UBC Social Ecological Economic Development Studies (SEEDS) Student Report

Project on server room management

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University of British Columbia

EECE 496

April 7, 2013

University of British Columbia

Department of Electrical and Computer Engineering

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Abstract

The University of British Columbia is a leader on sustainability. UBC has planned to reduce the GHG emissions at 2007 levels by 33% by 2015, by 66% by 2020 and 100% by 2050. The sustainable office has always complained about the temperature in the server room is very low. Therefore, the sustainable office offers this project to investigate the temperature in the server room and recommend a sustainable temperature. Two UBC technicians were interviewed to obtain the basic information of server rooms. From the information, constrains and limitations are found. If the constrains and limitations could be extend by changing the equipment in the server room, the temperature then could be raised to a higher degree. For example, the UPS has an operational environment of 25 degree, if the UPS can be replaced to a new model, which can operate at maximum temperature of 40 degree, and then the temperature of the server room can be raised up.

Raising up the temperature would affect the reliability of the server equipment. From the information gathered from the interview, an average of 4 servers fail each year, and the acceptable failure rate is 5 servers fail each year. If the temperature were raised up to 25 degree, through calculation, this would cause one more server to fail each year. Assuming the failed server equipment does not need to be fully replaced, the cost of fixing extra server each year is lower than the savings.

Through calculation, if the temperature were raised to 25 degree, the saving from energy consumption would be 25604.94 kWh.

Because 25 degree is within the temperature range that ASHRAE standard recommended, and the cost of fixing extra server each year is lower than the savings from electricity usage; therefore, 25 degree is recommended.

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GLOSSARY

ASHRAE **-** American Society of Heating, Refrigerating and Air-Conditioning Engineers

Uninterrupted Power Supply **–** Lead Acid Battery for back up power

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LIST OF ABBREVIATIONS

ASHRAE – American Society of Heating, Refrigerating and Air-Conditioning Engineers

GHG – Greenhouse Gas

UPS – Uninterrupted Power Supply

1.0 INTRODUCTION

The purpose of this project is to manage the temperature in a server room or communication room. By managing the temperature of a server room, we would be able to reduce the energy consumption and GHG emission. Our roles in this project are to work as consultants, and my client is the Sustainable Office. Our Project is to explore the possibility of raising the temperature in the server room to reduce the energy consumption and does not to damage the equipment

The objectives for this project are to provide a literature review and audit of UBC facility, evaluate the 27degree Celsius that ASHRAE's standard recommends, assess the current temperature of a subset of server rooms on campus, and quantify the benefits to UBC of raising the temperature. In order to fulfill these objectives, we divide this project into four components. My partner is going to focus on the IT side of this project. He is going to compare the maintenance cost for the equipment in the server rooms with the money saved and the amount of GHG been reduced from raising the temperature. I am going to focus on evaluation of the ASHRAE's standard, environment and energy calculation parts of the project. As for the ASHRAE's standard, I will be researching its website and trying to find how ASHRAE calculates the 27 degree Celsius for the server room. For the environment and energy calculation parts, my partner and I will contact and meet with several staff from different department who is willing to help us on this project with respect to information and data. I will gather information and data together and analyze that with detailed calculation to how much GHG can be reduced if the temperature is raised to 27 degree Celsius.

The Sustainable Office has noticed that the temperature in server rooms and communication rooms is very low meaning that the air conditioners are constantly consuming energy to produce cold air in order to keep the temperature under a certain degree Celsius. Cooling systems consume a large amount of energy and UBC's transmission infrastructure is reaching its maximum capacity so any reduction in energy would be helpful. Therefore, the Sustainable Office requests us, my partner and I to investigate if the current temperature in the server room is necessary and if not, what is the necessary temperature that would be able to reduce energy and also does not have an impact on the equipment in the server room.

This report is divided into the following sections.

2.0 Methodology

3.0 Result and recommendation

4.0 Conclusion

2.0 METHODOLOGY

2.1 Project Design

The sustainable office assigned us this project as an open-ended project. This project is different from the other EECE 496 project, which involves designing a system or building a specific engineering model. Our project requires us to obtain as much information as we can from faulty staffs and UBC technicians and use our knowledge of engineering to filter in any useful information and make reasonable assumptions. The challenge part is to make the reasonable assumptions and finding the right information because of the lack information we can reference to.

Therefore, we came up with a list that contains what we need to do to complete this project.

1. Contact with UBC staffs that our co-supervisor Dr. Lusina has provide us their information that may help us with this project.
2. Set up a meeting with the staffs.
3. Create some questions to ask the staffs about server rooms
4. Meeting with the staffs.
5. Organize the information we get from the meeting.
6. Research for possible solutions.
7. Completing the report.

2.1.1 Problem Analysis

The objectives of this project are

1. Evaluate the 27degree Celsius that ASHRAE's standard recommends
2. Assess the current temperature of a server room in Kaiser building
3. Quantify the benefits to UBC of raising the temperature, (Cost, Saving and GHG reductions).

To evaluate the ASHRAE's standard recommendations, we did a lot of research on this matter. The first technician we consulted with is Chris Dumont, Manager, Technical & Physical Resources, he gave us a tour to visit the server rooms in Kaiser building, McLeod Building and Computer science building. The information he gave us has pointed to several reasons for why the temperature is the way it is, and why they cannot raise the temperature. From the information he gave us, we started to look for solutions for the problems would occur if we raised the temperature.

My partner is responsible for calculating the energy consumption and GHG emission by the server room. I am responsible for evaluating the temperature that ASHRAE standard recommend, and I am also responsible for estimate the failure rate of servers and the cost of this increase the temperature.

2.1.1.1 Assumptions

In this section I will list any assumptions we made along this project.

Chris had shown us three different server rooms. The three server rooms have different room size; the surrounding walls are different, and the rooms use different air conditioner system, but there are more than a hundred different server rooms on campus; it is quite difficult for us to examine all the server rooms and audit each one of the rooms. Therefore, we specifically investigate the server room in Kaiser building and assume that all the server rooms on campus are similar to that one.

Because we do not have any proper equipment to measure the power out put of the server such as noise, light and heat, so we assume that all the input power turns into heat.

Also, we do not have access to the building temperature, so we have to assume that the ambient temperature is the room temperature, which is 25 degree Celsius.

To calculate the fail rate and the cost for the server fails, we assume that the failed server were getting fixed and not fully replaced because according to Ken, that he spend most of the time fixing the server not install new servers. We assume that for each server that fails, Ken spends 10 hours fixing it and if the server needs to be replaced, Ken spends the same amount of time to replace it. And we have asked Ken for his income, and we get that he is paid 35 dollar per hour.

If the server needs to be fully replaced, we would assume the cost for fully replaced is 2000 dollar, and we ignore the inflation for the lifespan of the server.

2.1.2 Project Phases

We separate this project into three phases; each phase includes a milestone mark. First phase includes the preparation for the meeting, searching for existing data for any server room and meeting. The outcomes of this phase are the relationship we build with the faculty staffs and the basic information we get for the meeting. The second phase includes calculations of the energy consumptions, GHG emissions, cost of operation and savings and failure rate. These variables in these calculations are from the information we gathered from the meeting, consulting from a professor in the other faulty and ASHRAE standards. The third phase is the presentation we will be doing.

2.2 Investigation

2.2.1 Technician information

The technicians we met are from EECE faulty. They are Chris Dumont, Manager, Technical & Physical Resources and Ken. When we are creating the questions for them, we mainly focus on the technical parts. For example, we asked him about the temperature in the server room and the reasons for the temperature setting. What is his concern if the temperature is raised? We also asked him about the failure rate of the equipment and the reliability. The question sheet is in the appendix.

2.2.2 ASHRAE investigation

ASHRAE is an organization, which stand for American Society Heating, Refrigerating and Air-conditioning Engineers. ASHRAE mainly focus on energy efficiency indoor air quality and sustainable within the member of this organization. Through researching, ASHRAE develops a set of standard for its members to consider. The standard includes the best temperature for human comfort in a classroom or an office; the temperature and humidity setting guideline in a server room that minimize the energy consumption as well as the rate of failure, and the air quality for people in a building. The goal for ASHRAE is to promote a sustainable world by advancing the system of heating, refrigerating and air-conditioning. The main research in done on "ASHRAE TC 9.9 2011 Thermal Guidelines for Data Processing Environments – Expanded Data Center Classes and Usage Guidance" and "2008 ASHRAE Environmental Guidelines for Datacom Equipment".

2.3 Calculation

2.3.1 Equipment Replacement Cost Calculation

To calculate the cost of fixing the equipment, I need to know the amount of time to fix the equipment and the how much the technician is paid hourly. The information is acquired from meeting with Ken. Ken is paid 35 dollar per hour, and for each server, Ken needs about 10 hours to fix it. Therefore,

Hours x Income x number of servers fail each year= cost of fixing server

To calculate the cost of replacing the equipment, we need to add the cost for new server to the equation.

(Hours x Income + cost for new servers) x number of servers fail each year = cost of replacing server

3.0 RESULT

3.1 Result from Investigation

3.1.1 Result from Interview

From the meeting with the technician, we found out the following information.
The server room air conditioner is setting at 21 degree Celsius and 50 percent humidity.

The equipment in the server rooms is very old, and most of servers that we examine are over ten years. The equipment in the server rooms is very expensive, and the cost for replace them is very high, therefore, the equipment is put them in the best operating condition to prevent malfunction and can be used as long time as possible.

Also, most of the servers do not have an alternative server for back up, this means that if one server is malfunction, there are no backs up, and the system will break down. Therefore, the reliable of the server equipment is the priority to the technician. For that reason, some servers even have multiple power supple to back up the power for the server. According to the technician, the server room, which we are investigating, has an average of 4 servers fail per year. The cost, to fully replace the failed server, is about 2000 dollars.

In some of the server rooms, the temperature of the server equipment is monitored. The sensor is installed on the server equipment. The temperature signal is constantly sent to the Chris's office. The alarm will go off if the temperature excesses the setting limit, which is 25 degree for cold aisle and 40 for hot aisle.

The orientation of the server rack is crucial as well. The server rack should be orientated so that cold air would flow in the cold aisle and hot air would come out tot the hot aisle. The cold aisle should be the cold air that flows into the server, and hot aisle is where the server blows the hot air. The hot air is sucked back into the air conditioner and cool down. See figure 1. This is how the server room should be oriented. However in one of the server room the server rack is miss-orientated so that the air conditioner needs more power to cool down that room.

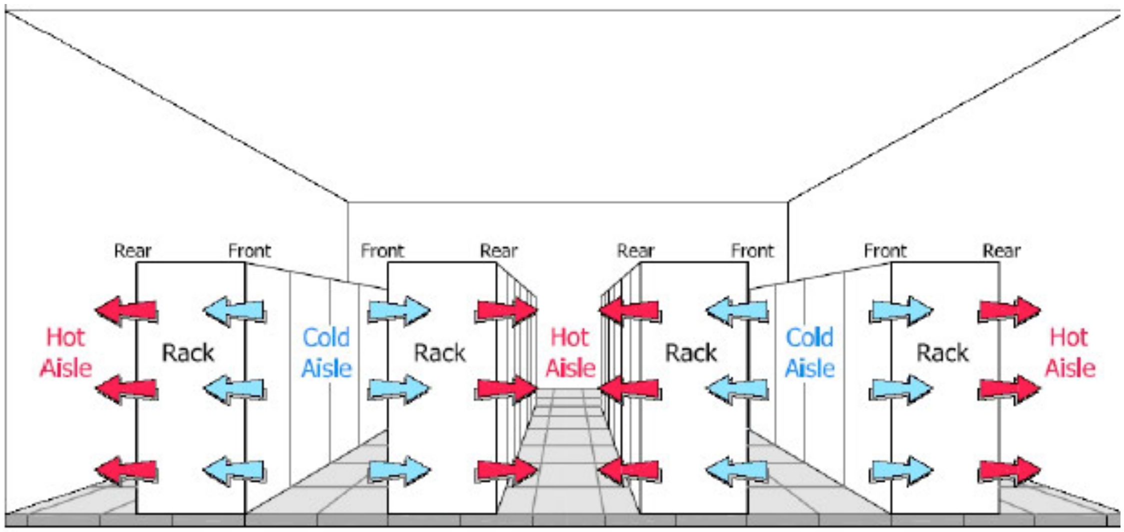

Figure 1 Figure of Cold and Hot Aisle

Each server room has a back up UPS. The UPS can provide about 20 minutes of power for the server room. The operation temperature for the UPS is at a maximum of 25 degree Celsius. If the temperature of the server room is higher than 25 degree Celsius, the warranty will not be effective.

3.1.2 Result from ASHRAE Investigation

According to the ASHRAE's Standard, the temperatures in the data center or server room are recommended to be 18 to 27 degree Celsius. See figure 2. The temperature that the ASHRAE recommends can provide the server equipment with maximum reliability and duration and minimize the energy consumption.

Table 1. ASHRAE 2004 and 2008 environmental guidelines

	Recommended		Allowable	
Year	2004	2008	2004	2008
Temperature Range	20ºC - 25ºC	18ºC - 27ºC	15ºC - 32ºC	10ºC - 35ºC
Moisture Range	40% - 55% RH	5.5ºC DP - 60% RH	20% - 80% RH	20% - 80% RH

Figure 2 ASHRAE recommended temperature range The following graph shows the relationship between the relative failure rates versus temperature.

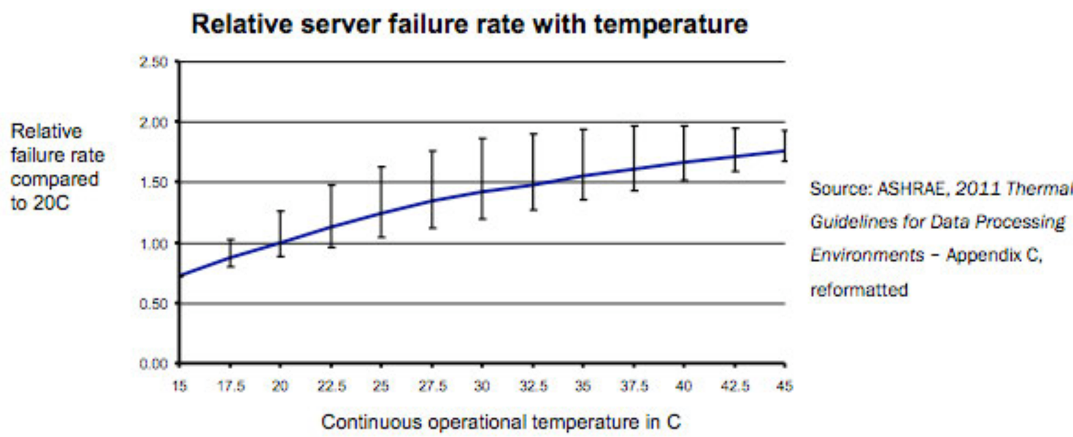

Figure 3 Graph of failure rate with temperature

The relative failure rate does not mean percentage of the failure rate. The relative failure rate is 1 at 20 degrees Celsius, and 1.25 at 25 degree. Assuming out of 1000 server equipment at 20degree, we expect an average of 4 of the equipment to fail. When the server room continuously operates at 25 degree, the relative failure rate is at 1.25; therefore, we are expecting 1.25*4 = 5 equipment fail over a year, this means that one additional equipment would fail in a year.

3.1.3 Result from Calculation

Using the following formulas, we can calculate the cost for fixing the server and replacing the server

For the cost of fixing the server:

Hours x Income x number of servers fail each year= cost of fixing server

We know that Ken is paid 35 dollar per hour and needs 10 hours to fix it; therefore, at 21 degree,

10 x 35 x 4 = 1400

the cost for fixing servers at 21 degree is 1400 dollar

The formula for the cost of replacing the servers is

(Hours x Income + cost for new servers) x number of servers fail each year = cost of replacing server

Therefore,

(10 x 35 +2000) x 4 = 2350

the cost for replacing the servers at 21 degree is 2350 dollars.

3.2 Recommendation

3.2.1 Statement of Objectives Achieved

The objectives are to evaluate the 27 degree Celsius that the ASHRAE recommend, to assess the current temperature of a server room in Kaiser building and to quantify the benefits to UBC of raising the temperature, (Cost, Saving and GHG reductions). We cannot test the 27 degree Celsius that the ASHRAE recommended because we are not authorize to change the setting of the air conditioner or do any experiment to the server room. The temperature that the ASHRAE recommends is from many experiments they have done in many data center around the world. They measure how many hours in different temperature in a year. ASHRASE has just updated their guideline and changed the recommended temperature range. This shows that the ASHRAE is continuing researching and experimenting the temperature in the sever room to find the most sustainable temperature range. In the Appendix, the graph shows the different areas and countries that ASHRAE has done research on.

3.2.2 Suggestion for Future Development

The challenge for this project is the lack of data and reference. Therefore, the calculation result maybe not accurate, and in the future more research is needed to find more accurate result. However, some recommendation may help to raise the temperature of the server room. Chris stated that the UPS limits the temperature of the server room; therefore, if the UPS can move to the other room then temperature of the server room can be raised to a higher degree. We have consulted some companies that manufactory the UPS, such as APC battery and ALPHA technology. Both of them stated that their product can operate in a temperature range of 0 degree to 40 degree. See figure. Which means that this type of UPS would not limit the temperature in the server room.

Environmental	
Operating Environment	0 - 40 °C
Operating Relative Humidity	0 - 95%
Operating Elevation	0-3000 meters
Storage Temperature	-15 - 45 °C
Storage Relative Humidity	0 - 95%

Figure 4 UPS environmental condition from APC technology

According to the ASHRAE guideline, the airflow is very crucial to cool down the sever equipment. If the server rack were not properly orientated, the airflow would not properly cool down the server, and this would result in the air conditioner providing more power to cool down the room. From the meeting, we visited a room that there is only one server rack in it because the air conditioner with 100% capacity can only cool down the heat produced from that rack. The air conditioner was installed very long time ago, and no one would think ten years after the air conditioner is not power enough. Therefore, in the future, when building a new sever room, a more powerful but sustainable air conditioner can be considered.

If we assume that the UPS does not limit the temperature, then we recommend setting the temperature of the server room to 25 degree Celsius. The reasons are that the 25 degree Celsius is within the range of ASHRAE's guideline recommended, and the relative failure rate according to the ASHRAE's graph is 1.25, which is 1 additional equipment fails per year. According to Chris and Ken that one more equipment fails is acceptable. And raising the temperature to 25 degree Celsius would reduce the GHG emission and the energy consumption by a certain percentage, which would result in the saving in the electric bill and contribute to reaching the goal that UBC set for reducing the GHG emission by 100% in 2050.

4.0 CONCLUSION

This report investigated the temperature of a server room located in Fred Kaiser Building. The objectives for this project were to evaluate the 27degree Celsius the ASHRAE guideline recommends, to access the current temperature of a subset of server rooms in Kaiser building, and quantify the benefits to UBC of raising the temperature.

This project my partner and I divided work, which I was in charge with the ASHRAE evaluation, and my partner was responsible for calculating the energy consumption, GHG reduction and cost saving.

At the beginning of this project, we had prepared a sheet of questions, which we prepared to ask the technician who was helping us with this project. From the meeting and server room tour, we found out that, in each server room an UPS is prepared for any black out. The operational condition for the UPS is below 25 degree Celsius. That is the main reason for setting the air conditioner in the server room at 21 degree Celsius. After consulting with Alpha technology and APC, we found out that the newest model of UPS can operate in between 0 to 40 degree Celsius. Therefore, we recommend that in the future, the old UPS can be replaced with the UPS that can operate within that range. So that, the server room temperature can be raised up. From the information given by the technician, about four servers from the Kaiser building server room fails every year. If the temperature was raised to my recommended temperature, 25 degree Celsius, the relative fail rate would be about 1.25; this means that one additional server would fail per year, which was acceptable by the technicians.

After look into the Guideline from ASHRAE, I found out that the recommended temperature range was setting that way to maximize the lifespan and reliability of servers, and minimize the energy consumption. The temperature range that ASHRAE came up with was from many experiments that ASHRAE did from different data center at many locations around North America and around the world. The ASHRAE also indicates the importance of the airflow in the server room. The better the airflow in the server room could provide better cooling effect. Our project gives a general over view of the server room. Because of the lack of data, many of the result are base on our assumption. In the future, other students can continue our work and focus on correcting our assumptions so that the result can be more accurate.

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Appendixes

Appendix A. Question sheet for Chris and Ken

Appendix B. excel sheet of the cost for the fixing servers

Appendix C. excel sheet for energy consumptions done by my partner Auburn Leung

Appendix D. cost for the operational Air Conditioner at different temperature done by my partner Auburn Leung

Appendix E. graphs for energy consumption in a year at different temperature done by my partner Auburn Leung

Appendix F. graph for annual cost and temperature done by my partner Auburn Leung

Appendix A. Question sheet for Chris and Ken

Questions

1. Can you please explain one or two worst cases of server room equipment failure?
2. What is the percentage use compare to the whole building?
3. What is the current temperature in the server room? (What is the energy consumption in server rooms?)
4. What is the standard temperature? And what is it based on?
5. What is the main concern if we raise the temperature? (Probably equipment rate of failure), is temperature the only factor of equipment failure? What about humidity?
6. What cause the equipment to fail?
7. What is the rate of equipment failure at standard temperature? (in %)
8. How old are the equipment? When was the last time they were replaced?
9. Does a lower temperature in server room actually decrease the rate of failure statistically?
10. Is energy consumption one of your concerns when buying equipment?
11. Do sustainability and reputation of UBC come to mind when deciding on new equipment?
12. For example higher temperature, sustainable campus, or better equipment advanced hardware for students?
13. What model is the cooling system?
14. Do you monitor equipment temperature? (Hardware temp/ambient temp?)
15. If yes then how do you monitor that?
16. How efficient are the cooling systems? Are the hardware exposed?

17. What are the peak hours for the server room and what are the purposes of this particular server room? Ever turn off the server equipment?

18. How often are server rooms maintained? (Dust)

19. What is the cost for installation fee?

Appendix B. excel sheet of the cost for the fixing servers

		Failure per yr	Annual Maintainance cost	Annual fixing cost
15	degree	3	$ 7,050.00	$1,050.00
17.5	degree	3.4	$ 7,990.00	$1,190.00
20	degree	4	$ 9,400.00	$1,400.00
22.5	degree	4.5	$10,575.00	$1,575.00
25	degree	5	$11,750.00	$1,750.00
27.5	degree	5.2	$12,220.00	$1,820.00
30	degree	5.4	$12,690.00	$1,890.00
32.5	degree	6	$14,100.00	$2,100.00
35	degree	6.2	$14,570.00	$2,170.00
37.5	degree	6.4	$15,040.00	$2,240.00
40	degree	6.6	$15,510.00	$2,310.00
42.5	degree	7	$16,450.00	$2,450.00
45	degree	7.2	$16,920.00	$2,520.00

Cost per failure: Technician hourly pay * number of hours + Cost of New Equipment

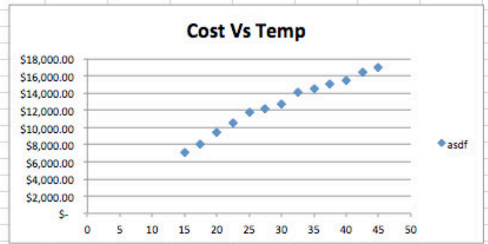
$2,350.00

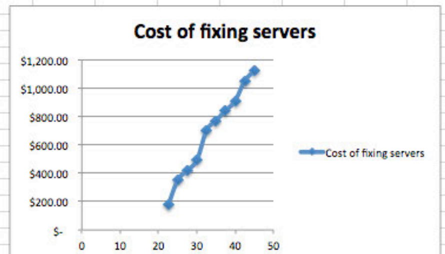
Technician hourly pay	35	per hr
Number of hours to setup	10	hrs
Cost of new equipment	##	$

annual equipment replace cost increase from 21 degree

22.5	degree	$1,175.00	$ 175.00
25	degree	$2,350.00	$ 350.00
27.5	degree	$2,820.00	$ 420.00
30	degree	$3,290.00	$ 490.00
32.5	degree	$4,700.00	$ 700.00
35	degree	$5,170.00	$ 770.00
37.5	degree	$5,640.00	$ 840.00
40	degree	$6,110.00	$ 910.00
42.5	degree	$7,050.00	$1,050.00
45	degree	$7,520.00	$1,120.00

NOTE: At 1 relative failure rate means its expected 4 comps fail in one server room at 20 degree





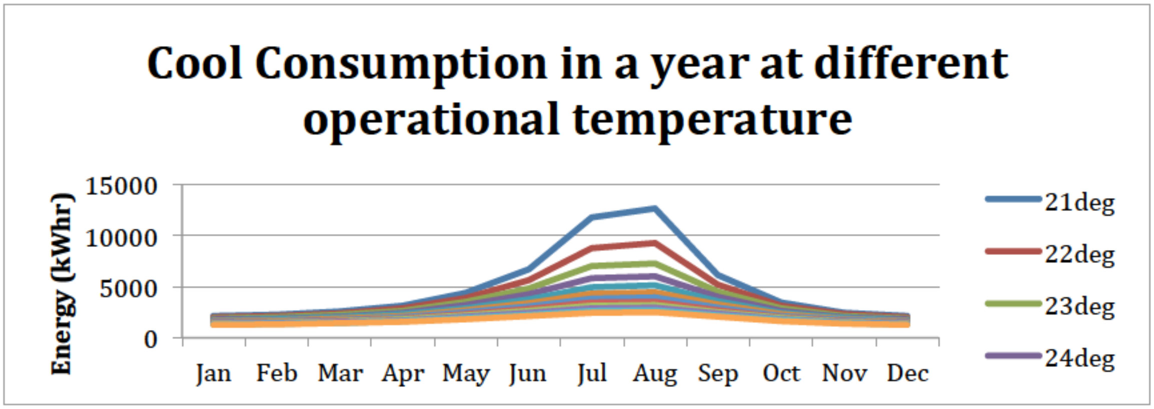
Appendix C. excel sheet for energy consumptions done by my partner Auburn Leung

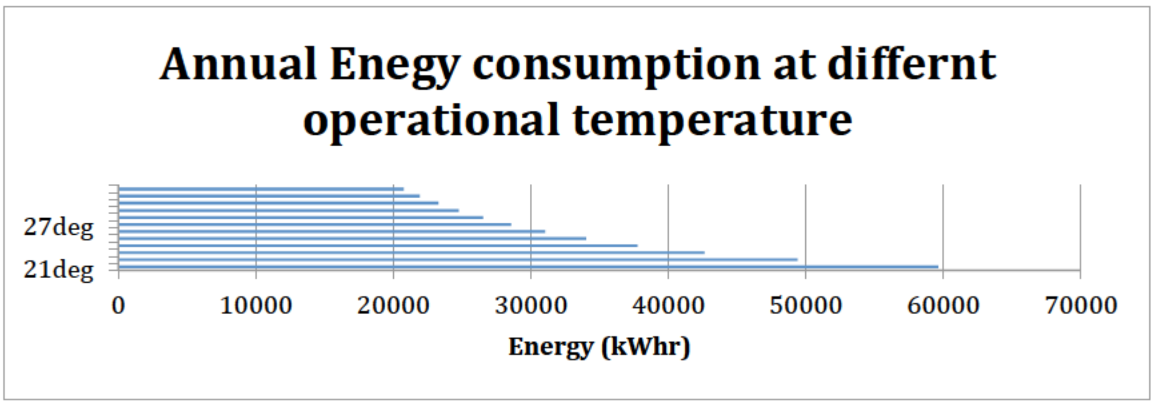
10	racks with	15	Amps											
1	racks with	7.7	Amps	**Lifetime Operating Cost Or "Second Price Tag" (multiply annual cost by 10)**										
1	racks with	8.5	Amps											
						The EER is calculated by taking the units potential BTU's and dividing it by the total wattage consumed								
	Total ampere	166.2	Amps			http://mech.ubc.ca/nima-atabaki/								
						CO2e=	carbon dioxide equivalent							
	Voltage:	208												
	Assume all input power turns into heat.													
	Assume no Lighting on(b/c lights are off when technician not in room)													
			Length(m)	Width(m)			Kaiser Ambient Temperature(oC)						Width cm)	Length
			7.4	5			25						2.5	3.7
												X200	500	740
	Room size (m^2)			37	Sqmeter		398.2643	Sqft			> needs	10,000.00	btu/hr	
	Equipment power dissipation			*19.04909478*	kW						Equivalent	0.833333333	RT	
	Efficiency (COP)			4							Equivalent	2.9307107	kW	
	Cooling consumption			4.762273695	kW				Cooling consumption		Equivalent to		FALSE	btu/hr
	Total energy consumtion			***23.81136848***	kW		Annual kWh(cooling+o		208,587.59			Annual Cooling kwh		41,717.52
	Price Of Electricity ($/kWh)			$0.03814			Emission factor = 25 tCO_2e/GWh					Annual operating kwh		166,870.07
	Applicacable Taxes			9.05%			Offset cost = $25/$tCO_2e$							
	Rate Rider(calculated before tax)			5.20%			Annual C02e(Tonnes)			5.21				
	Annual Operating Cost(Electricity)			$9,126.63										
	Annual Operating Cost(CO2e)			$ 130.37										
	Total Annual Operating Cost			$ 9,257.00										

Appendix D. cost for the operational Air Conditioner at different temperature

Opearting Temp	Annual Cooling Cost(electricity)	Annual cooling Environmental costs(CO2e)	Annual Energy Cost (Operating Consumption)19kW		Total Annual Cost (cooling+operating + CO2e co:
21	$ 2,608.71	$ 37.26	FIXED	$ 7,301.31	$ 9,947.28
22	$ 2,159.89	$ 30.85	FIXED	$ 7,301.31	$ 9,492.05
23	$ 1,865.11	$ 26.64	FIXED	$ 7,301.31	$ 9,193.05
24	$ 1,651.93	$ 23.60	FIXED	$ 7,301.31	$ 8,976.83
25	$ 1,488.38	$ 21.26	FIXED	$ 7,301.31	$ 8,810.95
26	$ 1,357.81	$ 19.40	FIXED	$ 7,301.31	$ 8,678.51
27	$ 1,250.50	$ 17.86	FIXED	$ 7,301.31	$ 8,569.67
28	$ 1,160.37	$ 16.58	FIXED	$ 7,301.31	$ 8,478.25
29	$ 1,083.36	$ 15.48	FIXED	$ 7,301.31	$ 8,400.14
30	$ 1,016.64	$ 14.52	FIXED	$ 7,301.31	$ 8,332.47
31	$ 958.18	$ 13.69	FIXED	$ 7,301.31	$ 8,273.18
32	$ 906.46	$ 12.95	FIXED	$ 7,301.31	$ 8,220.72

Appendix E. graphs for energy consumption in a year at different temperature





Appendix F. graph for annual cost and temperature