Evaluation of Energy and Airflow Performance of Data Centers with Centralized Thermosiphon

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Abstract

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The need of fast and uninterrupted online services and applications in our daily life leads to rapid expansion in both quantity and capacity of data centers to handle these huge amounts of digital information. However, the energy use associated with hundreds of information technology (IT) equipment running 24/7 in data centers creates a huge burden to the global economy and environment. Globally, electricity consumption of data centers accounts for about 238 billion kWh per year which is corresponding to about 1.3% of total global electricity consumption. In a typical data center, about 30-50% of its total energy is dedicated to remove the heat from running the IT equipment all year round. Conventional cooling energy saving strategy is to utilize outdoor air directly to cool the IT equipment when outdoor temperature is lower, which known as direct airside free cooling. However, the main concerns about this approach is the breakdown of IT equipment due to poor outdoor air quality. This could be a limiting factor in certain locations for using the direct free cooling system. Therefore, an indirect free cooling approach is more interested to be used under poor outdoor air environments.

In this thesis, an indirect airside free cooling based on thermosiphon loop is proposed and investigated to reduce energy consumption and improve the IT equipment reliability in a novel vertical data center (VDC) which is designed by Vert.com Inc. An energy model was established to evaluate the energy performance of this new proposed design in different selected cities across North America. The energy results show that approximately 41% to 59% of an annual overall

HVAC energy are saved with the thermosiphon free cooling system depending on the local climate conditions in comparison to the data center without any free cooling implementations.

Analysis of indoor airflow distribution was also conducted in this VDC project because it can help to optimize different design options and enhance cooling efficiency. Unlike other typical data centers that are designed horizontally and occupied a large footprint like warehouses, the proposed data center in this study is designed vertically like a tower with a compact rectangular form. In this thesis, two proposed locations of the indoor thermosiphon heat exchangers were compared and analyzed through CFD simulation. The simulation results indicate that there are many turbulent flows developed inside the building, especially at 90° bends, which can affect the air distribution uniformity and cooling performance through the heat exchanger.

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Nomenclature

A_{floor}	gross floor area (ft^2)
C_p	specific heat of air at constant pressure (kJ/kg-°C)
LPD	lighting power density (W/ft^2)
LHG	latent heat gain per occupant (W)
$\dot{m}$	air mass flow rate of (kg/s)
N	number of people in the space
P_{fan}	condenser fan power (W)
$q_{lighting}$	total power output of lighting (W)
q_{UPS}	total power output of UPS (W)
q_{PDU}	total power output of PDU (W)
$R_{chiller\_HX}$	partial energy use ratio of chiller during the thermosiphon free cooling
$R_{chiller\_oa}$	partial energy use ratio of chiller during the direct airside free cooling
R_{HX}	partial energy use ratio of condenser fan during the thermosiphon free cooling
R_m	fraction of outdoor air to total air supply
SHG	sensible heat gain per occupant (W)
T	air dry-bulb temperature (°C)
$T_{desired\_supp}$	desired supply air temperature (°C)
$T_{Lowest\_HX\_supp}$	lowest possible supply air temperature supplied by the heat exchanger (°C)

$T_{r,in}$, $T_{r,out}$	air temperature in and out of a rack (°C)
ΔT_{HX}	temperature difference provided by the thermosiphon heat exchanger (°C)
W	humidity ratio (kgv/kga)
ε	heat exchanger effectiveness
$\emptyset$	relative humidity (%)

Subscript

c	cold
h	hot
i	in
l	latent
LL	lower limit
m	mixed
o	out
oa	outdoor air
recir	recirculating
ret	return
r	rack
s	sensible
supp	supply
UL	upper limit
wb	wet-bulb

Abbreviation

ASHRAE	American Society of Heating, Refrigeration, and Air Conditioning Engineers
CAF	Conductive Anodic Failure
CFD	Computational Fluid Dynamics
CRAC	Computer Room Air Conditioner
CRAH	Computer Room Air Handler
FDS	Fire Dynamic Simulator
HDF	Hygroscopic Dust Failure
HX	Heat Exchanger
HVAC	Heating, Ventilating, and Air Conditioning
IT	Information Technology
ITE	Information Technology Equipment
PDU	Power Distribution Unit
PUE	Power Usage Effectiveness
RH	Relative Humidity
RHI	Return Heat Index
SHI	Supply Heat Index
UPS	Uninterruptable Power Supply
VDC	Vertical Data Center

1.0 Introduction

In today's modern society, the internet has become an indispensable part of daily life being used for sharing information, social media, and conducting business. All of these online activities are collected, managed and delivered through the uses of data centers (Delforge, 2015). Data centers are centralized facilities that providing a controlled environment (i.e. temperature, humidity) to house all information technology (IT) equipment such as computing servers, storage and networking devices to ultimately support our online activities (Geng, 2015). They exist in various forms and sizes from a simple server rack contained within an office space to large stand-alone units such as those of Google, and Facebook in which the entire building is filled with arrays of server racks. As society's desire for data transfer increases, more powerful and larger capacity data centers will be required to satisfy this hunger for speed and digital content delivery. Thus, the global environmental impact and energy consumption of these ever expanding data centers will be increasing concern in the coming future.

1.1 Need for Building Energy Efficient Data Centers

The high power density of IT equipment causes data centers to become energy intensive buildings. A typical data center can consume 10 to 100 times more electrical energy per unit area than a standard office building (CoE, 2016). Globally, electricity consumption of data centers has doubled from 2000 to 2005 and increased by 56% from 2005 to 2010. In 2010, electricity consumed by global data centers was estimated to be between 1.1% and 1.5% of the total global electricity consumption (avg. 238 billion kWh). For the U.S., it was between 1.7% and 2.2% of the total electricity consumption (avg. 78 billion kWh) according to studies of Koomey (2011). It is also estimated that electricity consumption of data centers in the U.S. alone will be about 140 billion kWh per year by 2020, which is equivalent to an annual output of fifty 500 mega-watt coal fired power plants and 150 million metric ton of CO_2 emission (Delforge, 2015).

In brief, the continued expansion of the data center industry and its high annual electricity consumption leads to huge amounts of greenhouse gases and other harmful pollutants to our environment from burning traditional energy sources such as fossil fuels. It is crucial to design energy-efficient and environmentally sustainable data centers. There are many focus areas to optimize the energy efficiency in a data center. For example, mechanical infrastructure (cooling system, free cooling) and airflow management (air distribution, internal layout) are major focus areas in this thesis. Other efficiency opportunities could be in electrical infrastructure (power supply, power distribution units), IT equipment (high efficient server, virtualization), etc.

1.2 Data Center Cooling and Airflow Management

Heat generated from running the electronic equipment must be removed properly in order to provide IT services with continuous operation and minimal downtime. Additionally, unlike the office buildings which require seasonal heating and cooling of their indoor environments, data centers require continuous cooling all year round. The majority of data centers today are still air cooled at the IT load (Almoli et al., 2012) which requires conditioned air to be supplied to the inlet of the racks to facilitate cooling. In a conventional air-cooled data center, the energy consumes by the air conditioning system accounts for 30-50% of its total energy consumption as illustrated in Figure 1 (Zhang et al., 2014).

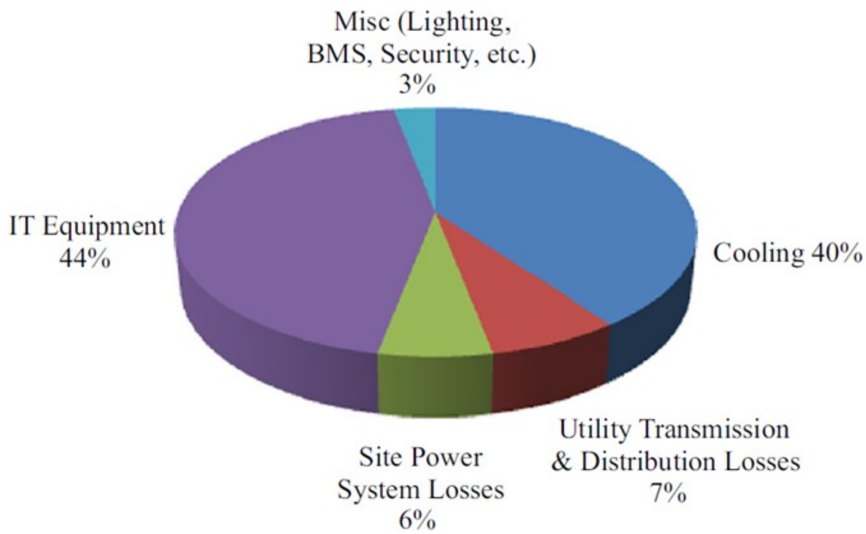


Figure 1 Typical Data Center Energy Use Breakdown (Zhang et al., 2014)

Vert.com has developed a novel vertical data center (VDC) that works in conjunction with direct outdoor air free cooling (economizer) technology to reduce the annual cooling energy use and CO_2 emission. More detail about the design is discussed in chapter 3. In short, the direct outdoor air free cooling system brings the colder outdoor air directly into the data center to cool the computer racks. This allows chillers or compressors to be shut off or operated at reduced capacity to save energy. However, poor outdoor air quality could affect the overall system performance and maintenance. Gaseous contamination (e.g. SO_2, H_2S) and particulate matter (dust, fine particles) could still penetrate through the filters and cause breakdown to the internal computer components (ASHRAE DS-8, 2013). To solve this design issue, an alternate free cooling solution is proposed to incorporate with the VDC design called the thermosiphon system. The thermosiphon itself is a heat transferring device as described more in chapter 2. Its closed loop operation feature allows heat transfer to occur between indoor air and outdoor air while keeping these two air streams unmixed. As a result, the thermosiphon system prevents the air pollutants from entering into data center while saving energy.

Another important area requiring attention is the airflow management when designing a new data center or trouble shooting an existing one. Air is the main medium for transporting heat and moisture in an air-cooled data center, the internal room architecture, rack placement, supply/return air openings, etc. can have large impacts on the air distribution. Cooling air must be effectively delivered to computer racks in order to satisfy the local cooling demand in addition to having appropriate overall cooling and fan capacity for the entire data center. The major airflow management challenge today is the recirculation of IT equipment exhaust hot air and bypassing of cooled air which causes hot spots and wasting energy (Fakhim et al. 2011). Computational Fluid Dynamics (CFD) simulation is one of the methods that can be used to model the airflow distribution in a data center. Therefore, CFD modelling can be utilized to evaluate the optimal location of thermosiphon heat exchangers to provide better overall airflow performance inside a proposed data center.

1.3 Objectives and Scope

The first objective of this thesis is to evaluate the energy performance of a data center with and without the centralized thermosiphon. The second objective is to conduct an experiment to study the thermal performance of an existing operational data center and valid the CFD simulation. The third objective is to evaluate the airflow performance of the VDC with two proposed placements for the indoor thermosiphon heat exchangers using CFD modeling.

This thesis documents the process of creating an energy model to estimate the energy use of a proposed data center design and the energy saving from the centralized thermosiphon. It is intended to support designers in making a decision during the preliminary design stage of a data center project. However, it can be also applied to existing data centers when sufficient information are available. The airflow distribution will be examined through the CFD modeling and will be validated with an existing operating data center. The cost of installing and purchasing these thermosiphon heat exchangers is not included in the scope of this thesis.

1.4 Outlines

Chapter 2 provides background knowledge and literature review of previous research regarding the thermosiphon concepts and applications, for HVAC design of data centers.

Chapter 3 describes the proposed data center layout and potential thermosiphon heat exchangers placement. Also, this chapter provides the process of establishing the energy model which includes basic inputs and equations to estimate the building cooling load, annual energy consumption and energy benefits with the airside free cooling. Both direct airside and thermosiphon free cooling approaches are compared with the each other in term of energy performance in different selected cities.

Chapter 4 analyzes and discusses the airflow performance of the new proposed VDC design during free cooling operation using CFD simulation. It also presents an on-site measurement along with CFD simulation verification of an existing operational data center.

Chapter 5 concludes the research and provides recommendations for further improvement using the centralized thermosiphon.

2.0 Literature Review

2.1 Thermosiphon

Thermosiphon refers to any device that drives the working fluid motion based on heat induced buoyancy force (natural convection). It was invented by Thomas Fowler (Lahoui and Pennel, 2008) in 1823 for the purpose of eliminating the need of conventional pumps to drive the working fluid in a heating system. The simplest form of thermosiphon is a sealed straight tube containing an appropriate amount of working fluid such as R410a refrigerant or water and oriented in vertical direction as shown in figure 2. When the lower part of the tube (evaporator section) is exposed to a warmer airstream, the working fluid absorbs the heat and vaporize. The less dense vapor rises to the top part (condenser section) and releases its heat to another colder airstream which causes the vapor condense back to liquid form. The condensed liquid returns back to the evaporator section by gravity which completing the cycle. As a result, large amounts of heat are transferred between two different temperatures sources by phase change (boiling/condensation) of the working fluid (Reay et al., 2014).

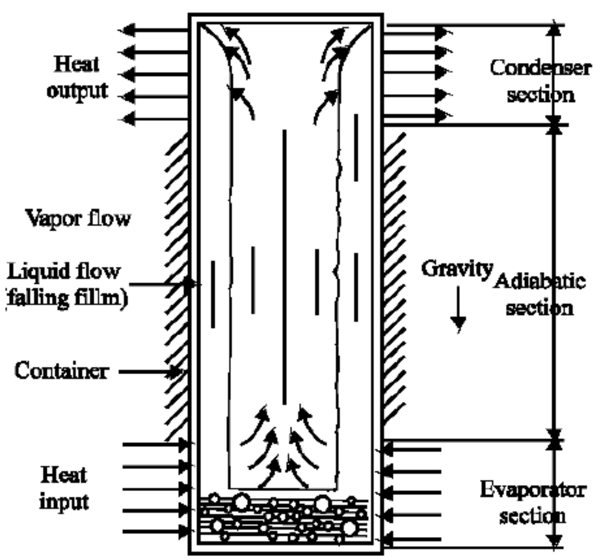


Figure 2 Schematic of a Thermosiphon Tube (Kannan and Natarjan, 2010)

Many research groups have performed fundamental studies of the thermosiphon regarding its heat transfer features at different conditions. For example, effect of filling ratio (Kannan and Natarajan, 2010; Payakaruk et al., 2000), different working fluids (Azizi et al., 2013; Payakaruk et al., 2000) and various titled angles (Zhang et al, 2014).

Another commonly used configuration of thermosiphon is the coil typed thermosiphon loop as shown in Figure 3. The condenser and evaporator coils can be set over long distance apart with connecting piping which does not require two airstreams to be adjacent to each other. The working principle in the thermosiphon loop is the same as the tube style where the condenser section must be located above the evaporator section to allow gravity to move the condensed fluid back to the evaporator section. (Chapter 26, ASHRAE, 2012). The thermosiphon is also referred to as a wickless heat pipe and has been used in many heat transferring applications such as solar water heating (Chien et al., 2011), building waste heat recovery (Ma et al., 2013), ground permafrost stabilization (Holubec, 2008), and geothermal heat extraction (Atrens et al., 2010). Recently, the thermosiphon is also an effective free cooling technology in data center applications as will be reviewed in section 2.2.4 free cooling section.

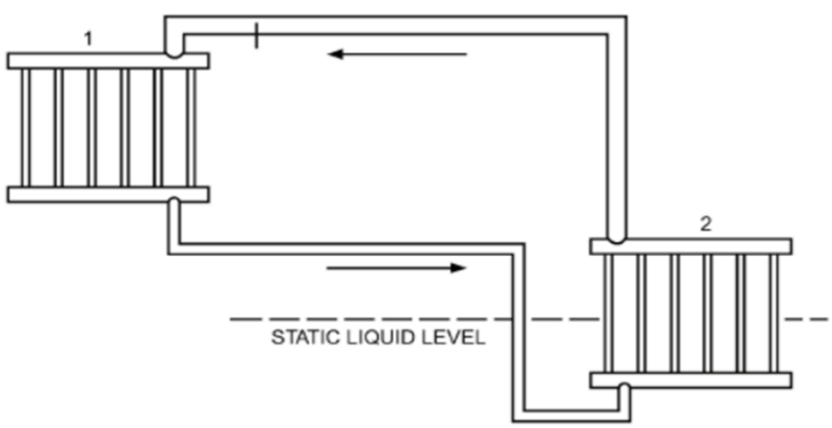


Figure 3 Schematic of Closed Thermosiphon loop (Chapter 26, ASHRAE, 2012)

2.2 HVAC for Data Centers

HVAC stands for heating, ventilation, and air condition and it generally serves the following main functions in buildings: 1) to provide the heating or cooling energy 2) to control and maintain satisfactory indoor environment conditions (temperature, humidity, air cleanness, noise, etc.), 3) to distribute conditioned air and outdoor fresh air to conditioned space (Wang, 2001).

There are many industry codes, standards, and guidelines developed to assist engineers to design a better data center HVAC system for efficient energy use. For example, the American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE) published the ASHRAE 90.1 Energy Standards for Buildings provides the minimum energy efficiency requirements of equipment. ASHRAE 62.1 provides minimum ventilation rate for acceptable indoor air quality for occupants. International Energy Conservation Code (IECC) and California Building Energy Efficiency Standards: Title 24 also provide guidelines when implementing the air and water economizers.

ASHRAE Technical Committee (TC) 9.9 and ANSI/BICSI 002-2014 - Data Center Design and Implementation Best Practices are also dedicated resources that regularly provide guidelines, publications, and other essentials information related to data centers and electronic equipment. Designers can access such information to design an energy efficient cooling and stable data center operation as well.

2.2.1 IT Equipment Environment Specification

The indoor environment plays an important role in a data center. It influences not only the IT equipment's reliability and performance but also the HVAC energy consumption. Additionally, the indoor environment requirements could vary from one data center to another because of the different types of IT equipment or different brands or even the facility manager operating strategies (Chapter 19, ASHRAE, 2011). So, ASHRAE TC 9.9 created the first version of thermal guidelines in 2004 for air-cooled equipment with the goal of providing a common and agreed sets of environmental guidelines that are reliable while providing energy-efficient operation for the IT industry (ASHRAE DS-1, 2012).

ASHRAE TC 9.9 also released two versions and created several environmental classes. The latest thermal guideline (2011) is shown in tables 1 and 2. The "A" classes are designed for data centers applications ranked from stricter to less control of indoor environment while other two classes for general offices or homes.

Table 1 Classes Definitions for Air-cooled Equipment (ASHRAE DS-1, 2012).

Classes	Applications	IT Equipment (ITE)	Environment Control
A1	Data Center	Enterprise servers, storage products	Tightly Controlled
A2		Volume servers storage products, personal computers, workstations	Some Control
A3			
A4			
B	Office, home, transportable environment, etc.	Personal computers, workstations, laptops, and printers	Minimal Control
C	Point-of-Sale, Light Industrial, Factory, etc.	Point of sale equipment, ruggedized controllers, or computers and PDAs	No Control

Table 2 shows the recommended temperature and humidity operating range that the facilities should be maintained under normal situations. These temperatures and humidity represent the inlet environment conditions of the IT equipment. Within this operating range there is little impact on the server energy consumption however there is large impact on the cooling system energy (Geng 2015).

Relative humidity (RH) is also another important parameter for equipment reliability. If the relative humidity is too low, it can produce an electrostatic discharge (ESD) and cause the equipment to malfunction (Chapter 19, ASHRAE, 2011). If the relative humidity is too high, it can cause hardware failure due to hygroscopic dust failure (HDF), conductive anodic failure (CAF), corrosion rate, and even condensation (ASHRAE DS-8, 2013, Chapter 19, ASHRAE, 2011). Therefore, keeping the inlet of IT equipment within this recommended design range, it ensures an energy efficient and reliable operation.

Keeping at a strict temperature and humidity operating range is energy intensive, therefore, in an effort to reduce the operating cost, the ASHRAE TC 9.9 has further expanded the operating envelope for each class and called it “Allowable” range to offer a more flexible indoor control conditions and increase free cooling available hours in a year (ASHRAE DS-1, 2012). Figure 4 shows an example of the recommended and allowable range of classic A on a psychrometric chart. The ASHRAE TC9.9 claims that the IT equipment is still functional if operated beyond the recommended range but within the allowable environmental range, however, there is no indication of its reliability and its exposure time for that operation (ASHRAE DS-1, 2012).

Table 2 2011 ASHRAE TC 9.9 Thermal Guideline for Air-cooled Equipment (ASHRAE DS-1, 2012).

Classes	Recommended Temperature Range	Recommended Humidity Range	Allowable Temperature Range	Allowable Humidity Range
A1	18 - 27 °C	5.5 - 15 °C DP and to 60% RH	15 - 32 °C	20% to 80% RH and Max 17 °C DP
A2			10 - 35 °C	20% to 80% RH and Max 21 °C DP
A3			5 - 40 °C	8% to 85% RH, and -12 to 24 °C DP
A4			5 - 45 °C	8% to 90% RH, and -12 to 24 °C DP

Note: DP stands for Dew Point, RH stands for Relative Humidity

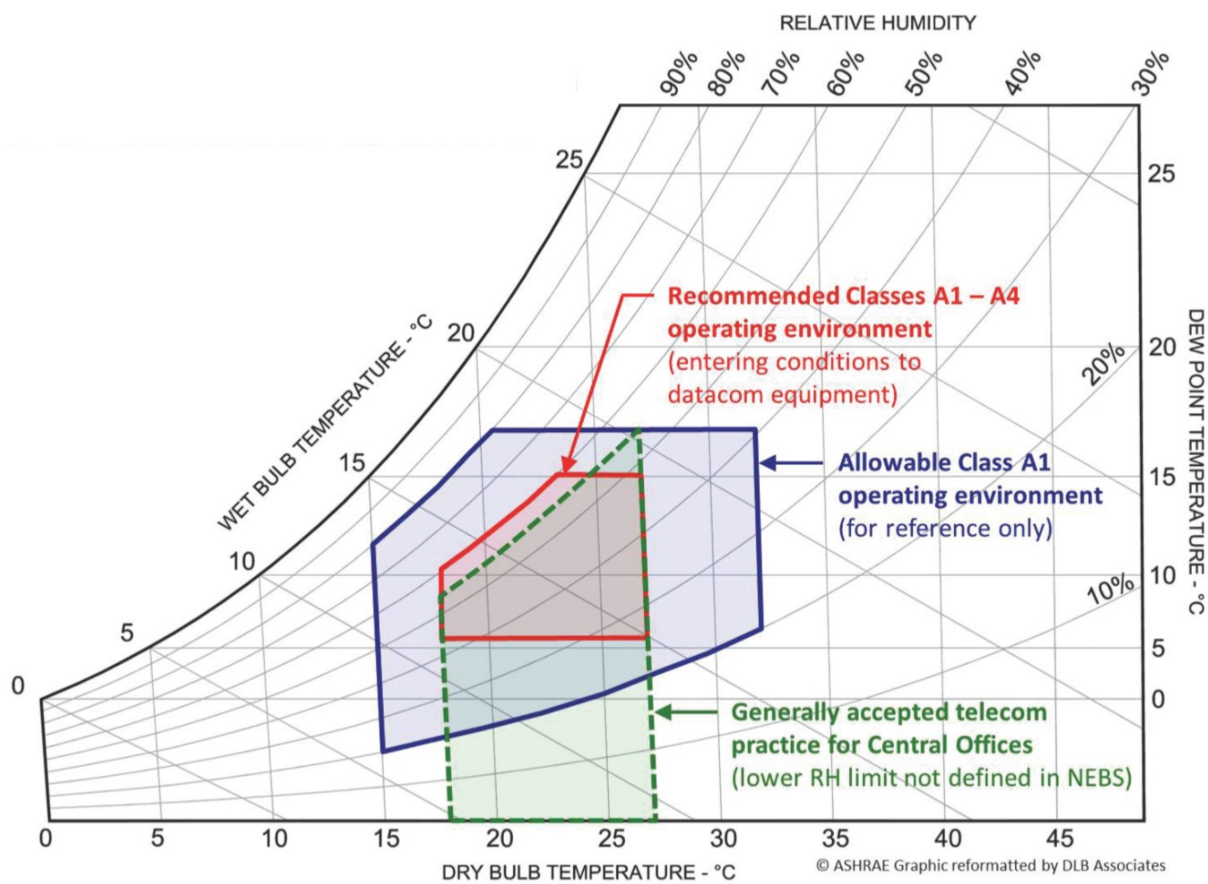


Figure 4 Example of Equipment Operating Conditions in Psychrometric Chart (ASHRAE DS-1, 2012).

2.2.2 Air Distribution Systems

Many data centers experience poor server performance and even malfunction due to hot spots as servers are increasingly configured to higher power per unit. Hot spots are locations where the IT equipment intake air temperature exceeds the recommended level (Table 2). Lin (2014) identified the root of causing hot spots is that there is inadequate useful cooling capacity to be used where it is needed due to improper airflow management. Managing the airflow pattern in the rack level and in the room level are ASHRAE recommended and effective ways to solve the hot spots problem.

2.2.2.1 Airflow through Equipment

In order to increase the rack's cooling effectiveness, Telcordia (2001) introduced a universal syntax regarding the location of the air intake and exhaust through the rack mounted equipment. The classification syntax provides a "common language" and has been adopted by the IT manufacturers. For example, front to rear (F-R) protocol represents the equipment air intake from the front side of the rack and exiting on the rear side.

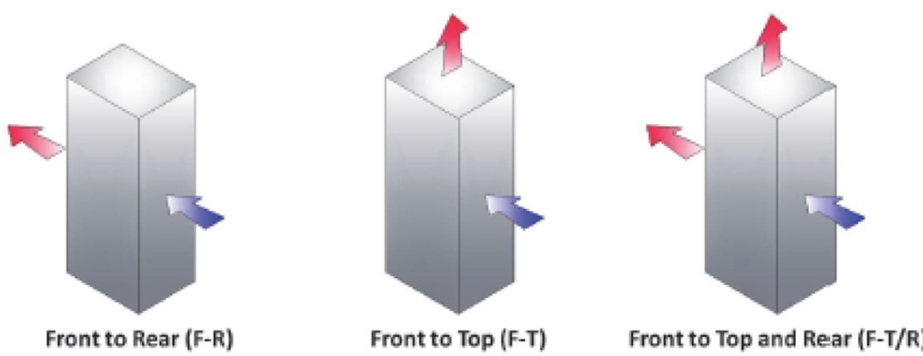


Figure 5 Recommended Airflow Directivity for IT Equipment (ASHRAE DS-1, 2012)

2.2.2.2 Airflow through Equipment Room

In addition to the equipment airflow protocols, the current best practice is to arrange equipment racks in hot-aisle/cold-aisle configuration in order to enhance the efficiency of delivering cooled air and capturing exhaust hot air (ASHRAE DS-1, 2012; Emerson Network Power, 2012). Under this arrangement, racks are generally aligned in rows with their front intake side faces each other forming the cold aisle. Similarly, rear exhaust sides of racks face each other forming the hot aisle. Conditioned air only needs to be supplied to cold aisles only either from floor perforated tiles or through ceiling opening.

Figure 6 shows an example of hot-aisle/cold-aisle with a raised configuration that is found in a typical data center. Air conditioners are located inside the IT room and conditioned air is distributed throughout the raised floor plenum (Typ. 12 to 24 inch high) passed though the perforated floor tiles feeding the IT equipment. The heated air is pulled back by the air conditioners to be cooled again which completing the cycle.

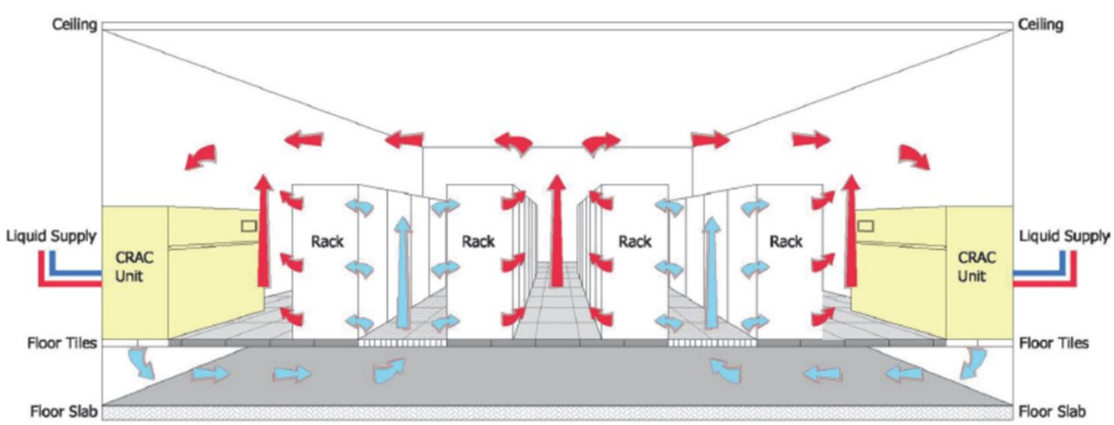


Figure 6 Classic Raised-Floor Hot-aisle/Cold-aisle Configuration (ASHRAE DS-1 2012)

Lin (2014) investigated the root cause of local hot spots in typical data centers based on a real case study performed by Schneider Electric. He explained that an inadequate cold air supply due to cold air by-passes or/and leakage (edges, cut-out holes) in a room causes server racks starting to draw air from somewhere else such as exhaust hot air from sides or/and above the racks which leading to mixings of cold and hot air. As a result, cooling energy are wasted due to mixing and hots spot are created due to recirculation.

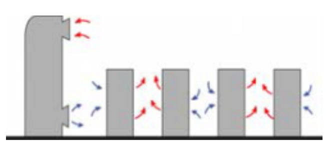
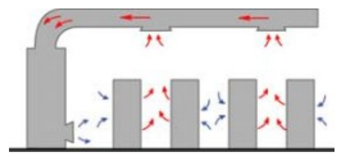
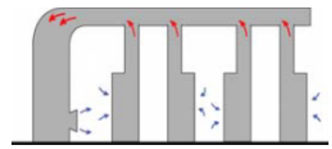
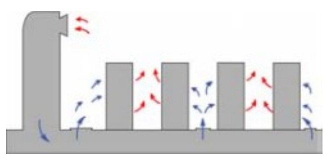
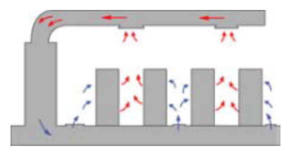
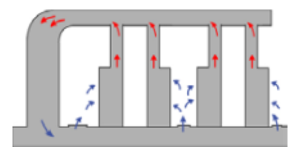
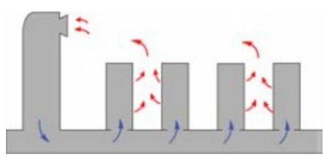
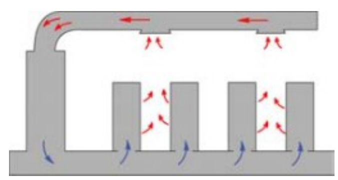
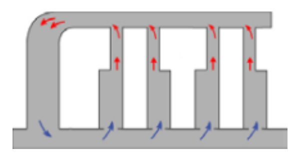
Examples of ineffective actions that had taken in the past by some facility operators trying to compensate this mixing issue are followings: lowering the supply temperature, placing perforated tiles in the hot aisle, adding additional portable cooling units (Lin, 2014). It is estimated that above attempts could lead to 10-25% more in cooling cost annually ($300,000 to $700, 000) for a 500 kW load data center over 10 year life time (Rasmussen, 2012).

2.2.2.3 Other types of Air Distribution Systems

Rasmussen (2003) has categorized various types of cooling distribution systems that are commonly applied in data centers according to the way of supplying conditioned air and returning air as shown in Table 3. Both supply and return systems can be one of the following three basic methods: 1) Flooded, 2) locally ducted, 3) Fully ducted. Toward the lower right configuration in table 3 gives the better control of airflow.

Today, the raised floor hot-aisle/cold aisle configuration is dominated in data center designs, other air delivering techniques are possible. In row-based cooling and rack rear door refrigerated-based cooling (Dunlap and Rasmussen, 2012) are increasing popularity and more precise of cooling.

Table 3 Example of 9 Basic Cooling Distribution Systems (Rasmussen, 2003)

	Flooded Return	Locally Ducted Return	Fully Ducted Return
Flood Supply			
Locally Ducted Supply			
Fully Ducted Supply			

2.2.2.4 Airflow Performance Index

Airflow performance indexes provide effective way to help designers to evaluate the air distribution and thermal conditions in a data center. Sharma et al. (2002) proposed two dimensionless parameters called the Supply Heat index (SHI) and the Return Heat Index (RHI). These two indexes are functioned of racks intake and exhaust temperatures, and the CRAC return and supply temperatures. The degree of cold air mixing with the hot air before using to cool the rack is emphasized by SHI whereas the degree of rack exhaust air mixing with cold bypass air before traveling back into the CRAC is emphasized by the RHI. Both indices are complemented to each other (sum of them equal to one). Higher the RHI or lower the SHI indicates the better thermal condition of the room (less mixing) as well as the overall cooling effectiveness.

Another dimensionless airflow performance index for evaluating the IT room thermal conditions is called the rack cooling index (RCI) as proposed by Herlin (2005). The index is based on the rack intake temperatures with ASHRAE thermal guidelines to generate a graphical representation of thermal conditions in a data center (Figure 7). He applied this index to evaluate the design between a raised floor cold air supply and an overhead cold air supply configuration. The results show that overhead cold air supply is a more effective configuration and shows a more even temperature distribution in the cold aisle intake sides under higher server heat loads.

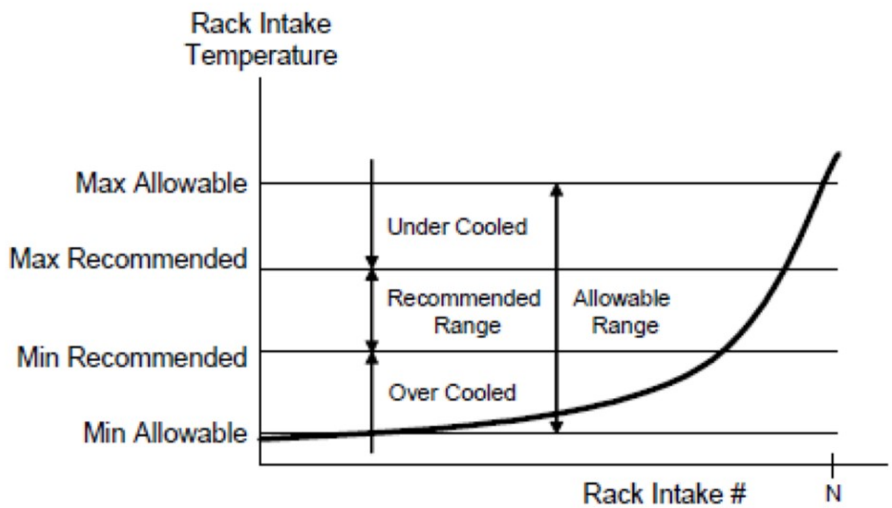


Figure 7 Graphical Definition of RCI (Herlin, 2005)

2.2.3 Cooling Systems

There are various types of cooling systems to transport the unwanted heat from indoor to outside atmosphere. Evans (2012) has studied 13 fundamental heat removal methods that are commonly applied in today as organized in table 4. Most of them utilize refrigeration-based cycle for the primary cooling. Some systems add an additional loop of fluid to isolate the refrigeration components from IT environment (i.e. chilled water systems). Others such as the direct and indirect fresh air evaporative cooling system can entirely use outdoor air for cooling in certain location.

Table 4 Fundamental of Heat Removal Methods (Evans, 2012)

System Name	Indoor air Cooling Method	Heat Transfer Medium between indoor and outdoor	Outdoor Heat Rejection Method
Chilled water system	Computer room air handler (CRAH)	Chilled Water	Water-cooled chiller + cooling tower
			Glycol cooled chiller + dry cooler
			Air cooled chiller
Pumped refrigerant for chilled water system	Pumped refrigerant heat exchanger	Chilled water	Water-cooled chiller + cooling tower
			Glycol cooled chiller + dry cooler
			Air cooled chiller
Air-cooled direct expansion (DX) system (2-piece)	Air-cooled CRAC	Refrigerant	Air cooled condenser
	Glycol-cooled CRAC	Glycol	Dry Cooler
	Water-cooled CRAC	Condenser	Cooling Tower
Air-cooled self-contained DX system (1-piece)	Air-cooled self-contained	Air	Air duct
Direct fresh air evaporative cooling system	Air duct	Air	Direct fresh air evaporative cooler
Indirect air evaporative cooling system			Indirect air evaporative cooler
Self-contained roof-top system			Roof-top cooling unit

Figure 8 below shows the schematic of the first heat removal method in Table 4, chilled water system with water-cooled chiller. The chilled water systems are typically used in large data centers with more than 200 kW IT load (Evans, 2012). The water (coolant) is first cooled by a chiller machine to a temperature about 8-15 ^{0}C (Evans, 2012). Then it is pumped to the cooling coils inside the air handler (terminal unit) to cool and/or dehumidify the IT room hot air. Finally, the water recirculated back to the chiller to be cooled again and all unwanted heat will be rejected to outdoor atmospheric air by a cooling tower.

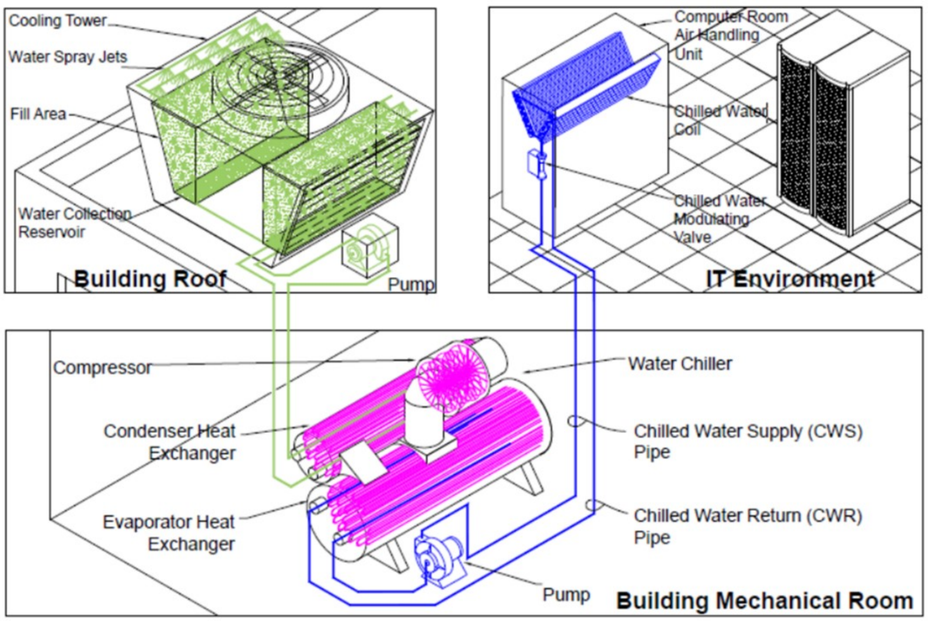


Figure 8 Schematic of Chilled Water System with water-cooled chiller (Evans, 2012)

Evans's work (2012) was intended to help IT professionals to have better understanding in the data center cooling solutions. Each configuration has its own advantages and disadvantages. Designers need to consider other factors as well to select the right cooling system. For instance, building location, local climate, building geometry, cooling load, and future expected load.

To evaluate the overall energy performance in a data center and compare it to others, the conventional benchmark, energy intensity (J/m^2) is not a sufficient indicator (Sun and Lee, 2006). For example, IT equipment could either pack densely in compact area or pack sparsely over a large area which leads to two different result of energy intensity with the same total energy use. Two additional metrics (Eqn. 2-1, 2-2) were suggested by Sun et al. (2006) in their study,

$$M1 = \frac{IT\ euqipment\ annual\ energy\ use\ (kWh)}{Total\ annual\ energy\ use\ (kWh)} \qquad \text{Eqn. 2-1}$$

$$M2 = \frac{HVAC\ annual\ energy\ use\ (kWh)}{IT\ equipment\ annual\ energy\ use\ (kWh)} \qquad \text{Eqn. 2-2}$$

M1 is the ratio of IT equipment energy consumption to the total data center energy consumption. Higher M1 means a better energy performance in a data center. In other words, the total energy consumption is smaller for the data center that has a better HVAC system, and/or better other supporting systems such as lighting and power systems while severing the same IT load. M2 is another metric focusing on the HVAC energy consumption relative to its IT energy consumption. Smaller the M2, the better the HVAC system in a given IT equipment energy use.

$$PUE = \frac{Total\ annual\ energy\ use\ (kWh)}{IT\ equipment\ annual\ energy\ use\ (kWh)} \qquad \text{Eqn. 2-3}$$

Inverse of M1 is the Power Usage Effectiveness (PUE) as developed by the Green Grid in 2007. It is estimated that about 80% of large data centers today were using this metric to monitor and benchmark their operating efficiency (Whitehead et al., 2014). The PUE can be also defined using annual average power (kW) and a PUE of 1 means the ideal case (all energy is used by IT equipment only). According the LBNL (2010) database, an average data center has a PUE value of 1.83, but some supper-efficient data centers from big companies like Google and Facebook are able to achieve around 1.1 (Sartor, 2013). It is also noted that the PUE index is not accounted for IT equipment efficiency (LBNL, 2010). As the IT equipment get older, and it will draw more power and could also give a lower PUE index.

2.2.4 Free Cooling

Another great strategy to decrease the PUE is through the use of free cooling. Free cooling is referred to any methods that utilizing the natural sources such as colder air or water to cool the process load. The free cooling operation is not totally "free", it still requires certain equipment such as fans or/and pumps for transporting the fluid. In certain climates, the annual cooling energy cost can save over 70% by operating the data center in free cooling mode (Niemann et al., 2011). Besides, it becomes a requirement today for data centers in most climate zones set by the ASHRAE Standard 90.1 (2010). There are various free cooling methods available today, the following two sections will mainly focus on exiting literatures and background knowledge of the direct airside and thermosiphon free cooling in data center applications.

2.2.4.1 Direct Airside Free Cooling

The direct airside free cooling system reduces the cooling energy of the mechanical refrigeration in a data center by flushing out the hot air inside and bringing outdoor colder air directly in to cool the computer racks. Figure 9 illustrates the concept of the system and it generally consists of ducts, dampers, mixing section, and other auxiliaries' controls (Niemann et al., 2011).

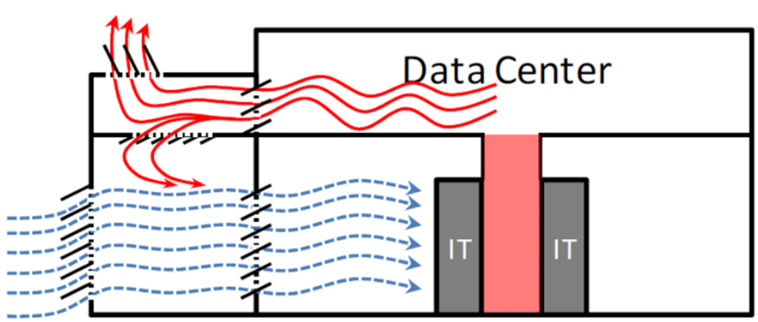


Figure 9 Schematic of Direct Airside Free Cooling in Data Center (Niemann, 2011)

The direct airside free cooling is a not a new technology, but it is a simple, effective and widely used solution around the world. According to The Green Grid survey, the direct airside free cooling is still the most common method in U.S. today for data centers with sizes ranged from 2,500 to 50,000 square foot or more (Kaiser, 2011). Furthermore, The Green Grid organization (Harvey et al., 2012) published free cooling maps for North America, Europe, and Japan to illustrate potential hours of using the direct air free cooling under various control settings. Dell is trying to develop their next generation servers to withstand an indoor temperature up to 45 $^{\circ}$C and 29 $^{\circ}$C dew point to aim for year round free cooling (Fitch, 2012). Siriwardana et al. (2013) investigated the potential of direct airside free cooling for different regions in Australia. Based on their calculations, they showed that Tasmania and Southern Australian cities can achieve more than 5000 free cooling hours per year. Intel conducted a 10 months experiment that uses 100% outdoor air up to 90 $^{\circ}$F with no humidity control for a data center located in a dry temperate climate. The result shows about 67% in energy saving in a data center as comparing to the one with only traditional DX air conditioning system. They further concluded that it could save approximately 2.87 million USD annually in a 10 MW data center (Atwood, 2008).

However, the primary concern associated with the direct airside free cooling is the outdoor air quality. IT equipment are sensitive and vulnerable to outdoor air pollutants. ASHRAE TC 9.9 has published a book entitled, “Particulate and Gaseous Contamination in Datacom Environment” to help designers to gain more knowledge of preventing hardware failure due to air contamination. It also provides the concentration limits of various indoor gaseous contaminations and particular matter based on widely used standards such as ISO 14644-1 and ANSI/ISA. Data centers are required to keep at the minimum ISO Class 8 cleanness as well (ASHRAE DS-8, 2013).

Figure 10 and 11 show two examples of copper sulfide corrosion and fine particle clogging in IT components. In brief, poor air environments are generated from variety sources, for instance, industry processes, fossil fuels burning, transportations, and other human activities. A backup of mechanical air conditioning system is required for closed loop operation when the outdoor environment is at risk.

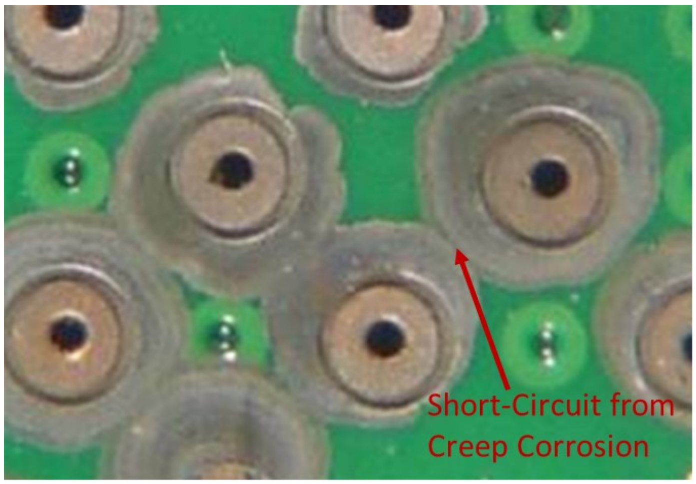


Figure 10 PCB Electrical Short Circuited Due to Copper Sulfide Corrosion (ASHRAE DS-8, 2013)

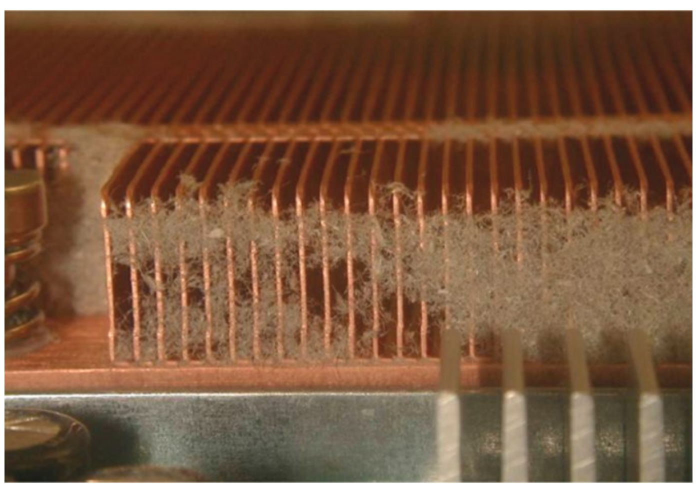


Figure 11 Heat Sink Airflow Interference Due to Fine Dust Accumulation (ASHRAE DS-8, 2013)

Another main concern associated with the direct outdoor free cooling approach is the outdoor air humidity level. Humidification or dehumidification of outdoor air is required depending on the local climate as per ASHRAE thermal guideline. According to the study by Lee and Chen (2013), their simulations showed that for data centers located in climate zones such as in very cold, subarctic, and cool-dry zones, the energy saving turns out to be negative due excessive energy use in humidification. One simple control strategy is to install outdoor humidity related sensors to disable the economizer during very cold and humid days to gain more operational benefits (PGE, 2006).

2.2.4.2 Thermosiphon Free Cooling

In contrast to the direct airside air free cooling, the thermosiphon system extracts the heat from the indoor hotter air and transfers it to outdoor cooler air indirectly by means of heat exchangers. Figure 12 illustrates the concept of earlier reviewed coil typed thermosiphon loop in a data center. Its sealed and flexible loop features allow no cross contamination between outdoor and indoor streams as compared to other indirect airside systems such as fixed plated heat exchangers and rotary wheels (Wang, 2001).

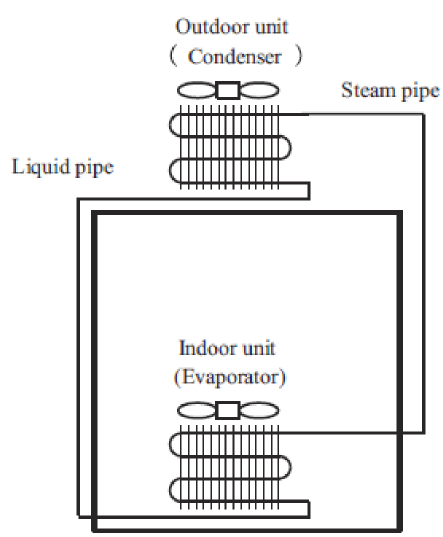


Figure 12 Concept of Thermo-siphon Loop in Data Centers (Tian et al., 2014)

Free cooling based on the thermosiphon system attracts many researchers because of its great heat transfer ability, and variety form and potential development. Zhou el al. (2011) conducted an experiment to investigate the energy consumption of a data center with and without a thermosiphon heat exchanger in Beijing during winter. Their results showed that the energy used by the thermosiphon heat exchanger was about 41% of an air conditioner and estimated the annual energy consumption could be reduced by 35.4%.

Zhang et al. (2016) proposed an integrated air conditioning system that combines the thermosiphon and mechanical refrigeration systems together in a single unit for data centers as shown in Figure 13. It utilizes a three fluid heat exchanger to join the mechanical refrigeration and thermosiphon loops together. This integrated system can work in three different operating modes (mechanical refrigeration, thermosiphon, and hybrid) depending on outdoor temperature. They investigated the free cooling performance of the thermosiphon in 31 major cities across China. The study showed that except those cities which located in the hot summer and warm winter zone like Guang Zhou and Nanning, most other cities have approximately 30-70% annual free cooling hours available and approximately 16-49% in annual energy saving with 1.7-4.3 years payback period. They further concluded that free cooling based on thermosiphon in data centers is applicable for most regions at middle and high latitudes of the world.

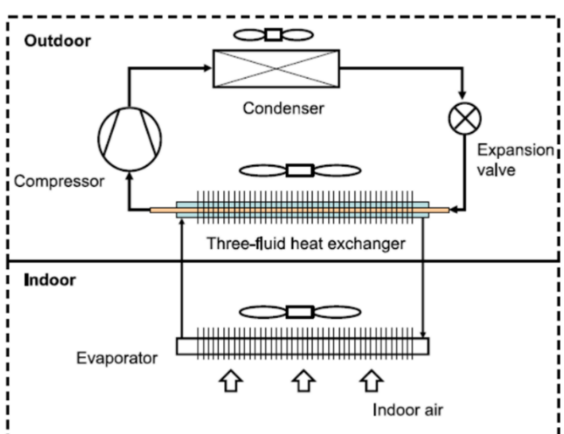


Figure 13 Schematic of Mechanical and Thermosiphon Cooling Integration (Zhang et al., 2016)

The thermosiphon free cooling technologies have been also applied in other smaller applications such as in telecommunication and mobile stations to enhance the operating efficiency (Samba et al., 2013; Han, 2014). Furthermore, the thermosiphon was also investigated to combine with the phase change materials (PCMs) in cold storage systems to remove the heat from IT equipment (Sundaram et al., 2010). Last but not least, ASHRAE has provided a comparison of various air to air energy recovery devices including thermosiphon heat exchangers. The thermosiphon heat exchanger is able to provide 40-60% sensible effectiveness in general heat transfer applications (Chapter 26, ASHRAE, 2012). In other words, the actual fluid temperature change to maximum fluid temperature change is about 40-60%.

Some general advantages of thermosiphon free cooling system are:

- No additional energy is need to circulate the thermosiphon heat exchanger working fluid because the system does not require any pump or wicks (calibration action) for circulation.
- Various working fluids are available (e.g. refrigerants, water, glycol mixtures, nanofluid, etc.) to enhance the heat transfer ability.
- No risk from the poor outdoor air quality during free cooling operation.
- Maintenance cost is lower than the direct airside free cooling (less frequent in filter cleaning and replacements, or using a lower rating of filter).
- More location choices available due to independent of outdoor air pollution and humidity.

Some general disadvantages of thermosiphon free cooling system are:

- Additional capital cost for the heat exchangers and energy used for the outdoor condenser fans.

- Adding more internal flow resistance to the existing systems means more powerful supply fans are required.
- Require qualified experts to properly install the refrigerant piping to ensure safety.

In brief, based on the literature review, the thermosiphon system are most applied in small and convential horizontal form data centers and mobile stations. There are limitng literature about the application of thermosiphon system in a larged scale data center especially in this novel vertical data center.

2.3 CFD Applications in Data Centers

Computational Fluid Dynamics (CFD) simulation is a powerful computing tool and it involves solving a sets of complex equations known as Navier-stokes equations to model/analysis the fluid behaviors. The CFD simulation has the ability to model the airflow distribution and estimate the fluid temperature, velocity, pressure and other fluid properties in data centers (Geng, 2015). It helps designers to manage the indoor thermal aspects or to evaluate different new design options and optimize the final design before being built.

Many researchers have also used CFD to help them to examine how the cooling system will perform under different circumstances in data centers. Cho et al. (2014) performed CFD modeling and combined with various airflow performance indices (RHI, RCI, etc.) to examine the airflow and thermal behavior of a data center in 46 different modifications such as change in supply air temperature, air delivery methods, room layouts, aisle containments, etc. King and Seymour (2013) analyzed the accuracy between the CFD models with experimental data at different levels of modeling details. CFD have been effectively applied to existing operational data center to troubleshoot and improve the cooling performance. Hassan, et al. (2013) used CFD to predict and analyze the airflow, temperature, and pressure distributions of a data center for the

CQUniversity. Fakhim et al. (2011) compared the CFD results with field temperature measurements in an operational data center. Both results are similar to each other and proved the existence of hotspots. They further evaluated different cooling solutions through the CFD simulations for the facility managers to eliminate the hotspots.

Hence, many software companies have developed CFD software specifically for data center to enhance user experiences. For example, 6SimgaDCX developed by the Future Facilities is a commercial CFD software to provide engineering simulation for any types of Data Centers. Other popular ones such as Flovent (Mentor Graphics Corporation), TileFlow (Innovation Research Inc.) and CoolSim (ANSYS) are widely used in data centers simulations.

3.0 Energy Performance Evaluation

The main purpose of this chapter is to analyse the energy performance of a data center with the thermosiphon system at a given site. In this thesis, the chosen vertical data center without any free cooling technologies is used as the baseline case and created using the building energy simulation tool known as eQUEST. It is a free software available today and is widely used by many professionals and researchers. The software predicts hourly energy consumption of a building over an entire year based on the local weather data and other users input parameters. The engineering assumptions and algorithms behind the eQUEST calculation are based on the DOE-2 Engineers Manual which gives an accurate and reliable energy use estimation.

3.1 Proposed Data Center Design with Centralized Thermosiphon

3.1.1 Building Description

The chosen data center for the study is a multi-story, vertically oriented building. Figure 14 and 15 illustrate the typical IT room layout and internal elevation section views of the building. Overall, the dimension of the building is 32’ wide x 42’ deep x 54’ high (13 m x 10 m x 16 m). IT racks are distributed on the 2nd, 3rd, and 4th floors as the primary heat generation. Chilled water cooling coils are located on bottom floor to ensure the final supply air remains at the desired supply temperature. Cold air is supplied from the bottom floor right side and split into two main air streams feeding the IT racks through the left and right cold aisles. The original proposed design is to use the direct airside economizer to reduce the operating cost. Depending on the outdoor air conditions, the sidewall louvers on the top level (Figure 15) are able to open and regulate a certain amount of outdoor air into the facility to assist the central plant in cooling. However, to operate the data center more reliably under poor outdoor air situations while reducing the operating cost, indirect airside free cooling based on thermosiphon loop is proposed to be incorporated with this vertical data center as a replacement for the original airside free cooling method. The next section will demonstrate two potential locations of indoor thermosiphon evaporators.

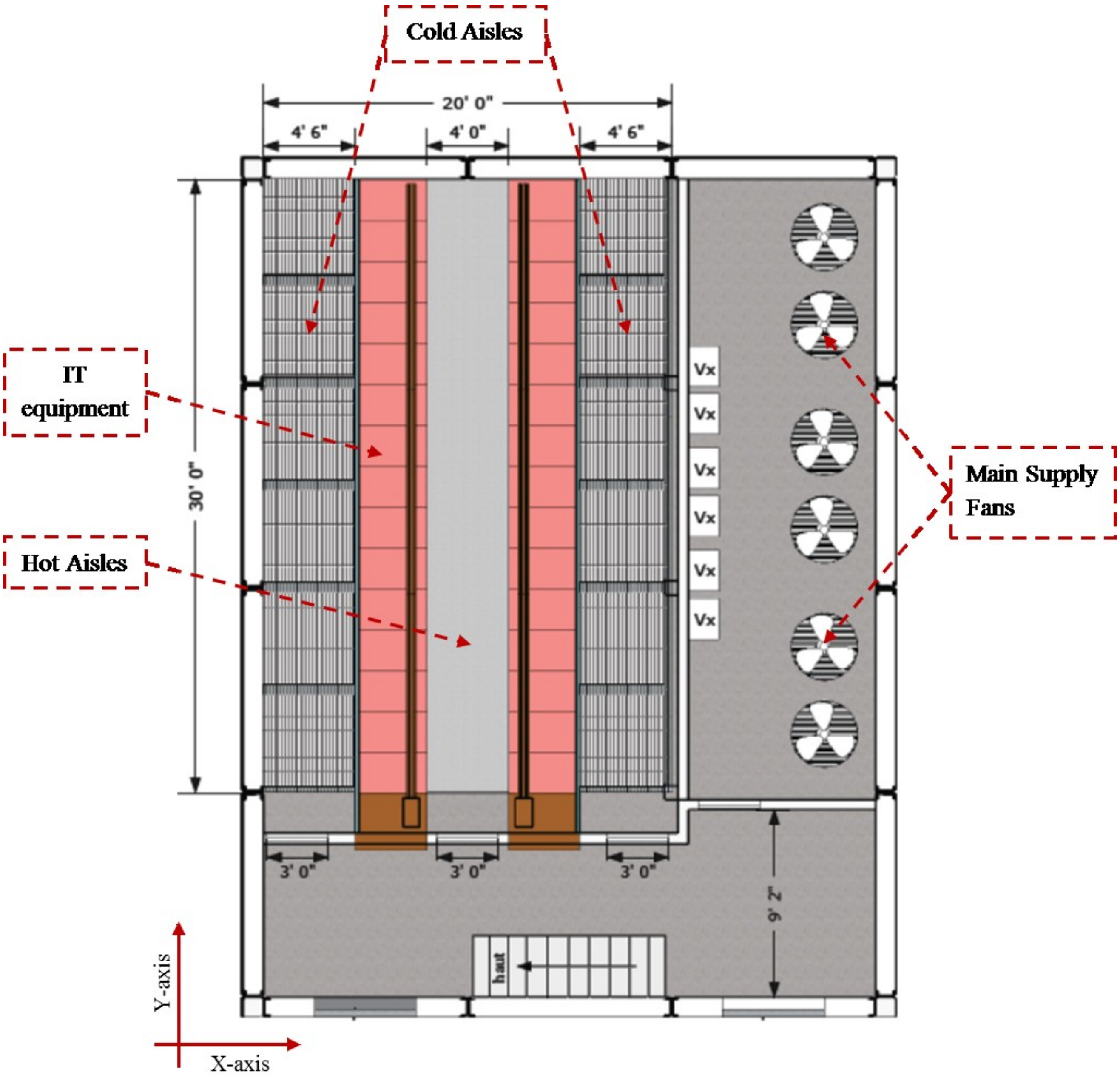


Figure 14 Floor Plan View of Second Floor (Vert.com Inc.)

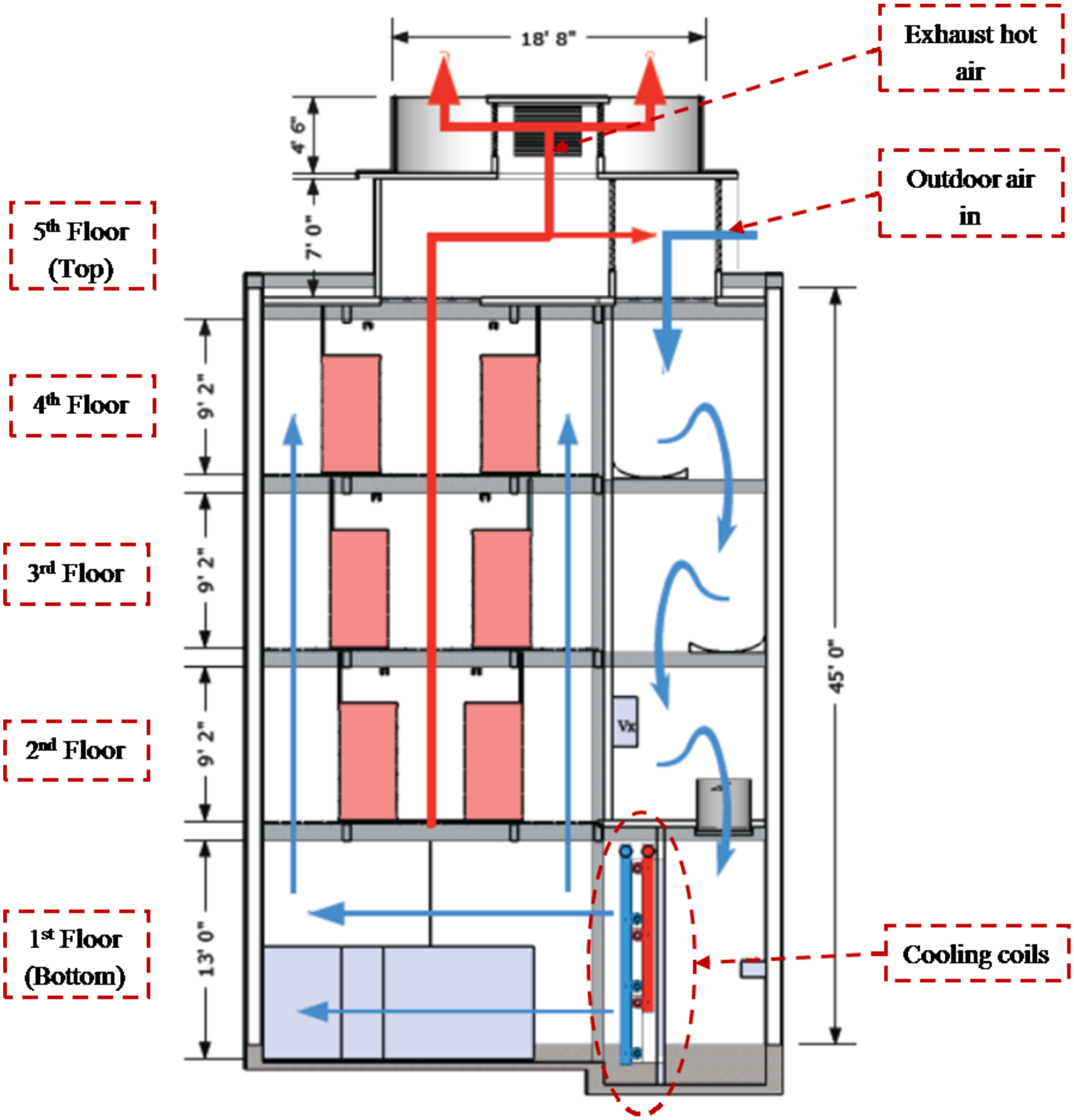


Figure 15 Schematic of Direct Airside Free Cooling System (Vert.com Inc)

3.1.2 Design Options for Thermosiphon Indoor Units

Figure 16 below illustrates two potential choices for locating the indoor thermosiphon evaporators. One option is to centralize the evaporators on the 1st floor (Figure 16, Left). The second option is to centralize them on the 5th floor (Figure 16, Right). The condensers can be located anywhere outside the building but must be above the evaporators. The operating conditions and overall energy performance of each free cooling approach are described in more detail in the next section. Airflow performance of each scenario will be discussed in Chapter 4.

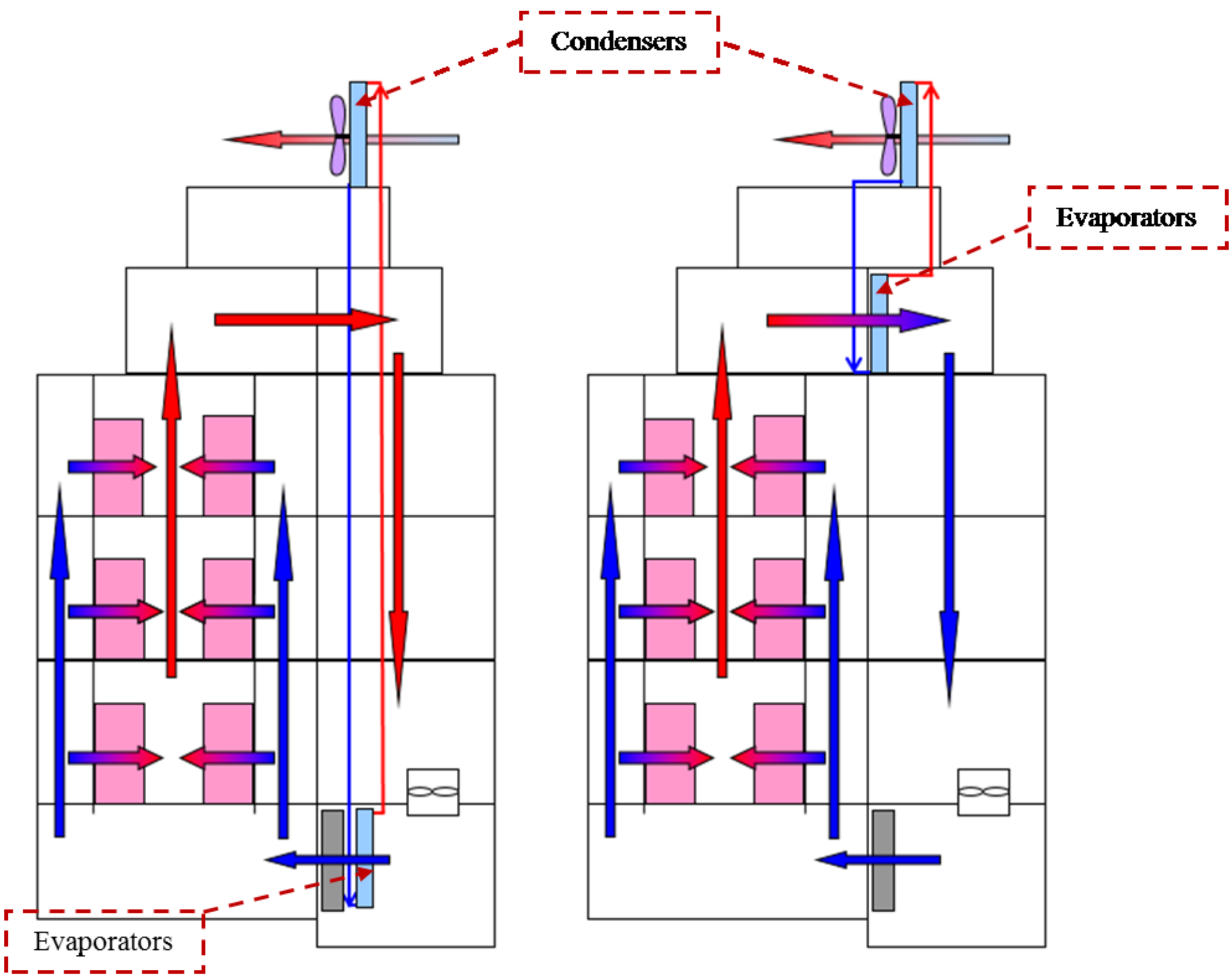


Figure 16 Schematic of Evaporators Placements: (Left) at 1st floor, (Right) at 5th floor

3.2 Baseline Energy Analysis

3.2.1 Building Site and Shell

The first building location for the baseline model study was set in Montreal, Quebec. The whole building has been divided into three parts for modeling as shown in Figure 17: bottom floor (1st level), middle floors (2nd to 4th levels), and top floor (5th level). The building features a rectangular shape and its 3-D view of the eQUEST model is shown in Figure 18. There is no detailed information about the building envelope constructions at this stage, therefore, thermal resistances of exterior components were assumed equal to the software default setting with building type similar to a typical mid-rise office building. For example, roof (R=25), walls (R=13), and ground floor (R=13). Also, the software default values are based on the minimum level of efficiency from industry standards (e.g. ASHRAE 90.1) and the impact of building envelope on energy use is relative small for a large data center especially running at a full capacity (Geng 2015). Three glass doors were assumed and a regular steel hollow core door on the front side with size of 7’ x 5’ as per drawing.

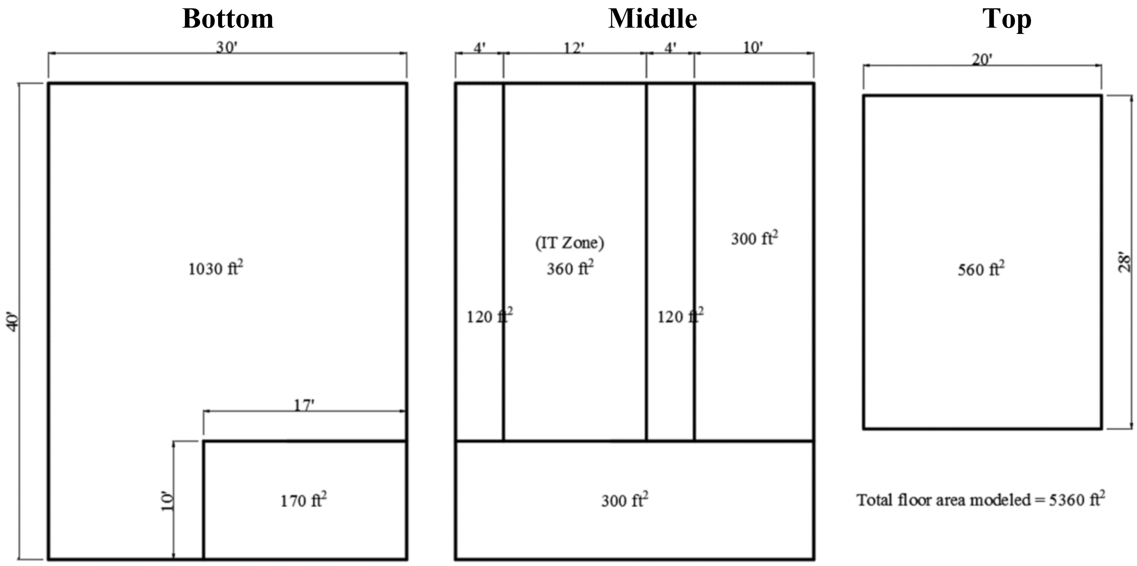


Figure 17 Simplified Floor Plans of the VDC

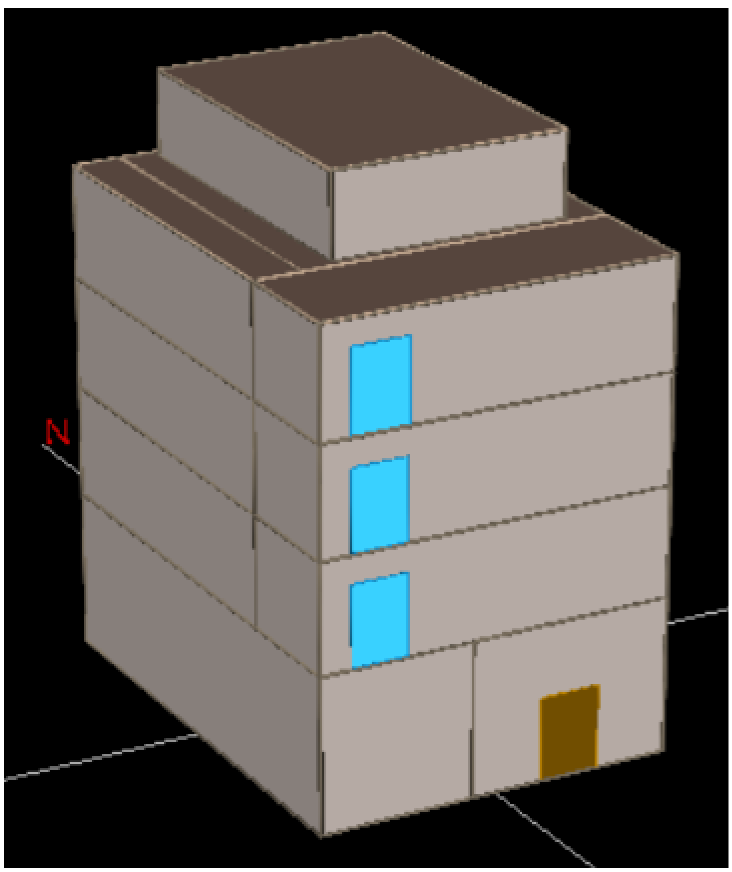


Figure 18 3D View of the Vertical Data Center model

3.2.2 Internal Load Input

Similar to large commercial buildings, data centers are internal-load-dominated buildings as a result of housing and operating a large amounts of IT equipment. The common heat sources in a typical data center include IT equipment, uninterruptible power supply (UPS), power distribution units (PDU), lighting and human occupancy. The heat release of each component can be estimated as follows:

- **IT equipment (Server racks)**

The total heat output of server racks could be approximated as its total power input. This is because the power transmitted by the IT equipment through the data lines is negligible, so all energy provided to servers would be eventually converted to heat (Rasmussen, 2011). The studied data center has a total of 90 racks and each assumed to have 12 kW of heat dissipation.

- **UPS and PDU**

The uninterruptible power supply (UPS) and power distribution systems (PDU) are parts of a data center electrical supporting systems. Both components contain a fixed power loss based on its own capacity plus an operating loss proportional to the IT power input. The heat output from the UPS and PDU should refer to manufacturer specifications but can be also estimated through Rasmussen's empirical equations without significant difference for different equipment brands and models (Rasmussen, 2011).

$$q_{UPS} = (0.04 * \ Power\ system\ rating\ ) + (0.05 * \ Total\ IT\ load\ power) \qquad \text{Eqn. 4-1}$$

$$q_{PDU} = \ (0.01 * \ Power\ system\ rating) + (0.02 * \ Total\ IT\ load\ power) \qquad \text{Eqn. 4-2}$$

where

q_{UPS} and q_{PDU} are total power output by the UPS and PDU respectively, [W]

0.04 and 0.05 are fixed and proportional heat loss factors for UPS

0.01 and 0.02 are fixed and proportional heat loss factors for PDU

- **Lighting**

The heat gain of lighting fixtures can be simply calculated using equation 4-3. The lighting power density (LPD) can be obtained from the lighting plan. In general, LPD in data centers typically range from about 0.2 to 3.6 W/ft^2 according to the benchmark guide by the Lawrence Berkeley National Laboratory (LBNL, 2010).

$$q_{lighting} = LPD * A_{floor} \qquad \text{Eqn 4-3}$$

where,

$q_{lighting}$ is the total power output by lighting, [W]

LPD is the lighting power density, $[\frac{W}{ft^2}]$

A_{floor} is the gross floor area, [ft^2]

- **Human Occupancy**

The heat output of occupants depends on the number of people and their degree of activities. In general, occupant density for a data center ranges from 100 ft^2 to 500 ft^2 (average 300 ft^2) per occupant (Geng, 2015) and should be considered as light work (Chapter 19, ASHRAE, 2011). The human body releases sensible and latent heat to the space and can be calculated using equation 4-4 and 4-5. The latent heat relates to the moisture emitted by the body and must be removed through ventilation or air conditioning.

$$q_s = N * SHG_o \qquad \text{Eqn. 4-4}$$

$$q_l = N * LHG_o \qquad \text{Eqn. 4-5}$$

Where,

q_s and q_l are total sensible and latent heat gain from occupancy respectively, [W]

N is number of people in the space

SHG is the sensble heat gain of each occupant, [W]

LHG is the latent heat gain of each occupant, [W]

Figure 19 below shows the internal loads breakdown of the above discussed components and detailed calculation are shown in Appendix A. Overall, the IT equipment occupied 84% of total heat gains (~1080 kW) which is the dominant source of all. Both the lighting and human occupancy show the least significant heat sources, which taken together, are only about 1% of total heat gains. Additionally, there are other potential indoor heat sources as well such as the heat from the supply fans and supplemental humidification and these are included in the software calculation.

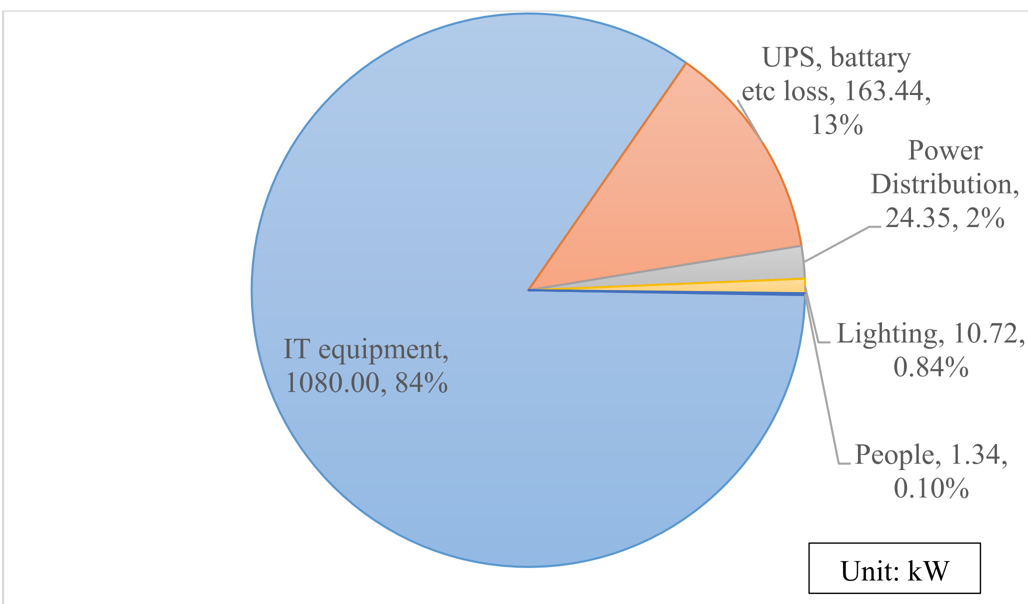


Figure 19 Internal Heat Gains Breakdown

3.2.3 Operating Schedules

- **Equipment Load Schedule**

To account for the load variation throughout the year, the equipment schedule (table 5) was modeled by dividing the whole year into three seasons. Each season consists of 4 months with load increment of 25% from month to month.

Table 5 Equipment Load Schedule (CBEES, 2013)

Fraction of Load	Season 1	Season 2	Season 3
0.25	Jan.	May.	Sept.
0.5	Feb.	Jun.	Oct.
0.75	Mar.	July.	Nov.
1	Apr.	Aug.	Dec.

- **Lighting Schedule**

The schedule for lighting was assumed to follow a typical office schedule (e.g. peak at 90% during occupied hours and bottom at 5% during unoccupied hours for weekday 8 am to 5 pm) according to ASHRAE 90.1 User's Manual (2010).

- **Occupancy Schedule**

The schedule for occupancy was also assumed to follow a typical office schedule (e.g. peak at 95% during occupied hours and bottom at 0% during unoccupied hours for weekday 8 am to 5 pm) according to ASHRAE 90.1 User's Manual (2010).

- **Fan Schedule**

Fans are assumed to be running continually, 24 hours per day 7 days per week.

3.2.4 Zone and System Parameters

Table 6 and 7 are inputs for the zone and HVAC related aspects of the software settings. Some of the design parameters are based on ASHRAE standards and others are based on a site visited in the CLUMEQ Silo data center in Laval University with one of the facility supervisors. Other detailed parameters such as chiller performance curves, equipment specification and rate conditions will be based on the program default values and equations.

Table 6 Zone Assumptions

Parameters	Descriptions	Notes or Sources
Min ventilation rate	$10\ \frac{CFM}{person}$ and $0.12\ \frac{CFM}{ft^2}$	ASHRAE 62.1 (ASHRAE Standard 62.1, 2004)
Cooling air supply temperature	20 ℃	Assume 20 ^{0}C (68 ^{0}F) conditioned air to servers, ASHRAE T.C 9.9 thermal guideline (ASHRAE DS-1, 2012)
Cooling design temperature	32.2 ℃	Assume desired space temperature, (Typical IT equipment return temperature range: 90 °F - 95°F, (PGE, 2006)
Return air min and max relative humidity	23-80 %	Assume the supply air at around 50% relative humidity

Table 7 Air-side and Water-side Systems Assumptions

Parameters	Descriptions	Notes or Sources
System	Variable air volume system with chilled water cooling and no heating	Figure 8 as reviewed in section 2.2.3
Fan supply-static pressure	1.0 inch w.g.	Assume the fan total static pressure
Supply fan Control	Variable speed drive	Assume the fan speed is able to vary based on the load
Supply Fan placement	Blow through	The Supply fan is located upstream of central cooling coils, Figure 14
Chilled water loop delta T	20 ℃	Assume the chilled water delta T
Chiller EIR efficiency	0.1763	Assume the same minimum efficiency as stated from ASHRAE 90.1 (converted from COP = 5.672 for an Water-cooled-electrically Operated reciprocating chiller > 1055 kW) (ASHRAE Standard 90.1, 2010)
Condenser type	Water cooled	Assume the chillers' condenser is cooled by water
Pump	Variable speed drive	Assume the pump speed is able to vary based on the load
Cooling Tower Fan Control	Variable speed drive	Assume the fan speed is able to vary so that the rejection capacity matches the load
Outside Air Economizer	Not installed	Assume the baseline model does not use any free cooling technology

3.2.5 Baseline Energy Results

Table 8 below shows the simulation result of annual energy consumption in term of 5 different aspects (IT equipment, UPS, PDU, Lighting, and HVAC) and its relative distribution is shown in Figure 20. Overall, the total annual energy consumption of the baseline model was estimated to be 8.6 million kWh with more than half of total energy used on the IT equipment (69.1%). The second greatest energy consumption was the HVAC aspect which is the main focus area in this research to reduce its operating cost. HVAC consumed almost 1.6 million kWh which is equivalent to 18.5% of total energy use based on the simulation. If the electricity rate is set at 7 cent per kWh, it would cost about $111,000 annually for overall cooling. The rest of the miscellaneous equipment (UPS and PDU) and lighting together accounted for the remaining 12.5%.

Table 8 Baseline Model Energy Use Breakdown

Groups	Value	Unit
IT equipment	5,922,721	kWh
UPS	896,421	kWh
PDU	130,537	kWh
Lighting	31,674	kWh
HVAC (Fans, chiller, pumps, etc.)	1,587,114	kWh
Total	**8,568,466**	**kWh**

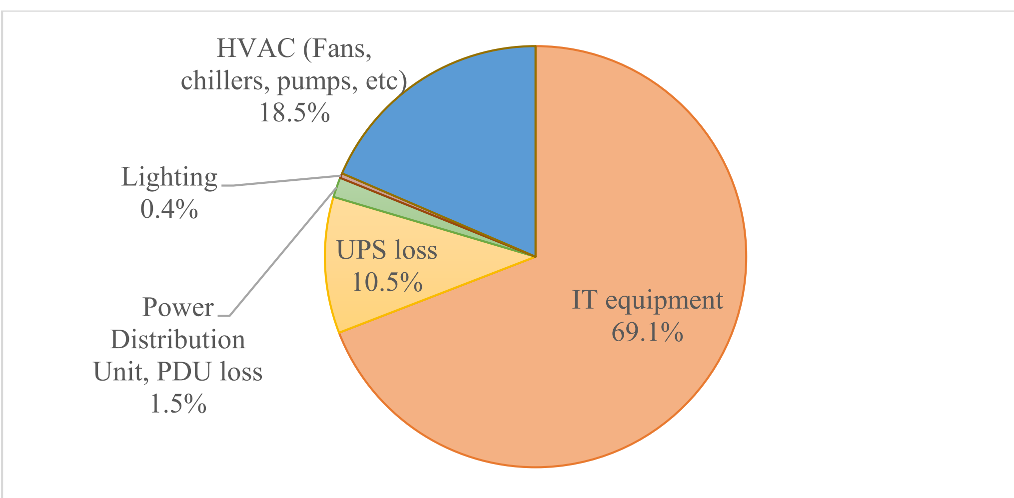


Figure 20 Annual Energy Consumption Breakdown

Table 9 below shows the baseline energy performance results in two of the most commonly used energy metrics. In term of energy intensity, the modeled data center was about 61.95 GJ/m^2 which is approximately 48 times more than the average commercial buildings (1.29 GJ/m$^{\wedge 2}$) according to Natural Resource Canada (2016). In term of the key metric, PUE, the baseline model was 1.45 which falls between a standard (2.0) and good performance (1.4) data centers based on LBNL (2010).

Table 9 Baseline Model Performance Metrics

Index	Value	Unit
Energy Intensity	61.95	GJ / m^2
Annual Power Usage Effectiveness, PUE	1.45	total kWh / total IT kWh

3.3 Free Cooling Energy Analysis

3.3.1 Thermosiphon Free Cooling

The methodology provided in this section to estimate the energy saving of a data center with thermosiphon free cooling is mainly based on “Data centers measure information template” from California Statewide Codes and Standards Program (CBEES, 2013). Continued from the previous baseline case, this new proposed design added an additional element, a set of indoor (evaporator) and outdoor (condenser) heat exchangers for indirect free cooling. Due to the inability of eQUEST to explicitly express this type of air-to-air heat transferring device, they were simulated using Excel and combined with the output from eQUEST for this analysis.

3.3.1.1 Operating Modes and Control Strategies

The new proposed design has three different operating modes as shown in table 10. In mode 1 (Hybrid), the thermosiphon heat exchangers cooling alone is insufficient to meet the entire cooling load. However, it provides as much cooling as possible to the recirculating air first, while the remaining cooling load is provided by the mechanical cooling. In mode 2 (Free cooling), the thermosiphon heat exchanger has more than enough cooling capacity and so its condenser fans can run at a reduced power to satisfy the cooling load without mechanical cooling. In mode 3 (Mechanical cooling), it is 100% mechanical cooling because the thermosiphon only works when the outdoor air temperature T_{oa}, is less than the return air temperature T_{ret}.

The operating mode in each hour is determined by the conditions as indicated in the last column in table 10. For example, the thermosiphon system is enabled only when $T_{oa} < T_{ret}$. Additionally, if the lowest possible supply air temperature that can be provided by the thermosiphon heat exchanger $T_{lowest\_HX\_supp}$, is greater than the desired supply temperature $T_{desired\_supp}$, further cool down by mechanical cooling is required which is mode 1 operation. Conversely, it would be mode 2 operation.

Table 10 Operating Modes of New Proposed Design

Mode	Operation	Thermosiphon Cooling	Mechanical Cooling	Temperature Checks
1	Hybrid	Full	Partial	$T_{oa} < T_{ret}$ & $T_{lowest\_HX\_supp} > T_{desired\_supp}$
2	Free cooling (FC)	Partial	Off	$T_{oa} < T_{ret}$ & $T_{lowest\_HX\_supp} \leq T_{desired\_supp}$
3	Mechanical cooling (MC)	Off	Full	$T_{oa} > T_{ret}$

3.3.1.2 Temperature Calculations

Table 11 below provides a summary of temperature related parameters for the mode determination (Table 10) and its obtaining methods. The outdoor, return, and desired supply air temperatures were directly extracted from the new proposed design eQUEST model hourly results. The lowest supply air temperature possible from the heat exchanger was manually calculated each hour based on the output temperatures and the prescribed cooling effectiveness ε, as shown in the next section table 12.

Table 11 Summary of Temperature Calculation for Operating Modes

List	Parameter	Source or Calculation
1	Outdoor air temperature, T_{oa}	eQUEST output variable "Outside dry-bulb temp"
2	Return air temperature, T_{ret}	eQUEST output variable, "Temp of air entering coil"
3	Desired supply air temperature to meet the cooling load, $T_{desired\_supp}$	eQUEST output variable, "Temp of air leaving coil"
4	Max. air temperature drop can be provided by the thermosiphon heat exchanger, ΔT_{HX}	$(T_{ret} - T_{oa}) * \varepsilon$
5	Lowest possible supply air temperature supplied by the heat exchanger, $T_{Lowest\_HX\_supp}$	$T_{ret} - \Delta T_{HX}$

3.3.1.3 Thermosiphon Heat Exchanger Parameters

Table 12 summarizes some key parameters of the thermosiphon heat exchanger that affects the free cooling performance and its estimated values. The first parameter is the sensible cooling effectiveness which is used to determine the fluid outlets' temperature between two airstreams. Higher effectiveness means better free cooling ability. It was assumed to be a constant in order to simplify the model. The next parameter is the airside pressure loss through the heat exchanger. The supply fan requires more power to overcome the additional resistance created by the indoor evaporator. It was estimated to be 0.96” wg. As a result, the new proposed model was run based on static fan pressure of 1.96” wg. instead of 1” wg. for the baseline model while others remain the same. The condenser fan efficiency was used to calculate fan power as discussed in the next section to account for the extra fan electricity consumption while the thermosiphon is operating.

Table 12 Heat Exchangers Performance Assumptions

List	Parameter	Description
1	Sensible effectiveness, ε_s	Assume a constant sensible effectiveness equal to 60% (Appendix B)
2	Airside pressure loss, ΔP_{loss_HX}	Assume an airside pressure loss through the heat exchanger equal to 0.96 inch wg. (240 Pa) (Appendix B)
3	Outdoor Condenser fan efficiency, η_{tf}	Assume the fan total efficiency equal to 53%, based on typical commercial available (CBEES 2013)

Note that the estimated performance values in table 12 are for the overall assembly. There could be multiple units of fans and heat exchangers in practice, but they are considered as a single unit individually for the analysis. The actual value should be based on supplier test data.

3.3.1.4 Partial Energy Use Calculations

During hybrid mode, the chiller’s partial power is directly proportional to the ratio of the remaining cooling required to be provided by the chiller in a given hour compared to the total cooling that would be provided by the chiller as if there were no thermosiphon heat exchanger in that hour. Hence, the hourly partial cooling energy use is equal to its corresponding total cooling energy (eQUEST output) times the cooling ratio. The cooling ratio is alternatively expressed in terms of air temperature change ratio as shown in Eqn. 4-1. Similarly, the actual energy use of other associated cooling equipment such as pumps and a cooling tower during mode 1 operation was also scaled down by the same ratio.

$$R_{chiller\_HX} = \frac{\Delta T\ provided\ by\ the\ cooling\ coil\ with\ HX}{\Delta T\ provided\ by\ the\ cooling\ coil\ without\ HX}$$

$$R_{chiller\_HX} = \frac{T_{Lowest\_HX\_supp} - T_{desired\_supp}}{T_{ret} - T_{desired\_supp}} \qquad \text{Eqn. 4-1}$$

Based on the Fan Laws, the fan power is proportional to the cube of its speed. Therefore, during the free cooling mode, the condenser fan's partial power is proportional to the cube of the ratio of the actual cooling that must be provided by the thermosiphon heat exchanger in a given hour to the maximum cooling that could be provided by the thermosiphon heat exchanger in that hour. Hence, the hourly partial condenser fan energy used is equal to its corresponding total fan power times the cooling ratio (Eqn. 4-2).

The fan power input P_{fan}, in W, was calculated using the Fan Equation 4-3 based on the assumed fan efficiency, and pressure drop in Pa (Table 12), and the supply airflow rate in m^3/s (eQUEST output).

$$R_{HX} = \left(\frac{Actual\ \Delta T\ provided\ by\ HX}{Maximum\ possible\ \Delta T\ provided\ by\ HX}\right)^3$$

$$R_{HX} = \left(\frac{T_{ret} - T_{desired\_supp}}{T_{ret} - T_{Lowest\_HX\_supp}}\right)^3 \qquad \text{Eqn. 4-2}$$

$$P_{fan} = \frac{\Delta P_{fan} * \dot{V_{fan}}}{\eta_{tf}} \qquad \text{Eqn. 4-3}$$

3.3.2 Direct Airside Free cooling

In the following sections, the free cooling performance of the original proposed design -the vertical data center with direct airside free cooling, is also explored for a comparison. The simulation followed the same approach as the previous section 4.2.1 that utilized Excel and combined it with the outputs from the eQUEST run.

3.3.2.1 Operating Modes and Control Strategies

Likewise, the direct airside free cooling has three different operating modes as shown in table 13. In mode 1 (Hybrid), 100% outdoor air is used as total supply airflow but it is not cool enough and requires further cooling by mechanical means in order to meet the entire cooling load. In mode 2 (Free cooling), the outdoor air is sufficiently cool, hence, it can be partially mixed with a portion of the return air to achieve a desired supply temperature without mechanical cooling. In mode 3 (Mechanical cooling), the free cooling operation is off and only mechanical cooling is used as the outdoor air conditions are no longer suitable for cooling.

Table 13 Operating Mode of Original Proposed Design

Mode	Operation	Direct Airside Cooling	Mechanical Cooling	Temperature Checks	Humidity Checks
1	Hybrid	Full	Partial	$T_{oa} < T_{ret}$ & $T_{oa} > T_{desired\_supp}$	$W_{LL} \leq W_{oa} \leq W_{UL}$ & $\emptyset \leq 60\%$
2	Free Cooling (FC)	Partial	Off	$T_{oa} < T_{ret}$ & $T_{oa} \leq T_{desired\_supp}$	$W_{LL} \leq W_m \leq W_{UL}$ & $\emptyset_m \leq 60\%$
3	Mechanical Cooling (MC)	Off	Full	$T_{oa} \geq T_{ret}$	$W_{oa} > W_{UL}$ & $W_{oa} < W_{LL}$

There are various control strategies for the direct airside free cooling depending on local climate conditions and designer's choice. A relatively simple control condition was applied as shown in the last two column in table 13. Unlike the control type in the thermosiphon case, the direct airside free cooling evaluates both dry-bulb temperature and moisture content of outdoor air at the same time to determine the appropriate mode of operation for each hour. The potential mode of operation is first sorted by the temperature, then checked with the humidity. If either the outdoor air temperature or moisture level is not desirable, the direct airside system will be disabled and the mechanical cooling will continue to run. More information about the parameters is shown in next section.

3.3.2.2 Temperature and Humidity Calculations

Table 14 also provides a summary of temperature and moisture related parameters for the mode determination (Table 13) and its obtaining methods. The eQUEST output variables were extracted from the baseline model, and the properties of air can be calculated through a series equations from the ASHRAE Phychrometrics (Chapter 1, ASHRAE 2013) The upper and lower limits of humidity ratio (0.0106 and 0.0056 $\frac{kgv}{kga}$) are set based on the ASHRAE recommended moisture range which corresponding to the upper (15 ^{0}C) and lower (5.5 ^{0}C) limits of dew point temperature (Table 2).

To calculate how much outdoor air should be brought in during mode 2 operation (Figure 21), Equations 4-5 to 4-9 were used with following simplifications: 1) ignore fan heat, 2) mixed air temperature based on sensible temperature balance, 3) well mixed. The fraction of outdoor air can be back calculated by setting the mixed air temperature equal to the desired supply temperature.

Table 14 Summary of Temperature and Moisture Calculation for Operating Modes

List	Components	Source or Calculation
1	Outdoor air dry-bulb and wet-bulb temperature, T_{oa} *and* T_{oa_wb}	eQUEST output variable "Outside dry-bulb temp" and "Outside wet-bulb temp"
2	Return air temperature, T_{ret}	eQUEST output variable, "Temp of air entering coil"
3	Desired supply air temperature to meet the cooling load $T_{desired\_supp}$	eQUEST output variable, "Temp of air leaving coil"
4	Return air humidity ratio, W_{ret}	eQUEST output variable, "Return air humidity ratio"
5	Higher and lower limit of humidity ratio, W_{HL} and W_{LL}	ASHRAE thermal guideline recommended moisture level
6	Outdoor air and mixed air humidity ratio, W_{oa} *and* W_m	Psychrometrics calculation
7	Outdoor air and mixed air relative humidity, $\emptyset_{oa}$ *and* $\emptyset_m$	Psychrometrics calculation

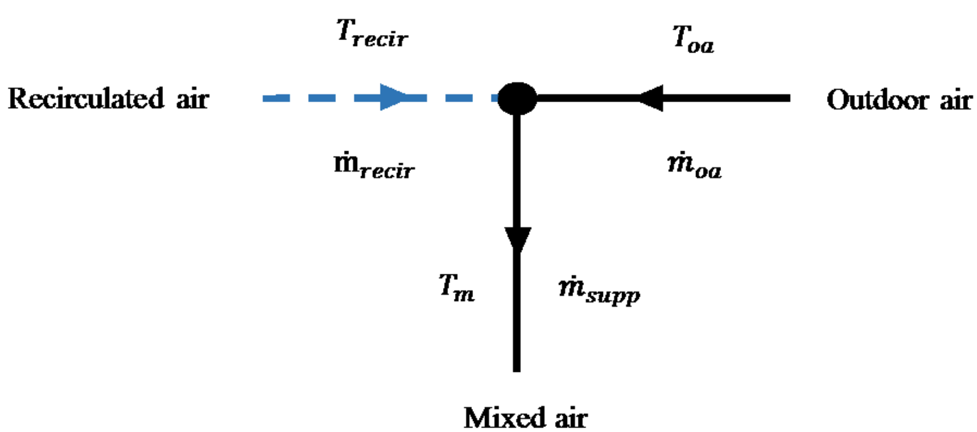


Figure 21 Adiabatic Mixing of Two Airstream Schematic

$$T_m = \frac{\dot{m}_{recir} * T_{ret} + \dot{m}_{oa} * T_{oa}}{\dot{m}_{supp}} \quad \text{Eqn. 4-5}$$

$$\dot{m}_{recir} = \dot{m}_{supp} - \dot{m}_{oa} \quad \text{Eqn. 4-6}$$

$$\dot{m}_{oa} = \left(\frac{T_{ret} - T_m}{T_{ret} - T_{oa}}\right) * \dot{m}_{supp} \quad \text{Eqn. 4-7}$$

$$R_m = \frac{T_{ret} - T_m}{T_{ret} - T_{oa}} * 100\% \quad \text{Eqn. 4-8}$$

where,

T_m is the mixed air temperature, ℃

$\dot{m}_{recir}$, $\dot{m}_{oa}$, $\dot{m}_{supp}$ are the mass flow rate of recirculated, outdoor, and mixed air, $\frac{kg}{s}$

R_m is the fraction of outdoor air to total air supply (Mixing ratio)

$$W_m = \frac{\dot{m}_{recir} * W_{ret} + \dot{m}_{oa} * W_{oa}}{\dot{m}_{supp}} \quad \text{Eqn. 4-9}$$

3.3.2.3 Partial Energy Use Calculation

The partial power of the chiller during the hybrid operation will also assumed vary directly with the cooling ratio of actual air temperature change in a given hour to the total air temperature change as if there was no outdoor air free cooling in that hour. The hourly partial cooling energy use is then equal to its corresponding total cooling energy times the cooling ratio (Eqn. 4-10).

$$R_{chiller\_OA} = \frac{\Delta T \text{ provided by cooling coil with } OA}{\Delta T \text{ provided by cooling coil without } OA}$$

$$= \frac{T_{OA} - T_{supp}}{T_{ret} - T_{supp}} \quad \text{Eqn. 4-10}$$

3.3.3 Results and Comparisons

Figure 22 below shows the distribution of annual operating hours for the VDC with two free cooling scenarios in the Montreal area. As discussed in earlier sections, the original proposed design is based on the baseline model plus direct airside free cooling while the new proposed design is based on baseline plus thermosiphon free cooling. Overall, the thermosiphon free cooling approach captures a greater number of hours in a year for both mode 1 and mode 2 operation compared to the direct airside free cooling approach. So, the new proposed design is able to reduce more workloads and run-times of the mechanical cooling annually. The reason the direct airside free cooling approach has less annual free cooling hours is attributed to humidity control. Montreal's climate is not only naturally cold but also very dry. Based on the weather data extracted from eQUEST, the outdoor air humidity above and below the specified limits are approximately 11% and 59% of annual hours respectively, which causes about 55% of time annually in fully mechanical cooling mode to avoid excessive dehumidification and humidification loads.

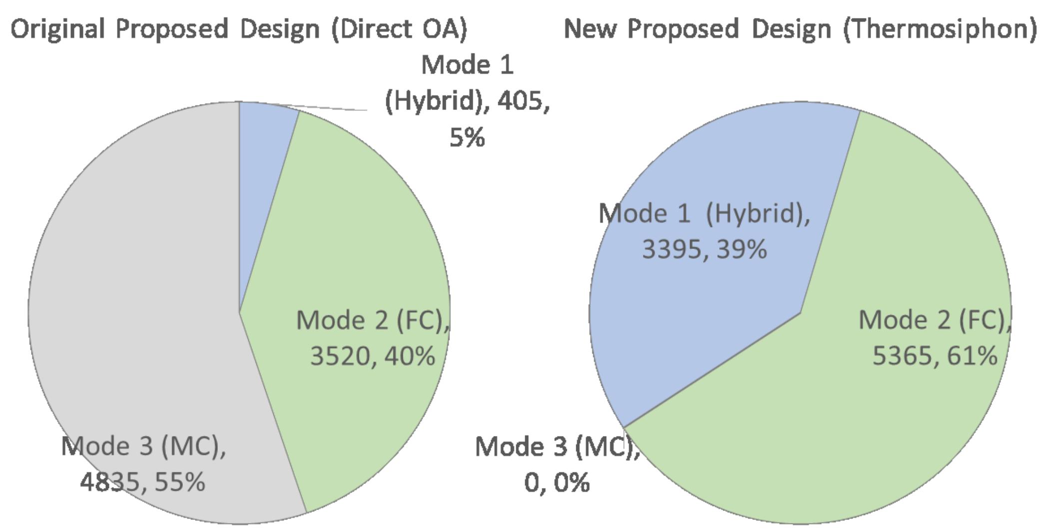


Figure 22 Annual Operation Breakdown in Montreal

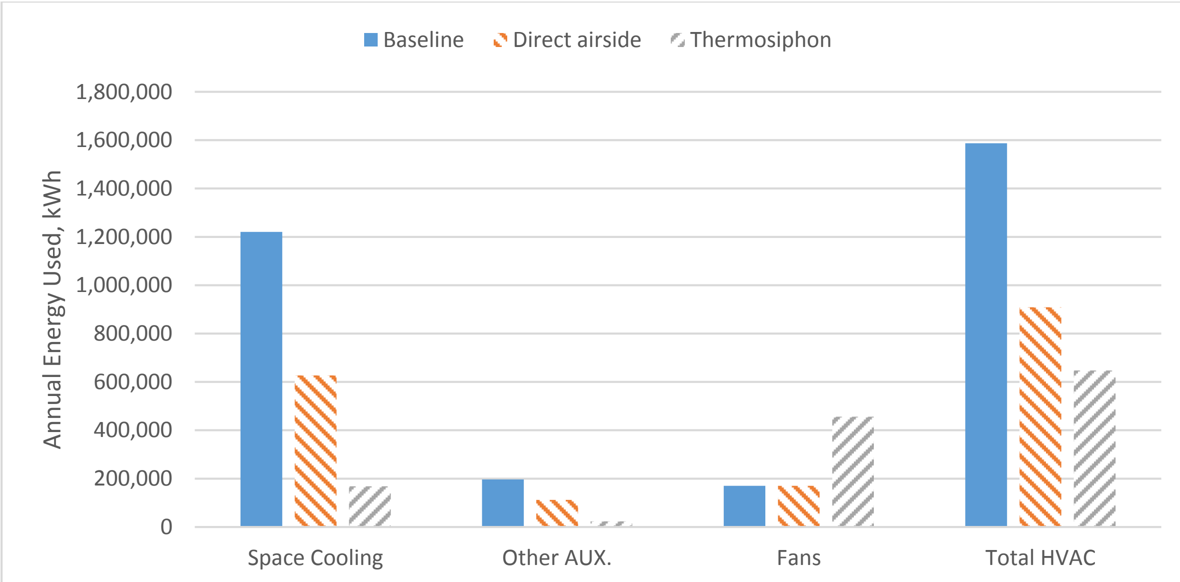


Figure 23 Annual Energy Consumption by End-Uses in Montreal

Table 15 Percentage Energy Saving with Respect to the Baseline Model

Design Scenarios	Space cooling	Others AUX.	Fans	Total HVAC	PUE
Baseline (no economizer)	Ref.	Ref.	Ref.	Ref.	Ref.
Original proposed (with direct airside free cooling)	49%	43%	0%	43%	8%
New proposed (with thermosiphon free cooling)	86%	88%	-168%	59%	11%

Figure 23 above shows the total HVAC energy consumption and its breakdown in space cooling (chiller), other auxiliaries (i.e. cooling towers and pumps), and fan energy consumption for three different scenarios. The baseline model was used as reference for the other two design scenarios. The percentage saving of each component is shown in table 15. Both free cooling approaches have the ability to improve the data center overall energy performance, with 8% reduction in PUE metric by the direct airside free cooling and 11% reduction by the thermosiphon free cooling with respect to the baseline PUE of 1.45.

The thermosiphon free cooling design reduced the energy used for cooling and other aux. by an average of 87% compared to the baseline. However, the fan energy use was increased by 168%. This increase of fan energy comes from two main aspects. One is from the supply fans that needs more energy to overcome the additional resistance created by the indoor heat exchangers. The other aspect is from the outdoor condenser fans driving the outdoor air. Because the baseline's cooling energy use is the major component in its total HVAC energy use (about 77%), while the fan energy is only about 11%, therefore, the decrease in chiller energy far outweighs the increase in fan energy. As a result, this design sees a net saving of 59% in the total HVAC energy use.

As for the original proposed design, the direct airside free cooling showed no increase in fan energy (assumed the same filtration system for all scenarios) but the total HVAC energy saving from the baseline was 16% less as compared to the thermosiphon free cooling approach due to the humidity constrains. If there was no humidity restrictions or operating at a wider allowable ranges, the savings for the direct airside free cooling system would increase, however, the risk moisture related failure in equipment increase as well.

3.3.3.1 Free Cooling Potential in Other Cities

To further examine the effect of weather conditions from different regions on both free cooling approaches, another two building locations were selected as shown in the North America climate zone map in Figure 24: 1) Atlanta, Georgia which is classified as warm and humid and located in zone 3, and San Francisco, California which is classified as warm and marine and located in zone 3.

Figure 24 ASHRAE Climate Zone Map (Roxul, 2016)

The overall HVAC energy consumption along with percent saving with respect to its baseline for each design scenario and their annual operating characteristic are shown in Table 16 to 18. In the City of Atlanta, total HVAC energy savings by the thermosiphon free cooling approach are 10% more than the direct airside free cooling approach in comparison to the baseline. This can be explained with similar reasoning as the Montreal case. The imposed humidity control in the direct airside system, and the reduced number of effective hours in mode 1 and mode 2 operation leads to this difference. For example, approximately 32% and 13% of the time annually would be operated in mode 1 and 2 respectively if outdoor air moisture content were not as humid as shown in Table 18.

For the city of San Francisco, the total HVAC energy saving by the direct airside free cooling approach was better than the thermosiphon free cooling approach (77% and 56% respectively). This is because the temperate climate feature in San Francisco allows the free cooling mode to become the primary operating mode for the original proposed design (about 79%) as shown in Table 18. The direct airside is also more efficient in heat transfer since there is no heat exchanger barrier between outdoor and indoor air when outdoor air conditions are right. However, San Francisco is classified as Marine region which means the salt content in the air is relative high. Therefore, directly using outdoor air even with filters could still have a higher chance of IT equipment failure due to corrosion from the coastal environment. Hence, the thermosiphon free cooling approach could be an alternative choice for designers even though it is less energy efficient than the direct airside free cooling.

Table 16 Annual HVAC Energy Use at Various Cities

Locations	Baseline	Direct airside		Thermosiphon	
	kWh	kWh	savings %	kWh	savings %
Montreal, Quebec	1,587,114	908,542	43%	647,368	59%
Atlanta, Georgia	1,596,036	1,102,935	31%	945,267	41%
San Francisco, California	1,580,762	369,549	77%	691,553	56%

Table 17 Annual Operation Breakdown at Various Cities for the New Proposed Design

Mode	Operation	Montreal	Atlanta	San Francisco
1	Hybrid	3395 (39.0%)	6033 (68.9%)	5604 (64.0%)
2	Free cooling	5365 (61.0%)	2697 (30.8%)	3148 (35.9%)
3	Mechanical cooling	0 (0.0%)	30 (0.3%)	8 (0.1%)

Table 18 A Closer Look of Annual Operation for the Original Proposed Design

Location	Humidification Required		No Humidification and Humidification Required		De-humidification Required	
	mode 1	mode 2	mode 1	mode 2	mode 1	mode 2
Montreal, Quebec	0.3%	37.0%	4.6%	40.2%	9.3%	8.6%
Atlanta, Georgia	0.9%	19.4%	7.1%	27.4%	31.6%	13.0%
San Francisco, California	0.4%	7.4%	4.9%	79.1%	0.8%	7.2%

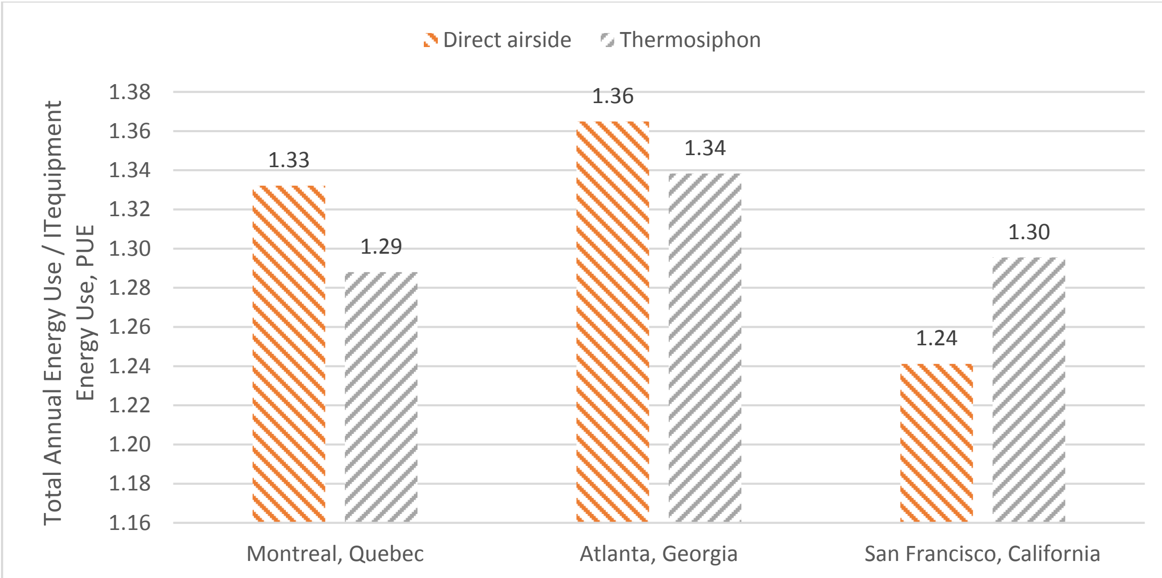


Figure 25 Comparison of Annual PUE at Various Cities

Figure 25 provides a quick glance of overall free cooling performance for each design scenario by location in term of the PUE metric. Since the annual energy used by equipment such IT servers and lighting is the same for all locations, therefore, a better HVAC system will translate to a smaller PUE value. The results showed that the thermosiphon free cooling performance improves as climates gets colder because the system is independent of the outdoor humidity. It has the lowest PUE, 1.29 in Montreal and greatest annual hours (61%) operating in purely free cooling mode 2 (Table 17). In contrast, the direct airside free cooling performance is controlled by a combination of outdoor air temperature and humidity in this study, therefore, it is not as effective as the thermosiphon heat exchangers method in a climate where the outside environment is very dry and/or humid for many hours in a year (e.g. Montreal and Atlanta).

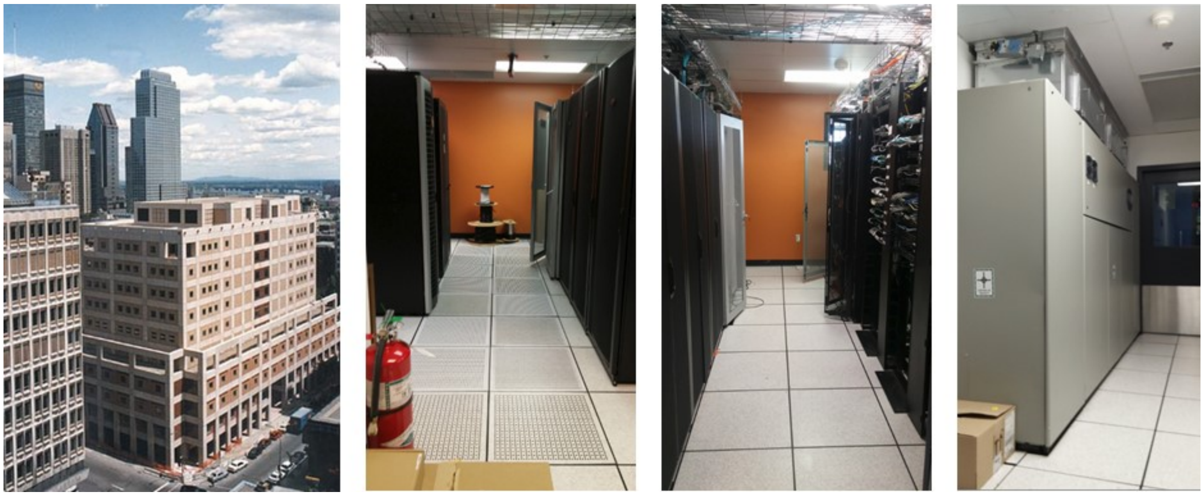
Lastly, the principle focus in this section is not to determine which free cooling method is the best since it depends on many other factors such as capital cost, climate conditions, and control types and logics, but rather to demonstrate the energy saving potential of a data center with the thermosiphon and encourage the use of this free cooling method.

4.0 Airflow Performance Evaluation

The main purpose of this chapter is to evaluate the internal airflow performance of the VDC with the thermosiphon and optimize the design before being built. As discussed in previous chapter 3, the new proposed VDC design has two location choices for the thermosiphon evaporators. Each case including the original proposed VDC design was examined through CFD modeling. The CFD analysis tool used in this study was a commercial free software tool, Fire Dynamics Simulator (FDS) provided from the National Institute of Standards and Technology (NIST). The FDS employs the Cartesian grid meshing and numerically solves the Navier-Stokes equations for low-speed (Ma < 0.3), thermally-driven flow with an emphasis on fire situations but can be also used to model situations without fire (Mcgrattan et al., 2010).

4.1 CFD Validation

The validation model was based on an operational data center located on the 8th floor in the Concordia's library building. The data center is about 11 years old and still ongoing development. Figure 26 shows the overall view of the building and inside looks of the server room. The geometry of the CFD model was create using the PyroSim (graphical interface tool for the FDS) as illustrated in Figure 27. The floor area was measured approximately 130 m^2 (12.0 m by 10.8 m) and 2.6 m floor to ceiling height. The chosen data center is a relatively small in term of total floor areas and quantity of server racks as compared to other large standalone data centers, but its air distribution system is followed the ASHRAE recommended configuration. It employs the conventional raised floor cold air supply and dropped ceiling hot air return style (Table 3).



a b C d

Figure 26 (a) Overall View of the Building, (b) Cold Aisle, (c) Hot Aisle, (d) CRAC

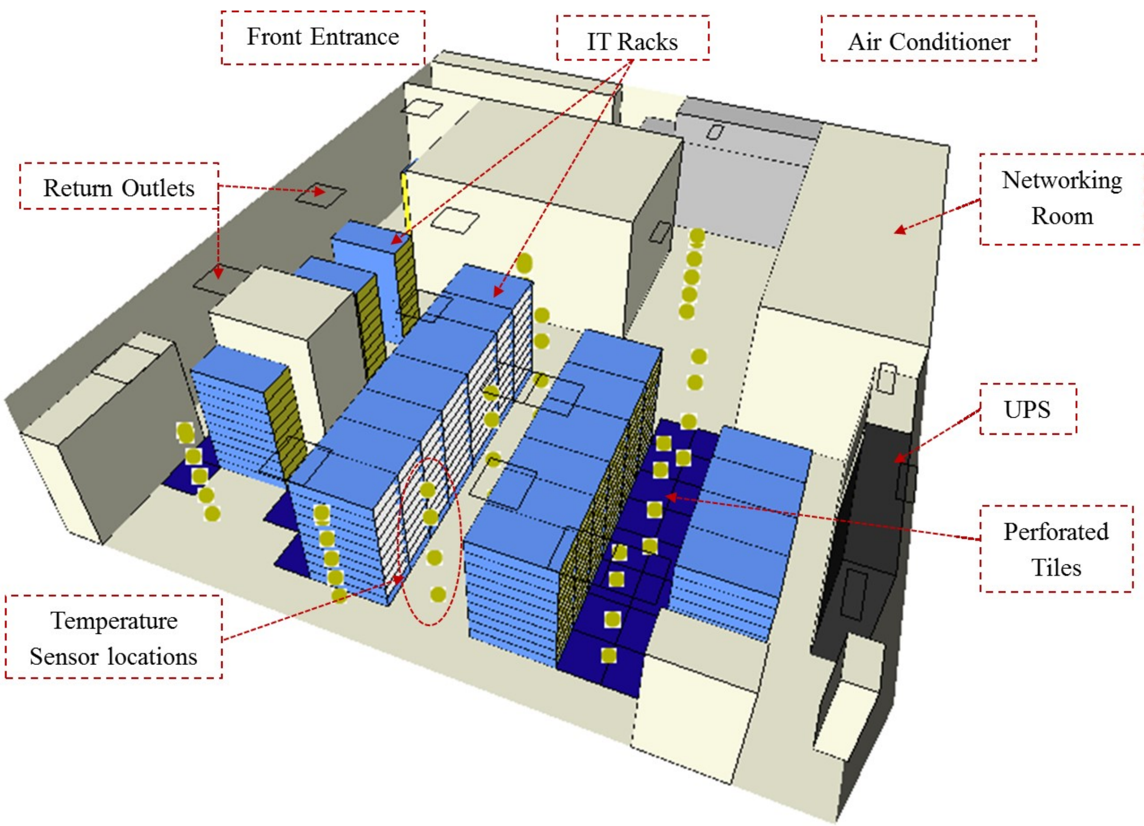


Figure 27 3D View of the Server Room Model

4.1.1 Measurement Methodology

The onsite measurement consists of determining the facility's ambient temperatures, rack heat loads, supply air flow rate of the perforated tiles, and wall surfaces temperatures. All air temperature was measured using Omega T-type thermocouples.

For hot aisle/cold aisle temperature measurements, thermocouples were attached to strings at various height 0.2 m, 1.0 m, 1.8 m, and 2.3 m (distance was set based on the 2 meter rack height and 2.6 meter ceiling height). The strings were hooked from the ceiling and set apart evenly along the aisle and midway between server rack rows according to the ASHRAE measurement guideline (DS-1, 2012) as shown in Figure 27 and 28a.

For the rack heat load, since there is no information available of servers' power usage, it was estimated using Eqn. 5-1 based on Cho et al. (2014) method. Two test stands (Figure 28b) were built to measure the temperature in and out of a rack (sensors were placed along the string at various height: 0.2, 0.6, 1.0, 1.4, 1.8 and 1.9m). The airflow rate of a rack was estimated by the product of the rack face area and its average inlet velocity. The speed of air was measured using a hotwire anemometer with total of 6 by 2 measurement points (0.2, 0.6, 1.0, 1.4, 1.8 and 1.9m vertically, and equal distributed horizontally).

$$q_r = \dot{m}_r * C_p * (T_{r,o} - T_{r,i}) \qquad \text{Eqn. 5-1}$$

where,

q_r is the rack heat output, kW

C_p is the specific heat of air at constant pressure, about 1.02, $\frac{kJ}{kg - °C}$

$\dot{m}_r$ is the mass flow rate through a rack, $\frac{kg}{s}$

$T_{r,o}$, $T_{r,i}$ are the average temperature in and out of a rack, °C

The cold air supply was assumed equal to the flow rate from the perforated tiles and was measured using the ALNOR flow measurement hood as shown in Figure 28c. The hood size is a bit smaller than the actual tiles sizes, so the measured flow rate was adjusted with the area ratio to compensate the lost. Solid surfaces such as walls, floor, and other auxiliaries' equipment surfaces were detected using the infrared camera. The final organized results from the measurements are shown in Appendix C.

a b c

Figure 28 Measurement Tools Pictures

4.1.2 Model Descriptions

Table 19 provides the summary of major simulation parameters and the detail input file of FDS model is shown in Appendix C. The mesh sensitive tests of the model were performed at different grid sizes with respect to the temperature at different locations in the room as shown in Figure 39 and 40 in Appendix C. The optimal mesh for this model is consisted of 42 thousand cells with cell size of 0.2 x 0.2 x 0.2 m.

Table 19 Model Parameters Info

Parameters	Value / Range	Unit
1. Room space		
Inside floor area (x, y plane)	129.6 (12 x 10.8)	m^2
Floor to ceiling height (z)	2.6	m
2. Boundary Condition		
Average surface temperature	21	^0C
3. Perforated tiles		
Size	0.6 x 0.6	m
QTY	34	#
Air flow rate (various)	0.19 – 0.28	m^3/s
4. Computer room air conditioner		
Dimension (x, y, z)	0.8 x 3.6 x 2.0	
Surface temperature	19	^0C
Total supply flow rate	8.1	m^3/s
Supply air temperature	17	^0C
5. Equipment rack		
Typical Dimension (x, y, z)	0.6 x 1.2 x 2.0	m
Quantity	21	#
Heat Load (varies)	0.22 – 10.6	kW
6. UPS equipment		
Dimension	2.2 x 0.6 x 2.0	m
Surface temperature	22	^0C
7. Outlet tiles		
Return opening type 1	0.6 m x 0.2 m	
type 1 QTY	5	#
Return opening type 2	0.6 m x 0.6 m	
type 2 QTY	10	#

4.1.3 Result and Discussion

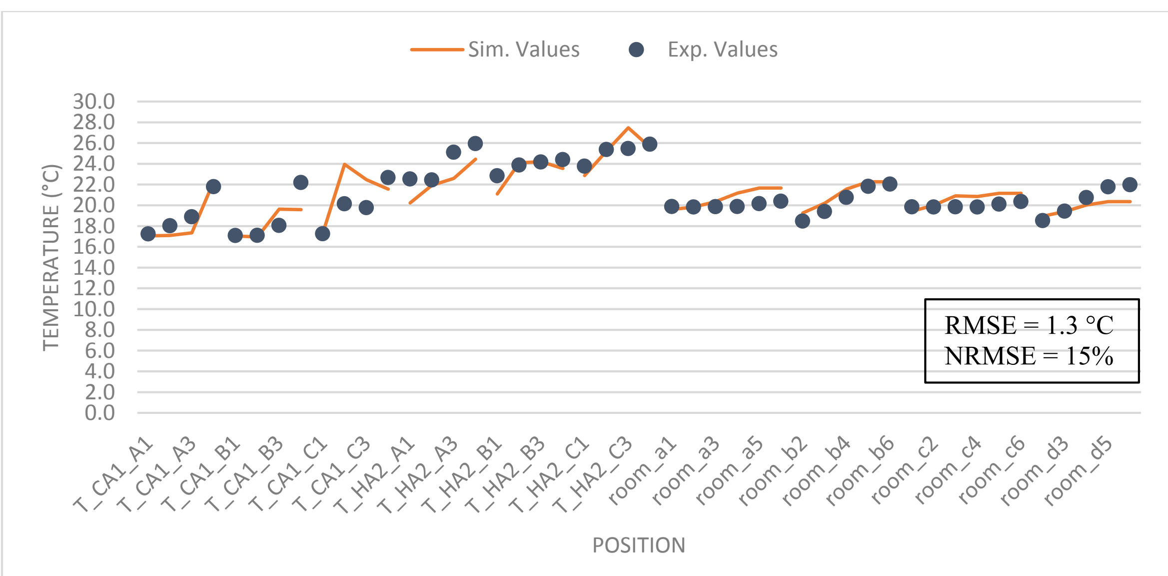


Figure 29 Comparison of Temperature between Experimental data and Simulation

Figure 29 shows the comparison of temperature between the simulation result and the field measurements at various locations (cold and hot aisles and common spaces). Overall, the simulated result followed closely with the measurement trend with root mean square error (RMSE) of 1.3 $^{\circ}$C and normalized percentage error of 15%.

There is no measured rack intake temperatures exceeding the ASHRAE recommended maximum inlet temperature limit (27 ^{0}C) at the current stage. However, there is a potential challenge if servers were upgrading to higher power in the future. As shown in Figure 30, there are many air recirculation presented inside the room. For instance, locations between the wall and the end of each row, front end of each row (section B-B'), and top part of the racks (section A-A') show more severe mixing. Many possible factors contribute to a poor air distribution in this data center such as internal layout (e.g. uneven number of racks in a row), misplaced perforated tiles, bypass cold air from floor holes (not modeled in this study) and too much cold air supply.

In short, it is recommended to avoid using ineffective actions such as allowing excessive cold or much colder air to be mixed with exhausted hot air (Lin, 2014). These kinds of approaches do help to lessen the degree of recirculation, but it wastes cooling energy and it is not effective for long term perspective. Hence, the following strategies are examples to boost cooling capacity based on the literature reviews for future upgrade:

- Fully ducted cold air supply or/and fully ducted hot air return system
- Hot aisle or cold aisle containment
- Vertical partition panel attached on the top of the rack
- Rack rear door refrigerated-based cooling
- Arrangement of supply and return vents

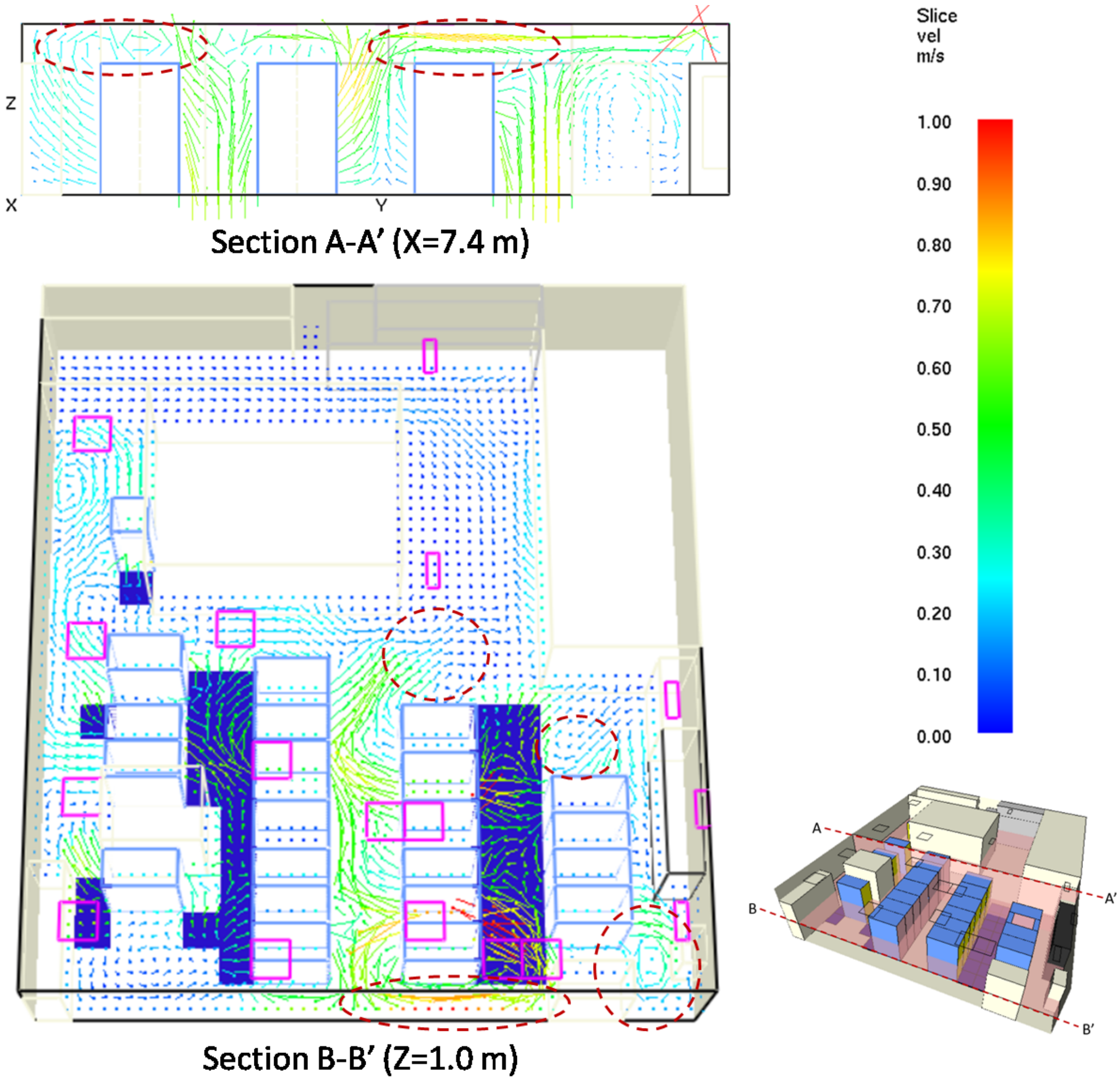


Figure 30 Velocity Profile

4.2 Proposed Data Center Design CFD Analysis

4.2.1 Model Descriptions

The original proposed VDC and the new proposed VDC with two options of locating the thermosiphon evaporators (Figure 16) are called case 1, 2 and 3 for short respectively in this section. The major simulation parameters for each model are summarized in Table 20 to 21. Detail input of the FDS file is shown in Appendix D. Figure 31 shows the full-scaled CFD model of the VDC with exterior walls hidden. In this study, heat produced from minor internal heat sources such as fans and UPS batteries are lumped together and assigned them to server racks for simplicity. A total heat output of 1200 kW was assumed to be produced by server racks. Racks were modeled same as the validation model approach that heat is uniformly generating inside the rack with server fans attached at the rack's intake side drawing surrounding air pass through. The thermosiphon heat exchanger was model as a heat sink with heat removing rate of 1200 kW. All other solid objects were modeled as basic surface type with no heat generation. Same number of meshes and mesh structure are applied to each case model. Each model is consisted of about 440 thousand total number of cells and it took about 34 hours actual time to simulate 1 hour of output by running on the Calcul Quebec, Briaree computer servers.

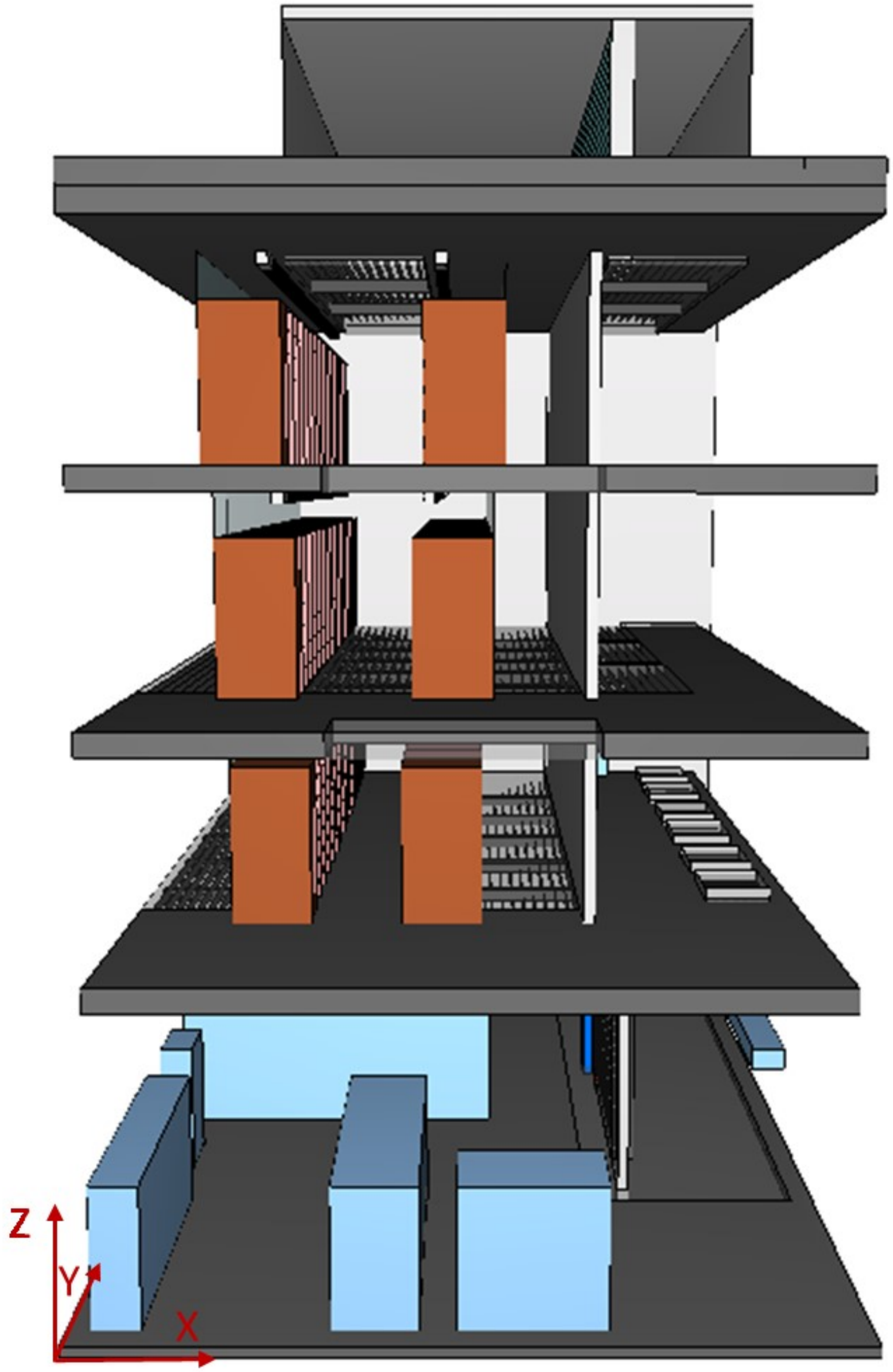


Figure 31 3D View of Interior of the VDC Model - Case 3 Example

Table 20 Common Model Parameters to All Cases

Parameters	Value / Range	Unit
1. Architecture		
Overall Dimension (x, y, z)	32 x 42 x 54	ft
2. Computational mesh		
x, y, z cell size	0.5 x 0.5 x 0.5	ft
Number of mesh	9	#
3. Computer racks		
Dimension (width, length, height)	3.5 x 2 x 7	ft
Total heat dissipation	1200	kW
Design Delta T	15	^{0}C
Quantity	90	#
Airflow rate per rack (based on air density of 1.2 kg/m^3)	0.726	m^3/s
3. Axial supply fans		
Face area	9	ft^2/fan
Quantity	6	#
Airflow rate total (based on air density of 1.2 kg/m^3)	65.359	m^3/s
7.0 Outdoor condition		
Outdoor temperature	20	^{0}C

Table 21 Additional Model Parameters for the Case 2 and 3

Parameters	Value / Range	Unit
1. Thermosiphon Heat Exchangers		
Face area (length x height)	25	m^2
Heat extraction rate	1200	kW

4.2.2 Result and Discussion

Figure 32 and Figure 33 shows the temperature and velocity distributions of all three cases operating at the free cooling mode situation. In case 1, the facility is operating in an open loop configuration with cold air pulling from outside. In contrast, cases 2 and 3 are operating in the closed loop configuration and cooling the recirculating air indirectly by heat exchangers. However, an abnormal phenomenon was found in both case 2 and case 3 at the heat exchanger regions. The CFD models of both cases show that very cold air (< 5 ^{0}C) is continuously producing right after passing the heat exchanger.

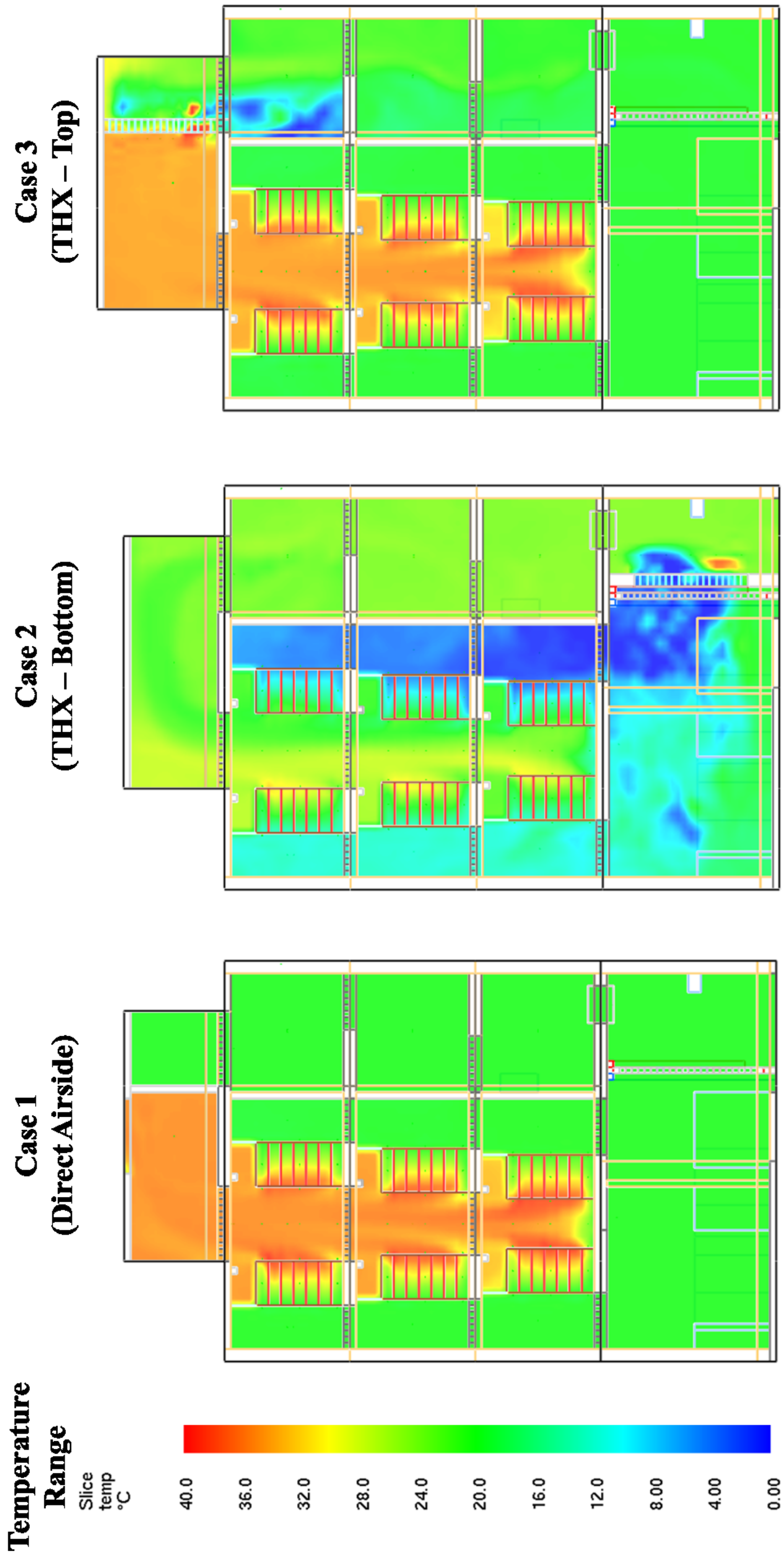


Figure 32 Slice Views of Temperature Distribution at Y = 18 ft (5.5 m)

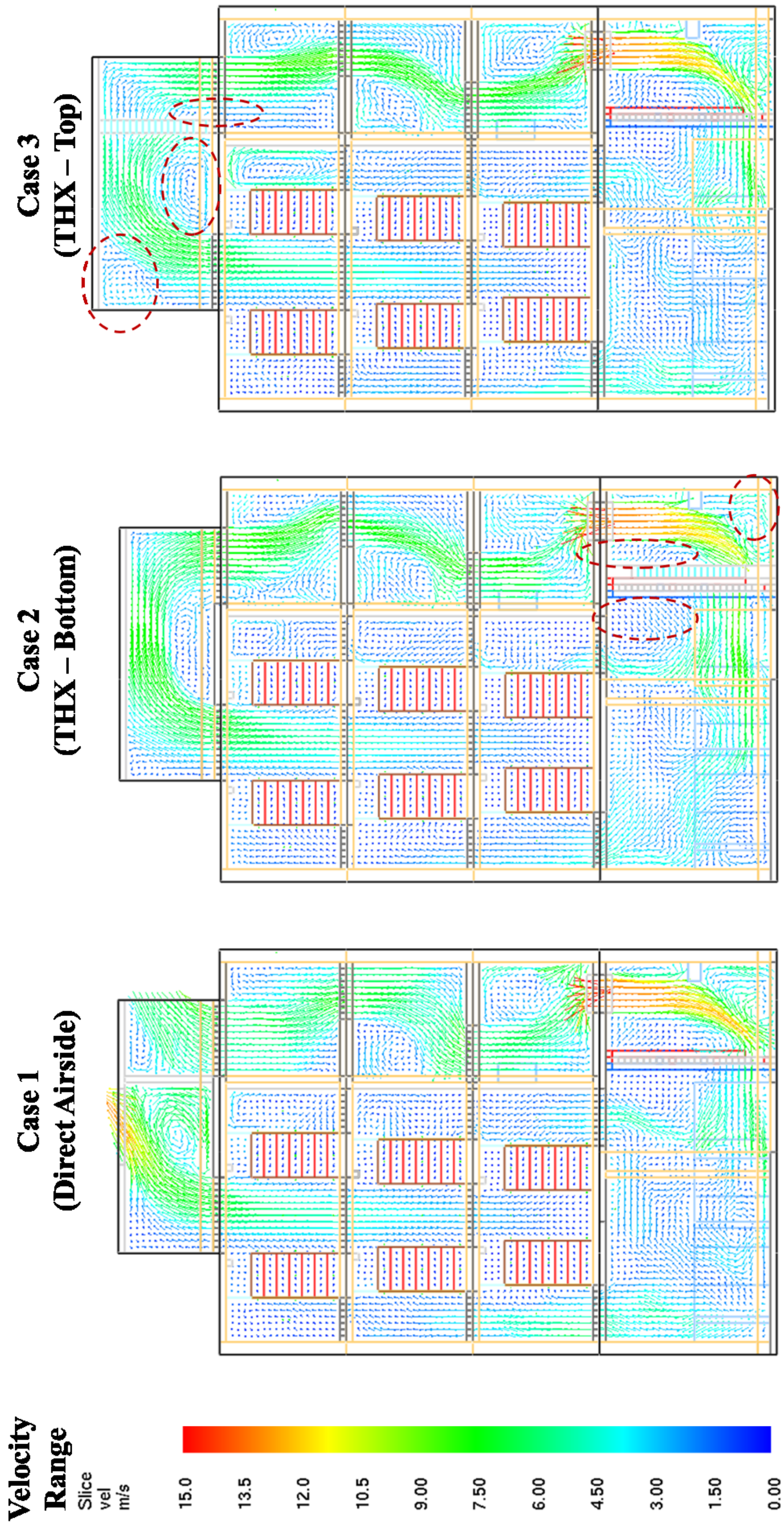


Figure 33 Slice Views of Velocity Distribution at Y = 18 ft (5.5 m)

An analysis of an airflow distribution can explain this abnormal thermal stratification in both cases. As shown in Figure 33, there are many eddies and stagnant flows formed inside the building, especially at those 90^0 bends where air are experienced sudden change in direction. According to Beale's study (2014), rectangular 90^0 bends are commonly found in HVAC ductworks. These inefficient bends increase the overall friction and create turbulent flow in a duct system.

In Figure 34, (a) a straight duct and (b) a 90° bended duct are created in order to compare and show the effect of a sharp-edge 90° bend before the air moving through a heat exchanger. These example cases are built based on similar parameters (total airflow rate and heat extracting rate) as the VDC model but in a 2m x 2m open ended duct. In Figure 35a, the air is straight moving through the duct and produces no recirculation; therefore, a uniform temperature profile can be obtained at the exit as expected (Figure 36a). However, the uniform velocity profile is no longer attainable after the air coming from a 90° sharp bend as shown in Figure 35b. This is because eddy is formed at the upper left corner and bottom portion of the duct and greatly decreases the velocity within the recirculation zone. Also, to keep up with the mass flow, the air in upper portion of the duct has to travel faster than before. In addition, the way the heat exchanger modeled in the current study is based on heat flux approach (kW/m^2) which means equal heat removing rate is assigned to each modeled surface, therefore, an uneven airflow through the heat exchanger can cause an uneven temperature profile. As illustrated in Figure 36b, it produces much warmer and colder air in the upper part and lower part of the duct respectively in comparison to Figure 36a.

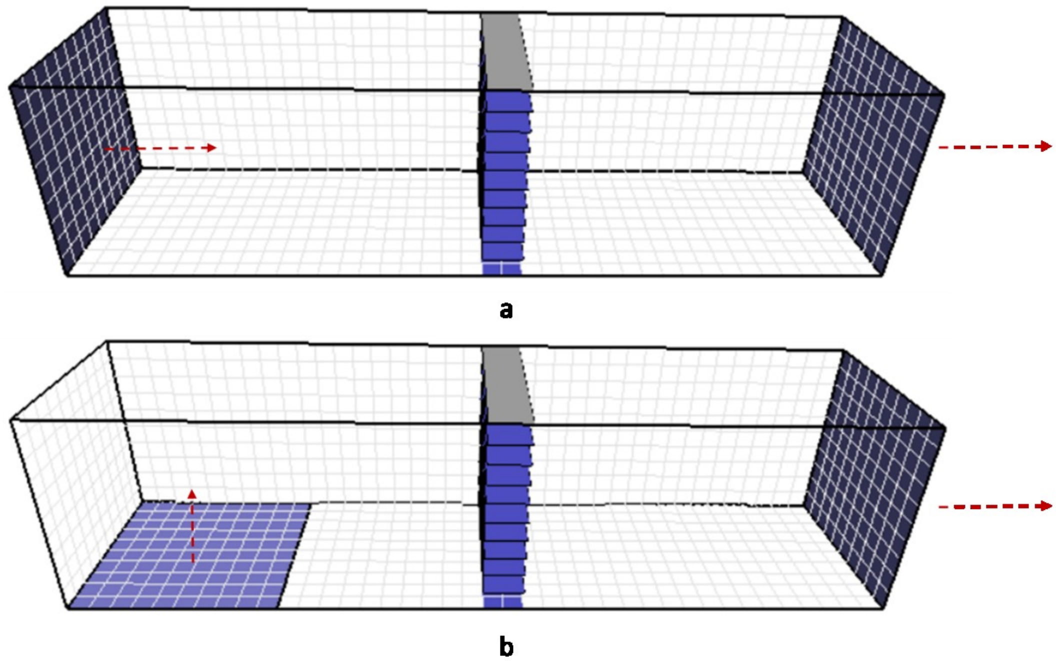


Figure 34 A Closer Look of Air Distribution in (a) a straight duct (b) a 90˚ Bend duct models

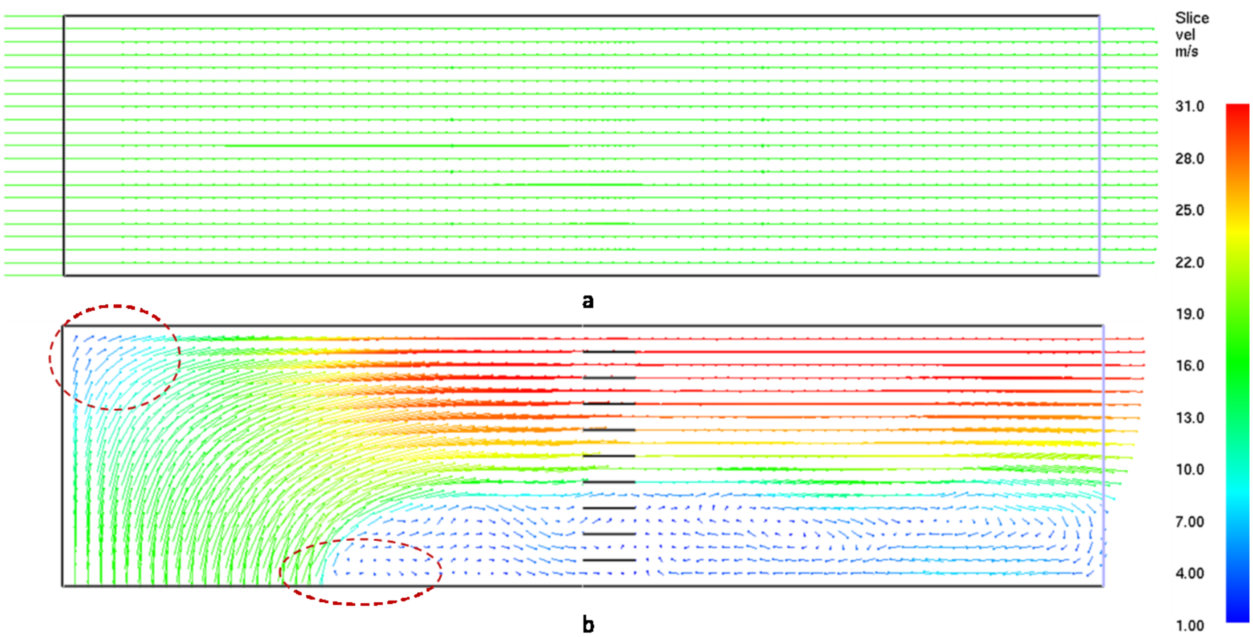


Figure 35 Velocity Distribution in (a) a straight duct (b) a 90˚ Bend duct models

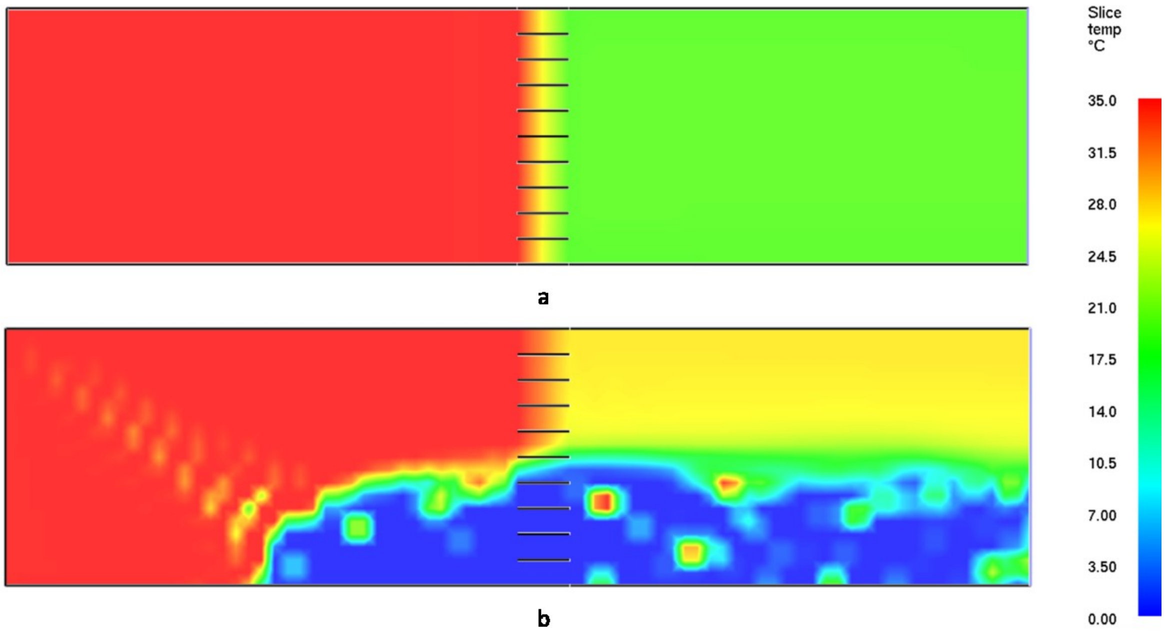


Figure 36 Temperature Distribution in (a) a straight duct (b) a 90° Bend duct models

In the current case studies, there are multiple rectangular bends which produce even more complex turbulent flow leading to a thermal stratification. The degree of low temperature output phenomenon depends on many factors such as velocity of airflow, air motion, types and sizes of bends. For example, the impact of turbulence is more pronounced in case 2 than case 3, since the heat exchanger in case 2 is located right near downstream of the supply fans, air is still moving at a very fast speed (about 9 m/s) after sudden changed in direction and transfer only through the lower portion of the heat exchanger. Moreover, in case 2, there is not enough warm air to be mixed with this extra low temperature air produced from the heat exchanger before reaching to the middle floors' cold aisles. Therefore, unlike the process in case 1 where air is being heated from servers only. Case 2 and case 3 are running in a loop with both heating and cooling activated. As mentioned in the example case (Figure 34), a non-uniform temperature output profile and undesired delta T can be developed due to lack of properly distributing the air.

One strategy to improve this airflow challenge is to install guide vanes in all 90° bends. The guide vane can help to increase the efficiency of turning by providing a smoother and more gradual change in direction. Although the turning guide vanes feature in duct is not a new technology, it has been examined and proven by many researchers and engineers as an effective solution in creating a more uniform airflow for air moving a 90° bend in a duct (Beale, 2014; Johnson, 2009). The effect of turning guide vanes is not simulated in current study because the FDS software has limitations to model the curve feature objects.

Despite both case 2 and case 3 have the challenge of distributing the air evenly through the heat exchanger coils, case 3 is better than case 2 in term of following aspects as shown in Table 22.

Table 22 Comparison between Case 2 and Case 3

Performance	Heat exchangers in case 3 are located further away upstream from the supply fans and has relatively slower face velocity from exhaust air (about 6-7 m/s) as opposed to case 2 that has concentrated and high speed airflow strike (about 8-9 m/s). In other word, case 3 has a better air distribution through the heat exchangers without guide vane at this given structure.
Compatibility	Location of heat exchanger in case 2 is next to the original mechanical cooling coils which means the conditioned air out of the thermosiphon heat exchangers may not mix well before reaching the mechanical cooling coil and has a relative shorter time frame for the mechanical cooling coils to react (Higher requirements in sensors and controlling related aspects). This could be an potential issue for them to functioning properly when both are running.
Fan Malfunction	Cold air is produced at the top heat exchanger in case 3 which will naturally flow down by gravity which helps when some of main supply fans are down

To sum up, a well-performed air distribution is essential for a data center to function properly even though the facility is equipped with well-designed cooling systems. Based on above analysis, it reveals that the proposed data center closed loop operation can be improved in the future either through a better HVAC design (e.g. turning guide vanes, heat exchanger shape and orientation), or a refined structure (e.g. symmetric structure - delivering the conditioned air from center up or both sides directly).

5.0 Conclusion and Future Work

5.1 Conclusion and Contribution

In conclusion, this thesis has proposed an indirect airside free cooling based on thermosiphon loop for the VDC project as opposed to the original direct airside free cooling approach. Energy model was established to evaluate the energy performance of the new proposed data center. Also a qualitative evaluation of airflow distribution of the VDC with two proposed thermosiphon evaporators' locations was investigated.

The following conclusions were found:

In the study of energy performance part, both thermosiphon free cooling and conventional direct airside free cooling approaches were compared in different cities across North America. The results shown that, in general, both approaches have the ability to save significant amounts of annual cooling energy for data center applications. However, the cooling energy saving potential of the direct airside free cooling approach also depends on the outdoor air humidity factor while it is independent for the thermosiphon system. In addition, data centers with the direct airside free cooling approach is more sensitive and vulnerable to outdoor air pollutant. Last, the main goal is not to decide which free cooling method the best in this study but rather to show that the energy saving potential of data centers with thermosiphon free cooling.

In the study of airflow performance part, the airflow distribution is not yet optimized for this specific VDC design. The overall rectangular shape feature creates a lot of complex turbulent and recirculation flows within the building. Turbulent flows are good for the purpose of mixing. However, it affects the air distribution especially when air travels through the 90° degree bends.

Through the CFD analysis, 90° sharp-edge bends can decrease the airflow's uniformity and affect the performance of heat exchangers in real life.

5.2 Recommendations for Future Work

The research and results in this thesis show that implementing the thermosiphon in a data center has the potential to reduce the energy consumption while protecting the IT equipment from being damaged by outdoor airborne pollutants during free cooling operations. There is also a challenge in placing the thermosiphon heat exchanger in this special rectangular vertical style data center as discussed in the current study. Therefore, in order to make the concept to be more practical. The following areas are recommended to be further explored in the near future.

- To update the energy model at a later detail design stage when more information are available such as building materials and location, and supplier test data of the heat exchanger, and other HVAC equipment detail info.
- To investigate the implementation of turning guide vanes in the VDC project because the overall building structure is based on rectangular shape. Airflow distribution is important to all data centers applications to ensure the HVAC cooling system working properly. It needs to develop a strategy as well to determine an optimal guide vanes configuration as many factors such as quantity, angle, alignments, and sizes affects the flow pattern.
- To analyze the pressure distribution for this VDC project. It is recommended to study leakage effect and incorporate into the CFD model.
- To collaborate with thermosiphon manufacturers for a custom designed and built of heat exchangers for this specific application. A prototype of smaller unit should be built first and test to verify the performance in real life environment. Also, the cost of

manufacturing and maintenance of such device and well as the final assembly should be investigated in order to determine its payback period.

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Appendix A – eQUEST Modeling Related Info

Internal Load Input Calculation

Table 23 Internal Heat Gain Summary

Components	Total Sensible heat	Total Latent heat	Area	Density
--	kW	kW	ft^2	$\frac{W}{ft^2}$
IT equipment	1080.00		1080	1000.00
UPS battery etc. loss	163.44		1030	158.68
Power Distribution	24.35		1080	22.55
Lighting	10.72		5360	2.00
Occupant	1.34	0.98	5360	0.43

- IT equipment

$$q_{IT} = 90 \text{ Racks} * \frac{12\text{kW}}{\text{Racks}} = 1080 \text{ kW}$$

$$\text{IT equiment power density} = \frac{1080 \text{ kW}}{1080 \text{ ft}^2} * \frac{1000 \text{ W}}{1 \text{ kW}} = 1000 \frac{\text{W}}{\text{ft}^2}$$

- UPS with batteries

The power rating of UPS is referred to Figure 40 below and assumed a power factor of 0.8 (Tanzer, 2011).

So using the Eqn. 4-1:

$$\text{Power Rating}_{UPS} = \left[(1500\text{V} * 480\text{A} + 2000\text{V} * 600\text{A}) * \frac{1 \text{ kVA}}{1000 \text{ VA}} + (300 \text{ kVA} * 5 \text{ unit})\right] * 0.8$$

$$= 2736 \text{ kW}$$

$$q_{UPS} = 0.04 * 2736 + 0.05 * 1080 = 163.44 \text{ kW}$$

$$\text{UPS power density} = \frac{163.44 \text{ kW}}{1030 \text{ ft}^2} * \frac{1000 \text{ W}}{1 \text{ kW}} = 158.68 \frac{\text{W}}{\text{ft}^2}$$

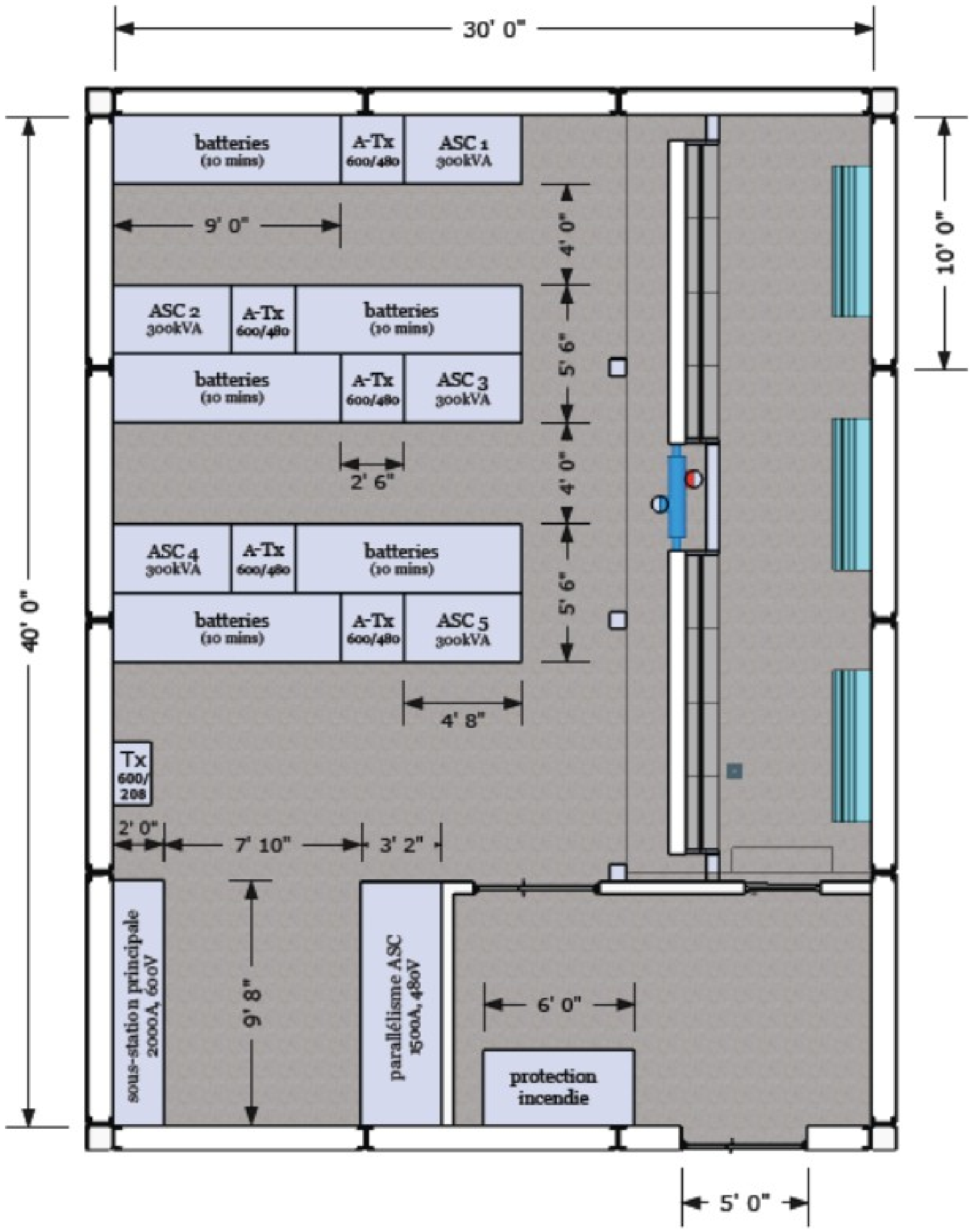


Figure 37 Ground Floor Plan (Vert.com Inc.)

- PDU

In typical power distribution system, the power rating is rated from 50 to 500 kVA throughout the IT room (Rasmussen, 2013) and assumed a same power factor as in UPS.

So using Eqn. 4-2:

$$\text{Power Rating}_{\text{PDU}} = 0.01 * \frac{(50 + 500)}{2} * 0.8 + 0.02 * 1080 = 23.8\ \text{kW}$$

$$\text{PDU power density} = \frac{23.8\ \text{kW}}{1080\ \text{ft}^2} * \frac{1000\ \text{W}}{1\ \text{kW}} = 22.04 \frac{\text{W}}{\text{ft}^2}$$

- Lighting

The lighting density is assumed at 2 $\frac{\text{W}}{\text{ft}^2}$ (Rasmussen, 2011) with total modeled floor area of 5360 ft^2.

So using Eqn. 4-3:

$$q_{\text{lighting}} = 2 * 5360\ \text{ft}^2 * 1 \frac{\text{kW}}{1000\ \text{W}} = 10.72\ \text{kW}$$

- Occupant

According to the ASHRAE Fundamental (Chapter 18, ASHRAE, 2013), the SHG (sensible heat gain) and LHG (latent heat gain) for a typical person at light work condition are 75W (256 btu/hr) and 55W (188 btu/hr) respectively.

So using Eqn. 4-4 and 4-5:

$$N = 5360\ \text{ft}^2 * \frac{\text{\# of occupant}}{300\ \text{ft}^2} = 18\ \text{occpants}$$

$$q_{o,s} = 17.87 * 75 \frac{\text{W}}{\text{occupant}} * 1 \frac{\text{kW}}{1000\text{W}} = 13.4\ \text{kW}$$

$$q_{o,l} = 17.87 * 55 \frac{\text{W}}{\text{occupant}} * 1 \frac{\text{kW}}{1000\text{W}} = 0.98\ \text{kW}$$

$$q_{tot} = 13.4 + 0.98 = 14.38\ \text{kW}$$

Appendix B – Heat Exchanger Info

- **Heat Exchanger Effectiveness for Sensible Heat Transfer**

The sensible effectiveness of a heat exchanger is defined as Eqn. B-1 and can be expressed in term of either Eqn. B-2a or B-2b (Chapter 26, ASHRAE, 2012):

$$\varepsilon_s = \frac{q}{q_{max}} \quad \text{Eqn. B-1}$$

$$\varepsilon_s = \frac{\dot{m}_h * C_{p,h} * (T_{h,i} - T_{h,o})}{C_{min} * (T_{h,i} - T_{c,i})} \quad \text{Eqn. B-2a}$$

$$\varepsilon_s = \frac{\dot{m}_c * C_{p,c} * (T_{c,o} - T_{c,i})}{C_{min} * (T_{h,i} - T_{c,i})} \quad \text{Eqn. B-2b}$$

Where,

ε_s is the sensible effectiveness of heat exchanger

q and q_{max} are actual and maximum sensible heat transfer rate, [kW]

$\dot{m}_h$ and $\dot{m}_c$ are mass flow rate of hot and cold air streams

$C_{p,h}$ and $C_{p,c}$ are specific heat of hot and cold air streams, $[\frac{kJ}{kg * °C}]$

C_{min} is the smaller of the heat capacity rate, $\dot{m}_h * C_{p,h}$ or $\dot{m}_c * C_{pc}$, $[\frac{kJ}{°C * s}]$

$T_{h,i}$ and $T_{h,o}$ are the inlet and outlet drybulb temperature of the hot air stream, [°C]

$T_{c,i}$ *and* $T_{c,o}$ are the inlet and outlet drybulb temperature of the cold air stream, [°C]

According to ASHRAE – HVAC Systems and Equipment handbook (2012), typical sensible effectiveness for thermosiphon energy recovery devices is 40% to 60%. A constant sensible effectiveness of 60% is assumed for my design in order to maximize the energy saving potential. Therefore, the hot recirculated fluid outlet temperature can be quickly determined by Eqn. B-3a from rearranging Eqn. B-3. Eqn.B-3 is obtained by further simplifying Eqn. B-2a or 2b with a balance flows situation assumption, $C_{ph} = \dot{m}_c * C_{pc} = C_{min}$, and Eqn. B-2 becomes Eqn. B-3.

$$\varepsilon_s = \frac{(T_{hi} - T_{ho})}{(T_{hi} - T_{ci})} = \frac{(T_{co} - T_{ci})}{(T_{hi} - T_{ci})} \qquad \text{Eqn. B-3}$$

$$T_{ho} = T_{hi} - \varepsilon_s * (T_{hi} - T_{ci}) \qquad \text{Eqn. B-3a}$$

- **Airside Pressure Drop**

Another major parameter that affects the free cooling performance is the airside pressure drop through the thermosiphon heat exchangers. Detail design of a heat exchanger is not the main goal and scope in this thesis. The design of heat exchanger is a complex and tedious process; it involves analysis of coils and fins configurations, material selection, refrigerant choices, and fluids properties, etc. in order to determine the overall heat transfer coefficient, pressure drop, and other performance data. In this study, the airside pressure drop through the thermosiphon evaporators section is calculated equal to 0.96 inch wg., which falls within the common range, 0.6 - 2 inch wg. (Chapter 26 ASHRAE 2012), based on the method provided by McQuiston et al. (2005). In Chapter 14 of McQuistin's handbook (2005), the authors provide a good source of heat exchangers preliminary design calculation based on industrial standards values, empirical equations, experimental data etc. This estimated pressure drop is also applied in the condenser fan power calculation. Actual performance should consult with manufacturer.

Appendix C Experimental Result and Data Reduction

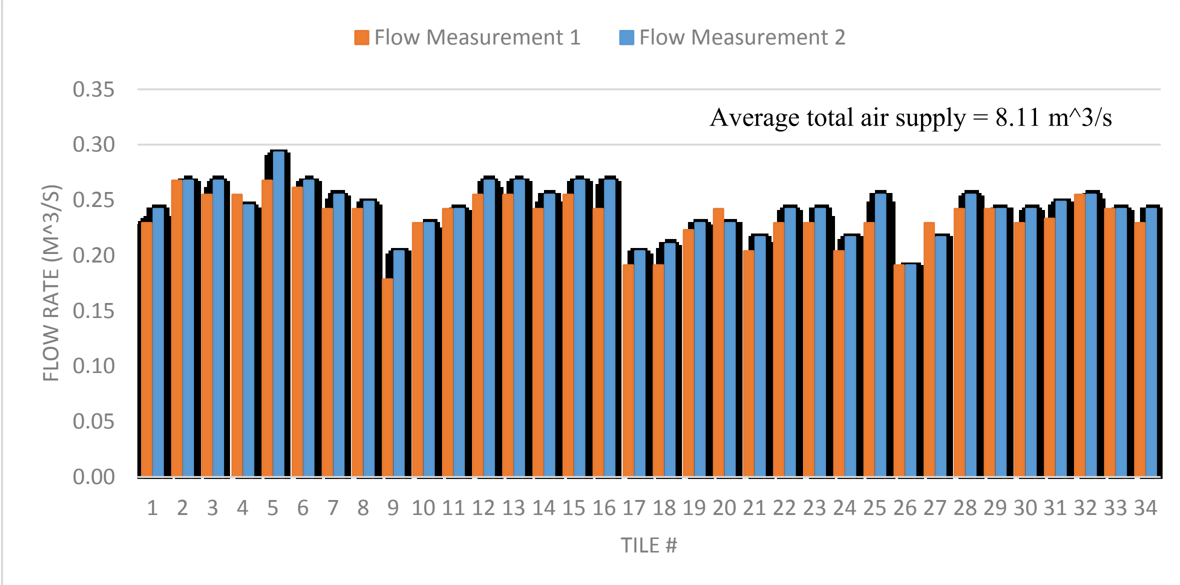
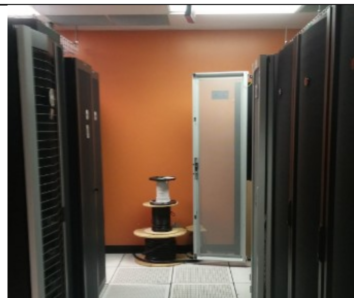
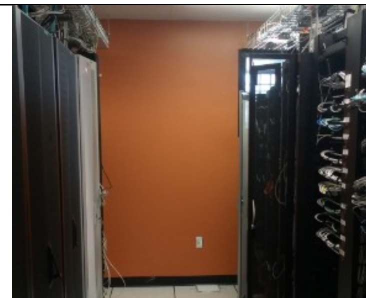
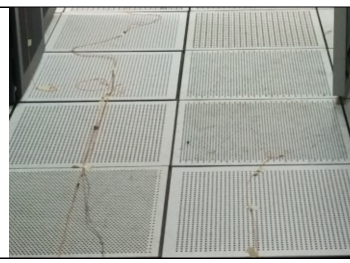
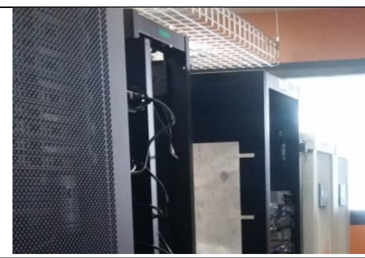
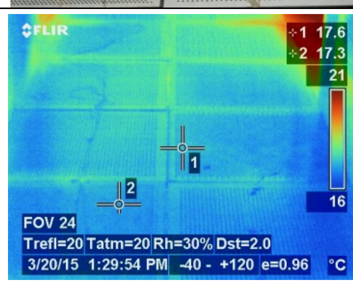


Figure 38 Perforated Tiles Flow Rate Measurements

Table 24 Rack Heat Load Estimation

Equipment Rack	Average Temp In, C	Average Temp Out, C	Delta T	Volume Flow, m^3/s	Estimated Load, kW
R1C1 (OFF)	N.A	N.A	N.A	N.A	N.A
R1C2	21.25	22.46	1.21	0.15	0.22
R1C3	19.23	25.14	5.91	0.21	1.53
R1C4	18.66	26.29	7.63	0.30	2.82
R2C1	19.97	23.61	3.64	0.30	1.34
R2C2	18.84	28.99	10.14	0.85	10.63
R2C3	18.85	26.71	7.86	0.27	2.62
R2C4	19.70	23.90	4.20	0.34	1.76
R2C5	20.23	25.95	5.72	1.00	7.02
R2C6	21.68	29.92	8.24	0.47	4.73
R3C1	17.46	24.14	6.68	0.40	3.31
R3C2	17.75	27.36	9.61	0.32	3.81
R3C3 (OFF)	N.A	N.A	N.A	N.A	N.A
R3C4 (OFF)	N.A	N.A	N.A	N.A	N.A
R3C5	19.64	25.24	5.60	0.31	2.14
R3C6	19.14	24.33	5.19	0.17	1.09
R3C7	18.74	25.21	6.47	0.32	2.55
R4C1	19.18	23.93	4.76	0.27	1.58
R4C2	19.18	23.93	4.76	0.27	1.58
R4C3	19.18	23.93	4.76	0.27	1.58
R4C4	19.18	23.93	4.76	0.27	1.58
Tape storage	19.44	25.23	5.79	0.40	2.88

Table 25 Infrared Images of Computer Room

<table>
<tr><td>Component</td><td>Cold Aisle</td><td>Hot Aisle</td></tr>
<tr><td>Normal Pic</td><td></td><td></td></tr>
<tr><td>Infrared Pic</td><td>
</td><td>
</td></tr>
<tr><td></td><td>Perforated tiles in cold aisle #1</td><td>Row 3 front side</td></tr>
<tr><td>Normal Pic</td><td></td><td></td></tr>
<tr><td>Infrared Pic</td><td>
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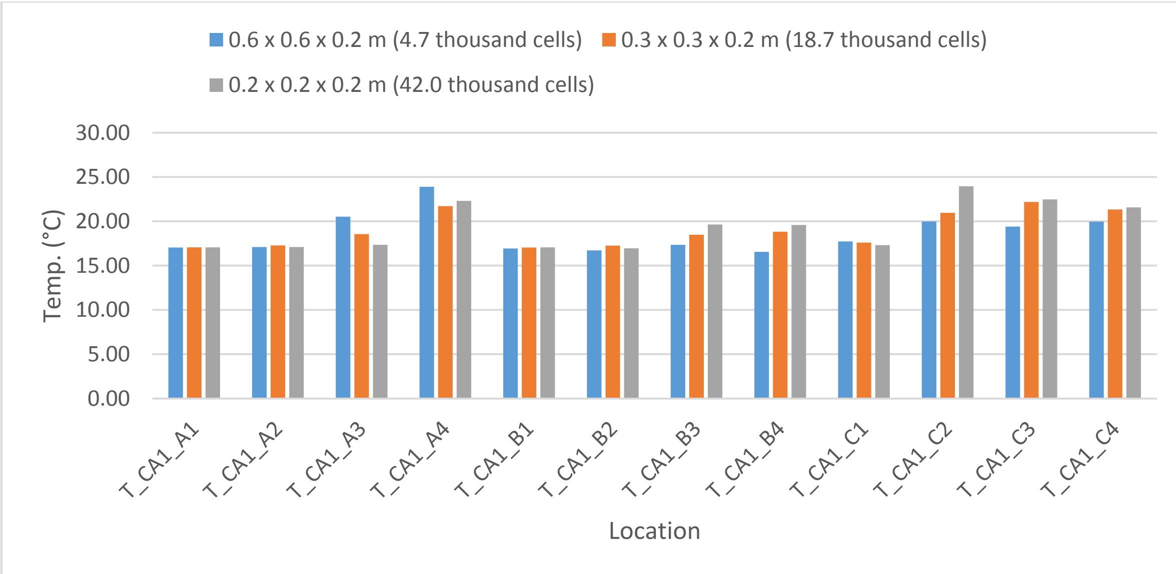

Figure 39 Cold Aisle Temperatures Comparison for Mesh Sensitive Analysis

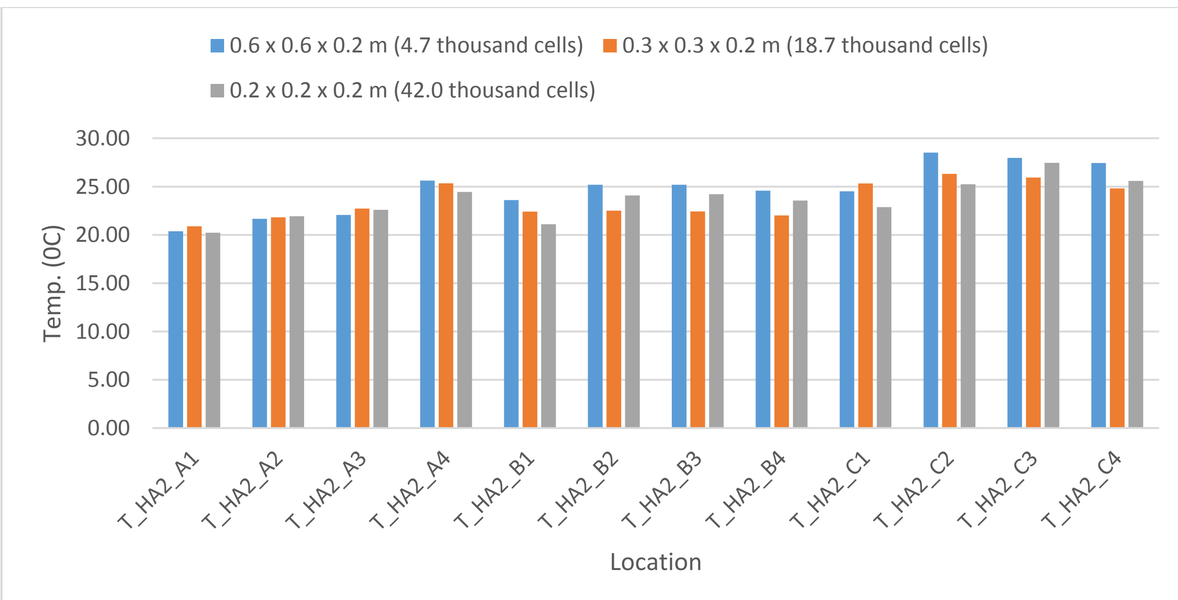

Figure 40 Hot Aisle Temperatures Comparison for Mesh Sensitive Analysis

FDS input Files – Validation (Library Server Room Model)

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R3C5-HS3
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R3C5-HS8
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R3C6-HS1
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R3C6-HS8
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R3C7-HS2
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R3C7-HS3
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R3C7-HS4
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R3C7-HS5
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R3C7-HS6
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R3C7-HS7
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R3C7-HS8
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R3C7-HS9
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R4C1-HS3
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R4C1-HS4
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R4C1-HS6
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R4C1-HS7
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R4C1-HS8
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R4C1-HS9
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R4C2c
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R4C2-HS2
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R4C2-HS3
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R4C2-HS4
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R4C2-HS6
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R4C2-HS7
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R4C2-HS8
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R4C2-HS9
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R4C3-HS1

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R4C3-HS3
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R4C3-HS4
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R4C3-HS6
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R4C3-HS7
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R4C4-HS1
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R4C4-HS2
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R4C4-HS3
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R4C4-HS4
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R4C4-HS6
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R4C4-HS7
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R4C4-HS8
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R4C4-HS9
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R1C4F1
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R2C3F1
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&VENT SURF_ID='OPEN', XB=5.8,6.4,3.0,3.6,2.6,2.6/ Retun11
&VENT SURF_ID='OPEN', XB=8.0,8.6,3.6,4.2,2.6,2.6/ Retun12
&VENT SURF_ID='OPEN', XB=11.2,11.8,3.6,4.2,2.6,2.6/ Retun13
&VENT SURF_ID='OPEN', XB=10.6,11.2,0.6,1.2,2.6,2.6/ Retun14
&VENT SURF_ID='OPEN', XB=8.6,9.2,0.6,1.2,2.6,2.6/ Retun15
&VENT SURF_ID='OPEN', XB=6.0,6.6,0.6,1.2,2.6,2.6/ Retun16
&VENT SURF_ID='OPEN', XB=2.4,3.0,0.6,1.2,2.6,2.6/ Retun17
&TAIL /

Appendix D VDC FDS Input Files - Case 3

Example of one of the big case models is shown in below. Mesh and geometry input in Pyrosim were based on English unit from the drawing but converted into SI unit automatically in text file during file generation.

```
case3p1.fds
Generated by PyroSim - Version 2012.1.1221
26-Feb-2016 9:29:15 PM

&HEAD CHID='case3p1'/
&TIME T_END=3600.0/
&DUMP RENDER_FILE='case3p1.ge1', DT_DEVC=20.0,
DT_RESTART=300.0/
&MISC C_HORIZONTAL=4.05, C_VERTICAL=3.08,
RADIATION=.FALSE./

&MESH ID='mesh1_ground_L', IJK=32,84,28,
XB=0.0,4.8768,0.0,12.8016,0.0,4.2672/
&MESH ID='mesh2_ground_R', IJK=32,84,28,
XB=4.8768,9.7536,0.0,12.8016,0.0,4.2672/
&MESH ID='mesh3_corridor1', IJK=20,66,20,
XB=6.7056,9.7536,2.7432,12.8016,4.2672,7.3152/
&MESH ID='mesh4_corridor2', IJK=20,66,20,
XB=6.7056,9.7536,2.7432,12.8016,7.3152,10.3632/
&MESH ID='mesh5_corridor3', IJK=20,66,20,
XB=6.7056,9.7536,2.7432,12.8016,10.3632,13.4112/
&MESH ID='mesh6_server_1', IJK=44,66,20,
XB=0.0,6.7056,2.7432,12.8016,4.2672,7.3152/
&MESH ID='mesh7_server_2', IJK=44,66,20,
XB=0.0,6.7056,2.7432,12.8016,7.3152,10.3632/
&MESH ID='mesh8_server_3', IJK=44,66,20,
XB=0.0,6.7056,2.7432,12.8016,10.3632,13.4112/
&MESH ID='mesh9_4th_flor', IJK=40,60,20,
XB=2.4384,8.5344,3.048,12.192,13.4112,16.4592/

&SURF ID='Wall',
    RGB=204,203,204,
    NET_HEAT_FLUX=0.0/
&SURF ID='Flors',
    COLOR='GRAY 40',
    NET_HEAT_FLUX=0.0/
&SURF ID='ADIABATIC',
    COLOR='GRAY 80',
    ADIABATIC=.TRUE./
&SURF ID='Supply Fans',
    COLOR='BLACK',
    MASS_FLUX_TOTAL=-15.634,
    POROUS=.TRUE./
&SURF ID='Cabinet Fan Left',
    RGB=255,255,51,
    TRANSPARENCY=0.8,
    MASS_FLUX_TOTAL=0.67,
    POROUS=.TRUE./
&SURF ID='Cabinet Fan Right',
    RGB=255,255,51,
    TRANSPARENCY=0.8,
    MASS_FLUX_TOTAL=-0.67,
    POROUS=.TRUE./
&SURF ID='Server Heater',
    RGB=255,51,51,
    CONVECTIVE_HEAT_FLUX=1.709/
&SURF ID='Cooler',
    RGB=153,255,255,
    CONVECTIVE_HEAT_FLUX=-12.663/

&OBST XB=0.0,0.3048,0.3048,12.4968,0.4572,14.1732,
COLOR='INVISIBLE', SURF_ID='Wall'/ Ext Wall Left
&OBST XB=9.4488,9.7536,0.3048,12.4968,0.4572,14.1732,
COLOR='INVISIBLE', SURF_ID='Wall'/ Ext Wall Right
&OBST XB=0.0,9.7536,0.0,0.3048,0.4572,14.1732,
COLOR='INVISIBLE', SURF_ID='Wall'/ Ext Wall Front
&OBST XB=0.0,9.7536,12.4968,12.8016,0.4572,14.1732,
COLOR='INVISIBLE', SURF_ID='Wall'/ Ext Wall Back
&OBST XB=0.0,9.7536,0.0,12.8016,0.0,0.1524,
SURF_ID='Flors'/ Flor_0th
&OBST XB=6.5532,9.4488,3.3528,12.4968,0.01524,0.01524,
PERMIT_HOLE=.FALSE., SURF_ID='Flors'/ Flor_0th_part2
&OBST XB=0.0,0.3048,0.3048,12.4968,0.1524,0.4572,
COLOR='INVISIBLE', SURF_ID='Wall'/ Bot Peri Obs_L
&OBST XB=9.4488,9.7536,0.3048,12.4968,0.1524,0.4572,
COLOR='INVISIBLE', SURF_ID='Wall'/ Bot Peri Obs_R
&OBST XB=0.0,9.7536,0.0,0.3048,0.1524,0.4572,
COLOR='INVISIBLE', SURF_ID='Wall'/ Bot Peri Obs_F
&OBST XB=0.0,9.7536,12.4968,12.8016,0.1524,0.4572,
COLOR='INVISIBLE', SURF_ID='Wall'/ Bot Peri Obs_B
&OBST XB=6.2484,9.7536,3.048,12.8016,-0.6096,0.0,
COLOR='GRAY 40', SURF_ID='INERT'/ Bot Extruded Part1
&OBST XB=4.2672,4.4196,0.3048,3.3528,0.1524,4.1148,
COLOR='INVISIBLE', SURF_ID='Wall'/ Wall 0F1
&OBST XB=4.4196,9.4488,3.2004,3.3528,0.1524,4.1148,
COLOR='INVISIBLE', SURF_ID='Wall'/ Wall 0F2
&OBST XB=7.0104,7.1628,8.5344,12.192,0.1524,4.1148,
COLOR='GRAY 80', SURF_ID='ADIABATIC'/
Top_Ori_HX_part1
&OBST XB=7.0104,7.1628,8.5344,12.192,0.0,0.1524,
COLOR='GRAY 80', PERMIT_HOLE=.FALSE.,
SURF_ID='ADIABATIC'/ Top_Ori_HX_part2
&OBST XB=7.0104,7.1628,3.6576,7.3152,0.0,4.1148,
COLOR='GRAY 80', SURF_ID='ADIABATIC'/
Bot_Ori_HX_part1
&OBST XB=7.0104,7.1628,3.6576,7.3152,0.0,0.1524,
COLOR='GRAY 80', PERMIT_HOLE=.FALSE.,
SURF_ID='ADIABATIC'/ Bot_Ori_HX_part2
&OBST XB=6.858,7.0104,7.9248,8.0772,0.0,4.1148,
RGB=0,102,255, PERMIT_HOLE=.FALSE.,
SURF_ID='ADIABATIC'/ Ori HX Part3
&OBST XB=6.858,7.0104,3.3528,7.9248,3.9624,4.1148,
RGB=0,102,255, SURF_ID='ADIABATIC'/ Ori HX Part4
&OBST XB=7.1628,7.3152,7.7724,7.9248,0.762,3.9624,
COLOR='RED', SURF_ID='ADIABATIC'/ Ori HX Part5
&OBST XB=7.1628,7.3152,3.3528,7.9248,3.9624,4.1148,
COLOR='RED', SURF_ID='ADIABATIC'/ Ori HX Part6
&OBST XB=7.0104,7.1628,7.3152,8.5344,3.81,3.9624,
COLOR='RED', SURF_ID='ADIABATIC'/ Ori HX Part7
&OBST XB=7.0104,7.1628,7.3152,8.5344,2.7432,2.8956,
RGB=0,102,255, SURF_ID='ADIABATIC'/ Ori HX Part8
&OBST XB=7.0104,7.1628,7.3152,8.5344,2.4384,2.5908,
COLOR='RED', SURF_ID='ADIABATIC'/ Ori HX Part9
```

```
&OBST XB=7.0104,7.1628,7.3152,8.5344,1.6764,1.8288,
RGB=0,102,255, SURF_ID='ADIABATIC'/ Ori HX Part10
&OBST XB=7.0104,7.1628,7.3152,8.5344,1.3716,1.524,
COLOR='RED', SURF_ID='ADIABATIC'/ Ori HX Part11
&OBST XB=7.0104,7.1628,7.3152,8.5344,0.1524,0.3048,
COLOR='RED', SURF_ID='ADIABATIC'/ Ori HX Part12
&OBST XB=7.0104,7.1628,8.8392,11.8872,0.6096,0.6096,
COLOR='GRAY 80', PERMIT_HOLE=.FALSE.,
SURF_ID='ADIABATIC'/ Top_Ori_HX_fin1
&OBST XB=7.0104,7.1628,8.8392,11.8872,0.762,0.762,
COLOR='GRAY 80', PERMIT_HOLE=.FALSE.,
SURF_ID='ADIABATIC'/ Top_Ori_HX_fin2
&OBST XB=7.0104,7.1628,8.8392,11.8872,0.9144,0.9144,
COLOR='GRAY 80', PERMIT_HOLE=.FALSE.,
SURF_ID='ADIABATIC'/ Top_Ori_HX_fin3
&OBST XB=7.0104,7.1628,8.8392,11.8872,1.0668,1.0668,
COLOR='GRAY 80', PERMIT_HOLE=.FALSE.,
SURF_ID='ADIABATIC'/ Top_Ori_HX_fin4
&OBST XB=7.0104,7.1628,8.8392,11.8872,1.2192,1.2192,
COLOR='GRAY 80', PERMIT_HOLE=.FALSE.,
SURF_ID='ADIABATIC'/ Top_Ori_HX_fin5
&OBST XB=7.0104,7.1628,8.8392,11.8872,1.3716,1.3716,
COLOR='GRAY 80', PERMIT_HOLE=.FALSE.,
SURF_ID='ADIABATIC'/ Top_Ori_HX_fin6
&OBST XB=7.0104,7.1628,8.8392,11.8872,1.524,1.524,
COLOR='GRAY 80', PERMIT_HOLE=.FALSE.,
SURF_ID='ADIABATIC'/ Top_Ori_HX_fin7
&OBST XB=7.0104,7.1628,8.8392,11.8872,1.6764,1.6764,
COLOR='GRAY 80', PERMIT_HOLE=.FALSE.,
SURF_ID='ADIABATIC'/ Top_Ori_HX_fin8
&OBST XB=7.0104,7.1628,8.8392,11.8872,1.8288,1.8288,
COLOR='GRAY 80', PERMIT_HOLE=.FALSE.,
SURF_ID='ADIABATIC'/ Top_Ori_HX_fin9
&OBST XB=7.0104,7.1628,8.8392,11.8872,1.9812,1.9812,
COLOR='GRAY 80', PERMIT_HOLE=.FALSE.,
SURF_ID='ADIABATIC'/ Top_Ori_HX_fin10
&OBST XB=7.0104,7.1628,8.8392,11.8872,2.1336,2.1336,
COLOR='GRAY 80', PERMIT_HOLE=.FALSE.,
SURF_ID='ADIABATIC'/ Top_Ori_HX_fin11
&OBST XB=7.0104,7.1628,8.8392,11.8872,2.286,2.286,
COLOR='GRAY 80', PERMIT_HOLE=.FALSE.,
SURF_ID='ADIABATIC'/ Top_Ori_HX_fin12
&OBST XB=7.0104,7.1628,8.8392,11.8872,2.4384,2.4384,
COLOR='GRAY 80', PERMIT_HOLE=.FALSE.,
SURF_ID='ADIABATIC'/ Top_Ori_HX_fin13
&OBST XB=7.0104,7.1628,8.8392,11.8872,2.5908,2.5908,
COLOR='GRAY 80', PERMIT_HOLE=.FALSE.,
SURF_ID='ADIABATIC'/ Top_Ori_HX_fin14
&OBST XB=7.0104,7.1628,8.8392,11.8872,2.7432,2.7432,
COLOR='GRAY 80', PERMIT_HOLE=.FALSE.,
SURF_ID='ADIABATIC'/ Top_Ori_HX_fin15
&OBST XB=7.0104,7.1628,8.8392,11.8872,2.8956,2.8956,
COLOR='GRAY 80', PERMIT_HOLE=.FALSE.,
SURF_ID='ADIABATIC'/ Top_Ori_HX_fin16
&OBST XB=7.0104,7.1628,8.8392,11.8872,3.048,3.048,
COLOR='GRAY 80', PERMIT_HOLE=.FALSE.,
SURF_ID='ADIABATIC'/ Top_Ori_HX_fin17
&OBST XB=7.0104,7.1628,8.8392,11.8872,3.2004,3.2004,
COLOR='GRAY 80', PERMIT_HOLE=.FALSE.,
SURF_ID='ADIABATIC'/ Top_Ori_HX_fin18
&OBST XB=7.0104,7.1628,8.8392,11.8872,3.3528,3.3528,
COLOR='GRAY 80', PERMIT_HOLE=.FALSE.,
SURF_ID='ADIABATIC'/ Top_Ori_HX_fin19
&OBST XB=7.0104,7.1628,8.8392,11.8872,3.5052,3.5052,
COLOR='GRAY 80', PERMIT_HOLE=.FALSE.,
SURF_ID='ADIABATIC'/ Top_Ori_HX_fin20
&OBST XB=7.0104,7.1628,8.8392,11.8872,3.6576,3.6576,
COLOR='GRAY 80', PERMIT_HOLE=.FALSE.,
SURF_ID='ADIABATIC'/ Top_Ori_HX_fin21
&OBST XB=7.0104,7.1628,3.9624,7.0104,0.6096,0.6096,
COLOR='GRAY 80', PERMIT_HOLE=.FALSE.,
SURF_ID='ADIABATIC'/ Bot_Ori_HX_fin1
&OBST XB=7.0104,7.1628,3.9624,7.0104,0.762,0.762,
COLOR='GRAY 80', PERMIT_HOLE=.FALSE.,
SURF_ID='ADIABATIC'/ Bot_Ori_HX_fin2
&OBST XB=7.0104,7.1628,3.9624,7.0104,0.9144,0.9144,
COLOR='GRAY 80', PERMIT_HOLE=.FALSE.,
SURF_ID='ADIABATIC'/ Bot_Ori_HX_fin3
&OBST XB=7.0104,7.1628,3.9624,7.0104,1.0668,1.0668,
COLOR='GRAY 80', PERMIT_HOLE=.FALSE.,
SURF_ID='ADIABATIC'/ Bot_Ori_HX_fin4
&OBST XB=7.0104,7.1628,3.9624,7.0104,1.2192,1.2192,
COLOR='GRAY 80', PERMIT_HOLE=.FALSE.,
SURF_ID='ADIABATIC'/ Bot_Ori_HX_fin5
&OBST XB=7.0104,7.1628,3.9624,7.0104,1.3716,1.3716,
COLOR='GRAY 80', PERMIT_HOLE=.FALSE.,
SURF_ID='ADIABATIC'/ Bot_Ori_HX_fin6
&OBST XB=7.0104,7.1628,3.9624,7.0104,1.524,1.524,
COLOR='GRAY 80', PERMIT_HOLE=.FALSE.,
SURF_ID='ADIABATIC'/ Bot_Ori_HX_fin7
&OBST XB=7.0104,7.1628,3.9624,7.0104,1.6764,1.6764,
COLOR='GRAY 80', PERMIT_HOLE=.FALSE.,
SURF_ID='ADIABATIC'/ Bot_Ori_HX_fin8
&OBST XB=7.0104,7.1628,3.9624,7.0104,1.8288,1.8288,
COLOR='GRAY 80', PERMIT_HOLE=.FALSE.,
SURF_ID='ADIABATIC'/ Bot_Ori_HX_fin9
&OBST XB=7.0104,7.1628,3.9624,7.0104,1.9812,1.9812,
COLOR='GRAY 80', PERMIT_HOLE=.FALSE.,
SURF_ID='ADIABATIC'/ Bot_Ori_HX_fin10
&OBST XB=7.0104,7.1628,3.9624,7.0104,2.1336,2.1336,
COLOR='GRAY 80', PERMIT_HOLE=.FALSE.,
SURF_ID='ADIABATIC'/ Bot_Ori_HX_fin11
&OBST XB=7.0104,7.1628,3.9624,7.0104,2.286,2.286,
COLOR='GRAY 80', PERMIT_HOLE=.FALSE.,
SURF_ID='ADIABATIC'/ Bot_Ori_HX_fin12
&OBST XB=7.0104,7.1628,3.9624,7.0104,2.4384,2.4384,
COLOR='GRAY 80', PERMIT_HOLE=.FALSE.,
SURF_ID='ADIABATIC'/ Bot_Ori_HX_fin13
&OBST XB=7.0104,7.1628,3.9624,7.0104,2.5908,2.5908,
COLOR='GRAY 80', PERMIT_HOLE=.FALSE.,
SURF_ID='ADIABATIC'/ Bot_Ori_HX_fin14
&OBST XB=7.0104,7.1628,3.9624,7.0104,2.7432,2.7432,
COLOR='GRAY 80', PERMIT_HOLE=.FALSE.,
SURF_ID='ADIABATIC'/ Bot_Ori_HX_fin15
&OBST XB=7.0104,7.1628,3.9624,7.0104,2.8956,2.8956,
COLOR='GRAY 80', PERMIT_HOLE=.FALSE.,
SURF_ID='ADIABATIC'/ Bot_Ori_HX_fin16
&OBST XB=7.0104,7.1628,3.9624,7.0104,3.048,3.048,
COLOR='GRAY 80', PERMIT_HOLE=.FALSE.,
SURF_ID='ADIABATIC'/ Bot_Ori_HX_fin17
&OBST XB=7.0104,7.1628,3.9624,7.0104,3.2004,3.2004,
COLOR='GRAY 80', PERMIT_HOLE=.FALSE.,
SURF_ID='ADIABATIC'/ Bot_Ori_HX_fin18
&OBST XB=7.0104,7.1628,3.9624,7.0104,3.3528,3.3528,
COLOR='GRAY 80', PERMIT_HOLE=.FALSE.,
SURF_ID='ADIABATIC'/ Bot_Ori_HX_fin19
&OBST XB=7.0104,7.1628,3.9624,7.0104,3.5052,3.5052,
COLOR='GRAY 80', PERMIT_HOLE=.FALSE.,
SURF_ID='ADIABATIC'/ Bot_Ori_HX_fin20
&OBST XB=7.0104,7.1628,3.9624,7.0104,3.6576,3.6576,
COLOR='GRAY 80', PERMIT_HOLE=.FALSE.,
SURF_ID='ADIABATIC'/ Bot_Ori_HX_fin21
&OBST XB=0.3048,0.9144,0.3048,3.3528,0.1524,1.9812,
RGB=153,204,255, SURF_ID='ADIABATIC'/ Equipment A1
&OBST XB=3.2004,4.2672,0.3048,3.3528,0.1524,1.9812,
RGB=153,204,255, SURF_ID='ADIABATIC'/ Equipment A2
&OBST XB=4.7244,6.5532,0.3048,1.2192,0.1524,1.9812,
COLOR='INVISIBLE', SURF_ID='ADIABATIC'/ Equipment A3
```

```
&OBST XB=0.3048,0.762,4.2672,5.0292,0.1524,1.9812,
RGB=153,204,255, SURF_ID='ADIABATIC'/ Equipment A4
&OBST XB=0.3048,3.048,5.8674,6.7056,0.1524,1.9812,
RGB=153,204,255, SURF_ID='ADIABATIC'/ Equipment A5
&OBST XB=3.048,3.81,5.8674,6.7056,0.1524,1.9812,
RGB=153,204,255, SURF_ID='ADIABATIC'/ Equipment A6
&OBST XB=3.81,5.1816,5.8674,6.7056,0.1524,1.9812,
RGB=153,204,255, SURF_ID='ADIABATIC'/ Equipment A7
&OBST XB=0.3048,1.7526,6.7056,7.5438,0.1524,1.9812,
RGB=153,204,255, SURF_ID='ADIABATIC'/ Equpment A8
&OBST XB=1.7526,2.5146,6.7056,7.5438,0.1524,1.9812,
RGB=153,204,255, SURF_ID='ADIABATIC'/ Equipment A9
&OBST XB=2.5146,5.1816,6.7056,7.5438,0.1524,1.9812,
RGB=153,204,255, SURF_ID='ADIABATIC'/ Equipment A10
&OBST XB=0.3048,3.048,8.763,9.6012,0.1524,1.9812,
RGB=153,204,255, SURF_ID='ADIABATIC'/ Equipment A11
&OBST XB=3.048,3.81,8.763,9.6012,0.1524,1.9812,
RGB=153,204,255, SURF_ID='ADIABATIC'/ Equipment A12
&OBST XB=3.81,5.1816,8.763,9.6012,0.1524,1.9812,
RGB=153,204,255, SURF_ID='ADIABATIC'/ Equipment A13
&OBST XB=0.3048,1.7526,9.6012,10.287,0.1524,1.9812,
RGB=153,204,255, SURF_ID='ADIABATIC'/ Equipment A14
&OBST XB=1.7526,2.5146,9.6012,10.287,0.1524,1.9812,
RGB=153,204,255, SURF_ID='ADIABATIC'/ Equipment A15
&OBST XB=2.5146,5.1816,9.6012,10.287,0.1524,1.9812,
RGB=153,204,255, SURF_ID='ADIABATIC'/ Equipment A16
&OBST XB=0.3048,3.048,11.6586,12.4968,0.1524,1.9812,
RGB=153,204,255, SURF_ID='ADIABATIC'/ Equipment A17
&OBST XB=3.048,3.81,11.6586,12.4968,0.1524,1.9812,
RGB=153,204,255, SURF_ID='ADIABATIC'/ Equipment A18
&OBST XB=3.81,5.1816,11.6586,12.4968,0.1524,1.9812,
RGB=153,204,255, SURF_ID='ADIABATIC'/ Equipment A19
&OBST XB=8.9916,9.4488,10.0584,11.8872,1.8288,2.1336,
RGB=153,204,255, SURF_ID='ADIABATIC'/ Equipment 22
&OBST XB=8.9916,9.4488,3.9624,5.7912,1.8288,2.1336,
RGB=153,204,255, SURF_ID='ADIABATIC'/ Equipment 20
&OBST XB=8.9916,9.4488,7.0104,8.8392,1.8288,2.1336,
RGB=153,204,255, SURF_ID='ADIABATIC'/ Equipment 21
&OBST XB=6.5532,7.0104,9.6012,10.2108,5.7912,6.7056,
RGB=153,204,255, SURF_ID='ADIABATIC'/ Equipment Vx6
&OBST XB=6.5532,7.0104,5.7912,6.4008,5.7912,6.7056,
RGB=153,204,255, SURF_ID='ADIABATIC'/ Equipment Vx1
&OBST XB=6.5532,7.0104,6.5532,7.1628,5.7912,6.7056,
RGB=153,204,255, SURF_ID='ADIABATIC'/ Equipment Vx2
&OBST XB=6.5532,7.0104,7.3152,7.9248,5.7912,6.7056,
RGB=153,204,255, SURF_ID='ADIABATIC'/ Equipment Vx3
&OBST XB=6.5532,7.0104,8.0772,8.6868,5.7912,6.7056,
RGB=153,204,255, SURF_ID='ADIABATIC'/ Equipment Vx4
&OBST XB=6.5532,7.0104,8.8392,9.4488,5.7912,6.7056,
RGB=153,204,255, SURF_ID='ADIABATIC'/ Equipment Vx5
&OBST XB=0.3048,9.4488,0.3048,12.4968,4.1148,4.4196,
SURF_ID='Flors'/ Flor_1st
&OBST XB=0.3048,6.5532,2.5908,2.7432,4.4196,7.1628,
COLOR='INVISIBLE', SURF_ID='Wall'/ Wall_1F1
&OBST XB=6.5532,9.4488,3.048,3.2004,4.4196,7.1628,
COLOR='INVISIBLE', SURF_ID='Wall'/ Wall_1F2
&OBST XB=6.4008,6.5532,2.7432,12.4968,4.4196,7.1628,
COLOR='GRAY 80', PERMIT_HOLE=.FALSE.,
SURF_ID='Wall'/ Wall_1F3
&OBST XB=0.3048,9.4488,0.3048,12.4968,7.1628,7.4676,
SURF_ID='Flors'/ Flor_2nd
&OBST XB=0.3048,6.5532,2.5908,2.7432,7.4676,10.2108,
COLOR='INVISIBLE', SURF_ID='Wall'/ Wall_2F1
&OBST XB=6.5532,9.4488,3.048,3.2004,7.4676,10.2108,
COLOR='INVISIBLE', SURF_ID='Wall'/ Wall_2F2
&OBST XB=6.4008,6.5532,2.7432,12.4968,7.4676,10.2108,
COLOR='GRAY 80', PERMIT_HOLE=.FALSE.,
SURF_ID='ADIABATIC'/ Wall_2F3
&OBST XB=0.3048,9.4488,0.3048,12.4968,10.2108,10.5156,
SURF_ID='Flors'/ Flor_3rd
&OBST XB=0.3048,6.5532,2.5908,2.7432,10.5156,13.2588,
COLOR='INVISIBLE', SURF_ID='Wall'/ Wall_3F1
&OBST XB=6.5532,9.4488,3.048,3.2004,10.5156,13.2588,
COLOR='INVISIBLE', SURF_ID='Wall'/ Wall_3F2
&OBST XB=6.4008,6.5532,2.7432,12.4968,10.5156,13.2588,
COLOR='GRAY 80', PERMIT_HOLE=.FALSE.,
SURF_ID='Wall'/ Wall_3F3
&OBST XB=0.3048,9.4488,0.3048,12.4968,13.2588,13.5636,
SURF_ID='Flors'/ Flor_4th
&OBST XB=0.3048,2.4384,0.3048,12.192,13.5636,13.8684,
PERMIT_HOLE=.FALSE., SURF_ID='Flors'/ Slab4F1
&OBST XB=0.3048,9.4488,12.192,12.4968,13.5636,13.8684,
COLOR='GRAY 40', PERMIT_HOLE=.FALSE.,
SURF_ID='ADIABATIC'/ Slab4F2
&OBST XB=8.5344,9.4488,0.3048,12.192,13.5636,13.8684,
PERMIT_HOLE=.FALSE., SURF_ID='Flors'/ Slab4F3
&OBST XB=2.4384,8.5344,0.3048,3.3528,13.5636,13.8684,
COLOR='INVISIBLE', PERMIT_HOLE=.FALSE.,
SURF_ID='Flors'/ Slab4F4
&OBST XB=2.4384,2.4384,3.3528,12.4968,13.4112,16.4592,
PERMIT_HOLE=.FALSE., SURF_ID='Wall'/ Wall_4F1
&OBST XB=2.4384,8.5344,3.3528,3.3528,13.4112,16.4592,
COLOR='INVISIBLE', PERMIT_HOLE=.FALSE.,
SURF_ID='Wall'/ Wall_4F2
&OBST XB=2.4384,8.5344,12.4968,12.4968,13.4112,16.4592,
PERMIT_HOLE=.FALSE., SURF_ID='Wall'/ Wall_4F3
&OBST XB=8.5344,8.5344,3.3528,12.4968,14.0208,16.4592,
SURF_ID='Wall'/ Wall_4F4
&OBST XB=8.5344,8.5344,3.3528,12.4968,13.4112,14.0208,
PERMIT_HOLE=.FALSE., SURF_ID='Wall'/ Wall_4F5
&OBST XB=2.4384,8.5344,3.3528,12.4968,16.3068,16.4592,
SURF_ID='Wall'/ Ceilling_4F
&OBST XB=1.6764,1.6764,2.7432,12.4968,6.5532,7.1628,
RGB=204,255,255, TRANSPARENCY=0.501961,
PERMIT_HOLE=.FALSE., SURF_ID='INERT'/ Air Partition 1FL
&OBST XB=5.0292,5.0292,2.7432,12.4968,6.5532,7.1628,
RGB=204,255,255, TRANSPARENCY=0.501961,
PERMIT_HOLE=.FALSE., SURF_ID='INERT'/ Air Partition 1FR
&OBST XB=1.524,1.524,2.7432,12.4968,9.6012,10.2108,
RGB=204,255,255, TRANSPARENCY=0.501961,
PERMIT_HOLE=.FALSE., SURF_ID='INERT'/ Air Partition 2FL
&OBST XB=5.1816,5.1816,2.7432,12.4968,9.6012,10.2108,
RGB=204,255,255, TRANSPARENCY=0.501961,
PERMIT_HOLE=.FALSE., SURF_ID='INERT'/ Air Partition 2FR
&OBST XB=1.3716,1.3716,2.7432,12.4968,12.6492,13.2588,
RGB=204,255,255, TRANSPARENCY=0.501961,
PERMIT_HOLE=.FALSE., SURF_ID='INERT'/ Air Partition 3FL
&OBST XB=5.334,5.334,2.7432,12.4968,12.6492,13.2588,
RGB=204,255,255, TRANSPARENCY=0.501961,
PERMIT_HOLE=.FALSE., SURF_ID='INERT'/ Air Partition 3FR
&OBST XB=2.4384,2.5908,2.7432,3.3528,7.0104,7.1628,
SURF_ID='ADIABATIC'/ Cable1F1a
&OBST XB=2.4384,2.5908,3.3528,12.4968,7.0104,7.1628,
COLOR='BLACK', SURF_ID='ADIABATIC'/ Cable1F1b
&OBST XB=4.1148,4.2672,2.7432,3.3528,7.0104,7.1628,
SURF_ID='ADIABATIC'/ Cable1F2a
&OBST XB=4.1148,4.2672,3.3528,12.4968,7.0104,7.1628,
COLOR='BLACK', SURF_ID='ADIABATIC'/ Cable1F2b
&OBST XB=4.2672,4.4196,3.3528,12.4968,10.0584,10.2108,
COLOR='BLACK', SURF_ID='ADIABATIC'/ Cable2F2b
&OBST XB=2.286,2.4384,2.7432,3.3528,10.0584,10.2108,
SURF_ID='ADIABATIC'/ Cable2F1a
&OBST XB=4.2672,4.4196,2.7432,3.3528,10.0584,10.2108,
SURF_ID='ADIABATIC'/ Cable2F1b
&OBST XB=2.286,2.4384,3.3528,12.4968,10.0584,10.2108,
COLOR='BLACK', SURF_ID='ADIABATIC'/ Cable2F2a
&OBST XB=2.1336,2.286,2.7432,3.3528,13.1064,13.2588,
SURF_ID='ADIABATIC'/ Cable3F1a
&OBST XB=2.1336,2.286,3.3528,12.4968,13.1064,13.2588,
COLOR='BLACK', SURF_ID='INERT'/ Cable3F1b
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&OBST XB=4.4196,4.572,2.7432,3.3528,13.1064,13.2588,
SURF_ID='ADIABATIC'/ Cable3F2a
&OBST XB=4.4196,4.572,3.3528,12.4968,13.1064,13.2588,
COLOR='BLACK', SURF_ID='INERT'/ Cable3F2b
&OBST XB=0.4572,0.4572,3.3528,12.4968,4.2672,4.4196,
PERMIT_HOLE=.FALSE., SURF_ID='Flors'/ Grill 1FL1
&OBST XB=0.6096,0.6096,3.3528,12.4968,4.2672,4.4196,
PERMIT_HOLE=.FALSE., SURF_ID='Flors'/ Grill 1FL2
&OBST XB=0.762,0.762,3.3528,12.4968,4.2672,4.4196,
PERMIT_HOLE=.FALSE., SURF_ID='Flors'/ Grill 1FL3
&OBST XB=0.9144,0.9144,3.3528,12.4968,4.2672,4.4196,
PERMIT_HOLE=.FALSE., SURF_ID='Flors'/ Grill 1FL4
&OBST XB=1.0668,1.0668,3.3528,12.4968,4.2672,4.4196,
PERMIT_HOLE=.FALSE., SURF_ID='Flors'/ Grill 1FL5
&OBST XB=1.2192,1.2192,3.3528,12.4968,4.2672,4.4196,
PERMIT_HOLE=.FALSE., SURF_ID='Flors'/ Grill 1FL6
&OBST XB=1.3716,1.3716,3.3528,12.4968,4.2672,4.4196,
PERMIT_HOLE=.FALSE., SURF_ID='Flors'/ Grill 1FL7
&OBST XB=1.524,1.524,3.3528,12.4968,4.2672,4.4196,
PERMIT_HOLE=.FALSE., SURF_ID='Flors'/ Grill 1FL8
&OBST XB=5.1816,5.1816,3.3528,12.4968,4.2672,4.4196,
PERMIT_HOLE=.FALSE., SURF_ID='Flors'/ Grill 1FR1
&OBST XB=5.334,5.334,3.3528,12.4968,4.2672,4.4196,
PERMIT_HOLE=.FALSE., SURF_ID='Flors'/ Grill 1FR2
&OBST XB=5.4864,5.4864,3.3528,12.4968,4.2672,4.4196,
PERMIT_HOLE=.FALSE., SURF_ID='Flors'/ Grill 1FR3
&OBST XB=5.6388,5.6388,3.3528,12.4968,4.2672,4.4196,
PERMIT_HOLE=.FALSE., SURF_ID='Flors'/ Grill 1FR4
&OBST XB=5.7912,5.7912,3.3528,12.4968,4.2672,4.4196,
PERMIT_HOLE=.FALSE., SURF_ID='Flors'/ Grill 1FR5
&OBST XB=5.9436,5.9436,3.3528,12.4968,4.2672,4.4196,
PERMIT_HOLE=.FALSE., SURF_ID='Flors'/ Grill 1FR6
&OBST XB=6.096,6.096,3.3528,12.4968,4.2672,4.4196,
PERMIT_HOLE=.FALSE., SURF_ID='Flors'/ Grill 1FR7
&OBST XB=6.2484,6.2484,3.3528,12.4968,4.2672,4.4196,
PERMIT_HOLE=.FALSE., SURF_ID='Flors'/ Grill 1FR8
&OBST XB=0.4572,0.4572,3.3528,12.4968,7.3152,7.4676,
PERMIT_HOLE=.FALSE., SURF_ID='Flors'/ Grill 2FL1
&OBST XB=0.6096,0.6096,3.3528,12.4968,7.3152,7.4676,
PERMIT_HOLE=.FALSE., SURF_ID='Flors'/ Grill 2FL2
&OBST XB=0.762,0.762,3.3528,12.4968,7.3152,7.4676,
PERMIT_HOLE=.FALSE., SURF_ID='Flors'/ Grill 2FL3
&OBST XB=0.9144,0.9144,3.3528,12.4968,7.3152,7.4676,
PERMIT_HOLE=.FALSE., SURF_ID='Flors'/ Grill 2FL4
&OBST XB=1.0668,1.0668,3.3528,12.4968,7.3152,7.4676,
PERMIT_HOLE=.FALSE., SURF_ID='Flors'/ Grill 2FL5
&OBST XB=1.2192,1.2192,3.3528,12.4968,7.3152,7.4676,
PERMIT_HOLE=.FALSE., SURF_ID='Flors'/ Grill 2FL6
&OBST XB=1.3716,1.3716,3.3528,12.4968,7.3152,7.4676,
PERMIT_HOLE=.FALSE., SURF_ID='Flors'/ Grill 2FL7
&OBST XB=5.334,5.334,3.3528,12.4968,7.3152,7.4676,
PERMIT_HOLE=.FALSE., SURF_ID='Flors'/ Grill 2FR1
&OBST XB=5.4864,5.4864,3.3528,12.4968,7.3152,7.4676,
PERMIT_HOLE=.FALSE., SURF_ID='Flors'/ Grill 2FR2
&OBST XB=5.6388,5.6388,3.3528,12.4968,7.3152,7.4676,
PERMIT_HOLE=.FALSE., SURF_ID='Flors'/ Grill 2FR3
&OBST XB=5.7912,5.7912,3.3528,12.4968,7.3152,7.4676,
PERMIT_HOLE=.FALSE., SURF_ID='Flors'/ Grill 2FR4
&OBST XB=5.9436,5.9436,3.3528,12.4968,7.3152,7.4676,
PERMIT_HOLE=.FALSE., SURF_ID='Flors'/ Grill 2FR5
&OBST XB=6.096,6.096,3.3528,12.4968,7.3152,7.4676,
PERMIT_HOLE=.FALSE., SURF_ID='Flors'/ Grill 2FR6
&OBST XB=6.2484,6.2484,3.3528,12.4968,7.3152,7.4676,
PERMIT_HOLE=.FALSE., SURF_ID='Flors'/ Grill 2FR7
&OBST XB=2.7432,2.7432,3.3528,12.4968,7.3152,7.4676,
PERMIT_HOLE=.FALSE., SURF_ID='Flors'/ Grill 2FM1
&OBST XB=2.8956,2.8956,3.3528,12.4968,7.3152,7.4676,
PERMIT_HOLE=.FALSE., SURF_ID='Flors'/ Grill 2FM2
&OBST XB=3.048,3.048,3.3528,12.4968,7.3152,7.4676,
PERMIT_HOLE=.FALSE., SURF_ID='Flors'/ Grill 2FM3
&OBST XB=3.2004,3.2004,3.3528,12.4968,7.3152,7.4676,
PERMIT_HOLE=.FALSE., SURF_ID='Flors'/ Grill 2FM4
&OBST XB=3.3528,3.3528,3.3528,12.4968,7.3152,7.4676,
PERMIT_HOLE=.FALSE., SURF_ID='Flors'/ Grill 2FM5
&OBST XB=3.5052,3.5052,3.3528,12.4968,7.3152,7.4676,
PERMIT_HOLE=.FALSE., SURF_ID='Flors'/ Grill 2FM6
&OBST XB=3.6576,3.6576,3.3528,12.4968,7.3152,7.4676,
PERMIT_HOLE=.FALSE., SURF_ID='Flors'/ Grill 2FM7
&OBST XB=3.81,3.81,3.3528,12.4968,7.3152,7.4676,
PERMIT_HOLE=.FALSE., SURF_ID='Flors'/ Grill 2FM8
&OBST XB=3.9624,3.9624,3.3528,12.4968,7.3152,7.4676,
PERMIT_HOLE=.FALSE., SURF_ID='Flors'/ Grill 2FM9
&OBST XB=6.7056,6.7056,3.3528,6.2484,7.3152,7.4676,
PERMIT_HOLE=.FALSE., SURF_ID='Flors'/ Grill 2FC1a
&OBST XB=6.858,6.858,3.3528,6.2484,7.3152,7.4676,
PERMIT_HOLE=.FALSE., SURF_ID='Flors'/ Grill 2FC2a
&OBST XB=7.0104,7.0104,3.3528,6.2484,7.3152,7.4676,
PERMIT_HOLE=.FALSE., SURF_ID='Flors'/ Grill 2FC3a
&OBST XB=7.1628,7.1628,3.3528,6.2484,7.3152,7.4676,
PERMIT_HOLE=.FALSE., SURF_ID='Flors'/ Grill 2FC4a
&OBST XB=7.3152,7.3152,3.3528,6.2484,7.3152,7.4676,
PERMIT_HOLE=.FALSE., SURF_ID='Flors'/ Grill 2FC5a
&OBST XB=7.4676,7.4676,3.3528,6.2484,7.3152,7.4676,
PERMIT_HOLE=.FALSE., SURF_ID='Flors'/ Grill 2FC6a
&OBST XB=7.62,7.62,3.3528,6.2484,7.3152,7.4676,
PERMIT_HOLE=.FALSE., SURF_ID='Flors'/ Grill 2FC7a
&OBST XB=7.7724,7.7724,3.3528,6.2484,7.3152,7.4676,
PERMIT_HOLE=.FALSE., SURF_ID='Flors'/ Grill 2FC8a
&OBST XB=6.7056,6.7056,6.4008,9.2964,7.3152,7.4676,
PERMIT_HOLE=.FALSE., SURF_ID='Flors'/ Grill 2FC1b
&OBST XB=6.858,6.858,6.4008,9.2964,7.3152,7.4676,
PERMIT_HOLE=.FALSE., SURF_ID='Flors'/ Grill 2FC2b
&OBST XB=7.0104,7.0104,6.4008,9.2964,7.3152,7.4676,
PERMIT_HOLE=.FALSE., SURF_ID='Flors'/ Grill 2FC3b
&OBST XB=7.1628,7.1628,6.4008,9.2964,7.3152,7.4676,
PERMIT_HOLE=.FALSE., SURF_ID='Flors'/ Grill 2FC4b
&OBST XB=7.3152,7.3152,6.4008,9.2964,7.3152,7.4676,
PERMIT_HOLE=.FALSE., SURF_ID='Flors'/ Grill 2FC5b
&OBST XB=7.4676,7.4676,6.4008,9.2964,7.3152,7.4676,
PERMIT_HOLE=.FALSE., SURF_ID='Flors'/ Grill 2FC6b
&OBST XB=7.62,7.62,6.4008,9.2964,7.3152,7.4676,
PERMIT_HOLE=.FALSE., SURF_ID='Flors'/ Grill 2FC7b
&OBST XB=7.7724,7.7724,6.4008,9.2964,7.3152,7.4676,
PERMIT_HOLE=.FALSE., SURF_ID='Flors'/ Grill 2FC8b
&OBST XB=6.7056,6.7056,9.4488,12.4968,7.3152,7.4676,
PERMIT_HOLE=.FALSE., SURF_ID='Flors'/ Grill 2FC1c
&OBST XB=6.858,6.858,9.4488,12.4968,7.3152,7.4676,
PERMIT_HOLE=.FALSE., SURF_ID='Flors'/ Grill 2FC2c
&OBST XB=7.0104,7.0104,9.4488,12.4968,7.3152,7.4676,
PERMIT_HOLE=.FALSE., SURF_ID='Flors'/ Grill 2FC3c
&OBST XB=7.1628,7.1628,9.4488,12.4968,7.3152,7.4676,
PERMIT_HOLE=.FALSE., SURF_ID='Flors'/ Grill 2FC4c
&OBST XB=7.3152,7.3152,9.4488,12.4968,7.3152,7.4676,
PERMIT_HOLE=.FALSE., SURF_ID='Flors'/ Grill 2FC5c
&OBST XB=7.4676,7.4676,9.4488,12.4968,7.3152,7.4676,
PERMIT_HOLE=.FALSE., SURF_ID='Flors'/ Grill 2FC6c
&OBST XB=7.62,7.62,9.4488,12.4968,7.3152,7.4676,
PERMIT_HOLE=.FALSE., SURF_ID='Flors'/ Grill 2FC7c
&OBST XB=7.7724,7.7724,9.4488,12.4968,7.3152,7.4676,
PERMIT_HOLE=.FALSE., SURF_ID='Flors'/ Grill 2FC8c
&OBST XB=0.4572,0.4572,3.3528,12.4968,10.3632,10.5156,
PERMIT_HOLE=.FALSE., SURF_ID='Flors'/ Grill 3FL1
&OBST XB=0.6096,0.6096,3.3528,12.4968,10.3632,10.5156,
PERMIT_HOLE=.FALSE., SURF_ID='Flors'/ Grill 3FL2
&OBST XB=0.762,0.762,3.3528,12.4968,10.3632,10.5156,
PERMIT_HOLE=.FALSE., SURF_ID='Flors'/ Grill 3FL3
&OBST XB=0.9144,0.9144,3.3528,12.4968,10.3632,10.5156,
PERMIT_HOLE=.FALSE., SURF_ID='Flors'/ Grill 3FL4
&OBST XB=1.0668,1.0668,3.3528,12.4968,10.3632,10.5156,
PERMIT_HOLE=.FALSE., SURF_ID='Flors'/ Grill 3FL5
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&OBST XB=1.2192,1.2192,3.3528,12.4968,10.3632,10.5156,
PERMIT_HOLE=.FALSE., SURF_ID='Flors'/ Grill 3FL6
&OBST XB=5.4864,5.4864,3.3528,12.4968,10.3632,10.5156,
PERMIT_HOLE=.FALSE., SURF_ID='Flors'/ Grill 3FR1
&OBST XB=5.6388,5.6388,3.3528,12.4968,10.3632,10.5156,
PERMIT_HOLE=.FALSE., SURF_ID='Flors'/ Grill 3FR2
&OBST XB=5.7912,5.7912,3.3528,12.4968,10.3632,10.5156,
PERMIT_HOLE=.FALSE., SURF_ID='Flors'/ Grill 3FR3
&OBST XB=5.9436,5.9436,3.3528,12.4968,10.3632,10.5156,
PERMIT_HOLE=.FALSE., SURF_ID='Flors'/ Grill 3FR4
&OBST XB=6.096,6.096,3.3528,12.4968,10.3632,10.5156,
PERMIT_HOLE=.FALSE., SURF_ID='Flors'/ Grill 3FR5
&OBST XB=6.2484,6.2484,3.3528,12.4968,10.3632,10.5156,
PERMIT_HOLE=.FALSE., SURF_ID='Flors'/ Grill 3FR6
&OBST XB=2.5908,2.5908,3.429,12.4968,10.3632,10.5156,
PERMIT_HOLE=.FALSE., SURF_ID='Flors'/ Grill 3FM1
&OBST XB=2.7432,2.7432,3.429,12.4968,10.3632,10.5156,
PERMIT_HOLE=.FALSE., SURF_ID='Flors'/ Grill 3FM2
&OBST XB=2.8956,2.8956,3.429,12.4968,10.3632,10.5156,
PERMIT_HOLE=.FALSE., SURF_ID='Flors'/ Grill 3FM3
&OBST XB=3.048,3.048,3.429,12.4968,10.3632,10.5156,
PERMIT_HOLE=.FALSE., SURF_ID='Flors'/ Grill 3FM4
&OBST XB=3.2004,3.2004,3.429,12.4968,10.3632,10.5156,
PERMIT_HOLE=.FALSE., SURF_ID='Flors'/ Grill 3FM5
&OBST XB=3.3528,3.3528,3.429,12.4968,10.3632,10.5156,
PERMIT_HOLE=.FALSE., SURF_ID='Flors'/ Grill 3FM6
&OBST XB=3.5052,3.5052,3.429,12.4968,10.3632,10.5156,
PERMIT_HOLE=.FALSE., SURF_ID='Flors'/ Grill 3FM7
&OBST XB=3.6576,3.6576,3.429,12.4968,10.3632,10.5156,
PERMIT_HOLE=.FALSE., SURF_ID='Flors'/ Grill 3FM8
&OBST XB=3.81,3.81,3.429,12.4968,10.3632,10.5156,
PERMIT_HOLE=.FALSE., SURF_ID='Flors'/ Grill 3FM9
&OBST XB=3.9624,3.9624,3.429,12.4968,10.3632,10.5156,
PERMIT_HOLE=.FALSE., SURF_ID='Flors'/ Grill 3FM10
&OBST XB=4.1148,4.1148,3.429,12.4968,10.3632,10.5156,
PERMIT_HOLE=.FALSE., SURF_ID='Flors'/ Grill 3FM11
&OBST XB=8.2296,8.2296,3.3528,6.2484,10.3632,10.5156,
PERMIT_HOLE=.FALSE., SURF_ID='Flors'/ Grill 3FC1a
&OBST XB=8.382,8.382,3.3528,6.2484,10.3632,10.5156,
PERMIT_HOLE=.FALSE., SURF_ID='Flors'/ Grill 3FC2a
&OBST XB=8.5344,8.5344,3.3528,6.2484,10.3632,10.5156,
PERMIT_HOLE=.FALSE., SURF_ID='Flors'/ Grill 3FC3a
&OBST XB=8.6868,8.6868,3.3528,6.2484,10.3632,10.5156,
PERMIT_HOLE=.FALSE., SURF_ID='Flors'/ Grill 3FC4a
&OBST XB=8.8392,8.8392,3.3528,6.2484,10.3632,10.5156,
PERMIT_HOLE=.FALSE., SURF_ID='Flors'/ Grill 3FC5a
&OBST XB=8.9916,8.9916,3.3528,6.2484,10.3632,10.5156,
PERMIT_HOLE=.FALSE., SURF_ID='Flors'/ Grill 3FC6a
&OBST XB=9.144,9.144,3.3528,6.2484,10.3632,10.5156,
PERMIT_HOLE=.FALSE., SURF_ID='Flors'/ Grill 3FC7a
&OBST XB=9.2964,9.2964,3.3528,6.2484,10.3632,10.5156,
PERMIT_HOLE=.FALSE., SURF_ID='Flors'/ Grill 3FC8a
&OBST XB=8.2296,8.2296,6.4008,9.2964,10.3632,10.5156,
PERMIT_HOLE=.FALSE., SURF_ID='Flors'/ Grill 3FC1b
&OBST XB=8.382,8.382,6.4008,9.2964,10.3632,10.5156,
PERMIT_HOLE=.FALSE., SURF_ID='Flors'/ Grill 3FC2b
&OBST XB=8.5344,8.5344,6.4008,9.2964,10.3632,10.5156,
PERMIT_HOLE=.FALSE., SURF_ID='Flors'/ Grill 3FC3b
&OBST XB=8.6868,8.6868,6.4008,9.2964,10.3632,10.5156,
PERMIT_HOLE=.FALSE., SURF_ID='Flors'/ Grill 3FC4b
&OBST XB=8.8392,8.8392,6.4008,9.2964,10.3632,10.5156,
PERMIT_HOLE=.FALSE., SURF_ID='Flors'/ Grill 3FC5b
&OBST XB=8.9916,8.9916,6.4008,9.2964,10.3632,10.5156,
PERMIT_HOLE=.FALSE., SURF_ID='Flors'/ Grill 3FC6b
&OBST XB=9.144,9.144,6.4008,9.2964,10.3632,10.5156,
PERMIT_HOLE=.FALSE., SURF_ID='Flors'/ Grill 3FC7b
&OBST XB=9.2964,9.2964,6.4008,9.2964,10.3632,10.5156,
PERMIT_HOLE=.FALSE., SURF_ID='Flors'/ Grill 3FC8b
&OBST XB=8.2296,8.2296,9.4488,12.3444,10.3632,10.5156,
PERMIT_HOLE=.FALSE., SURF_ID='Flors'/ Grill 3FC1c
&OBST XB=8.382,8.382,9.4488,12.3444,10.3632,10.5156,
PERMIT_HOLE=.FALSE., SURF_ID='Flors'/ Grill 3FC2c
&OBST XB=8.5344,8.5344,9.4488,12.3444,10.3632,10.5156,
PERMIT_HOLE=.FALSE., SURF_ID='Flors'/ Grill 3FC3c
&OBST XB=8.6868,8.6868,9.4488,12.3444,10.3632,10.5156,
PERMIT_HOLE=.FALSE., SURF_ID='Flors'/ Grill 3FC4c
&OBST XB=8.8392,8.8392,9.4488,12.3444,10.3632,10.5156,
PERMIT_HOLE=.FALSE., SURF_ID='Flors'/ Grill 3FC5c
&OBST XB=8.9916,8.9916,9.4488,12.3444,10.3632,10.5156,
PERMIT_HOLE=.FALSE., SURF_ID='Flors'/ Grill 3FC6c
&OBST XB=9.144,9.144,9.4488,12.3444,10.3632,10.5156,
PERMIT_HOLE=.FALSE., SURF_ID='Flors'/ Grill 3FC7c
&OBST XB=9.2964,9.2964,9.4488,12.3444,10.3632,10.5156,
PERMIT_HOLE=.FALSE., SURF_ID='Flors'/ Grill 3FC8c
&OBST XB=2.59385,2.59385,3.048,12.192,13.4112,13.5636,
PERMIT_HOLE=.FALSE., SURF_ID='Flors'/ Grill 4FL1
&OBST XB=2.74625,2.74625,3.048,12.192,13.4112,13.5636,
PERMIT_HOLE=.FALSE., SURF_ID='Flors'/ Grill 4FL2
&OBST XB=2.89865,2.89865,3.048,12.192,13.4112,13.5636,
PERMIT_HOLE=.FALSE., SURF_ID='Flors'/ Grill 4FL3
&OBST XB=3.05105,3.05105,3.048,12.192,13.4112,13.5636,
PERMIT_HOLE=.FALSE., SURF_ID='Flors'/ Grill 4FL4
&OBST XB=3.20345,3.20345,3.048,12.192,13.4112,13.5636,
PERMIT_HOLE=.FALSE., SURF_ID='Flors'/ Grill 4FL5
&OBST XB=3.35585,3.35585,3.048,12.192,13.4112,13.5636,
PERMIT_HOLE=.FALSE., SURF_ID='Flors'/ Grill 4FL6
&OBST XB=3.50825,3.50825,3.048,12.192,13.4112,13.5636,
PERMIT_HOLE=.FALSE., SURF_ID='Flors'/ Grill 4FL7
&OBST XB=3.66065,3.66065,3.048,12.192,13.4112,13.5636,
PERMIT_HOLE=.FALSE., SURF_ID='Flors'/ Grill 4FL8
&OBST XB=3.81305,3.81305,3.048,12.192,13.4112,13.5636,
PERMIT_HOLE=.FALSE., SURF_ID='Flors'/ Grill 4FL9
&OBST XB=3.96545,3.96545,3.048,12.192,13.4112,13.5636,
PERMIT_HOLE=.FALSE., SURF_ID='Flors'/ Grill 4FL10
&OBST XB=4.11785,4.11785,3.048,12.192,13.4112,13.5636,
PERMIT_HOLE=.FALSE., SURF_ID='Flors'/ Grill 4FL11
&OBST XB=6.86105,6.86105,3.048,12.192,13.4112,13.5636,
PERMIT_HOLE=.FALSE., SURF_ID='Flors'/ Grill 4FR1
&OBST XB=7.01345,7.01345,3.048,12.192,13.4112,13.5636,
PERMIT_HOLE=.FALSE., SURF_ID='Flors'/ Grill 4FR2
&OBST XB=7.16585,7.16585,3.048,12.192,13.4112,13.5636,
PERMIT_HOLE=.FALSE., SURF_ID='Flors'/ Grill 4FR3
&OBST XB=7.31825,7.31825,3.048,12.192,13.4112,13.5636,
PERMIT_HOLE=.FALSE., SURF_ID='Flors'/ Grill 4FR4
&OBST XB=7.47065,7.47065,3.048,12.192,13.4112,13.5636,
PERMIT_HOLE=.FALSE., SURF_ID='Flors'/ Grill 4FR5
&OBST XB=7.62305,7.62305,3.048,12.192,13.4112,13.5636,
PERMIT_HOLE=.FALSE., SURF_ID='Flors'/ Grill 4FR6
&OBST XB=7.77545,7.77545,3.048,12.192,13.4112,13.5636,
PERMIT_HOLE=.FALSE., SURF_ID='Flors'/ Grill 4FR7
&OBST XB=7.92785,7.92785,3.048,12.192,13.4112,13.5636,
PERMIT_HOLE=.FALSE., SURF_ID='Flors'/ Grill 4FR8
&OBST XB=8.08025,8.08025,3.048,12.192,13.4112,13.5636,
PERMIT_HOLE=.FALSE., SURF_ID='Flors'/ Grill 4FR9
&OBST XB=8.23265,8.23265,3.048,12.192,13.4112,13.5636,
PERMIT_HOLE=.FALSE., SURF_ID='Flors'/ Grill 4FR10
&OBST XB=8.38505,8.38505,3.048,12.192,13.4112,13.5636,
PERMIT_HOLE=.FALSE., SURF_ID='Flors'/ Grill 4FR11
&OBST XB=0.3048,1.6764,4.7244,4.8768,4.1148,4.2672,
COLOR='GRAY 40', PERMIT_HOLE=.FALSE.,
SURF_ID='ADIABATIC'/ Flor_support_1FL1
&OBST XB=0.3048,1.6764,6.2484,6.4008,4.1148,4.2672,
COLOR='GRAY 40', PERMIT_HOLE=.FALSE.,
SURF_ID='ADIABATIC'/ Flor_support_1FL2
&OBST XB=0.3048,1.6764,7.7724,7.9248,4.1148,4.2672,
COLOR='GRAY 40', PERMIT_HOLE=.FALSE.,
SURF_ID='ADIABATIC'/ Flor_support_1FL3
&OBST XB=0.3048,1.6764,9.2964,9.4488,4.1148,4.2672,
COLOR='GRAY 40', PERMIT_HOLE=.FALSE.,
SURF_ID='ADIABATIC'/ Flor_support_1FL4
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&OBST XB=0.3048,1.6764,10.8204,10.9728,4.1148,4.2672,
COLOR='GRAY 40', PERMIT_HOLE=.FALSE.,
SURF_ID='ADIABATIC'/ Flor_support_1FL5
&OBST XB=5.0292,6.4008,4.7244,4.8768,4.1148,4.2672,
COLOR='GRAY 40', PERMIT_HOLE=.FALSE.,
SURF_ID='ADIABATIC'/ Flor_support_1FR1
&OBST XB=5.0292,6.4008,6.2484,6.4008,4.1148,4.2672,
COLOR='GRAY 40', PERMIT_HOLE=.FALSE.,
SURF_ID='ADIABATIC'/ Flor_support_1FR2
&OBST XB=5.0292,6.4008,7.7724,7.9248,4.1148,4.2672,
COLOR='GRAY 40', PERMIT_HOLE=.FALSE.,
SURF_ID='ADIABATIC'/ Flor_support_1FR3
&OBST XB=5.0292,6.4008,9.2964,9.4488,4.1148,4.2672,
COLOR='GRAY 40', PERMIT_HOLE=.FALSE.,
SURF_ID='ADIABATIC'/ Flor_support_1FR4
&OBST XB=5.0292,6.4008,10.8204,10.9728,4.1148,4.2672,
COLOR='GRAY 40', PERMIT_HOLE=.FALSE.,
SURF_ID='ADIABATIC'/ Flor_support_1FR5
&OBST XB=0.3048,1.524,4.7244,4.8768,7.1628,7.3152,
COLOR='GRAY 40', PERMIT_HOLE=.FALSE.,
SURF_ID='ADIABATIC'/ Flor_support_2FL1
&OBST XB=0.3048,1.524,6.2484,6.4008,7.1628,7.3152,
COLOR='GRAY 40', PERMIT_HOLE=.FALSE.,
SURF_ID='ADIABATIC'/ Flor_support_2FL2
&OBST XB=0.3048,1.524,7.7724,7.9248,7.1628,7.3152,
COLOR='GRAY 40', PERMIT_HOLE=.FALSE.,
SURF_ID='ADIABATIC'/ Flor_support_2FL3
&OBST XB=0.3048,1.524,9.2964,9.4488,7.1628,7.3152,
COLOR='GRAY 40', PERMIT_HOLE=.FALSE.,
SURF_ID='ADIABATIC'/ Flor_support_2FL4
&OBST XB=0.3048,1.524,10.8204,10.9728,7.1628,7.3152,
COLOR='GRAY 40', PERMIT_HOLE=.FALSE.,
SURF_ID='ADIABATIC'/ Flor_support_2FL5
&OBST XB=5.1816,6.4008,4.7244,4.8768,7.1628,7.3152,
COLOR='GRAY 40', PERMIT_HOLE=.FALSE.,
SURF_ID='ADIABATIC'/ Flor_support_2FR1
&OBST XB=5.1816,6.4008,6.2484,6.4008,7.1628,7.3152,
COLOR='GRAY 40', PERMIT_HOLE=.FALSE.,
SURF_ID='ADIABATIC'/ Flor_support_2FR2
&OBST XB=5.1816,6.4008,7.7724,7.9248,7.1628,7.3152,
COLOR='GRAY 40', PERMIT_HOLE=.FALSE.,
SURF_ID='ADIABATIC'/ Flor_support_2FR3
&OBST XB=5.1816,6.4008,9.2964,9.4488,7.1628,7.3152,
COLOR='GRAY 40', PERMIT_HOLE=.FALSE.,
SURF_ID='ADIABATIC'/ Flor_support_2FR4
&OBST XB=5.1816,6.4008,10.8204,10.9728,7.1628,7.3152,
COLOR='GRAY 40', PERMIT_HOLE=.FALSE.,
SURF_ID='ADIABATIC'/ Flor_support_2FR5
&OBST XB=2.5908,4.1148,4.7244,4.8768,7.1628,7.3152,
COLOR='GRAY 40', PERMIT_HOLE=.FALSE.,
SURF_ID='ADIABATIC'/ Flor_support_2FM1
&OBST XB=2.5908,4.1148,6.2484,6.4008,7.1628,7.3152,
COLOR='GRAY 40', PERMIT_HOLE=.FALSE.,
SURF_ID='ADIABATIC'/ Flor_support_2FM2
&OBST XB=2.5908,4.1148,7.7724,7.9248,7.1628,7.3152,
COLOR='GRAY 40', PERMIT_HOLE=.FALSE.,
SURF_ID='ADIABATIC'/ Flor_support_2FM3
&OBST XB=2.5908,4.1148,9.2964,9.4488,7.1628,7.3152,
COLOR='GRAY 40', PERMIT_HOLE=.FALSE.,
SURF_ID='ADIABATIC'/ Flor_support_2FM4
&OBST XB=2.5908,4.1148,10.8204,10.9728,7.1628,7.3152,
COLOR='GRAY 40', PERMIT_HOLE=.FALSE.,
SURF_ID='ADIABATIC'/ Flor_support_2FM5
&OBST XB=6.5532,7.9248,9.2964,9.4488,7.1628,7.4676,
COLOR='GRAY 40', PERMIT_HOLE=.FALSE.,
SURF_ID='ADIABATIC'/ Flor_support_2FCooridor2
&OBST XB=6.5532,7.9248,6.2484,6.4008,7.1628,7.4676,
COLOR='GRAY 40', PERMIT_HOLE=.FALSE.,
SURF_ID='ADIABATIC'/ Flor_support_2FCooridor1
&OBST XB=0.3048,1.3716,4.7244,4.8768,10.2108,10.3632,
COLOR='GRAY 40', PERMIT_HOLE=.FALSE.,
SURF_ID='ADIABATIC'/ Flor_support_3FL1
&OBST XB=0.3048,1.3716,6.2484,6.4008,10.2108,10.3632,
COLOR='GRAY 40', PERMIT_HOLE=.FALSE.,
SURF_ID='ADIABATIC'/ Flor_support_3FL2
&OBST XB=0.3048,1.3716,7.7724,7.9248,10.2108,10.3632,
COLOR='GRAY 40', PERMIT_HOLE=.FALSE.,
SURF_ID='ADIABATIC'/ Flor_support_3FL3
&OBST XB=0.3048,1.3716,9.2964,9.4488,10.2108,10.3632,
COLOR='GRAY 40', PERMIT_HOLE=.FALSE.,
SURF_ID='ADIABATIC'/ Flor_support_3FL4
&OBST XB=0.3048,1.3716,10.8204,10.9728,10.2108,10.3632,
COLOR='GRAY 40', PERMIT_HOLE=.FALSE.,
SURF_ID='ADIABATIC'/ Flor_support_3FL5
&OBST XB=5.334,6.4008,4.7244,4.8768,10.2108,10.3632,
COLOR='GRAY 40', PERMIT_HOLE=.FALSE.,
SURF_ID='ADIABATIC'/ Flor_support_3FR1
&OBST XB=5.334,6.4008,6.2484,6.4008,10.2108,10.3632,
COLOR='GRAY 40', PERMIT_HOLE=.FALSE.,
SURF_ID='ADIABATIC'/ Flor_support_3FR2
&OBST XB=5.334,6.4008,7.7724,7.9248,10.2108,10.3632,
COLOR='GRAY 40', PERMIT_HOLE=.FALSE.,
SURF_ID='ADIABATIC'/ Flor_support_3FR3
&OBST XB=5.334,6.4008,9.2964,9.4488,10.2108,10.3632,
COLOR='GRAY 40', PERMIT_HOLE=.FALSE.,
SURF_ID='ADIABATIC'/ Flor_support_3FR4
&OBST XB=5.334,6.4008,10.8204,10.9728,10.2108,10.3632,
COLOR='GRAY 40', PERMIT_HOLE=.FALSE.,
SURF_ID='ADIABATIC'/ Flor_support_3FR5
&OBST XB=2.4384,4.2672,4.7244,4.8768,10.2108,10.3632,
COLOR='GRAY 40', PERMIT_HOLE=.FALSE.,
SURF_ID='ADIABATIC'/ Flor_support_3FM1
&OBST XB=2.4384,4.2672,6.2484,6.4008,10.2108,10.3632,
COLOR='GRAY 40', PERMIT_HOLE=.FALSE.,
SURF_ID='ADIABATIC'/ Flor_support_3FM2
&OBST XB=2.4384,4.2672,7.7724,7.9248,10.2108,10.3632,
COLOR='GRAY 40', PERMIT_HOLE=.FALSE.,
SURF_ID='ADIABATIC'/ Flor_support_3FM3
&OBST XB=2.4384,4.2672,9.2964,9.4488,10.2108,10.3632,
COLOR='GRAY 40', PERMIT_HOLE=.FALSE.,
SURF_ID='ADIABATIC'/ Flor_support_3FM4
&OBST XB=2.4384,4.2672,10.8204,10.9728,10.2108,10.3632,
COLOR='GRAY 40', PERMIT_HOLE=.FALSE.,
SURF_ID='ADIABATIC'/ Flor_support_3FM5
&OBST XB=2.4384,4.2672,12.3444,12.4968,10.2108,10.3632,
COLOR='GRAY 40', PERMIT_HOLE=.FALSE.,
SURF_ID='ADIABATIC'/ Flor_support_3FM6
&OBST XB=8.0772,9.4488,6.2484,6.4008,10.2108,10.5156,
COLOR='GRAY 40', PERMIT_HOLE=.FALSE.,
SURF_ID='ADIABATIC'/ Flor_support_3FCooridor1
&OBST XB=8.0772,9.4488,9.2964,9.4488,10.2108,10.5156,
COLOR='GRAY 40', PERMIT_HOLE=.FALSE.,
SURF_ID='ADIABATIC'/ Flor_support_3FCooridor2
&OBST XB=8.0772,9.4488,12.3444,12.4968,10.2108,10.5156,
COLOR='GRAY 40', PERMIT_HOLE=.FALSE.,
SURF_ID='ADIABATIC'/ Flor_support_3FCooridor3
&OBST XB=2.4384,4.2672,6.4008,6.5532,13.2588,13.4112,
COLOR='GRAY 40', PERMIT_HOLE=.FALSE.,
SURF_ID='ADIABATIC'/ Flor_support_4FL1
&OBST XB=2.4384,4.2672,9.144,9.2964,13.2588,13.4112,
COLOR='GRAY 40', PERMIT_HOLE=.FALSE.,
SURF_ID='ADIABATIC'/ Flor_support_4Fl2
&OBST XB=6.7056,8.5344,6.4008,6.5532,13.2588,13.4112,
COLOR='GRAY 40', PERMIT_HOLE=.FALSE.,
SURF_ID='ADIABATIC'/ Flor_support_4FR1
&OBST XB=6.7056,8.5344,9.144,9.2964,13.2588,13.4112,
COLOR='GRAY 40', PERMIT_HOLE=.FALSE.,
SURF_ID='ADIABATIC'/ Flor_support_4FR2
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&OBST XB=8.2296,9.144,3.81,4.7244,4.4196,4.4196,
PERMIT_HOLE=.FALSE., SURF_ID='Supply Fans'/ Fan1
&OBST XB=8.2296,9.144,5.1816,6.096,4.4196,4.4196,
PERMIT_HOLE=.FALSE., SURF_ID='Supply Fans'/ Fan2
&OBST XB=8.2296,9.144,6.858,7.7724,4.4196,4.4196,
PERMIT_HOLE=.FALSE., SURF_ID='Supply Fans'/ Fan3
&OBST XB=8.2296,9.144,8.2296,9.144,4.4196,4.4196,
PERMIT_HOLE=.FALSE., SURF_ID='Supply Fans'/ Fan4
&OBST XB=8.2296,9.144,9.906,10.8204,4.4196,4.4196,
PERMIT_HOLE=.FALSE., SURF_ID='Supply Fans'/ Fan5
&OBST XB=8.2296,9.144,11.2776,12.192,4.4196,4.4196,
PERMIT_HOLE=.FALSE., SURF_ID='Supply Fans'/ Fan6
&OBST XB=8.2296,8.2296,3.81,4.7244,3.9624,4.572,
PERMIT_HOLE=.FALSE., SURF_ID='ADIABATIC'/ Cover_1a
&OBST XB=9.144,9.144,3.81,4.7244,3.9624,4.572,
PERMIT_HOLE=.FALSE., SURF_ID='ADIABATIC'/ Cover_1b
&OBST XB=8.2296,9.144,3.81,3.81,3.9624,4.572,
PERMIT_HOLE=.FALSE., SURF_ID='ADIABATIC'/ Cover_1c
&OBST XB=8.2296,9.144,4.7244,4.7244,3.9624,4.572,
PERMIT_HOLE=.FALSE., SURF_ID='ADIABATIC'/ Cover_1d
&OBST XB=8.2296,8.2296,5.1816,6.096,3.9624,4.572,
PERMIT_HOLE=.FALSE., SURF_ID='ADIABATIC'/ Cover_2a
&OBST XB=9.144,9.144,5.1816,6.096,3.9624,4.572,
PERMIT_HOLE=.FALSE., SURF_ID='ADIABATIC'/ Cover_2b
&OBST XB=8.2296,9.144,5.1816,5.1816,3.9624,4.572,
PERMIT_HOLE=.FALSE., SURF_ID='ADIABATIC'/ Cover_2c
&OBST XB=8.2296,9.144,6.096,6.096,3.9624,4.572,
PERMIT_HOLE=.FALSE., SURF_ID='ADIABATIC'/ Cover_2d
&OBST XB=8.2296,8.2296,6.858,7.7724,3.9624,4.572,
PERMIT_HOLE=.FALSE., SURF_ID='ADIABATIC'/ Cover_3a
&OBST XB=9.144,9.144,6.858,7.7724,3.9624,4.572,
PERMIT_HOLE=.FALSE., SURF_ID='ADIABATIC'/ Cover_3b
&OBST XB=8.2296,9.144,6.858,6.858,3.9624,4.572,
PERMIT_HOLE=.FALSE., SURF_ID='ADIABATIC'/ Cover_3c
&OBST XB=8.2296,9.144,7.7724,7.7724,3.9624,4.572,
PERMIT_HOLE=.FALSE., SURF_ID='ADIABATIC'/ Cover_3d
&OBST XB=8.2296,8.2296,8.2296,9.144,3.9624,4.572,
PERMIT_HOLE=.FALSE., SURF_ID='ADIABATIC'/ Cover_4a
&OBST XB=9.144,9.144,8.2296,9.144,3.9624,4.572,
PERMIT_HOLE=.FALSE., SURF_ID='ADIABATIC'/ Cover_4b
&OBST XB=8.2296,9.144,8.2296,8.2296,3.9624,4.572,
PERMIT_HOLE=.FALSE., SURF_ID='ADIABATIC'/ Cover_4c
&OBST XB=8.2296,9.144,9.144,9.144,3.9624,4.572,
PERMIT_HOLE=.FALSE., SURF_ID='ADIABATIC'/ Cover_4d
&OBST XB=8.2296,8.2296,9.906,10.8204,3.9624,4.572,
PERMIT_HOLE=.FALSE., SURF_ID='ADIABATIC'/ Cover_5a
&OBST XB=9.144,9.144,9.906,10.8204,3.9624,4.572,
PERMIT_HOLE=.FALSE., SURF_ID='ADIABATIC'/ Cover_5b
&OBST XB=8.2296,9.144,9.906,9.906,3.9624,4.572,
PERMIT_HOLE=.FALSE., SURF_ID='ADIABATIC'/ Cover_5c
&OBST XB=8.2296,9.144,10.8204,10.8204,3.9624,4.572,
PERMIT_HOLE=.FALSE., SURF_ID='ADIABATIC'/ Cover_5d
&OBST XB=8.2296,8.2296,11.2776,12.192,3.9624,4.572,
PERMIT_HOLE=.FALSE., SURF_ID='ADIABATIC'/ Cover_6a
&OBST XB=9.144,9.144,11.2776,12.192,3.9624,4.572,
PERMIT_HOLE=.FALSE., SURF_ID='ADIABATIC'/ Cover_6b
&OBST XB=8.2296,9.144,11.2776,11.2776,3.9624,4.572,
PERMIT_HOLE=.FALSE., SURF_ID='ADIABATIC'/ Cover_6c
&OBST XB=8.2296,9.144,12.192,12.192,3.9624,4.572,
PERMIT_HOLE=.FALSE., SURF_ID='ADIABATIC'/ Cover_6d
&OBST XB=1.6764,1.6764,3.3528,3.9624,4.4196,4.7244,
SURF_ID='Cabinet Fan Left'/ R1C1-S1-F
&OBST XB=1.6764,1.6764,3.3528,3.9624,4.7244,5.0292,
SURF_ID='Cabinet Fan Left'/ R1C1-S2-F
&OBST XB=1.6764,1.6764,3.3528,3.9624,5.0292,5.334,
SURF_ID='Cabinet Fan Left'/ R1C1-S3-F
&OBST XB=1.6764,1.6764,3.3528,3.9624,5.334,5.6388,
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&OBST XB=1.6764,1.6764,3.3528,3.9624,5.6388,5.9436,
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&OBST XB=5.334,5.334,5.1816,5.7912,10.5156,10.8204,
SURF_ID='Cabinet Fan Right'/ R6C4-S1-F
&OBST XB=5.334,5.334,5.1816,5.7912,10.8204,11.1252,
SURF_ID='Cabinet Fan Right'/ R6C4-S2-F
&OBST XB=5.334,5.334,5.1816,5.7912,11.1252,11.43,
SURF_ID='Cabinet Fan Right'/ R6C4-S3-F
&OBST XB=5.334,5.334,5.1816,5.7912,11.43,11.7348,
SURF_ID='Cabinet Fan Right'/ R6C4-S4-F
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SURF_ID='Cabinet Fan Right'/ R6C4-S5-F
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SURF_ID='Cabinet Fan Right'/ R6C4-S7-F
&OBST XB=5.334,5.334,5.7912,6.4008,10.5156,10.8204,
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&OBST XB=5.334,5.334,5.7912,6.4008,10.8204,11.1252,
SURF_ID='Cabinet Fan Right'/ R6C5-S2-F
&OBST XB=5.334,5.334,5.7912,6.4008,11.1252,11.43,
SURF_ID='Cabinet Fan Right'/ R6C5-S3-F
&OBST XB=5.334,5.334,5.7912,6.4008,11.43,11.7348,
SURF_ID='Cabinet Fan Right'/ R6C5-S4-F
&OBST XB=5.334,5.334,5.7912,6.4008,11.7348,12.0396,
SURF_ID='Cabinet Fan Right'/ R6C5-S5-F
&OBST XB=5.334,5.334,5.7912,6.4008,12.0396,12.3444,
SURF_ID='Cabinet Fan Right'/ R6C5-S6-F
&OBST XB=5.334,5.334,5.7912,6.4008,12.3444,12.6492,
SURF_ID='Cabinet Fan Right'/ R6C5-S7-F
&OBST XB=5.334,5.334,6.4008,7.0104,10.5156,10.8204,
SURF_ID='Cabinet Fan Right'/ R6C6-S1-F
&OBST XB=5.334,5.334,6.4008,7.0104,10.8204,11.1252,
SURF_ID='Cabinet Fan Right'/ R6C6-S2-F
&OBST XB=5.334,5.334,6.4008,7.0104,11.1252,11.43,
SURF_ID='Cabinet Fan Right'/ R6C6-S3-F
&OBST XB=5.334,5.334,6.4008,7.0104,11.43,11.7348,
SURF_ID='Cabinet Fan Right'/ R6C6-S4-F
&OBST XB=5.334,5.334,6.4008,7.0104,11.7348,12.0396,
SURF_ID='Cabinet Fan Right'/ R6C6-S5-F
&OBST XB=5.334,5.334,6.4008,7.0104,12.0396,12.3444,
SURF_ID='Cabinet Fan Right'/ R6C6-S6-F
&OBST XB=5.334,5.334,6.4008,7.0104,12.3444,12.6492,
SURF_ID='Cabinet Fan Right'/ R6C6-S7-F
&OBST XB=5.334,5.334,7.0104,7.62,10.5156,10.8204,
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SURF_ID='Cabinet Fan Right'/ R6C7-S2-F
&OBST XB=5.334,5.334,7.0104,7.62,11.1252,11.43,
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SURF_ID='Cabinet Fan Right'/ R6C7-S5-F
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SURF_ID='Cabinet Fan Right'/ R6C7-S6-F
&OBST XB=5.334,5.334,7.0104,7.62,12.3444,12.6492,
SURF_ID='Cabinet Fan Right'/ R6C7-S7-F
&OBST XB=5.334,5.334,7.62,8.2296,10.5156,10.8204,
SURF_ID='Cabinet Fan Right'/ R6C8-S1-F
&OBST XB=5.334,5.334,7.62,8.2296,10.8204,11.1252,
SURF_ID='Cabinet Fan Right'/ R6C8-S2-F
&OBST XB=5.334,5.334,7.62,8.2296,11.1252,11.43,
SURF_ID='Cabinet Fan Right'/ R6C8-S3-F
&OBST XB=5.334,5.334,7.62,8.2296,11.43,11.7348,
SURF_ID='Cabinet Fan Right'/ R6C8-S4-F
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SURF_ID='Cabinet Fan Right'/ R6C8-S5-F
&OBST XB=5.334,5.334,7.62,8.2296,12.0396,12.3444,
SURF_ID='Cabinet Fan Right'/ R6C8-S6-F
&OBST XB=5.334,5.334,7.62,8.2296,12.3444,12.6492,
SURF_ID='Cabinet Fan Right'/ R6C8-S7-F
&OBST XB=5.334,5.334,8.2296,8.8392,10.5156,10.8204,
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SURF_ID='Cabinet Fan Right'/ R6C9-S2-F
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SURF_ID='Cabinet Fan Right'/ R6C9-S3-F
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SURF_ID='Cabinet Fan Right'/ R6C9-S5-F
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SURF_ID='Cabinet Fan Right'/ R6C9-S6-F
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SURF_ID='Cabinet Fan Right'/ R6C9-S7-F
&OBST XB=5.334,5.334,8.8392,9.4488,10.5156,10.8204,
SURF_ID='Cabinet Fan Right'/ R6C10-S1-F
&OBST XB=5.334,5.334,8.8392,9.4488,10.8204,11.1252,
SURF_ID='Cabinet Fan Right'/ R6C10-S2-F
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SURF_ID='Cabinet Fan Right'/ R6C10-S3-F
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SURF_ID='Cabinet Fan Right'/ R6C10-S4-F
&OBST XB=5.334,5.334,8.8392,9.4488,11.7348,12.0396,
SURF_ID='Cabinet Fan Right'/ R6C10-S5-F
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SURF_ID='Cabinet Fan Right'/ R6C10-S6-F
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SURF_ID='Cabinet Fan Right'/ R6C10-S7-F
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SURF_ID='Cabinet Fan Right'/ R6C11-S2-F
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SURF_ID='Cabinet Fan Right'/ R6C11-S3-F
&OBST XB=5.334,5.334,9.4488,10.0584,11.43,11.7348,
SURF_ID='Cabinet Fan Right'/ R6C11-S4-F
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SURF_ID='Cabinet Fan Right'/ R6C11-S5-F

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SURF_ID='Cabinet Fan Right'/ R6C11-S7-F
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&OBST XB=5.334,5.334,10.0584,10.668,10.8204,11.1252,
SURF_ID='Cabinet Fan Right'/ R6C12-S2-F
&OBST XB=5.334,5.334,10.0584,10.668,11.1252,11.43,
SURF_ID='Cabinet Fan Right'/ R6C12-S3-F
&OBST XB=5.334,5.334,10.0584,10.668,11.43,11.7348,
SURF_ID='Cabinet Fan Right'/ R6C12-S4-F
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SURF_ID='Cabinet Fan Right'/ R6C12-S5-F
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SURF_ID='Cabinet Fan Right'/ R6C12-S6-F
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SURF_ID='Cabinet Fan Right'/ R6C13-S1-F
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SURF_ID='Cabinet Fan Right'/ R6C13-S2-F
&OBST XB=5.334,5.334,10.668,11.2776,11.1252,11.43,
SURF_ID='Cabinet Fan Right'/ R6C13-S3-F
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SURF_ID='Cabinet Fan Right'/ R6C13-S5-F
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SURF_ID='Cabinet Fan Right'/ R6C13-S6-F
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SURF_ID='Cabinet Fan Right'/ R6C13-S7-F
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SURF_ID='Cabinet Fan Right'/ R6C14-S1-F
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SURF_ID='Cabinet Fan Right'/ R6C14-S2-F
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SURF_ID='Cabinet Fan Right'/ R6C14-S4-F
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SURF_ID='Cabinet Fan Right'/ R6C14-S5-F
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SURF_ID='Cabinet Fan Right'/ R6C14-S6-F
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SURF_ID='Cabinet Fan Right'/ R6C14-S7-F
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SURF_ID='Cabinet Fan Right'/ R6C15-S2-F
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SURF_ID='Cabinet Fan Right'/ R6C15-S3-F
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SURF_ID='Cabinet Fan Right'/ R6C15-S4-F
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SURF_ID='Cabinet Fan Right'/ R6C15-S6-F
&OBST XB=5.334,5.334,11.8872,12.4968,12.3444,12.6492,
SURF_ID='Cabinet Fan Right'/ R6C15-S7-F
&OBST XB=1.6764,2.7432,3.3528,3.9624,4.7244,4.7244,
RGB=255,51,51, SURF_IDS='Server
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&OBST XB=1.6764,2.7432,3.3528,3.9624,5.0292,5.0292,
RGB=255,51,51, SURF_IDS='Server
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RGB=255,51,51, SURF_IDS='Server
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RGB=255,51,51, SURF_IDS='Server
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RGB=255,51,51, SURF_IDS='Server
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RGB=255,51,51, SURF_IDS='Server
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RGB=255,51,51, SURF_IDS='Server
Heater','ADIABATIC','Server Heater'/ R1C2-H1
&OBST XB=1.6764,2.7432,3.9624,4.572,5.0292,5.0292,
RGB=255,51,51, SURF_IDS='Server
Heater','ADIABATIC','Server Heater'/ Sever Heater
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RGB=255,51,51, SURF_IDS='Server
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RGB=255,51,51, SURF_IDS='Server
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RGB=255,51,51, SURF_IDS='Server
Heater','ADIABATIC','Server Heater'/ Server Heater
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RGB=255,51,51, SURF_IDS='Server
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RGB=255,51,51, SURF_IDS='Server
Heater','ADIABATIC','Server Heater'/ R1C3-H1
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RGB=255,51,51, SURF_IDS='Server
Heater','ADIABATIC','Server Heater'/ Sever Heater
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RGB=255,51,51, SURF_IDS='Server
Heater','ADIABATIC','Server Heater'/ Sever Heater
&OBST XB=1.6764,2.7432,4.572,5.1816,5.6388,5.6388,
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RGB=255,51,51, SURF_IDS='Server
Heater','ADIABATIC','Server Heater'/ R1C4-H1
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RGB=255,51,51, SURF_IDS='Server
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Heater','ADIABATIC','Server Heater'/ Server Heater
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RGB=255,51,51, SURF_IDS='Server
Heater','ADIABATIC','Server Heater'/ Server Heater
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RGB=255,51,51, SURF_IDS='Server
Heater','ADIABATIC','Server Heater'/ Server Heater
&OBST XB=1.6764,2.7432,5.7912,6.4008,4.7244,4.7244,
RGB=255,51,51, SURF_IDS='Server
Heater','ADIABATIC','Server Heater'/ R1C5-H1
&OBST XB=1.6764,2.7432,5.7912,6.4008,5.0292,5.0292,
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Heater','ADIABATIC','Server Heater'/ Sever Heater
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RGB=255,51,51, SURF_IDS='Server
Heater','ADIABATIC','Server Heater'/ Server Heater
&OBST XB=1.6764,2.7432,6.4008,7.0104,4.7244,4.7244,
RGB=255,51,51, SURF_IDS='Server
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RGB=255,51,51, SURF_IDS='Server
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RGB=255,51,51, SURF_IDS='Server
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RGB=255,51,51, SURF_IDS='Server
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RGB=255,51,51, SURF_IDS='Server
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Heater','ADIABATIC','Server Heater'/ Sever Heater
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Heater','ADIABATIC','Server Heater'/ Server Heater
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RGB=255,51,51, SURF_IDS='Server
Heater','ADIABATIC','Server Heater'/ Server Heater
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RGB=255,51,51, SURF_IDS='Server
Heater','ADIABATIC','Server Heater'/ Server Heater
&OBST XB=1.6764,2.7432,8.2296,8.8392,4.7244,4.7244,
RGB=255,51,51, SURF_IDS='Server
Heater','ADIABATIC','Server Heater'/ R1C9-H1
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RGB=255,51,51, SURF_IDS='Server
Heater','ADIABATIC','Server Heater'/ Sever Heater
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RGB=255,51,51, SURF_IDS='Server
Heater','ADIABATIC','Server Heater'/ Sever Heater
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RGB=255,51,51, SURF_IDS='Server
Heater','ADIABATIC','Server Heater'/ Server Heater
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Heater','ADIABATIC','Server Heater'/ Server Heater
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RGB=255,51,51, SURF_IDS='Server
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Heater','ADIABATIC','Server Heater'/ R1C12-H1
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Heater','ADIABATIC','Server Heater'/ Sever Heater
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RGB=255,51,51, SURF_IDS='Server
Heater','ADIABATIC','Server Heater'/ Sever Heater
&OBST XB=1.6764,2.7432,10.0584,10.668,5.6388,5.6388,
RGB=255,51,51, SURF_IDS='Server
Heater','ADIABATIC','Server Heater'/ Server Heater
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RGB=255,51,51, SURF_IDS='Server
Heater','ADIABATIC','Server Heater'/ Server Heater
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&OBST XB=1.6764,2.7432,10.668,11.2776,4.7244,4.7244, RGB=255,51,51, SURF_IDS='Server Heater','ADIABATIC','Server Heater'/ R1C13-H1
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&OBST XB=1.6764,2.7432,10.668,11.2776,5.6388,5.6388, RGB=255,51,51, SURF_IDS='Server Heater','ADIABATIC','Server Heater'/ Server Heater
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&OBST XB=1.6764,2.7432,11.2776,11.8872,4.7244,4.7244, RGB=255,51,51, SURF_IDS='Server Heater','ADIABATIC','Server Heater'/ R1C14-H1
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&OBST XB=1.6764,2.7432,11.2776,11.8872,5.334,5.334, RGB=255,51,51, SURF_IDS='Server Heater','ADIABATIC','Server Heater'/ Sever Heater
&OBST XB=1.6764,2.7432,11.8872,12.4968,4.7244,4.7244, RGB=255,51,51, SURF_IDS='Server Heater','ADIABATIC','Server Heater'/ Server Heater
&OBST XB=1.6764,2.7432,11.8872,12.4968,5.0292,5.0292, RGB=255,51,51, SURF_IDS='Server Heater','ADIABATIC','Server Heater'/ Sever Heater
&OBST XB=1.6764,2.7432,11.8872,12.4968,5.334,5.334, RGB=255,51,51, SURF_IDS='Server Heater','ADIABATIC','Server Heater'/ Sever Heater
&OBST XB=1.6764,2.7432,11.8872,12.4968,5.6388,5.6388, RGB=255,51,51, SURF_IDS='Server Heater','ADIABATIC','Server Heater'/ Server Heater
&OBST XB=1.6764,2.7432,11.8872,12.4968,5.9436,5.9436, RGB=255,51,51, SURF_IDS='Server Heater','ADIABATIC','Server Heater'/ Server Heater
&OBST XB=1.6764,2.7432,11.8872,12.4968,6.2484,6.2484, RGB=255,51,51, SURF_IDS='Server Heater','ADIABATIC','Server Heater'/ R1C15-H1
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&OBST XB=1.6764,2.7432,11.2776,11.8872,5.9436,5.9436, RGB=255,51,51, SURF_IDS='Server Heater','ADIABATIC','Server Heater'/ Server Heater
&OBST XB=1.6764,2.7432,11.2776,11.8872,6.2484,6.2484, RGB=255,51,51, SURF_IDS='Server Heater','ADIABATIC','Server Heater'/ Server Heater
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&OBST XB=3.9624,5.0292,3.3528,3.9624,5.0292,5.0292, RGB=255,51,51, SURF_IDS='Server Heater','ADIABATIC','Server Heater'/ Sever Heater
&OBST XB=3.9624,5.0292,3.3528,3.9624,5.334,5.334, RGB=255,51,51, SURF_IDS='Server Heater','ADIABATIC','Server Heater'/ Sever Heater
&OBST XB=3.9624,5.0292,3.3528,3.9624,5.6388,5.6388, RGB=255,51,51, SURF_IDS='Server Heater','ADIABATIC','Server Heater'/ Server Heater
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&OBST XB=3.9624,5.0292,3.3528,3.9624,6.2484,6.2484, RGB=255,51,51, SURF_IDS='Server Heater','ADIABATIC','Server Heater'/ Server Heater
&OBST XB=3.9624,5.0292,3.9624,4.572,4.7244,4.7244, RGB=255,51,51, SURF_IDS='Server Heater','ADIABATIC','Server Heater'/ R2C2-H1
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&OBST XB=3.9624,5.0292,3.9624,4.572,5.334,5.334, RGB=255,51,51, SURF_IDS='Server Heater','ADIABATIC','Server Heater'/ Sever Heater
&OBST XB=3.9624,5.0292,3.9624,4.572,5.6388,5.6388, RGB=255,51,51, SURF_IDS='Server Heater','ADIABATIC','Server Heater'/ Server Heater
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&OBST XB=3.9624,5.0292,4.572,5.1816,5.6388,5.6388, RGB=255,51,51, SURF_IDS='Server Heater','ADIABATIC','Server Heater'/ Server Heater
&OBST XB=3.9624,5.0292,4.572,5.1816,5.9436,5.9436, RGB=255,51,51, SURF_IDS='Server Heater','ADIABATIC','Server Heater'/ Server Heater
&OBST XB=3.9624,5.0292,4.572,5.1816,6.2484,6.2484, RGB=255,51,51, SURF_IDS='Server Heater','ADIABATIC','Server Heater'/ Server Heater
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&OBST XB=3.9624,5.0292,5.1816,5.7912,5.9436,5.9436, RGB=255,51,51, SURF_IDS='Server Heater','ADIABATIC','Server Heater'/ Server Heater
&OBST XB=3.9624,5.0292,5.1816,5.7912,6.2484,6.2484, RGB=255,51,51, SURF_IDS='Server Heater','ADIABATIC','Server Heater'/ Server Heater
&OBST XB=3.9624,5.0292,5.7912,6.4008,4.7244,4.7244, RGB=255,51,51, SURF_IDS='Server Heater','ADIABATIC','Server Heater'/ R2C5-H1
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&OBST XB=3.9624,5.0292,5.7912,6.4008,5.9436,5.9436, RGB=255,51,51, SURF_IDS='Server Heater','ADIABATIC','Server Heater'/ Server Heater
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&OBST XB=3.9624,5.0292,6.4008,7.0104,4.7244,4.7244, RGB=255,51,51, SURF_IDS='Server Heater','ADIABATIC','Server Heater'/ R2C6-H1
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&OBST XB=3.9624,5.0292,6.4008,7.0104,6.2484,6.2484, RGB=255,51,51, SURF_IDS='Server Heater','ADIABATIC','Server Heater'/ Server Heater
&OBST XB=3.9624,5.0292,7.0104,7.62,4.7244,4.7244, RGB=255,51,51, SURF_IDS='Server Heater','ADIABATIC','Server Heater'/ R2C7-H1
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&OBST XB=3.9624,5.0292,7.62,8.2296,4.7244,4.7244, RGB=255,51,51, SURF_IDS='Server Heater','ADIABATIC','Server Heater'/ R2C8-H1
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&OBST XB=3.9624,5.0292,8.2296,8.8392,5.6388,5.6388, RGB=255,51,51, SURF_IDS='Server Heater','ADIABATIC','Server Heater'/ Server Heater
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&OBST XB=3.9624,5.0292,8.8392,9.4488,4.7244,4.7244, RGB=255,51,51, SURF_IDS='Server Heater','ADIABATIC','Server Heater'/ R2C10-H1
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&OBST XB=3.9624,5.0292,8.8392,9.4488,5.6388,5.6388, RGB=255,51,51, SURF_IDS='Server Heater','ADIABATIC','Server Heater'/ Server Heater
&OBST XB=3.9624,5.0292,8.8392,9.4488,5.9436,5.9436, RGB=255,51,51, SURF_IDS='Server Heater','ADIABATIC','Server Heater'/ Server Heater
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&OBST XB=3.9624,5.0292,9.4488,10.0584,4.7244,4.7244, RGB=255,51,51, SURF_IDS='Server Heater','ADIABATIC','Server Heater'/ R2C11-H1
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&OBST XB=3.9624,5.0292,10.0584,10.668,4.7244,4.7244, RGB=255,51,51, SURF_IDS='Server Heater','ADIABATIC','Server Heater'/ R2C12-H1
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Heater','ADIABATIC','Server Heater'/ Server Heater
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&OBST XB=4.1148,5.1816,5.1816,5.7912,7.7724,7.7724, RGB=255,51,51, SURF_IDS='Server Heater','ADIABATIC','Server Heater'/ R4C4-H1
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Heater','ADIABATIC','Server Heater'/ Sever Heater
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Heater','ADIABATIC','Server Heater'/ Server Heater
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&OBST XB=4.2672,5.334,8.8392,9.4488,12.0396,12.0396,
RGB=255,51,51, SURF_IDS='Server
Heater','ADIABATIC','Server Heater'/ Server Heater
&OBST XB=4.2672,5.334,8.8392,9.4488,12.3444,12.3444,
RGB=255,51,51, SURF_IDS='Server
Heater','ADIABATIC','Server Heater'/ Server Heater
&OBST XB=4.2672,5.334,9.4488,10.0584,10.8204,10.8204,
RGB=255,51,51, SURF_IDS='Server
Heater','ADIABATIC','Server Heater'/ R6C11-H1
&OBST XB=4.2672,5.334,9.4488,10.0584,11.1252,11.1252,
RGB=255,51,51, SURF_IDS='Server
Heater','ADIABATIC','Server Heater'/ Sever Heater
&OBST XB=4.2672,5.334,9.4488,10.0584,11.43,11.43,
RGB=255,51,51, SURF_IDS='Server
Heater','ADIABATIC','Server Heater'/ Sever Heater
&OBST XB=4.2672,5.334,9.4488,10.0584,11.7348,11.7348,
RGB=255,51,51, SURF_IDS='Server
Heater','ADIABATIC','Server Heater'/ Server Heater
&OBST XB=4.2672,5.334,9.4488,10.0584,12.0396,12.0396,
RGB=255,51,51, SURF_IDS='Server
Heater','ADIABATIC','Server Heater'/ Server Heater
&OBST XB=4.2672,5.334,9.4488,10.0584,12.3444,12.3444,
RGB=255,51,51, SURF_IDS='Server
Heater','ADIABATIC','Server Heater'/ Server Heater
&OBST XB=4.2672,5.334,10.0584,10.668,10.8204,10.8204,
RGB=255,51,51, SURF_IDS='Server
Heater','ADIABATIC','Server Heater'/ R6C12-H1
&OBST XB=4.2672,5.334,10.0584,10.668,11.1252,11.1252,
RGB=255,51,51, SURF_IDS='Server
Heater','ADIABATIC','Server Heater'/ Sever Heater
&OBST XB=4.2672,5.334,10.0584,10.668,11.43,11.43,
RGB=255,51,51, SURF_IDS='Server
Heater','ADIABATIC','Server Heater'/ Sever Heater
&OBST XB=4.2672,5.334,10.0584,10.668,11.7348,11.7348,
RGB=255,51,51, SURF_IDS='Server
Heater','ADIABATIC','Server Heater'/ Server Heater
&OBST XB=4.2672,5.334,10.0584,10.668,12.0396,12.0396,
RGB=255,51,51, SURF_IDS='Server
Heater','ADIABATIC','Server Heater'/ Server Heater
&OBST XB=4.2672,5.334,10.0584,10.668,12.3444,12.3444,
RGB=255,51,51, SURF_IDS='Server
Heater','ADIABATIC','Server Heater'/ Server Heater
&OBST XB=4.2672,5.334,10.668,11.2776,10.8204,10.8204,
RGB=255,51,51, SURF_IDS='Server
Heater','ADIABATIC','Server Heater'/ R6C13-H1
&OBST XB=4.2672,5.334,10.668,11.2776,11.1252,11.1252,
RGB=255,51,51, SURF_IDS='Server
Heater','ADIABATIC','Server Heater'/ Sever Heater
&OBST XB=4.2672,5.334,10.668,11.2776,11.43,11.43,
RGB=255,51,51, SURF_IDS='Server
Heater','ADIABATIC','Server Heater'/ Sever Heater
&OBST XB=4.2672,5.334,10.668,11.2776,11.7348,11.7348,
RGB=255,51,51, SURF_IDS='Server
Heater','ADIABATIC','Server Heater'/ Server Heater
&OBST XB=4.2672,5.334,10.668,11.2776,12.0396,12.0396,
RGB=255,51,51, SURF_IDS='Server
Heater','ADIABATIC','Server Heater'/ Server Heater
&OBST XB=4.2672,5.334,10.668,11.2776,12.3444,12.3444,
RGB=255,51,51, SURF_IDS='Server
Heater','ADIABATIC','Server Heater'/ Server Heater
&OBST XB=4.2672,5.334,11.2776,11.8872,10.8204,10.8204,
RGB=255,51,51, SURF_IDS='Server
Heater','ADIABATIC','Server Heater'/ R6C14-H1
&OBST XB=4.2672,5.334,11.2776,11.8872,11.1252,11.1252,
RGB=255,51,51, SURF_IDS='Server
Heater','ADIABATIC','Server Heater'/ Sever Heater
&OBST XB=4.2672,5.334,11.2776,11.8872,11.43,11.43,
RGB=255,51,51, SURF_IDS='Server
Heater','ADIABATIC','Server Heater'/ Sever Heater
&OBST XB=4.2672,5.334,11.2776,11.8872,11.7348,11.7348,
RGB=255,51,51, SURF_IDS='Server
Heater','ADIABATIC','Server Heater'/ Server Heater
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&OBST XB=4.2672,5.334,11.2776,11.8872,12.0396,12.0396,
RGB=255,51,51, SURF_IDS='Server
Heater','ADIABATIC','Server Heater'/ Server Heater
&OBST XB=4.2672,5.334,11.2776,11.8872,12.3444,12.3444,
RGB=255,51,51, SURF_IDS='Server
Heater','ADIABATIC','Server Heater'/ Server Heater
&OBST XB=4.2672,5.334,11.8872,12.4968,10.8204,10.8204,
RGB=255,51,51, SURF_IDS='Server
Heater','ADIABATIC','Server Heater'/ R6C15-H1
&OBST XB=4.2672,5.334,11.8872,12.4968,11.1252,11.1252,
RGB=255,51,51, SURF_IDS='Server
Heater','ADIABATIC','Server Heater'/ Sever Heater
&OBST XB=4.2672,5.334,11.8872,12.4968,11.43,11.43,
RGB=255,51,51, SURF_IDS='Server
Heater','ADIABATIC','Server Heater'/ Sever Heater
&OBST XB=4.2672,5.334,11.8872,12.4968,11.7348,11.7348,
RGB=255,51,51, SURF_IDS='Server
Heater','ADIABATIC','Server Heater'/ Server Heater
&OBST XB=4.2672,5.334,11.8872,12.4968,12.0396,12.0396,
RGB=255,51,51, SURF_IDS='Server
Heater','ADIABATIC','Server Heater'/ Server Heater
&OBST XB=4.2672,5.334,11.8872,12.4968,12.3444,12.3444,
RGB=255,51,51, SURF_IDS='Server
Heater','ADIABATIC','Server Heater'/ Server Heater
&OBST XB=1.6764,2.7432,2.7432,3.3528,4.4196,6.5532,
COLOR='SIENNA', SURF_ID='ADIABATIC'/ Header_1FL
&OBST XB=3.9624,5.0292,2.7432,3.3528,4.4196,6.5532,
COLOR='SIENNA', SURF_ID='ADIABATIC'/ Header_1FR
&OBST XB=1.524,2.5908,2.7432,3.3528,7.4676,9.6012,
COLOR='SIENNA', SURF_ID='INERT'/ Header_2FL
&OBST XB=4.1148,5.1816,2.7432,3.3528,7.4676,9.6012,
COLOR='SIENNA', SURF_ID='INERT'/ Header_2FR
&OBST XB=4.2672,5.334,2.7432,3.3528,10.5156,12.6492,
COLOR='SIENNA', SURF_ID='INERT'/ Header_3FR
&OBST XB=1.3716,2.4384,2.7432,3.3528,10.5156,12.6492,
COLOR='SIENNA', SURF_ID='INERT'/ Header_3FL
&OBST XB=1.6764,2.7432,3.3528,3.3528,4.4196,6.5532,
RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame Side
&OBST XB=1.6764,2.7432,3.3528,3.9624,6.5532,6.5532,
RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame Top
&OBST XB=1.6764,2.7432,3.9624,3.9624,4.4196,6.5532,
RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame
Side[1]
&OBST XB=1.6764,2.7432,3.9624,4.572,6.5532,6.5532,
RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame Top[1]
&OBST XB=1.6764,2.7432,4.572,4.572,4.4196,6.5532,
RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame
Side[2]
&OBST XB=1.6764,2.7432,4.572,5.1816,6.5532,6.5532,
RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame Top[2]
&OBST XB=1.6764,2.7432,5.1816,5.1816,4.4196,6.5532,
RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame
Side[3]
&OBST XB=1.6764,2.7432,5.1816,5.7912,6.5532,6.5532,
RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame Top[3]
&OBST XB=1.6764,2.7432,5.7912,5.7912,4.4196,6.5532,
RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame
Side[4]
&OBST XB=1.6764,2.7432,5.7912,6.4008,6.5532,6.5532,
RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame Top[4]
&OBST XB=1.6764,2.7432,6.4008,6.4008,4.4196,6.5532,
RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame
Side[5]
&OBST XB=1.6764,2.7432,6.4008,7.0104,6.5532,6.5532,
RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame Top[5]
&OBST XB=1.6764,2.7432,7.0104,7.0104,4.4196,6.5532,
RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame
Side[6]
&OBST XB=1.6764,2.7432,7.0104,7.62,6.5532,6.5532,
RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame Top[6]
&OBST XB=1.6764,2.7432,7.62,7.62,4.4196,6.5532,
RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame
Side[7]
&OBST XB=1.6764,2.7432,7.62,8.2296,6.5532,6.5532,
RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame Top[7]
&OBST XB=1.6764,2.7432,8.2296,8.2296,4.4196,6.5532,
RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame
Side[8]
&OBST XB=1.6764,2.7432,8.2296,8.8392,6.5532,6.5532,
RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame Top[8]
&OBST XB=1.6764,2.7432,8.8392,8.8392,4.4196,6.5532,
RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame
Side[9]
&OBST XB=1.6764,2.7432,8.8392,9.4488,6.5532,6.5532,
RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame Top[9]
&OBST XB=1.6764,2.7432,9.4488,9.4488,4.4196,6.5532,
RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame
Side[10]
&OBST XB=1.6764,2.7432,9.4488,10.0584,6.5532,6.5532,
RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame
Top[10]
&OBST XB=1.6764,2.7432,10.0584,10.0584,4.4196,6.5532,
RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame
Side[11]
&OBST XB=1.6764,2.7432,10.0584,10.668,6.5532,6.5532,
RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame
Top[11]
&OBST XB=1.6764,2.7432,10.668,10.668,4.4196,6.5532,
RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame
Side[12]
&OBST XB=1.6764,2.7432,10.668,11.2776,6.5532,6.5532,
RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame
Top[12]
&OBST XB=1.6764,2.7432,11.2776,11.2776,4.4196,6.5532,
RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame
Side[13]
&OBST XB=1.6764,2.7432,11.2776,11.8872,6.5532,6.5532,
RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame
Top[13]
&OBST XB=1.6764,2.7432,11.8872,11.8872,4.4196,6.5532,
RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame
Side[14]
&OBST XB=1.6764,2.7432,11.8872,12.4968,6.5532,6.5532,
RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame
Top[14]
&OBST XB=1.6764,2.7432,12.4968,12.4968,4.4196,6.5532,
RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame
Side[15]
&OBST XB=3.9624,5.0292,3.3528,3.3528,4.4196,6.5532,
RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame Side
&OBST XB=3.9624,5.0292,3.3528,3.9624,6.5532,6.5532,
RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame Top
&OBST XB=3.9624,5.0292,3.9624,3.9624,4.4196,6.5532,
RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame
Side[1]
&OBST XB=3.9624,5.0292,3.9624,4.572,6.5532,6.5532,
RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame Top[1]
&OBST XB=3.9624,5.0292,4.572,4.572,4.4196,6.5532,
RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame
Side[2]
&OBST XB=3.9624,5.0292,4.572,5.1816,6.5532,6.5532,
RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame Top[2]
&OBST XB=3.9624,5.0292,5.1816,5.1816,4.4196,6.5532,
RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame
Side[3]
&OBST XB=3.9624,5.0292,5.1816,5.7912,6.5532,6.5532,
RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame Top[3]
&OBST XB=3.9624,5.0292,5.7912,5.7912,4.4196,6.5532,
RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame
Side[4]
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&OBST XB=3.9624,5.0292,5.7912,6.4008,6.5532,6.5532,
RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame Top[4]
&OBST XB=3.9624,5.0292,6.4008,6.4008,4.4196,6.5532,
RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame
Side[5]
&OBST XB=3.9624,5.0292,6.4008,7.0104,6.5532,6.5532,
RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame Top[5]
&OBST XB=3.9624,5.0292,7.0104,7.0104,4.4196,6.5532,
RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame
Side[6]
&OBST XB=3.9624,5.0292,7.0104,7.62,6.5532,6.5532,
RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame Top[6]
&OBST XB=3.9624,5.0292,7.62,7.62,4.4196,6.5532,
RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame
Side[7]
&OBST XB=3.9624,5.0292,7.62,8.2296,6.5532,6.5532,
RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame Top[7]
&OBST XB=3.9624,5.0292,8.2296,8.2296,4.4196,6.5532,
RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame
Side[8]
&OBST XB=3.9624,5.0292,8.2296,8.8392,6.5532,6.5532,
RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame Top[8]
&OBST XB=3.9624,5.0292,8.8392,8.8392,4.4196,6.5532,
RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame
Side[9]
&OBST XB=3.9624,5.0292,8.8392,9.4488,6.5532,6.5532,
RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame Top[9]
&OBST XB=3.9624,5.0292,9.4488,9.4488,4.4196,6.5532,
RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame
Side[10]
&OBST XB=3.9624,5.0292,9.4488,10.0584,6.5532,6.5532,
RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame
Top[10]
&OBST XB=3.9624,5.0292,10.0584,10.0584,4.4196,6.5532,
RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame
Side[11]
&OBST XB=3.9624,5.0292,10.0584,10.668,6.5532,6.5532,
RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame
Top[11]
&OBST XB=3.9624,5.0292,10.668,10.668,4.4196,6.5532,
RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame
Side[12]
&OBST XB=3.9624,5.0292,10.668,11.2776,6.5532,6.5532,
RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame
Top[12]
&OBST XB=3.9624,5.0292,11.2776,11.2776,4.4196,6.5532,
RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame
Side[13]
&OBST XB=3.9624,5.0292,11.2776,11.8872,6.5532,6.5532,
RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame
Top[13]
&OBST XB=3.9624,5.0292,11.8872,11.8872,4.4196,6.5532,
RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame
Side[14]
&OBST XB=3.9624,5.0292,11.8872,12.4968,6.5532,6.5532,
RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame
Top[14]
&OBST XB=3.9624,5.0292,12.4968,12.4968,4.4196,6.5532,
RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame
Side[15]
&OBST XB=1.524,2.5908,3.3528,3.3528,7.4676,9.6012,
RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame Side
&OBST XB=1.524,2.5908,3.3528,3.9624,9.6012,9.6012,
RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame Top
&OBST XB=1.524,2.5908,3.9624,3.9624,7.4676,9.6012,
RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame
Side[1]
&OBST XB=1.524,2.5908,3.9624,4.572,9.6012,9.6012,
RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame Top[1]
&OBST XB=1.524,2.5908,4.572,4.572,7.4676,9.6012,
RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame
Side[2]
&OBST XB=1.524,2.5908,4.572,5.1816,9.6012,9.6012,
RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame Top[2]
&OBST XB=1.524,2.5908,5.1816,5.1816,7.4676,9.6012,
RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame
Side[3]
&OBST XB=1.524,2.5908,5.1816,5.7912,9.6012,9.6012,
RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame Top[3]
&OBST XB=1.524,2.5908,5.7912,5.7912,7.4676,9.6012,
RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame
Side[4]
&OBST XB=1.524,2.5908,5.7912,6.4008,9.6012,9.6012,
RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame Top[4]
&OBST XB=1.524,2.5908,6.4008,6.4008,7.4676,9.6012,
RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame
Side[5]
&OBST XB=1.524,2.5908,6.4008,7.0104,9.6012,9.6012,
RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame Top[5]
&OBST XB=1.524,2.5908,7.0104,7.0104,7.4676,9.6012,
RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame
Side[6]
&OBST XB=1.524,2.5908,7.0104,7.62,9.6012,9.6012,
RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame Top[6]
&OBST XB=1.524,2.5908,7.62,7.62,7.4676,9.6012,
RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame
Side[7]
&OBST XB=1.524,2.5908,7.62,8.2296,9.6012,9.6012,
RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame Top[7]
&OBST XB=1.524,2.5908,8.2296,8.2296,7.4676,9.6012,
RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame
Side[8]
&OBST XB=1.524,2.5908,8.2296,8.8392,9.6012,9.6012,
RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame Top[8]
&OBST XB=1.524,2.5908,8.8392,8.8392,7.4676,9.6012,
RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame
Side[9]
&OBST XB=1.524,2.5908,8.8392,9.4488,9.6012,9.6012,
RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame Top[9]
&OBST XB=1.524,2.5908,9.4488,9.4488,7.4676,9.6012,
RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame
Side[10]
&OBST XB=1.524,2.5908,9.4488,10.0584,9.6012,9.6012,
RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame
Top[10]
&OBST XB=1.524,2.5908,10.0584,10.0584,7.4676,9.6012,
RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame
Side[11]
&OBST XB=1.524,2.5908,10.0584,10.668,9.6012,9.6012,
RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame
Top[11]
&OBST XB=1.524,2.5908,10.668,10.668,7.4676,9.6012,
RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame
Side[12]
&OBST XB=1.524,2.5908,10.668,11.2776,9.6012,9.6012,
RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame
Top[12]
&OBST XB=1.524,2.5908,11.2776,11.2776,7.4676,9.6012,
RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame
Side[13]
&OBST XB=1.524,2.5908,11.2776,11.8872,9.6012,9.6012,
RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame
Top[13]
&OBST XB=1.524,2.5908,11.8872,11.8872,7.4676,9.6012,
RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame
Side[14]
&OBST XB=1.524,2.5908,11.8872,12.4968,9.6012,9.6012,
RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame
Top[14]

&OBST XB=1.524,2.5908,12.4968,12.4968,7.4676,9.6012,
RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame
Side[15]
&OBST XB=4.1148,5.1816,3.3528,3.3528,7.4676,9.6012,
RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame Side
&OBST XB=4.1148,5.1816,3.3528,3.9624,9.6012,9.6012,
RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame Top
&OBST XB=4.1148,5.1816,3.9624,3.9624,7.4676,9.6012,
RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame
Side[1]
&OBST XB=4.1148,5.1816,3.9624,4.572,9.6012,9.6012,
RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame Top[1]
&OBST XB=4.1148,5.1816,4.572,4.572,7.4676,9.6012,
RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame
Side[2]
&OBST XB=4.1148,5.1816,4.572,5.1816,9.6012,9.6012,
RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame Top[2]
&OBST XB=4.1148,5.1816,5.1816,5.1816,7.4676,9.6012,
RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame
Side[3]
&OBST XB=4.1148,5.1816,5.1816,5.7912,9.6012,9.6012,
RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame Top[3]
&OBST XB=4.1148,5.1816,5.7912,5.7912,7.4676,9.6012,
RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame
Side[4]
&OBST XB=4.1148,5.1816,5.7912,6.4008,9.6012,9.6012,
RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame Top[4]
&OBST XB=4.1148,5.1816,6.4008,6.4008,7.4676,9.6012,
RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame
Side[5]
&OBST XB=4.1148,5.1816,6.4008,7.0104,9.6012,9.6012,
RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame Top[5]
&OBST XB=4.1148,5.1816,7.0104,7.0104,7.4676,9.6012,
RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame
Side[6]
&OBST XB=4.1148,5.1816,7.0104,7.62,9.6012,9.6012,
RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame Top[6]
&OBST XB=4.1148,5.1816,7.62,7.62,7.4676,9.6012,
RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame
Side[7]
&OBST XB=4.1148,5.1816,7.62,8.2296,9.6012,9.6012,
RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame Top[7]
&OBST XB=4.1148,5.1816,8.2296,8.2296,7.4676,9.6012,
RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame
Side[8]
&OBST XB=4.1148,5.1816,8.2296,8.8392,9.6012,9.6012,
RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame Top[8]
&OBST XB=4.1148,5.1816,8.8392,8.8392,7.4676,9.6012,
RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame
Side[9]
&OBST XB=4.1148,5.1816,8.8392,9.4488,9.6012,9.6012,
RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame Top[9]
&OBST XB=4.1148,5.1816,9.4488,9.4488,7.4676,9.6012,
RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame
Side[10]
&OBST XB=4.1148,5.1816,9.4488,10.0584,9.6012,9.6012,
RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame
Top[10]
&OBST XB=4.1148,5.1816,10.0584,10.0584,7.4676,9.6012,
RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame
Side[11]
&OBST XB=4.1148,5.1816,10.0584,10.668,9.6012,9.6012,
RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame
Top[11]
&OBST XB=4.1148,5.1816,10.668,10.668,7.4676,9.6012,
RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame
Side[12]
&OBST XB=4.1148,5.1816,10.668,11.2776,9.6012,9.6012,
RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame
Top[12]
&OBST XB=4.1148,5.1816,11.2776,11.2776,7.4676,9.6012,
RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame
Side[13]
&OBST XB=4.1148,5.1816,11.2776,11.8872,9.6012,9.6012,
RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame
Top[13]
&OBST XB=4.1148,5.1816,11.8872,11.8872,7.4676,9.6012,
RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame
Side[14]
&OBST XB=4.1148,5.1816,11.8872,12.4968,9.6012,9.6012,
RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame
Top[14]
&OBST XB=4.1148,5.1816,12.4968,12.4968,7.4676,9.6012,
RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame
Side[15]
&OBST XB=1.3716,2.4384,3.3528,3.3528,10.5156,12.6492,
RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame Side
&OBST XB=1.3716,2.4384,3.3528,3.9624,12.6492,12.6492,
RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame Top
&OBST XB=1.3716,2.4384,3.9624,3.9624,10.5156,12.6492,
RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame
Side[1]
&OBST XB=1.3716,2.4384,3.9624,4.572,12.6492,12.6492,
RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame Top[1]
&OBST XB=1.3716,2.4384,4.572,4.572,10.5156,12.6492,
RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame
Side[2]
&OBST XB=1.3716,2.4384,4.572,5.1816,12.6492,12.6492,
RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame Top[2]
&OBST XB=1.3716,2.4384,5.1816,5.1816,10.5156,12.6492,
RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame
Side[3]
&OBST XB=1.3716,2.4384,5.1816,5.7912,12.6492,12.6492,
RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame Top[3]
&OBST XB=1.3716,2.4384,5.7912,5.7912,10.5156,12.6492,
RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame
Side[4]
&OBST XB=1.3716,2.4384,5.7912,6.4008,12.6492,12.6492,
RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame Top[4]
&OBST XB=1.3716,2.4384,6.4008,6.4008,10.5156,12.6492,
RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame
Side[5]
&OBST XB=1.3716,2.4384,6.4008,7.0104,12.6492,12.6492,
RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame Top[5]
&OBST XB=1.3716,2.4384,7.0104,7.0104,10.5156,12.6492,
RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame
Side[6]
&OBST XB=1.3716,2.4384,7.0104,7.62,12.6492,12.6492,
RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame Top[6]
&OBST XB=1.3716,2.4384,7.62,7.62,10.5156,12.6492,
RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame
Side[7]
&OBST XB=1.3716,2.4384,7.62,8.2296,12.6492,12.6492,
RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame Top[7]
&OBST XB=1.3716,2.4384,8.2296,8.2296,10.5156,12.6492,
RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame
Side[8]
&OBST XB=1.3716,2.4384,8.2296,8.8392,12.6492,12.6492,
RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame Top[8]
&OBST XB=1.3716,2.4384,8.8392,8.8392,10.5156,12.6492,
RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame
Side[9]
&OBST XB=1.3716,2.4384,8.8392,9.4488,12.6492,12.6492,
RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame Top[9]
&OBST XB=1.3716,2.4384,9.4488,9.4488,10.5156,12.6492,
RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame
Side[10]
&OBST XB=1.3716,2.4384,9.4488,10.0584,12.6492,12.6492,
RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame
Top[10]

&OBST XB=1.3716,2.4384,10.0584,10.0584,10.5156,12.6492, RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame Side[11]
&OBST XB=1.3716,2.4384,10.0584,10.668,12.6492,12.6492, RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame Top[11]
&OBST XB=1.3716,2.4384,10.668,10.668,10.5156,12.6492, RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame Side[12]
&OBST XB=1.3716,2.4384,10.668,11.2776,12.6492,12.6492, RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame Top[12]
&OBST XB=1.3716,2.4384,11.2776,11.2776,10.5156,12.6492, RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame Side[13]
&OBST XB=1.3716,2.4384,11.2776,11.8872,12.6492,12.6492, RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame Top[13]
&OBST XB=1.3716,2.4384,11.8872,11.8872,10.5156,12.6492, RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame Side[14]
&OBST XB=1.3716,2.4384,11.8872,12.4968,12.6492,12.6492, RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame Top[14]
&OBST XB=1.3716,2.4384,12.4968,12.4968,10.5156,12.6492, RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame Side[15]
&OBST XB=4.2672,5.334,3.3528,3.3528,10.5156,12.6492, RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame Side
&OBST XB=4.2672,5.334,3.3528,3.9624,12.6492,12.6492, RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame Top
&OBST XB=4.2672,5.334,3.9624,3.9624,10.5156,12.6492, RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame Side[1]
&OBST XB=4.2672,5.334,3.9624,4.572,12.6492,12.6492, RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame Top[1]
&OBST XB=4.2672,5.334,4.572,4.572,10.5156,12.6492, RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame Side[2]
&OBST XB=4.2672,5.334,4.572,5.1816,12.6492,12.6492, RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame Top[2]
&OBST XB=4.2672,5.334,5.1816,5.1816,10.5156,12.6492, RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame Side[3]
&OBST XB=4.2672,5.334,5.1816,5.7912,12.6492,12.6492, RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame Top[3]
&OBST XB=4.2672,5.334,5.7912,5.7912,10.5156,12.6492, RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame Side[4]
&OBST XB=4.2672,5.334,5.7912,6.4008,12.6492,12.6492, RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame Top[4]
&OBST XB=4.2672,5.334,6.4008,6.4008,10.5156,12.6492, RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame Side[5]
&OBST XB=4.2672,5.334,6.4008,7.0104,12.6492,12.6492, RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame Top[5]
&OBST XB=4.2672,5.334,7.0104,7.0104,10.5156,12.6492, RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame Side[6]
&OBST XB=4.2672,5.334,7.0104,7.62,12.6492,12.6492, RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame Top[6]
&OBST XB=4.2672,5.334,7.62,7.62,10.5156,12.6492, RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame Side[7]
&OBST XB=4.2672,5.334,7.62,8.2296,12.6492,12.6492, RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame Top[7]
&OBST XB=4.2672,5.334,8.2296,8.2296,10.5156,12.6492, RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame Side[8]
&OBST XB=4.2672,5.334,8.2296,8.8392,12.6492,12.6492, RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame Top[8]
&OBST XB=4.2672,5.334,8.8392,8.8392,10.5156,12.6492, RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame Side[9]
&OBST XB=4.2672,5.334,8.8392,9.4488,12.6492,12.6492, RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame Top[9]
&OBST XB=4.2672,5.334,9.4488,9.4488,10.5156,12.6492, RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame Side[10]
&OBST XB=4.2672,5.334,9.4488,10.0584,12.6492,12.6492, RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame Top[10]
&OBST XB=4.2672,5.334,10.0584,10.0584,10.5156,12.6492, RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame Side[11]
&OBST XB=4.2672,5.334,10.0584,10.668,12.6492,12.6492, RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame Top[11]
&OBST XB=4.2672,5.334,10.668,10.668,10.5156,12.6492, RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame Side[12]
&OBST XB=4.2672,5.334,10.668,11.2776,12.6492,12.6492, RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame Top[12]
&OBST XB=4.2672,5.334,11.2776,11.2776,10.5156,12.6492, RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame Side[13]
&OBST XB=4.2672,5.334,11.2776,11.8872,12.6492,12.6492, RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame Top[13]
&OBST XB=4.2672,5.334,11.8872,11.8872,10.5156,12.6492, RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame Side[14]
&OBST XB=4.2672,5.334,11.8872,12.4968,12.6492,12.6492, RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame Top[14]
&OBST XB=4.2672,5.334,12.4968,12.4968,10.5156,12.6492, RGB=255,153,153, SURF_ID='ADIABATIC'/ Rack Frame Side[15]
&OBST XB=6.7056,7.0104,3.3528,12.4968,13.716,13.716, PERMIT_HOLE=.FALSE., SURF_ID='Cooler'/ THX_fin1
&OBST XB=6.7056,7.0104,3.3528,12.4968,13.8684,13.8684, PERMIT_HOLE=.FALSE., SURF_ID='Cooler'/ THX_fin2
&OBST XB=6.7056,7.0104,3.3528,12.4968,14.0208,14.0208, PERMIT_HOLE=.FALSE., SURF_ID='Cooler'/ THX_fin3
&OBST XB=6.7056,7.0104,3.3528,12.4968,14.1732,14.1732, PERMIT_HOLE=.FALSE., SURF_ID='Cooler'/ THX_fin4
&OBST XB=6.7056,7.0104,3.3528,12.4968,14.3256,14.3256, PERMIT_HOLE=.FALSE., SURF_ID='Cooler'/ THX_fin5
&OBST XB=6.7056,7.0104,3.3528,12.4968,14.478,14.478, PERMIT_HOLE=.FALSE., SURF_ID='Cooler'/ THX_fin6
&OBST XB=6.7056,7.0104,3.3528,12.4968,14.6304,14.6304, PERMIT_HOLE=.FALSE., SURF_ID='Cooler'/ THX_fin7
&OBST XB=6.7056,7.0104,3.3528,12.4968,14.7828,14.7828, PERMIT_HOLE=.FALSE., SURF_ID='Cooler'/ THX_fin8
&OBST XB=6.7056,7.0104,3.3528,12.4968,14.9352,14.9352, PERMIT_HOLE=.FALSE., SURF_ID='Cooler'/ THX_fin9
&OBST XB=6.7056,7.0104,3.3528,12.4968,15.0876,15.0876, PERMIT_HOLE=.FALSE., SURF_ID='Cooler'/ THX_fin10
&OBST XB=6.7056,7.0104,3.3528,12.4968,15.24,15.24, PERMIT_HOLE=.FALSE., SURF_ID='Cooler'/ THX_fin11
&OBST XB=6.7056,7.0104,3.3528,12.4968,15.3924,15.3924, PERMIT_HOLE=.FALSE., SURF_ID='Cooler'/ THX_fin12
&OBST XB=6.7056,7.0104,3.3528,12.4968,15.5448,15.5448, PERMIT_HOLE=.FALSE., SURF_ID='Cooler'/ THX_fin13
&OBST XB=6.7056,7.0104,3.3528,12.4968,15.6972,15.6972, PERMIT_HOLE=.FALSE., SURF_ID='Cooler'/ THX_fin14
&OBST XB=6.7056,7.0104,3.3528,12.4968,15.8496,15.8496, PERMIT_HOLE=.FALSE., SURF_ID='Cooler'/ THX_fin15

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&OBST XB=6.7056,7.0104,3.3528,12.4968,16.002,16.002,
PERMIT_HOLE=.FALSE., SURF_ID='Cooler'/ THX_fin16
&OBST XB=6.7056,7.0104,3.3528,12.4968,16.1544,16.1544,
PERMIT_HOLE=.FALSE., SURF_ID='Cooler'/ THX_fin17
&OBST XB=6.7056,7.0104,3.3528,3.3528,13.2588,16.3068,
PERMIT_HOLE=.FALSE., SURF_ID='ADIABATIC'/
THX_Frame1
&OBST XB=6.7056,7.0104,3.3528,12.4968,13.5636,13.5636,
PERMIT_HOLE=.FALSE., SURF_ID='ADIABATIC'/
THX_Frame3

&HOLE XB=6.5532,9.4488,3.3528,12.4968,-0.0762,0.1524/
Flor_1F hole
&HOLE XB=6.94944,7.25424,3.9624,7.0104,0.4572,3.81/ Bot Ori
HX hole
&HOLE XB=6.94944,7.25424,8.8392,11.8872,0.4572,3.81/ Top
Ori HX hole
&HOLE XB=8.2296,9.144,3.81,4.7244,3.9624,4.572/ Fan Hole1
&HOLE XB=8.2296,9.144,5.1816,6.096,3.9624,4.572/ Fan Hole2
&HOLE XB=8.2296,9.144,6.858,7.7724,3.9624,4.572/ Fan Hole3
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