometry of the outlet port. Nonetheless, scroll compressors can typically generate relatively high pressures — 100 to 150 psi — in single-stage units.

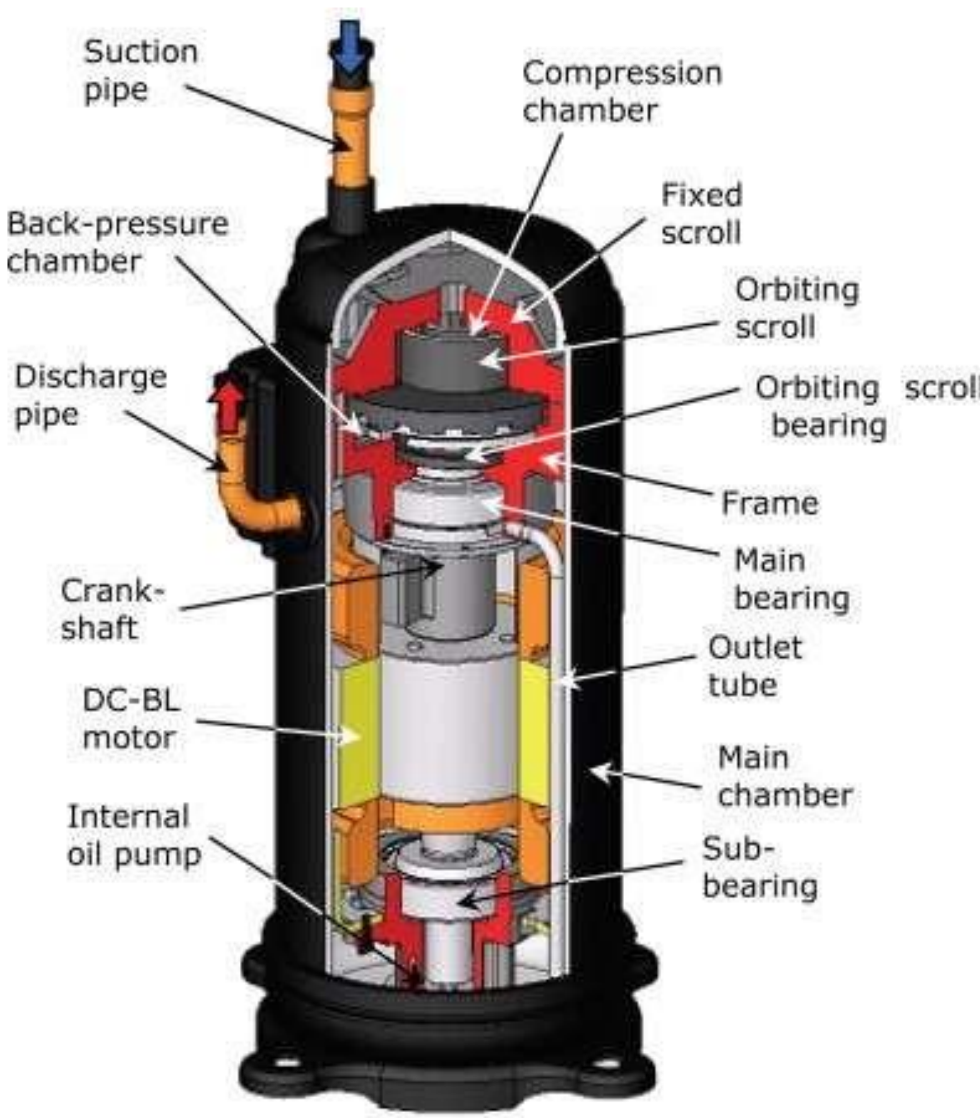


Figure: 3.3.1 Scroll Compressors

CHAPTER-04

Result and Discussion

4.1 Problem:

An air-conditioned room that stands on a well-ventilated basement measures 37 m length, 3 m high and 30 m wide. There are no heat gains through the walls other than the one facing west. Calculate the sensible, latent and total heat gains on the room, room sensible heat factor from the following information. What is the required cooling capacity?

Inside conditions: $25^{o}C$ dry bulb, 50 percent
RH Outside conditions: $43^{o}C$ dry bulb, $24^{o}C$ wet
bulb U-value for wall: 1.78 $W/m^2.K$
U-value for roof: 1.316 $W/m^2.K$
U-value for floor: 1.2 $W/m^2.K$

Effective Temp. Difference (ETD) for wall: $25^{o}C$ Effective Temp. Difference (ETD) for roof: $30^{o}C$ U-value for glass; 3.12 $W/m^2.K$

Solar Heat Gain (SHG) of glass; 300 W/m^2

Internal Shading Coefficient (SC) of glass: 0.86

Occupancy: 240 (90 W sensible heat/person) (40 W latent heat/person)

Lighting load: 33 W/m^2 of floor area

Appliance load: 30000w (Sensible) + 30000 W
(latent) Infiltration: 0.5 Air Changes per Hour (ACH)
Barometric pressure: 101 kPa

Ans.**:** From psychometric chart,

For the inside conditions of 25^oC dry bulb, 50 percent RH:

W_i = 9, 9167 x 10^{-3} kgw/kgda

For the outside conditions of 43^oC dry bulb, 24^oC wet bulb:

W_o = 0.0107 kgw/kgda, density of dry air = 1.095 kg/m^3

External loads**:**

a) Heat transfer rate through the walls: Since only west wall measuring 3m x 3m with a glass windows of 1.5m x 1.5m is exposed; the heat transfer rate through this wall is given by: $Q_{wall} = U_{wall}A_{wall}ETD_{wall}$ = 1.78 x 111 x 25 = 4.94 Kw (Sensible)

b) Heat transfer rate through roof:

$Q_{roof} = U_{roof}A_{roof}ETD_{roof}$ = 1.316 x 1110 x 30 = 43.82 Kw (Sensible)

c) Heat transfer rate through floor: Since the room stands on a well-ventilated basement, we can assume the conditions in the basement to be same as that of the outside (i.e., 43^oC dry bulb and 24^oC (Wet bulb), since the floor is not exposed to solar radiation, the driving temperature difference for the roof is the temperature difference between the outdoor and indoor, hence:

$Q_{floor} = U_{floor}A_{floor}ETD_{floor}$ = 1.2 x 1110 x 18 = 23.97 Kw (Sensible)

d) Heat transfer rate through glass: This consists of the radioactive as well as conductive components. Since no information is available on the value of CLF, it is taken as 1.0. Hence the total heat transfer rate through the glass window is given by:

$Q_{glass} = A_{glass} [U_{glass}(T_o-T_i)+SHGF_{max}SC]$ = 7.76[3.12 x 18 + 300 x 0.86] = 2.5 Kw (Sensible)

e) Heat transfer due to infiltration: The infiltration rate is 0.5 ACH, converting this into mass flow rate, the infiltration rate in kg/s is given by: m_{inf} = density of air x (ACH x volume of the room)/3600

= 1.095 x (0.5 x 37x30x3)/3600

m_{inf} = .5064 kg/s

Sensible heat transfer rate due to infiltration, $Q_{s,inf;}$

$Q_{s,inf} = m_{inf}cpm(To-Ti)$ = 8.2125 x 10-3 x 1021.6 x (43 – 25) = 151 W (Sensible)

Latent heat transfer rate due to infiltration, $Q_{l,inf}$:

$Q_{l,inf} = m_{inf}h_{fg}(W_o-W_i)$ = 0.5064x 2501x10^3(0.0107–0.0099)=16.4 W (sensible)

Internal loads:

a) Load due to occupants: The sensible and latent load due to occupants are:

$Q_{s,occ}$ = no.of occupants x SHG = 420 x 90 = 37.8 Kw

$Q_{l,occ}$ = no.of occupants x LHG = 420 x 40 = 16.8 Kw

b) Load due to lighting: Assuming a CLF value of 1.0, the load due to lighting is:

Q_{lights} = 33 x floor area = 33 x 1110 = 36.63 kw (Sensible)

c) Load due to appliance:

$Q_{s,app}$ = 30 Kw (Sensible)
$Q_{l,app}$ = 15 Kw (Latent)

Total sensible and latent loads are obtained by summing-up all the sensible and latent load components (both external as well as internal) as:

$Q_{s,total}$ = 4.94+43.82+23.97+2.5+1.51+3.60+36.63+30 = 146.97 Kw (Ans.) $Q_{l,total}$ = 16.4+16.8+15 = 33.4kw (Ans.)

Total load on the building is:

$Q_{total} = Q_{s,total} + Q_{l,total}$ = 146.97 + 33.4 = 180.37 Kw (Ans.)

Room Sensible Heat Factor (RSHF) is given by:

RSHF = $Q_{s,total}/Q_{total}$ = 146.97/180.37 = 0.814 (Ans.)

To calculate the required cooling capacity, one must know the losses in return air ducts. Ventilation may be neglected as the infiltration can take care of the small ventilation requirement. Hence using a safety factor of 1.25, the required cooling capacity is:

Required cooling capacity = 180.37 x 1.25 = 225.46 kw ≈ 64.0 TR (Ans.)

Now we need chiller this project (64X1.15) =74 TR So

need 178 GPM chilled water, Control temperature

4.2 Project Cooling load calculation:

AIR CONDITIONING LOAD ESTIMATION									
Textile	121	99	**11979**	Sun gain	10	119790	**Btu / hr**	**Outdoor cond^n:**	
Item	Length	Wide	SQ.FT		Height	CU.FT		Temp.: 100F	(180gr/ib)
SOLAR GAIN – GLASS						Factor			
								Humidity: 70%RH	
GLASS (N)		SQFT	X		X		-		
GLASS (S)		SQFT	X		X		-	**Indoor cond^n:**	
GLASS (E)		SQFT	X		X		-	Temp.: 75F	63 gr/ib)
GLASS (W)		SQFT	X		X		-	Humidity: 60%RH	
SKYLIGHT		SQFT	X		X		-	May vary (55~65) %RH	
SOLAR & TRANS GAIN - WALLS & ROOF							-		
WALL (N)	1210	SQFT	X	12	X	0.24	3,485	**Machine cond^n:**	
WALL (S)	1210	SQFT	X	12	X	0.24	3,485	Outlet Temp. : 58^{0}F	
WALL (E)	990	SQFT	X	12	X	0.24	2,851	Inlet Temp.: 75^{0}F	
WALL (W)	990	SQFT	X	12	X	0.24	2,851		
ROOF - SUN		SQFT	X		X		-	**Design Data:**	
ROOF - SHADED		SQFT	X		X	0.51	-	Total. Co. load TR	39.13
TRANS GAIN - EXCEPT WALLS & FOOF							-	**Supply air CFM**	11558
ALLGLASS		SQFT	X		X		-	Outdoor air CFM	1597
PARTITION		SQFT	X		X		-		
CEILING		SQFT	X		X		-	**For Supply Air:**	
FLOOR		SQFT	X		X		-	RSH (BTU/HR)/1.09*(75-58)	
INFILTRATION		SQFT	X		X		-	Supply Air CFM	**11,558**
INTERNAL HEAT							-		
PEOPLE		240		People	x	245	58,800		
POWER		30		Hp or KW	X	3,400	102,000	**Given data:**	
LIGHTS		8,970		Watts	x	3.4	30,498	No. of light (TA)	299
APPLICANCES, ETC.							-	No. of Persons	240
ADDITIONAL HEAT GAINS							-	Machine Elec. KW	30

						SUB TOTAL:	**203,970**
STORAGE				SQFT	X		
						SUB TOTAL:	**203,970**
SAFEY FACTOR						5%	10,199
						ROOM SENSIBLE HEAT (RSH):	**214,169**
SUPPLY DUCT	SUPPLY DUCT		&	FAN H.P.			
HEAT GAIN 1%	LEAK LOSS	1%				2%	4283
O / A CFM	1597	24	F	BF	0.2	1.08	8280
						EFFECTIVE ROOM SENSIBLE HEAT (ERSH):	**226,732**
		LATENT HEAT					
INFILTRATION		CFM	X		Gr/lb		-
PEOPLE	240		X			205	49,200
STEAM		Lb/hr					-
APPLICANCES, ETC.			X				
ADDITIONAL HEAT GAINS					X		
VAPOR TRANS		Sq. ft.			Gr/lb		
						SUBTOTAL:	**49,200**
SAFEY FACTOR						2%	4283
						ROOM LATENT HEAT (RLH):	**53,483**
SUPPLY DUCT LEAKAAGE LOSS						2%	1,070
OUTDOOR AIR	1597	CFM	180	Gr/lb	0.2BF	0.68	39,099
						EFFECTIVE ROOM LATENT HEAT [ERLH]:	**93,652**
						EFFECTIVE ROOM TOTAL HEAT [ERTH]:	**320,384**
		OUTDOOR AIR HEAT					
SENSIBLE	1597	CFM	28	F X	(1-0.2 BF) X	1.09	38,997
LATENT HEAT	1597	CFM	117	Gr/lb	(1-0.2 BF) X	0.68	101,659
RETURN DUCT HEAT GAIN 1%RSH			RETURN DUCT LEAK GAIN 1%RSH			1%	2142
HP PUMP			DEHUM. & PIPE				
	1	%RSH	LOSS	1	%RSH	3%	6425
						GRAND TOTAL HEAT OR AIR CONDITIONING LOAD:	**469,607**

Table: 4.2.1 cooling load calculation sheet

110 GPM Ice melting water, Control temperature.

We know,

$Q= ms\ \Delta T+ml$

$= 2080x4200x25+2080x336000= 917280000$

Here

M= mass of water

S= Water specific heat

ΔT= Temperature Different

$= 917280000/14400= 63700w = 64\ kw$

TABLE 19–EQUIVALENT TEMPERATURE DIFFERENCE (DEG F)

FOR DARK COLORED† , SUNLIT AND SHADED WALLS*

Based on Dark Colored Walls; 95 F db Outdoor Design Temp; Constant 80F db Room Temp; 20 deg F Daily Range; 24-hour Operation; July and 40 N. Lat.†

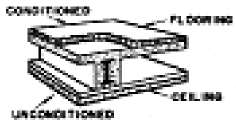
EXPOSURE	WEIGHTS OF WALL ‡ (lb/sq ft)	SUN TIME																							
		AM							PM													AM				
		6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5
Northeast	20	5	15	22	23	24	19	14	13	12	13	14	14	14	12	10	8	6	4	2	0	-2	-3	-4	-2
	60	-1	-2	-2	5	24	22	20	15	10	11	12	13	14	13	12	11	10	8	6	4	2	1	0	-1
	100	4	3	4	4	4	10	16	16	14	12	10	11	12	12	12	11	10	9	8	7	6	6	5	6
	140	5	5	6	6	6	6	8	10	14	16	14	12	10	10	10	10	10	10	10	9	9	8	7	7
East	20	1	17	30	33	36	35	32	20	12	13	14	14	14	12	10	8	6	4	2	0	-1	-2	-3	-3
	60	-1	-1	9	21	30	31	31	19	14	13	12	13	14	13	12	11	10	8	5	4	3	1	1	0
	100	5	5	6	8	14	20	24	25	24	20	18	16	14	14	14	13	12	11	10	9	8	7	7	6
	140	11	10	10	9	8	9	10	15	18	19	18	17	16	14	12	12	14	14	14	13	13	12	12	12
Southeast	20	10	8	13	19	26	27	28	26	21	19	16	15	14	12	10	8	6	4	2	0	-1	-1	-2	-2
	60	1	1	5	12	20	24	26	26	26	21	16	16	14	13	12	11	10	8	6	5	4	3	3	2
	100	7	7	6	6	6	11	16	17	18	19	18	16	14	13	12	11	10	10	10	9	9	8	8	7
	140	9	8	8	8	8	7	6	11	14	15	16	18	16	15	14	10	12	12	12	11	11	10	10	9
South	20	-1	-2	-4	1	4	14	22	27	30	28	26	20	16	12	10	7	6	3	2	1	1	0	0	-1
	60	-1	-3	-4	-3	-2	7	12	20	24	25	26	23	20	16	12	10	6	5	4	2	1	1	0	-1
	100	4	4	2	2	2	3	4	8	12	15	16	18	18	15	14	11	10	9	8	8	7	6	6	5
	140	7	6	6	5	4	4	4	4	4	7	10	13	14	15	16	16	14	12	10	10	9	9	8	7
Southwest	20	-2	-4	-4	-2	0	4	6	19	26	34	40	41	42	30	24	12	6	4	2	1	1	0	-1	-1
	60	2	1	0	0	0	1	2	8	12	24	32	38	38	35	34	20	10	7	6	5	4	4	3	3
	100	7	5	6	5	4	5	6	7	8	12	14	19	22	23	24	23	22	16	10	10	9	9	8	7
	140	8	8	8	8	8	7	6	6	6	7	8	9	10	15	18	19	20	13	8	8	8	8	8	8
West	20	-2	-3	-4	-2	0	3	6	14	20	32	40	45	46	34	22	14	8	5	2	1	0	0	-1	-1
	60	2	1	0	0	0	2	4	7	10	19	26	34	40	41	36	28	16	10	6	5	4	3	3	2
	100	7	7	6	6	6	6	6	7	8	10	12	17	20	25	28	27	26	19	14	12	11	10	9	8
	140	12	11	10	9	8	8	8	8	10	10	10	11	12	14	16	21	22	23	22	20	18	16	15	13
Northwest	20	-2	-4	-4	-2	0	3	6	10	12	19	24	33	40	37	34	18	6	4	2	0	-1	-1	-2	-2
	60	-2	-3	-4	-3	-2	0	2	8	8	10	12	21	30	31	32	21	12	8	6	4	3	1	0	-1
	100	5	4	4	4	4	4	4	4	4	5	6	9	12	17	20	21	22	14	8	7	7	6	6	5
	140	8	7	6	6	6	6	6	6	6	6	6	7	8	9	10	14	18	19	20	16	7	11	10	9
North (Shade)	20	-3	-3	-4	-3	-2	1	4	8	10	12	14	13	12	10	8	6	4	2	0	0	13	-1	-2	-2
	60	-3	-3	-4	-3	-2	-1	0	3	6	8	10	11	12	12	12	10	6	5	4	2	-1	0	-1	-2
	100	1	1	0	0	0	0	0	1	2	3	4	5	5	5	6	7	6	5	4	3	1	2	2	1
	140	1	1	0	0	0	0	0	0	0	1	2	3	4	5	6	7	8	7	6	4	3	2	2	1
		6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5
		AM							PM													AM				
		SUN TIME																							

Table 4.2.1 Equivalent Temperature Different Chart

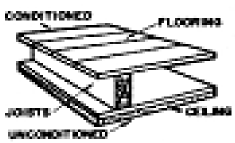
TABLE 29—TRANSMISSION COEFFICIENT U—CEILING AND FLOOR, (Heat Flow Up)

Based on Still Air Both Sides, Btu/(hr) (sq ft) (deg F temp diff)

All numbers in parentheses indicate weight per sq ft. Total weight per sq ft is sum of ceiling and floor.



FLOOR	CONCRETE SUBFLOOR	THICKNESS (inches) and WEIGHT (lb per sq ft)	MASONRY CEILING: Not Furred: None or 1/2" Sand Plaster (5)	Not Furred: 1/2" Lt Wt Plaster (3)	Not Furred: Acoustical Tile Glued: 1/2" Tile (1)	Acoustical Tile Glued: 3/4" Tile (1)	Suspended or Furred: Metal Lath Plastered: 3/4" Sand Plaster (7)	Metal Lath Plastered: 3/4" Lt Wt Plaster (3)	3/8" Gypsum or Wood Lath Plastered: 1/2" Sand Plaster (5)	3/8" Gypsum or Wood Lath Plastered: 1/2" Lt Wt Plaster (2)	Insulating Board Plain or 1/2" Sand Agg Plastered: 1/2" Board (2)	Insulating Board Plain or 1/2" Sand Agg Plastered: 1" Board (4)	Acoustical Tile on Furring or 3/8" Gypsum: 1/2" Tile (1)	Acoustical Tile on Furring or 3/8" Gypsum: 3/4" Tile (1)
None or 1/8" Linoleum or Floor Tile	Sand Agg	2 (19)	.70	.53	.38	.31	.43	.38	.44	.41	.26	.19	.28	.24
		4 (39)	.63	.49	.36	.30	.41	.36	.41	.38	.25	.18	.26	.23
		6 (59)	.57	.45	.34	.28	.38	.34	.39	.36	.24	.18	.25	.22
		8 (79)	.52	.42	.32	.27	.36	.32	.37	.34	.23	.17	.24	.21
		10 (99)	.48	.39	.31	.26	.34	.31	.35	.32	.23	.17	.23	.21
	Lt Wt Agg 80 lb/ft³	2 (15)	.48	.39	.31	.26	.34	.31	.35	.32	.23	.17	.23	.21
		4 (28)	.35	.30	.25	.22	.27	.25	.37	.26	.19	.15	.20	.18
		6 (41)	.27	.24	.21	.18	.22	.21	.22	.21	.17	.13	.17	.15
1 5/8" Wood Block on Slab	Sand Agg	2 (20)	.47	.39	.30	.26	.33	.30	.33	.40	.22	.17	.23	.20
		4 (40)	.44	.36	.29	.25	.31	.28	.32	.38	.22	.16	.22	.20
		6 (60)	.41	.34	.28	.24	.30	.27	.30	.36	.21	.16	.22	.19
		8 (80)	.38	.33	.26	.23	.28	.26	.29	.34	.20	.15	.21	.19
		10 (100)	.36	.31	.25	.22	.27	.25	.27	.32	.19	.15	.20	.18
	Lt Wt Agg 80 lb/ft³	2 (16)	.36	.31	.25	.22	.27	.25	.27	.32	.19	.15	.20	.18
		4 (29)	.28	.25	.21	.19	.22	.21	.23	.26	.17	.13	.17	.16
		6 (42)	.23	.21	.18	.16	.19	.18	.19	.21	.15	.12	.15	.14
Floor Tile or 1/8" Linoleum on 5/8" Plywood on 2" x 2" Sleepers	Sand Agg	2 (22)	.32	.28	.23	.21	.31	.28	.32	.30	.18	.14	.18	.17
		4 (42)	.31	.27	.23	.20	.30	.27	.30	.28	.18	.14	.18	.17
		6 (62)	.29	.26	.22	.19	.28	.26	.29	.27	.17	.14	.18	.16
		8 (82)	.28	.25	.21	.19	.27	.25	.27	.26	.17	.13	.17	.16
		10 (102)	.27	.24	.20	.18	.26	.24	.26	.25	.16	.13	.17	.15
	Lt Wt Agg 80 lb/ft³	2 (19)	.27	.24	.20	.18	.26	.24	.26	.25	.16	.13	.17	.15
		4 (31)	.22	.20	.17	.16	.22	.20	.22	.21	.14	.12	.15	.14
		6 (44)	.19	.17	.15	.14	.18	.17	.19	.18	.13	.11	.13	.12
3/4" Hardwood on 25/32" Subfloor on 2" x 2" Sleepers	Sand Agg	2 (24)	.26	.23	.20	.18	.25	.23	.25	.24	.16	.13	.16	.15
		4 (44)	.25	.22	.19	.17	.24	.22	.24	.23	.16	.13	.16	.15
		6 (64)	.24	.21	.19	.17	.23	.21	.23	.22	.15	.12	.16	.14
		8 (84)	.23	.21	.18	.16	.22	.21	.22	.21	.15	.12	.15	.14
		10 (104)	.22	.20	.17	.16	.21	.20	.22	.21	.14	.12	.15	.14
	Lt Wt Agg 80 lb/ft³	2 (20)	.22	.20	.17	.16	.21	.20	.22	.21	.14	.12	.15	.14
		4 (33)	.19	.17	.15	.14	.18	.17	.18	.18	.13	.11	.13	.12
		6 (46)	.16	.15	.14	.13	.16	.15	.16	.16	.12	.099	.12	.11



FLOOR	SUBFLOOR	FRAME CONSTRUCTION CEILING: Not Furred: None	Not Furred: Acoustical Tile Glued: 1/2" Tile (1)	Acoustical Tile Glued: 3/4" Tile (1)	Suspended or Furred: Metal Lath Plastered: 3/4" Sand Plaster (7)	Metal Lath Plastered: 3/4" Lt Wt Plaster (3)	3/8" Gypsum or Wood Lath Plastered: 1/2" Sand Plaster (5)	3/8" Gypsum or Wood Lath Plastered: 1/2" Lt Wt Plaster (2)	Insulating Board Plain or 1/2" Sand Agg Plastered: 1/2" Board (2)	Insulating Board Plain or 1/2" Sand Agg Plastered: 1" Board (4)	Acoustical Tile on Furring or 3/8" Gypsum: 1/2" Tile (1)	Acoustical Tile on Furring or 3/8" Gypsum: 3/4" Tile (1)
None	None				.74	.59	.61	.54	.37	.24	.39	.31
	25/32" Wood (2)	.45	.30	.26	.31	.28	.29	.27	.22	.17	.23	.20
	2" Wood (5)	.27	.20	.18	.22	.20	.20	.19	.17	.14	.17	.15
1/2" Ceramic Tile on 1 1/2" Cement	25/32" Wood (21)	.38	.21	.19	.28	.26	.26	.24	.20	.16	.21	.19
	2" Wood (24)	.24	.19	.17	.20	.19	.19	.18	.16	.13	.16	.15
3/4" Hardwood Floor or Linoleum on 5/8" Plywood	25/32" Wood (5)	.33	.24	.21	.25	.23	.23	.22	.18	.15	.19	.17
	2" Wood (7)	.22	.17	.16	.18	.17	.17	.17	.15	.12	.15	.14
1/8" Linoleum on 1/4" Hardboard on 1/2" Insulating Board	25/32" Wood (5)	.28	.21	.19	.22	.20	.21	.20	.17	.14	.18	.16
	2" Wood (8)	.20	.16	.15	.17	.16	.16	.16	.14	.12	.14	.13

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Equations: Heat flow up, Unconditioned space below: Heat Gain, Btu/hr = (Area, sq ft) × (U value) × (outdoor temp − inside temp − 5 F).

Kitchen or boiler room below: Heat Gain, Btu/hr = (Area, sq ft) × (U value) × (actual temp diff, or outdoor temp − inside temp + 15 F to 25 F).

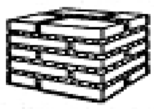
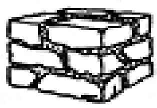
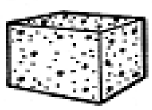
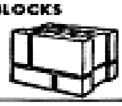
Table: 4.2.2 Transmission Coefficient U- ceiling and roof

TABLE 21—TRANSMISSION COEFFICIENT U—MASONRY WALLS*

FOR SUMMER AND WINTER

Btu/(hr) (sq ft) (deg F temp diff)

All numbers in parentheses indicate weight per sq ft. Total weight per sq ft is sum of wall and finishes.

EXTERIOR FINISH		THICKNESS (Inches) and WEIGHT (lb per sq ft)	INTERIOR FINISH: None	⅜" Gypsum Board (Plaster Board) (2)	⅝" Plaster on Wall: Sand Agg (6)	⅝" Plaster on Wall: Lt Wt Agg (3)	Metal Lath Plastered on Furring: ¾" Sand Plaster (7)	Metal Lath Plastered on Furring: ¾" Lt Wt Plaster (3)	⅜" Gypsum or Wood Lath Plastered on Furring: ½" Sand Plaster (7)	⅜" Gypsum or Wood Lath Plastered on Furring: ½" Lt Wt Plaster (2)	Insulating Board Plain or Plastered on Furring: ½" Board (2)	Insulating Board Plain or Plastered on Furring: 1" Board (4)
SOLID BRICK 	Face & Common	8 (87)	.48	.41	.45	.41	.31	.28	.29	.27	.22	.16
		12 (123)	.35	.31	.33	.30	.25	.33	.23	.22	.19	.14
		16 (173)	.27	.25	.26	.25	.21	.19	.20	.19	.16	.13
	Common Only	8 (80)	.41	.36	.39	.35	.28	.26	.26	.25	.21	.15
		12 (120)	.31	.28	.30	.27	.23	.22	.22	.21	.18	.14
		16 (160)	.25	.23	.24	.23	.19	.18	.18	.18	.16	.12
STONE 		8 (100)	.67	.55	.63	.53	.39	.34	.35	.32	.26	.18
		12 (150)	.55	.47	.52	.46	.34	.31	.31	.29	.24	.17
		16 (200)	.47	.41	.45	.40	.31	.28	.28	.27	.22	.16
		24 (300)	.36	.32	.35	.32	.26	.24	.24	.23	.19	.15
ADOBE-BLOCKS OR BRICK		8 (26)	.34	.30	.32	.30	.25	.23	.23	.22	18	.12
		12 (40)	.35	.23	.24	.23	.20	.18	.18	.18	.15	.14
POURED CONCRETE 	140 lb/cu ft	6 (70)	.75	.55	.69	.58	.41	.36	.37	.34	.27	.18
		8 (93)	.67	.49	.63	.53	.39	.34	.35	.32	.26	.17
		10 (117)	.61	.44	.57	.49	.36	.32	.33	.31	.25	.17
		12 (140)	.55	.40	.52	.45	.34	.31	.31	.29	.24	.16
	80 lb/cu ft	6 (40)	.31	.28	.30	.27	.23	.21	.22	.21	.18	.14
		8 (53)	.25	.23	.24	.23	.19	.18	.18	.18	.16	.12
		10 (66)	.21	.19	.20	.19	.17	.16	.15	.14	.14	.11
		12 (80)	.18	.17	.17	.15	.15	.14	.14	.14	.12	.10
	30 lb/cu ft	6 (15)	.13	.13	.13	.13	.12	.11	.11	.11	.13	.09
		8 (20)	.10	.10	.10	.10	.09	.09	.09	.09	.10	.07
		10 (25)	.08	.08	.08	.08	.08	.07	.08	.07	.08	.06
		12 (30)	.07	.07	.07	.07	.07	.07	.06	.06	.07	.06
HOLLOW CONCRETE BLOCKS 	Sand & Gravel Agg	8 (43)	.52	.44	.48	.43	.33	.29	.30	.28	.23	.17
		12 (63)	.47	.41	.45	.40	.31	.28	.28	.27	.22	.16
	Cinder Agg	8 (37)	.39	.35	.37	.34	.27	.25	.25	.24	.20	.15
		12 (53)	.36	.33	.35	.32	.26	.24	.23	.23	.19	.15
	Lt Wt Agg	8 (32)	.35	.32	.34	.31	.26	.23	.24	.22	.19	.15
		12 (43)	.32	.29	.31	.28	.24	.22	.22	.21	.18	.14
STUCCO ON HOLLOW CLAY TILE		8 (39)	.36	.32	.34	.32	.26	.24	.24	.23	.19	.15
		10 (44)	.32	.29	.31	.28	.23	.22	.22	.21	.18	.14
		12 (49)	.29	.27	.28	.26	.22	.20	.21	.20	.17	.13

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Equations: Heat Gain, Btu/hr = (Area, sq ft) × (U value) × (equivalent temp diff, Table 19)
Heat Loss, Btu/hr = (Area, sq ft) × (U value) × (outdoor temp − inside temp)

*For addition of insulation and air spaces to above walls, refer to *Table 31, page 75.*

Table: 4.2.3 Transmission Coefficient U- Wall

TABLE 53-HEAT GAIN FROM ELECTRIC MOTORS

CONTINUOUS OPERATION*

NAMEPLATE† OR BRAKE HORSEPOWER	FULL LOAD MOTOR EFFICIENCY PERCENT	LOCATION OF EQUIPMENT WITH RESPECT TO CONDITIONED SPACE OR AIR STREAM‡		
		Motor In- Driven Machine in HPX2545 / % Eff	Motor Out- Driven Machine in HPX2545	Motor In- Driven Machine out HPX2545 (1-% Eff) / % Eff
		Btu per Hour		
1/20	40	320	130	190
1/12	49	430	210	220
1/8	55	580	320	260
1/6	60	710	430	280
1/4	64	1,000	640	360
1/3	66	1,290	850	440
1/2	70	1,820	1,280	540
3/4	72	2,680	1,930	750
1	79	3,220	2,540	680
1 1/2	80	4,770	3,820	950
2	80	6,380	5,100	1,280
3	81	9,450	7,650	1,800
5	82	15,600	12,800	2,800
7 1/2	85	22,500	19,100	3,400
10	85	30,000	25,500	4,500
15	86	44,500	38,200	6,300
20	87	58,500	51,000	7,500
25	88	72,400	63,600	8,800
30	89	85,800	76,400	9,400
40	89	115,000	102,000	13,000
50	89	143,000	127,000	16,000
60	89	172,000	153,000	19,000
75	90	212,000	191,000	21,000
100	90	284,000	255,000	29,000
125	90	354,000	318,000	36,000
150	91	420,000	382,000	38,000
200	91	560,000	510,000	50,000
250	91	700,000	636,000	64,000

*For intermittent operation, an appropriate usage factor should be used, preferably measured.

†If motors are overloaded and amount of overloading is unknown, multiply the above heat gain factors by the following maximum service factors:

Maximum Service Factors

Horsepower	1/20 - 1/8	1/6 - 1/3	1/2 - 3/4	1	1 1/2 - 2	3 - 250
AC Open Type	1.4	1.35	1.25	1.25	1.20	1.15
DC Open Type	–	–	–	1.15	1.15	1.15

Table: 4.2.4 Heat gain From Electric Motor

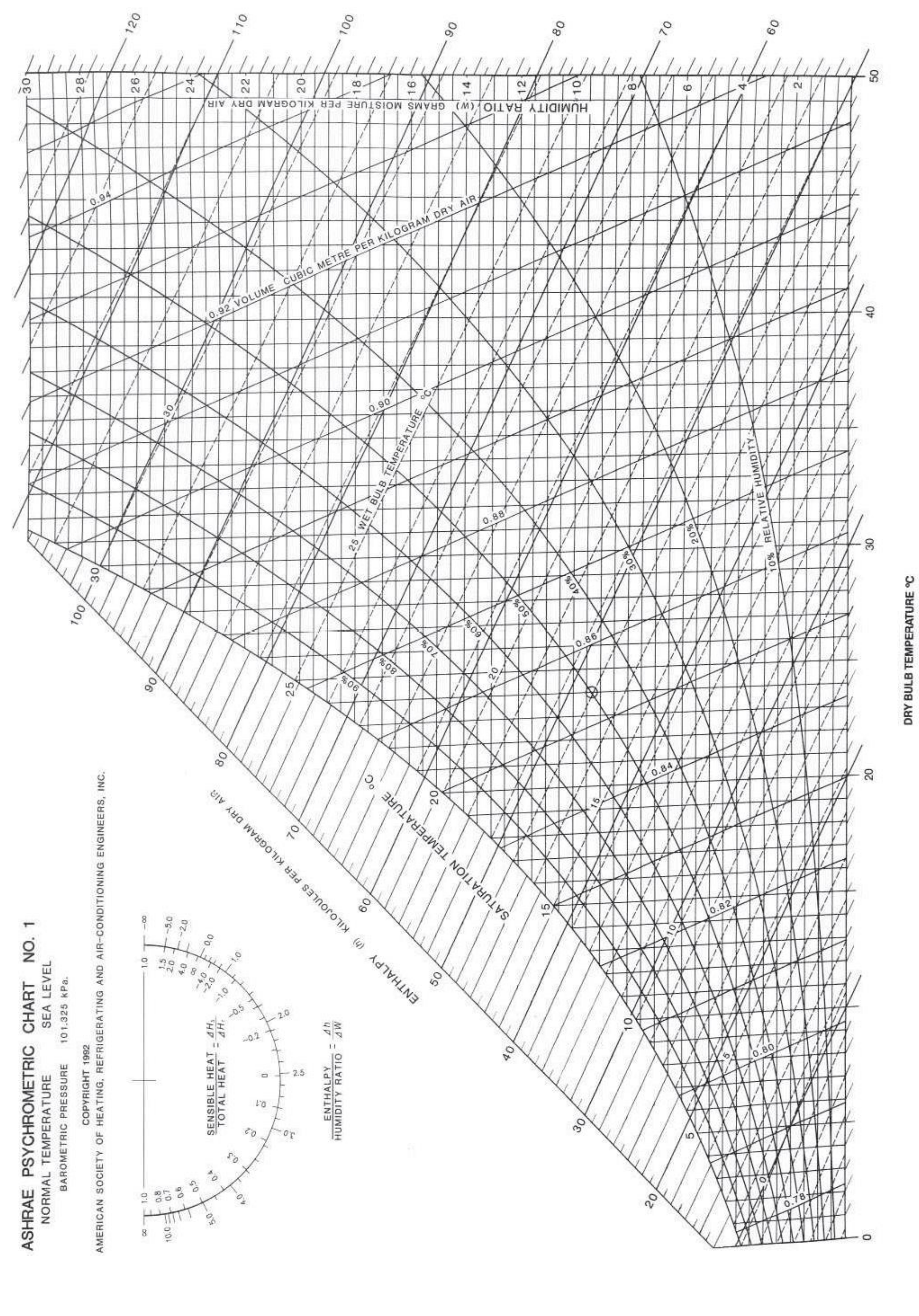

Table 4.2.5 Psychometric chart

4.3 Result:

If we use Chiller System in our Project, The Cooling Capacity would be around 75 TR. It will also use around 101 kW of Electrical Power per hour operation time.

Our Ice Bank System has a Cooling Capacity of 40 TR. 64 kW compressor are required for this Project which will use around 23 kW of Electrical Power per hour operation time.

Maintenance of Ice Bank System is relatively

easier. Installation procedure is quite easier.

This is more environments friendly

Unit cost is lower that Chilling system.

Increased operating flexibility Energy savings in case when the generation of cooling is performed during the night resulting in higher efficiency of refrigeration equipment due to lower ambient and therefore condensing temperatures.

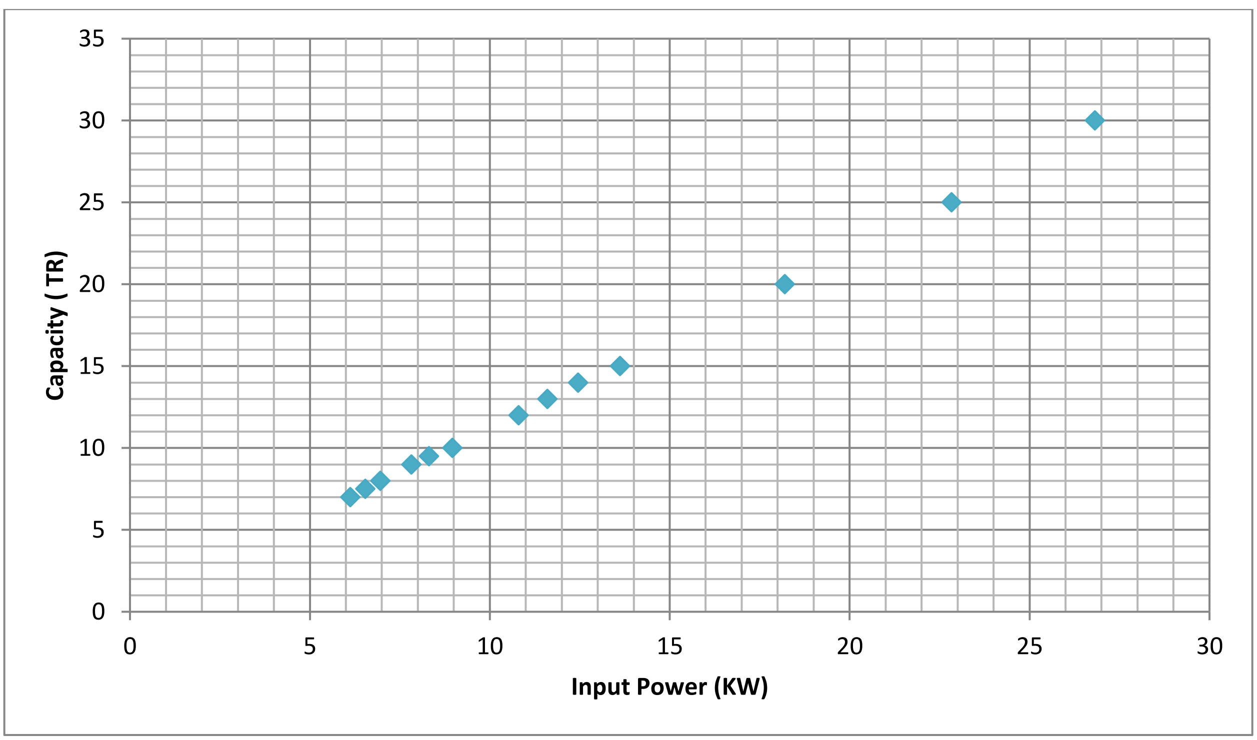

Figure: 4.3.1 Graphical representation of the results.

Electricity Bill calculation:

Note: Compressor Running at 4 hours Per Day
Compressor Input power 23 kw
So, Electricity bill per day= (23x4x9.25) = 851 Taka / Day
Electricity cost Per Month= 92x30= 2760 kWh = 25530 TK

COP With Chiller

$$\text{Co-efficient of Performance, (COP)} = \frac{\text{Output}}{\text{Input}} = \frac{1055}{404} = 2.611$$

COP without Chiller

$$\text{Co-efficient of Performance, (COP)} = \frac{\text{Output}}{\text{Input}} = \frac{563}{92} = 6.11$$

CHAPTER 05

Conclusion

Experimental investigation on the ice bank thermal storage system was performed. Static, indirect, cool thermal storage system, with an external ice-on-coil melting was considered. A chiller with ice storage offers you more operational flexibility, while reducing your space cooling expenses. Just keep in mind that each project is unique, and the potential savings from ice storage strongly depend on your electricity tariff. You can get a professional energy audit and energy modeling for your building to identify the most promising upgrades

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