International Journal of Research in Engineering and Science (IJRES)
ISSN (Online): 2320-9364, ISSN (Print): 2320-9356
www.ijres.org Volume 4 Issue 11 ǁ November. 2016 ǁ PP.87-104

Specifying Air Conditioning Requirements for Commercial Buildings in Ethiopia

Jemal Worku[1], Dr.-Ing. Demiss Alemu[2]
[1]*Lecturer, School Of Mechanical Engineering, Jimma Institute Of Technology, Jimma Ethiopia*
[2]*Associate Professor, School Of Mechanical And Industrial Engineering,*
Addis Ababa Institute Of Technology, Addis Ababa, Ethiopia

Abstract: *Having a standardized air conditioning for building is a non-questionable comfort issue for both commercial and residential buildings. To do so there should be sated requirements or standards for air conditioning design so that the required comfort will effectively be attained. Specifying the local or national air conditioning standards or requirements is the only way to effectively attain the human comfort while constructing any building.*

The main intension of this paper is to specify the air conditioning requirements or standards based on local or national data. Mainly the cooling load in w/m^2 which is the main parameter for AC design is determined for representative areas of Ethiopia using the HAP software. These selected areas are at different temperature zones. These are Addis Ababa for moderate temperature, Bahir-Dar for warm temperature, Dire-Dawa for hot temperature, and Semera for very hot temperature.

While doing this paper first the weather data for the selected areas of Ethiopia are collected from the National Metrology Agency. Also the architectural data or floor plans are gathered for each representative room types. Then all the data are entered in to the software and analyzed by keeping some parameters like relative humidity as a checking point for comfort conditions. Finally the main AC design parameters are specified. Mainly the cooling load in w/m^2 for all representative areas of the country is specified for rooms of various applications.

The results show that the air conditioning design for commercial buildings depend on many factors. These are geographical locations, orientation of the building, types of applications to which the building is used for, number of population, the floor to which the room is located and the material to which the building is made. In general it is observed that north oriented buildings have lower cooling load in relative to other orientations. Hence it is recommended for the air conditioning designers of the commercial building to use these local or national standards in which the above factors are considered and to have an effective air conditioning system.

***Keywords**:-* *Comfort, air conditioning requirements, cooling load, commercial and residential buildings*

I. INTRODUCTION

Air conditioning is the process of altering the properties of air (primarily temperature and humidity) to more favorable conditions. More generally, air conditioning can refer to any form of technological cooling, heating, ventilation, or disinfection, which modifies the condition of air to a more favorable one. It is a process that simultaneously conditions air; distributes it combined with the outdoor air to the conditioned space; and at the same time controls and maintains the required space's temperature, humidity, air movement, air cleanliness, sound level, and pressure differential within predetermined limits for the health and comfort of the occupants, for product processing, or both [27].

Now a day Ethiopia is developing rapidly in various aspects. And the living standard and seeking for comfort condition of the population in both working and residential area is also increasing rapidly from time to time. And in fact there are modern buildings with air conditioned such as; Hotels in Addis Ababa like, Capital Hotel, Radison blue, Harmony, Kenenisa, lexsus and the like are. Not only in Addis but also in other parts like Semera in almost all governmental office buildings using split AC, in Mekele example Yirdaw Hotel, and some hotels and conference halls in bahir dar have a nice designed Air conditions.

Having a conditioned, comfort and world wise computable buildings of various purposes is one of the development or change. This is attained by having standards for air condition and considering the comfort from the AC aspect during the design and the construction of the building so that the building will have better aesthetic value and comfort.

It is difficult for engineers to design or calculate air conditioning design parameters for each and every building or to use non local standards while designing or constructing buildings of various applications such as institutional buildings, commercial buildings, residential buildings or buildings for manufacturing purpose. But if there are local or national standards the design of AC will be easier and sustainable. Even if the designer is out of the standards for convincing reasons these standards helps to be within the acceptable range and avoids errors and simplifies the design. This creates the conditioned room that is comfortable and healthy for the people staying inside the room. In air conditioning the main parameters to be controlled are temperature, humidity, cleanness of the air and air motion.

Specifying AC requirements or standards for building of our country Ethiopia or national standards, play a major role by simplifying the duty of the AC engineers, designers, constructors and controllers of such engineering works and helps to have uniform AC parameters in buildings of different purpose and to have an accurate design. It also helps to controls and maintains the temperature, humidity, air movement, air cleanliness, sound level, and pressure differential in a space within predetermined limits for the comfort and health of the occupants of the conditioned space or for the purpose of product processing. But yet there are no specified local AC parameters or standards at national level. The standards used today are mostly ASHRAE (American Society of Heating, Refrigeration and Air conditioning Engineers) standards. Having the local Ac requirements or standards will have a great role to make the design more accurate and sustainable.

Heating and Cooling Loads

Heating and cooling loads are the measure of energy needed to be added or removed from a space by the Heating Ventilation and Air Conditioning (HVAC) system to provide the desired level of comfort within a space. Right-sizing the HVAC system begins with an accurate understanding of the heating and cooling loads on a space. Right-sizing is selecting HVAC equipment and designing the air distribution system to meet the accurate predicted heating and cooling loads of the house. The values determined by the heating and cooling load calculation process will dictate the equipment selection and duct design to deliver conditioned air to the rooms of the house, right-sizing the HVAC system. The heating and cooling load calculation results will have a direct impact on first construction costs along with the operating energy efficiency, occupant comfort, indoor air quality, and building durability. [15]

The heat gain or heat loss through a building depends on: the temperature difference between outside temperature and our desired temperature, the type of construction and the amount of insulation in ceiling and walls, how much shade is on the building’s windows, walls, and roof, the area of the room, including wall, window, roof and door, the amount of air that leaks into indoor space from the outside, the amount of heat generated by the appliances and occupants, activities and other equipment within a building, amount of lighting in the room. The following fig shows the sources of cooling load in a particular room of the building.

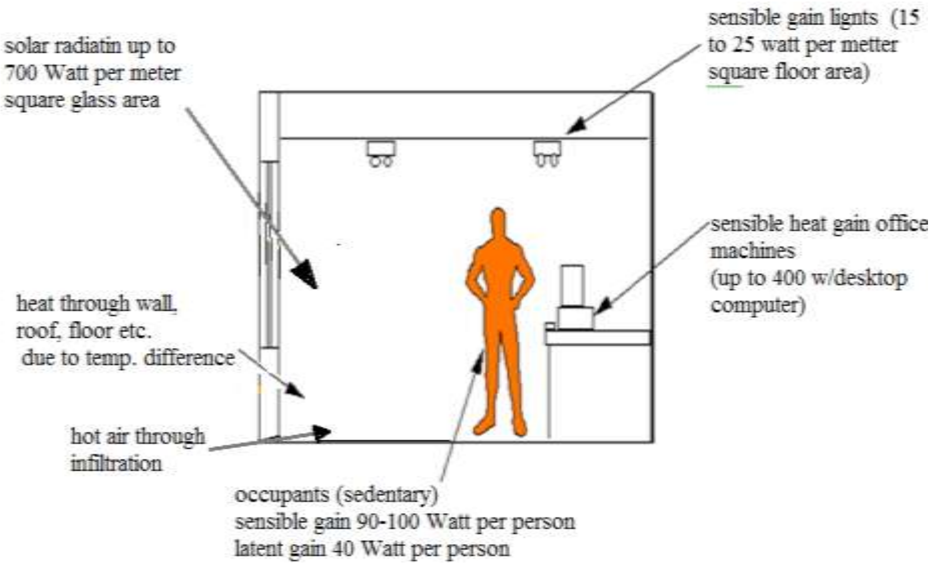

Fig. 1: Sources of Cooling Loads Building

Generally there are two types of heat gains, these are:

Sensible Heat Gain (related with increase of Temperature). It may be external or internal.

a) External Loads:

- Solar Heat gain From: Roof; Wall; Window; door etc.
- Ambient Temperature: Roof; Wall; Window; door etc
- Hot air infiltration.
-

b) Internal Loads:

- Electric Lamp; Occupants; Electric apparatus etc

Latent Heat Gain (related with moisture content and relative Humidity). It may also be external or internal

a) External Loads:

- Humid air infiltration.

b) Internal Loads:

- Occupants; Boiler; Hot food etc

The load calculation is the first step of the HVAC design procedure, as a full HVAC design involves much more than just the load calculation. The loads modeled by the heating and cooling load calculation process will dictate the equipment selection and duct design to deliver conditioned air to the rooms of the house. This load can be calculated by analytically or by using AC software like HAP (Hourly Analysis Program).

Air Conditioning Requirements for Human Comfort

The general definition for thermal comfort is that, “Thermal Comfort is that condition of mind that expresses satisfaction with the thermal environment” (ASHRAE Standard 55). ASHRAE Standard 55 recommends temperature range guidelines perceived as “comfortable” to be 74 to 82^{o}F (23to 28^{o}C) during the summer and 68 to 78oF (20 to 25.5^{o}C) during winter as shown in the figure below.

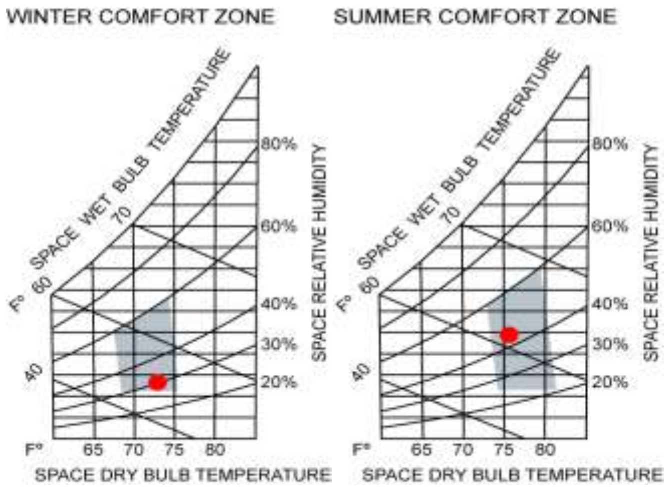

Fig.2: ASHREA Comfort Zones for Winter and Summer

The following table shows the comfort dry bulb temperature and relative humidity ranges for different commercial applications.

Table 1: DB Temperature and RH for Comfort Air Conditioning **[13]**

Typical applications	Recommended ranges for Commercial practice	
	Dry bulb (^{o}c)	Rel. Humid (%)
General comfort: airport, house, hotel, office, hospital, school, etc.	25-26	55-45
Retail shops (short term occupancy): bank, barber, or beauty salon, dept. store, supermarket, etc.	26-27	55-45
Low sensible heat factor applications (high latent load): auditorium, church, bar, restaurant, kitchen, etc.	26-27	60-50
Factory comfort: Assembly areas, machine rooms, etc.	26-30	60-50

Factors Affecting Building Air Conditioning Loads

As the intensity of solar heat gain is the major factor for the cooling or heating load in a particular building there are also many factors that influence on the AC load. This includes building materials, building envelopes, orientations, geographical location of the building, the purpose of the building or building type, even the floor level to which the room is located within same building, population size of the room, infiltration and ventilation, room size, internal Loads and etc.

II. METHODOLOGY

- Collecting metrological data

The annual temperature and humidity level for ten years are obtained from the Ethiopian Metrology Agency, and it is used as a base line for the work.

- Conducting a visit on representative buildings

The visiting of sample or representative buildings is helpful for load calculation and to estimate different load conditions from the four directions as well as in between.

- Calculate and estimating different types of loads for buildings with the help of HAP (Hourly Analysis Program) software, which provides versatile features for designing HVAC (heating ventilation and air conditioning) systems for commercial buildings. Input data and results from system design calculations can be used directly in energy studies.
- Analyzing the result

Once loads are calculated the design standard temperatures, humidity and air velocity are estimated for a particular type of building.

- Discussion and concluding the result

Finally the results will be set as standards for any buildings around the case study area and also apply it through various parts of the country with a little modification of the analysis.

III. ESTIMATING AC REQUIREMENTS FOR COMMERCIAL BUILDINGS IN ETHIOPIA USING HAP SOFTWARE

The step by step approaches done with this software for this thesis are summarized as follow.

A. Defining the Problem

In this paper mainly the cooling load in w/m^2 for commercial buildings in representative areas of Ethiopia will be estimated. This cooling load should satisfy human comfort conditions like relative humidity, dry bulb temperature. Not only the cooling loads but also the heating loads will be estimated as a design even if they have no or rear applications in our country. Based on this, equipments like supply fan, space and zone data will be sized and Space required supply airflow rates in L/S will be estimated. Buildings considered have different purposes which are, for hotel bed room, conference hall, bank lobby, shop, and office. The room varies, like at the ground floor, middle floor, roof floor and corner floor. The research is done for representative areas of our country Ethiopia. These are Addis Ababa (moderate temperature), Bahir-Dar (warm temperature), Dire-Dawa (hot temperature) and Semera (very hot temperature).The standard is mainly applied for buildings stated above. The floor plan for different types of commercial buildings is obtained from the architects.

B. Data Gathering

The weather data has gathered which includes monthly maximum and minimum dry bulb and wet bulb temperatures, design DB temperatures for both summer and winter, summer coincident WB, winter coincident WB, region, location, city, latitude, longitude, elevation, and the sunshine hour, for the area of interests which are Addis Ababa, Bahir-Dar, Dire-Dawa and Semera, which are collected from the National Metrology Agency (NME).

The row data was hourly for each day of the 10 year. Then the average values for each month has calculated and tabulated as shown by table in the next page. This dry bulb and wet bulb temperature data will be entered in the software under design temperature.

The temperature of the air measured by the ordinary thermometer, when exposed to the atmosphere, is called as the dry bulb temperature of air, commonly referred as DBT. It is nothing but the atmospheric temperature.

The wet bulb temperature of air is also measured by the ordinary thermometer, but the only difference is that the bulb of the thermometer is covered by the wet cloth (a piece of cotton wick).

The dew point temperature of the air or DPT is the temperature at which the water vapor within the air at some temperature starts condensing. When the dew is formed the air is said to be in saturated condition.

Relative humidity; Humidity is the amount of water vapor in a given space. The humidity ratio or specific humidity is the weight of water vapor per unit weight of dry air; it is given in either grains per pound or pound per pound (kg/kg).

The thermal effect of humidity on the comfort of sedentary persons is small, that is, comfort is maintained over a wide range of humidity conditions.

In winter, the body feels no discomfort over a range of RH from 50 percent down to 20 percent. In summer, the tolerance range extends even higher, up to 60 percent RH when the temperature is 240c; above that, the skin feels sweaty.

Nevertheless, some types of industrial applications, such as textile manufacturing, optical lens grinding, and food storage, maintain RH above 60 percent because of equipment, manufacturing processes, or product storage requirements. At the other extreme, certain pharmaceutical products, plywood cold pressing, and some other processes require an RH below 20 percent. Hospitals also must carefully control humidity since the level of bacteria propagation is lowest between 50 and 55 percent RH.

In general Human comfort requires the relative humidity to be in the range25 - 60%RH.But it may vary depending on the type of applications to which the buildings are used.

The monthly design maximum and minimum dry-bulb and wet-bulb temperatures for each location is also entered under design temperature column for each location [11].

Table: Monthly Maximum and Minimum Temperature Values for Different Locations

Representative locations Addis Ababa, Bahr-Dar, Dire-Dawa, and Semera are selected for the design. These parts of the country represent the low temperature, warm temperature, hot and very hot regions of the country respectively.

These weather data including the minimum and maximum dry-bulb and wet-bulb temperatures are entered in to the software using the weather column as shown in the figure bellow for each of the five locations.

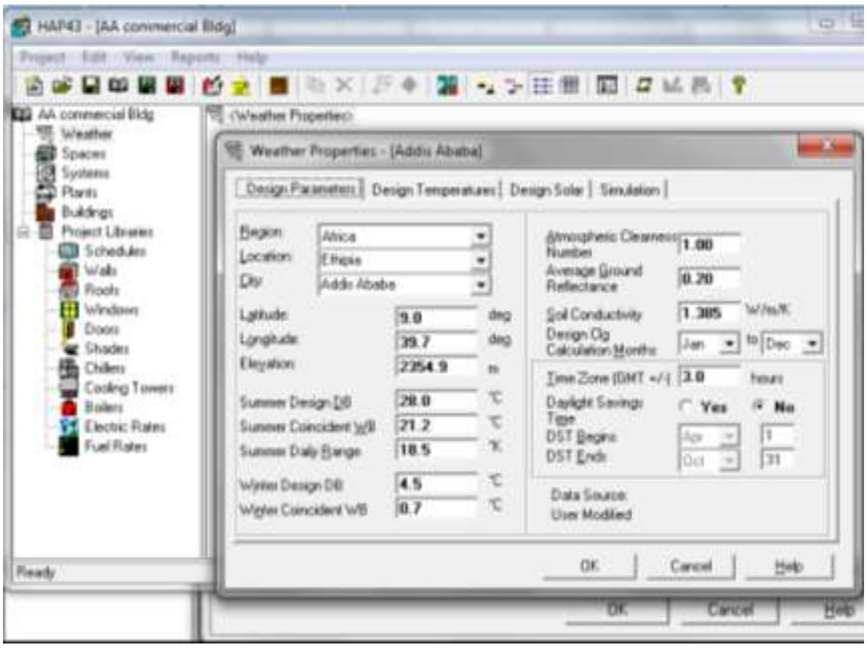

Fig.3: Weather Input Data for Addis Ababa

C. Space Data

There are a variety of spaces considered for this project and their characteristics were derived from architectural floor plans and professionals on that area and some of these informations are described below.

Walls: -In present day most parts of the walls are glasses which increase the need for air conditioning. In this project the size of the window in some room is taken to maximum size to consider the maximum heat transfer through the wall that is exposed to sun light. One common wall construction is used for all exterior wall types located in different locations. The construction consists of 13mm gypsum plaster finish, 102mm LW concrete block, and an air space. The exterior surface absorption can be dark, medium or light. But for this case it is taken to be the “Medium” category.

The overall U-value is 1.789W/m^2/k and the overall weight is 80.2kg/ m^2. And the different types of building orientation are considered.

Roofs: -There may be different roof types used while constructing different buildings. But I have taken the most commonly used roof types observation and by asking those professionals on that area. The roof type used is horizontal roof construction to enhance the position for air conditioning equipment. Hence the roof construction considered consists of built-up roofing, 22 gage steel deck, Air space, 16mm plywood.

The exterior surface absorption is in the “light” category. The overall U-value is 2.099W/m^2/k. The overall weight is 15.3kg/ m^2. The roof considered above is for the last floor roof, but if the room is at the intermediate floor or ground floor the roof may be concrete. In that case the property of concrete will be taken.

Windows & External Shading:-Windows of different size are used for different room types. The windows units' measures are 2mx1.2m, 1mx1.2m or 1.67mx0.6m and are double glazed with an aluminum frame. No internal Shades are used. These windows have a U-value of 3.685W/m^2/k and a shading coefficient of 0.82.

Doors:- Doors contain a single-glazing in an aluminum frame. The doorunit's measures are 2.1mx1.5m, 2mx1.2m. Frame thickness of 3mm. These doors have a U-value of 1.703 W/m^2/k and a shading coefficient of 0.94.

Lighting: - Recessed, unvented lighting fixtures are used for all rooms in this commercial building. A lighting density of 32.29 W/m^2 is used. The fixture ballast multiplier is 1.0. And an electrical equipment of 8.75w/m^2 for bank is used.

Occupants:- The number of occupants varies by space. For example for conference hall it is taken to be 500, 2 people for bed room, 5 people for office,70 people for bank lobby and 5 people for shop. For hotel bed room and conference hall a "seated at rest" activity level will be used (with sensible heat of 67.4w/$m^2$and latent heat of 35.2w/m^2) and for other applications "office work" activity level will be used (with sensible heat of 71.8w/$m^2$and latent heat of 60.1w/m^2).

Spaces:-Spaces are defined for different application of commercial buildings like; office, bank lobby, conference hall, hotel bed room, and shopare interred on the space column as shown below.

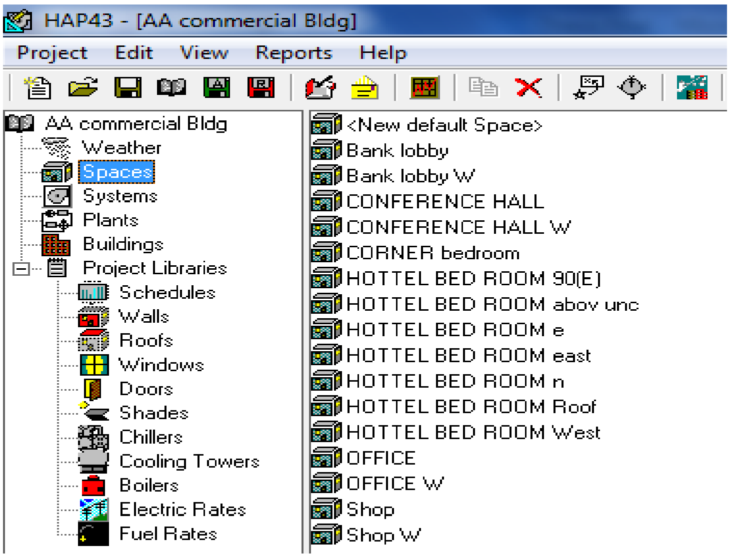

Fig. 4: Defined Spaces in the HAP for the Case of AA Commercial Buildings

D. Air System Data

The air handling unit used in this case is chilled water air handling unit, and the air system is constant air volume single zone. The design is done for a single room then it will be applied to many rooms having the same conditions. The design supply temperature is taken to be 14.4^{0}c and 12.8 ^{0}c. All the data from A to C will be entered in to the HAP and the next step is to generate the design reports.

IV. USE HAP TO GENERATE DESIGN REPORTS

The design reports includes system sizing summary, zone sizing summary, system load summary, zone load summary, space load summary, hourly system and zone loads and system psychometrics for each and every space or room types in each locations. For example the system sizing summary, zone sizing and system psychometric for conference hall at Semera are shown below.

Air System Sizing Summary for CONFERENCE HALL

Project Name: Semera commercial bldg — 12/16/2013
Prepared by: AI — 05:42PM

Air System Information

Air System Name	CONFERENCE HALL	Number of zones	1
Equipment Class	CW AHU	Floor Area	1200.0 m²
Air System Type	SZCAV	Location	Semera, Ethiopia

Sizing Calculation Information

Zone and Space Sizing Method:

Zone L/s	Peak zone sensible load	Calculation Months	Jan to Dec
Space L/s	Individual peak space loads	Sizing Data	Calculated

Central Cooling Coil Sizing Data

Total coil load	563.5 kW	Load occurs at	Jun 1400
Sensible coil load	316.6 kW	OA DB / WB	42.8 / 31.6 °C
Coil L/s at Jun 1400	18873 L/s	Entering DB / WB	29.3 / 22.2 °C
Max block L/s	18873 L/s	Leaving DB / WB	14.4 / 13.8 °C
Sum of peak zone L/s	18886 L/s	Coil ADP	12.7 °C
Sensible heat ratio	0.560	Bypass Factor	0.100
m²/kW	2.1	Resulting RH	50 %
W/m²	469.6	Design supply temp.	14.0 °C
Water flow@ 5.6 °K rise	24.28 L/s	Zone T-stat Check	1 of 1 OK
		Max zone temperature deviation	0.0 °K

Central Heating Coil Sizing Data

Max coil load	58.0 kW	Load occurs at	Des Htg
Coil L/s at Des Htg	18873 L/s	W/m²	48.3
Max coil L/s	18873 L/s	Ent. DB / Lvg DB	19.1 / 21.8 °C
Water flow@ 11.1 °K drop	1.25 L/s		

Supply Fan Sizing Data

Actual max L/s	18873 L/s	Fan motor BHP	18.06 BHP
Standard L/s	17499 L/s	Fan motor kW	13.48 kW
Actual max L/(s-m²)	15.73 L/(s-m²)	Fan static	500 Pa

Outdoor Ventilation Air Data

Design airflow L/s	5000 L/s	L/s/person	10.00 L/s/person
L/(s-m²)	4.17 L/(s-m²)		

Fig.5: System sizing summary for conference hall at Semera

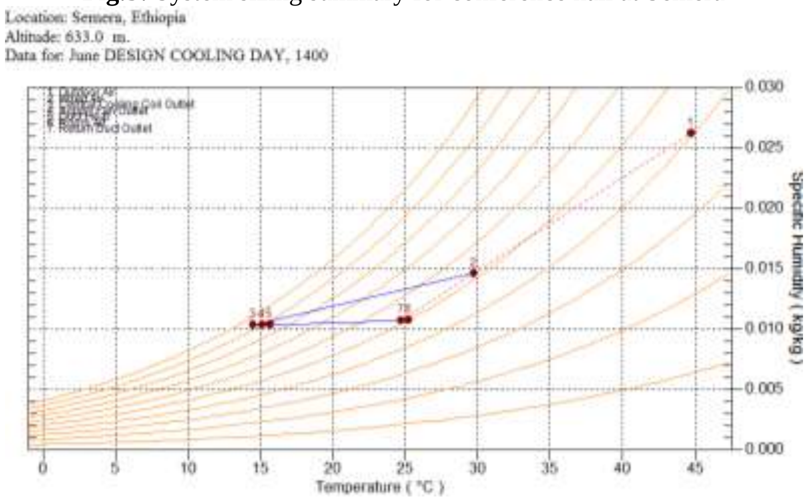

Fig.6: System psychometry for conference hall at Semera

V. FINDINGS AND DISCUSSION

Findings

The air conditioning parameters for commercial buildings can be specified by considering different cases. These parameters are different for different geographical locations of the country.

Addis Ababa, Bahir-Dar, Dire-Dawa and Semera are the selected regions of the country which represent the rest areas as well. Addis Ababa with annual dry bulb temperature of 28^{o}c represents the moderate temperature areas like Mekele (29.4^{o}c). Bahir-Dar (32.2^{o}c) represents the warm temperature areas like Adama (32.6 ^{o}c), Jigjiga (31.7^{o}c), Assosa (34^{o}c), and Hawassa (31^{o}c). Dire-Dawa (37.6^{o}c) represents the hot areas like Gode (38.7^{o}c) and finally Semera represents the very hot areas like Gambela (41.5^{o}c).

The outputs from the HAP (hourly analysis program) software are illustrated as follow for different cases and for different locations. It is shown the results for different countries or locations and different room applications as well as for rooms at different floor levels of the buildings. And also the design is done at different building orientations to see its effect on cooling load hence the orientation with lower cooling load will be recommended.

North Orientation

The building may be either north, east or west oriented. But most existing buildings are either north or west oriented, even if there are also other oriented buildings. In the north orientation the building is assumed to face to north direction. That is the envelopes with higher heat transfer are faced to north. For example door and window or wall (if some parts of the external wall for the building are composed of glass), are assumed to be faced due north. And the cases for each room type will be discussed individually as follow.

a) Hotel Bed Room

There may be various bedrooms may be in terms of area, orientation, materials for envelope and others. But the room considered represents most of the existing rooms and has the following parameters. The same thing is done for other rooms also.

- Number of people =2
- Room area A =34.3m^2(area of most existing bed rooms)
- Average ceiling height =2.8m (used for most existing bed rooms)
- Room location is at intermediate floor(the floor at the middle floor of the building**)**
- Building orientation North
- Coil bypass=0.1(the property of the air conditioning system)

Then these parameters are used to design the room air conditioning by the help of HAP software. Hence the outputs HAP for air conditioning design parameters are given in the following table for different geographical locations.

Table 2: AC Design Parameters for Bedroom at Different Locations of Ethiopia

Parameter/Location	**A/A**	**B/DAR**	**DIRE**	**SEMERA**
Air System Information				
Equipment Class	FCUAHU	FCUAHU	FCU AHU	FCU AHU
Air System Type	SZCAV	SZCAV	SZCAV	SZCAV
Central Cooling Coil Sizing Data				
Total coil load (kw)	3.3	3.6	5.1	6.9
W/m²	96.2	104.8	149.2	199.8
OA DB / WB (^{0}C)	29.2/24.2	31.9 / 26.2	37.0 / 26.0	44.6 / 31.4
Entering DB / WB (^{0}C)	24.9/17.7	24.9 / 17.5	25.1 / 18.1	25.3/ 17.9
Leaving DB / WB (^{0}C)	15.0/14.3	13.5 / 12.8	15.0 / 14.4	13.7 / 13.0
Coil ADP (^{0}C)	13.2	12.3	13.9	12.8
Resulting RH	50%	48%	51%	49 %
Design supply temp(^{0}C)	12.8	14.4	14.0	12.8
Central Heating Coil Sizing				
Max coil load (kw)	2.0	2.0	0.8	0.4
Max coil L/s	279	333	430	408
W/m²	57.2	58.4	21.9	11.9
Supply Fan Sizing Data				
*Actual max L/s	242	319	430	408
Standard L/s	182	256	372	378
Outdoor Ventilation Air				
Design airflow L/s	15	15	15	15
L/s/person	7.5	7.5	7.5	7.5
L/(s-m²)	0.44	0.44	0.44	0.44
Zone Sizing Data				
Maximum cooling sensible	2.8	2.9	4.4	5.4
Maximum heating load (KW)	1.9	2.2	0.7	0.4
Space Loads and Airflows				
Cooling sensible (KW)	2.8	2.9	4.4	5.4
Heating load (KW)	1.9	2.2	0.7	0.4

*actual max L/s=space air flow L/s =zone design air flow L/s= Max block L/s cooling
OA= outdoor air, ADP=apparatus dew point

The system psychrometry can also be obtained for different locations. In the following two figures it is shown for bed rooms in Addis Ababa and Semera. For the case of Addis Ababa it is observed from the figure that the temperature of the air is reduce from 27^{0}c at outside to 25^{0}c inside the room with a relative humidity of 50% which is within the range of human comfort as described in the literature. To do so the required cooling load is

96.2w/m^2. For the case of Semera air DT temperature is reduced from 45^{0}c at outside to 25.3^{0}c inside the room with the relative humidity value of 59%. To get this the design cooling load is 199.8w/m^2.

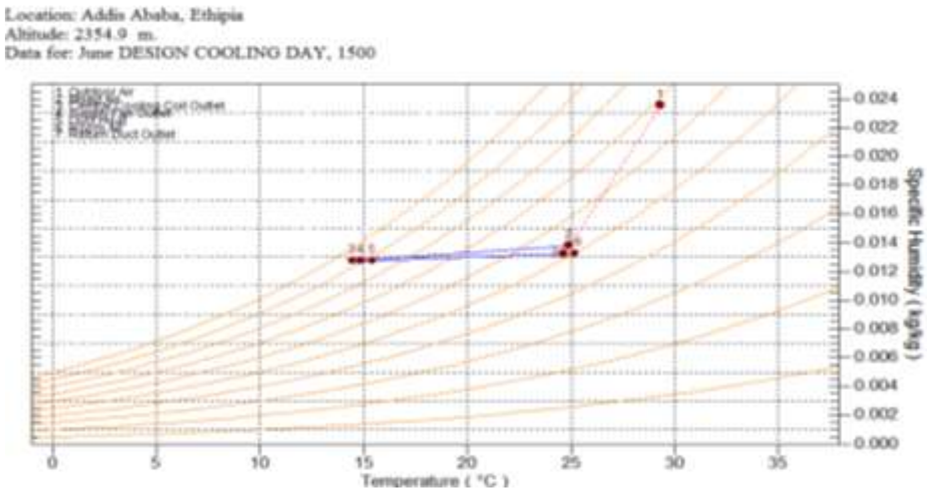

Fig. 7: System Psychometric Chart for Hotel Bedroom at Addis Ababa

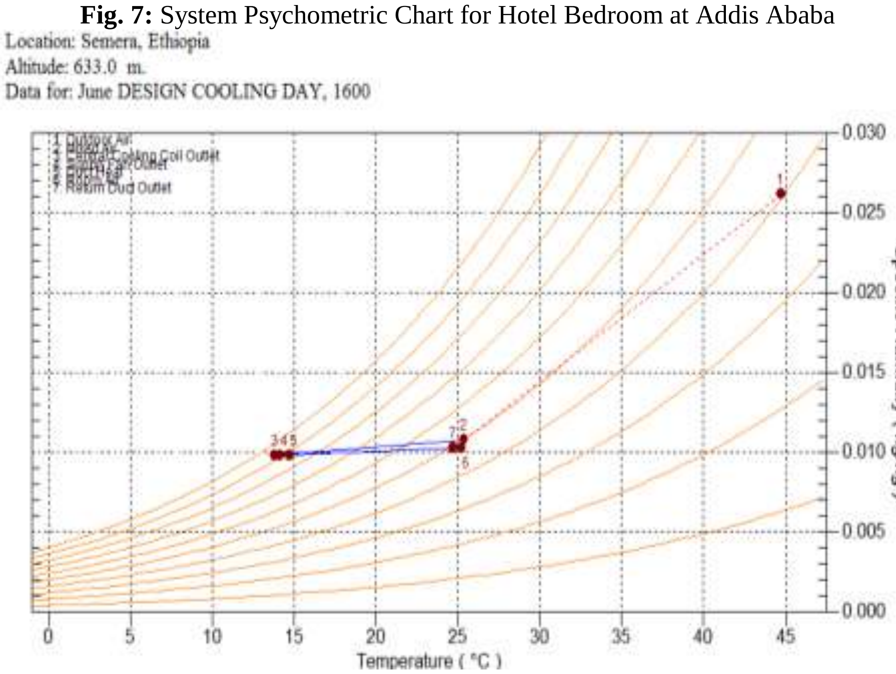

Fig.8: System Psychometric Chart for Hotel Bedroom at Semera

Similarly to bedroom the system psychometric chart for all types of rooms can also be plotted for all locations.

b) Conference Hall

Similar to the case of hotel bedroom conference hall can also be varied based on different parameters like number of populations, room area, orientation and the like. The one taken here is the most commonly observed and existing. The floor plan is at the appendix. The effect of number of population and room area will be discussed latter.

- Room area A = 1200m^2
- Average ceiling height =5m
- Number of people=500
- Building **orientation North**
- Equipment Class FC AHU, Air System Type SZCAV

Table 3: AC Design Parameters for Conference Hall at Different Locations

Parameter/Location	**A/A**	**B/DAR**	**DIRE DAWA**	**SEMERA**
Central Cooling Coil Sizing Data				
Total coil load (kw)	318.6	365.0	391.9	563.5
W/m²	265.5	304.2	326.6	469.6

OA DB / WB (^{0}C)	28.3/ 24.2	31.7 / 26.3	36.4 / 25.9	42.5 / 31.6
Entering DB / W (^{0}C)	25.6/ 19.5	26.7 / 20.5	27.7 / 20.0	29.2 / 22.2
Leaving DB / WB (^{0}C)	4.9 / 14.4	15.0 / 14.4	14.4 / 13.7	14.4 / 13.8
Coil ADP (^{0}C)	13.7	13.7	12.9	12.7
Resulting RH	52%	52%	50%	50%
Design supply temp(^{0}C)	14.0	14.0	14.0	14.0
Central Heating Coil Sizing Data				
Max coil load (kw)	128.6	145.7	76.3	58.0
Max coil L/s	19292	18022	18861	18873
W/m²	107.2	121.4	63.6	48.3
Zone Sizing Data				
Maximum cooling sensible (KW)	172.9	173.0	194.9	208.9
Maximum heating load (kw)	66.6	70.7	40.1	29.4
Space Loads and Airflows				
Cooling sensible (kw)	172.9	173.0	194.9	208.9
Heating load (kw)	66.6	70.7	40.1	29.4

The cooling load is increasing as the dry bulb temperature for the area is increasing. The relative humidity is within the comfort range, hence the design is safe. That is the equipment having this capacity will be selected.

c) bank lobby

- Area of bank lobby A = 70m^2
- Average ceiling height =3.5m
- Number of people=70
- Building **orientation North**
- Coil bypass=0.1 Equipment Class CW AHU Air System Type SZCAV

Table 4: AC Design Parameters for Bank Lobby at Different Locations

Parameter/Location	A/A	B/DAR	DIRE DAWA	SEMERA
Central Cooling Coil Sizing Data				
Total coil load (kw)	36.8	44.1	46.5	67.0
W/m²	525.2	629.8	664.2	956.6
OA DB / WB (^{0}C)	28.3 / 24.2	32.2 / 26.5	36.4 / 25.9	43.2 / 31.7
Entering DB / WB (^{0}C)	25.7 / 19.8	26.9 / 20.7	28.0 / 20.1	29.9 / 22.5
Leaving DB / WB (^{0}C)	14.0 / 13.6	13.8 / 13.3	13.3 / 12.7	13.7 / 13.2
Coil ADP (^{0}C)	12.8	12.3	11.7	11.9
Resulting RH	52%	52 %	49%	50%
Design supply temp(^{0}C)	12.8	12.8	12.8	12.8
Central Heating Coil Sizing Data				
Max coil load (kw)	15.3	17.4	9.6	7.4
Max coil L/s	1668	1796	1911	2017
W/m²	216.5	247.9	136.9	105.9
Zone Sizing Data				
Maximum cooling sensible (KW)	18.7	19.3	22.1	25.0
Maximum heating load (kw)	7.8	8.5	4.4	3.2
Space Loads and Airflows				
Cooling sensible (kw)	18.7	19.3	22.1	25.0
Heating load (kw)	7.8	8.5	4.4	3.2

Since the internal loads and the population taken are higher other rooms, the cooling load is also higher. And also the relative humidity for each location is within the comfort range

d) Office

- Room location is at **intermediate floor**
- Room area A = 51.6m^2
- Average ceiling height =2.8m
- Number of people=5
- Building **orientation North** and Air System Name Office

Table 5: AC Design Parameters for Office at Different Locations

Parameter/Location	A/A	B/DAR	DIRE DAWA	SEMERA
Central Cooling Coil Sizing Data				
Total coil load (kw)	5.5	6.9	8.8	11.8
W/m²	106.6	132.9	171.3	227.9
OA DB / WB (^{0}C)	29.2/24.2	31.9/26.2	37.0 / 26.0	42.5 / 31.6
Entering DB / WB (^{0}C)	25.1/ 18.3	25.4 / 18.5	25.6 / 18.0	26.0 / 18.8
Leaving DB / WB (^{0}C)	14.4/ 3.8	14.3 / 13.7	13.8 / 13.1	13.7 / 13.1
Coil ADP (^{0}C)	13.2	13.1	12.5	12.4

Resulting RH	51 %	51%	48 %	48 %
Design supply temp(^{0}C)	12.8	12.8	12.8	12.8
Central Heating Coil Sizing Data				
Max coil load (kw)	3.6	3.8	1.5	0.9
Max coil L/s	394	446	576	627
W/m²	69.1	74.4	29.7	18.1
Zone Sizing Data				
Maximum cooling sensible (KW)	4.0	4.8	6.7	7.8
Maximum heating load (kw)	3.1	3.3	1.2	0.7
Space Loads and Airflows				
Cooling sensible (kw)	4.0	4.8	6.7	7.8
Heating load (kw)	3.1	3.3	1.2	0.7

These results are specific for the above conditions. To take for the applications other than the above conditions, there is some change. For example if the area is increased the cooling load will decrease, if the number of people inside the room is increase, the cooling load will also increase.

e) Shop

The floor plan for the shop is also at the back of the paper. This room is considered to be super market. The number of people may be higher or lower than this.

- Room location is at **intermediate floor**
- Area of shop A = 15m^2
- Average ceiling height =3m
- Number of people=5
- Building **orientation North**

Table 5: AC Design Parameters for Shop at Different Locations

Parameter/Location	A/A	B/DAR	DIRE DAWA	SEMERA
Central Cooling Coil Sizing Data				
Total coil load (kw)	3.7	4.3	5.3	7.2
W/m²	243.8	289.3	350.8	482.4
OA DB / WB (^{0}C)	27.4/ 21.2	31.9/26.2	37.0 / 26.0	43.2 / 31.7
Entering DB / WB (^{0}C)	25.2/ 18.2	25.9 / 19.5	26.3 / 18.7	27.0/ 20.0
Leaving DB / WB (^{0}C)	14.3/ 13.6	14.2 /13.6	13.8 / 13.1	13.7 / 13.1
Coil ADP (^{0}C)	13.1	12.9	12.4	12.2
Resulting RH	52%	52%	49%	51%
Design supply temp(^{0}C)	12.9	12.8	12.8	12.8
Central Heating Coil Sizing Data				
Max coil load (kw)	1.7	2.0	0.9	0.6
Max coil L/s	221	231	291	311
W/m²	112.7	131.0	59.2	39.0
Zone Sizing Data				
Maximum cooling sensible (KW)	2.0	2.4	3.2	3.7
Maximum heating load (kw)	1.2	1.3	0.6	0.4
Space Loads and Airflows				
Cooling sensible (kw)	2.0	2.4	3.2	3.7
Heating load (kw)	1.2	1.3	0.6	0.4

Similar to the above cases the cooling load is highest for Semera.

West orientation

In the west orientation the building is assumed to face in the west direction. That is the envelopes with higher heat transfer are faced to west. For example doors, windows or wall with glass material are assumed to be faced due west. And the cases for each room type will be discussed individually as follow. The specifications for the room used in the north orientation are also used here to compare the effect.

a) Hotel bedroom

The same room as in the north orientation is considered to see the difference
(A =34.3m^{2}andfor 2 people)

Table 7: AC Design Parameters for Bedroom at Different Locations

Parameter/Location	A/A	B/DAR	DIRE DAWA	SEMERA

Central Cooling Coil Sizing Data				
Total coil load (kw)	4.2	4.5	5.7	7.1
W/m²	122.4	130.1	165.6	206.0
OA DB / WB (^{0}C)	27.4 / 21.1	31.7 / 26.3	37.0 / 25.9	42.5 / 31.6
Entering DB / WB (^{0}C)	24.7 / 17.1	24.8 / 17.2	25.0 / 18.0	25.2 / 18.0
Leaving DB / WB (^{0}C)	14.3 / 13.6	13.5 / 12.8	15.0 / 14.3	13.8 / 13.1
Coil ADP (^{0}C)	13.1	12.3	13.9	12.6
Resulting RH	49%	47%	51%	48%
Design supply temp(^{0}C)	12.8	14.4	14.0	12.8
Central Heating Coil Sizing Data				
Max coil load (kw)	2.0	2.0	0.8	0.4
Max coil L/s	320	427	486	456
W/m²	56.3	58.2	22.7	11.7
Zone Sizing Data				
Maximum cooling sensible (KW)	3.2	3.9	5.0	5.7
Maximum heating load (kw)	1.9	2.1	0.7	0.4
Space Loads and Airflows				
Cooling sensible (kw)	3.7	3.9	5.0	5.7
Heating load (kw)	1.9	2.1	0.7	0.4

Cleary the cooling load for west orientation is higher than for north orientation. For example for Addis Ababa it was 96.2w/m^2 for north orientation, now it is 122.4w/m^2 for west orientation. This applied for all of the following room types.

b) Conference hall

(Room area, A = 1200m^2, and for 500 people)

Table 8: Ac Design Parameters for Conference Hall in Different Locations

Parameter/Location	**A/A**	**B/DAR**	**D/DAWA DAWA**	**SEMERA**
Central Cooling Coil Sizing Data				
Total coil load (kw)	241.0	369.4	392.9	567.2
W/m²	200.9	307.8	327.4	472.6
OA DB / WB (^{0}C)	26.9 / 21.1	31.7 / 26.3	36.4 / 25.9	42.5 / 31.6
Entering DB / WB (^{0}C)	25.3 / 18.5	26.6 / 20.4	27.7 / 19.9	29.3 / 22.1
Leaving DB / WB (^{0}C)	14.7 / 14.1	14.9 / 14.3	14.4 / 13.7	14.3 / 13.8
Coil ADP (^{0}C)	13.5	13.5	13.0	12.6
Resulting RH	51%	52%	50%	50%
Design supply temp(^{0}C)	14.0	14.0	14.0	14.0
Central Heating Coil Sizing Data				
Max coil load (kw)	125.4	142.1	82.5	61.1
Max coil L/s	17345	18198	19041	19011
W/m²	104.5	118.4	68.8	50.9
Zone Sizing Data				
Maximum cooling sensible (KW)	155.4	174.7	196.8	210.4
Maximum heating load (kw)	66.6	70.7	40.1	29.4
Space Loads and Airflows				
Cooling sensible (kw)	155.4	174.7	196.8	210.4
Heating load (kw)	66.6	70.7	40.1	29.4

c) Bank lobby

(Room area of, A = 70m^2, and size for 70 people)

Table 9: Ac Design Parameters for Bank Lobby in Different Locations

Parameter/Location	**A/A**	**B/DAR**	**D/DAWA**	**SEMERA**
Air System Name	Bank lobby	Bank lobby	Bank lobby	Bank lobby
Central Cooling Coil Sizing Data				
Total coil load (kw)	29.7	46.3	47.2	68.2
W/m²	424.1	661.4	674.8	973.8
OA DB / WB (^{0}C)	27.4 / 21.2	32.4 / 26.7	37.6 / 26.0	43.8 / 31.7
Entering DB / WB (^{0}C)	25.5 / 18.6	26.9 / 20.6	28.3 / 20.1	29.7 / 22.3
Leaving DB / WB (^{0}C)	13.7 / 13.1	13.8 / 13.3	13.6 / 12.9	13.4 / 12.9
Coil ADP (^{0}C)	12.4	12.3	11.9	11.6
Resulting RH	51%	51%	49%	50%
Central Heating Coil Sizing Data				
Max coil load (kw)	15.4	17.3	9.8	7.4
W/m²	219.6	247.6	139.5	105.7

Zone Sizing Data				
Maximum cooling sensible (KW)	17.6	20.7	23.0	25.7
Maximum heating load (kw)	7.8	8.5	4.4	3.2
Space Loads and Airflows				
Cooling sensible (kw)	17.6	20.7	23.0	25.7
Heating load (kw)	7.8	8.5	4.4	3.2

d) Office

(Area of the office, A = 51.6m^2, and for 7 people)

Table 10: Ac Design Parameters for Office in Different Locations

Parameter/Location	**A/A**	**B/DAR**	**D/DAWA**	**SEMERA**
Air System Name	Office	Office	Office	Office
Central Cooling Coil Sizing Data				
Total coil load (kw)	5.0	8.3	9.6	12.7
W/m²	96.7	161.4	186.0	246.0
OA DB / WB (^{0}C)	27.4 / 21.1	31.7 / 26.3	37.0 / 25.9	43.0 / 31.6
Entering DB / WB (^{0}C)	24.9 / 17.6	25.2 / 18.1	25.6 / 17.9	25.9 / 18.6
Leaving DB / WB (^{0}C)	14.4 / 13.7	14.1 / 13.4	14.0 / 13.3	13.7 / 13.1
Coil ADP (^{0}C)	13.2	12.8	12.7	12.4
Resulting RH	50%	49%	48%	48%
Central Heating Coil Sizing Data				
Max coil load (kw)	3.5	3.9	1.6	0.8
W/m²	68.8	75.7	30.9	15.2
Zone Sizing Data				
Maximum cooling sensible (KW)	4.2	6.2	7.6	8.7
Maximum heating load (kw)	3.1	3.3	1.2	0.7
Space Loads and Airflows				
Cooling sensible (kw)	4.2	6.2	7.6	8.7
Heating load (kw)	3.1	3.3	1.2	0.7

e) Shop

(A = 15m^2), 5 people keeping other parameters the same.

Table 11: Ac Design Parameters for Bank lobby in Different Locations

Parameter/Location	**A/A**	**B/DAR**	**D/DAWA**	**SEMERA**
Air System Name	Shop	Shop	Shop	Shop
Central Cooling Coil Sizing Data				
Total coil load (kw)	3.3	5.5	5.8	7.9
W/m²	221.7	363.5	387.9	524.4
OA DB / WB (^{0}C)	26.9 / 21.1	31.5 / 26.1	37.0 / 25.9	43.0 / 31.6
Entering DB / WB (^{0}C)	25.0 / 18.0	25.5 / 18.6	26.1 / 18.5	26.5 / 19.6
Leaving DB / WB (^{0}C)	14.5 / 13.8	13.8 / 13.2	14.0 / 13.3	13.8 / 13.2
Coil ADP (^{0}C)	13.3	12.6	12.7	12.3
Resulting RH	51%	50%	49%	50%
Central Heating Coil Sizing Data				
Max coil load (kw)	1.7	1.9	0.9	0.6
W/m²	115.3	125.8	59.7	39.9
Zone Sizing Data				
Maximum cooling sensible (KW)	2.5	3.3	3.8	4.3
Maximum heating load (kw)	1.2	1.3	0.6	0.4
Space Loads and Airflows				
Cooling sensible (kw)	2.5	3.3	3.8	4.3
Heating load (kw)	1.2	1.3	0.6	0.4

- The effect of room location

In Hotel bedroom of area A =34.3m^2 and for 2 persons.

Table 12: Ac Design Parameters at Different Room for Bed Room @N-orientation for AA

Parameter/room type	**Room above un-conditioned**	**Room flip @90**	**Intermediate floor room**	**Corner room**	**Roof floor room**
Central Cooling Coil Sizing					
Total coil load (kw)	2.5	2.6	2.8	3.4	4.4
W/m²	74.0	77.1	81.9	98.5	128.1
OA DB / WB (^{0}C)	27.4 / 21.2	28.0 / 21.2	37.0 / 26.0	27.4 / 21.2	26.9 / 21.1
Entering DB / WB (^{0}C)	24.6 / 17.9	24.8 / 17.4	24.9 / 17.7	24.7 / 17.3	24.7 / 16.9
Leaving DB / WB (^{0}C)	15.4 / 14.8	14.6 / 13.9	15.0 / 14.3	14.5 / 13.8	14.1 / 13.4
Coil ADP (^{0}C)	14.4	13.4	13.9	13.4	12.9

Resulting RH	54%	50%	50%	49%	48%
Design supply temp(^{0}C)	12.8	12.8	12.8	12.8	12.8
Central Heating Coil Sizing					
Max coil load (kw)	3.1	2.0	2.0	2.7	1.9
W/m²	91.1	58.5	56.9	78.5	54.9
Zone Sizing Data					
Maximum cooling sensible	2.7	2.5	2.4	3.3	4.2
Maximum heating load (kw)	3.3	1.9	1.9	2.7	1.9
Space Loads and Airflows					
Cooling sensible (kw)	2.7	2.5	2.4	3.3	4.2
Heating load (kw)	3.3	1.9	1.9	2.7	1.9

DISCUSSION

Factors Affecting the Cooling Load

From the results shown so far the air conditioning load in W/m^2 is the main air conditioning design parameter for each location. The other parameters like the relative humidity, entering and leaving wet-bulb and dry-bulb temperatures are used as a checking, so that the system will be within the human comfort range. Hence by multiplying these values of the cooling loads for a particular room by the respective room area,one can get the cooling load of that particular room.

Finally the room checked via system psychometric chart so that the system will be at the comfort conditions. If the system is not with in comfort condition by observing RH, DB and the like, then the design will be done again. For example the psychometric chart for one of the room is shown in figure 5.1 bellow. The room air is located by point 6, in which the dry bulb temperature is almost 25 ^{0}c and the relative humidity is approximately 52%. This is within the acceptable limit for human comfort condition.

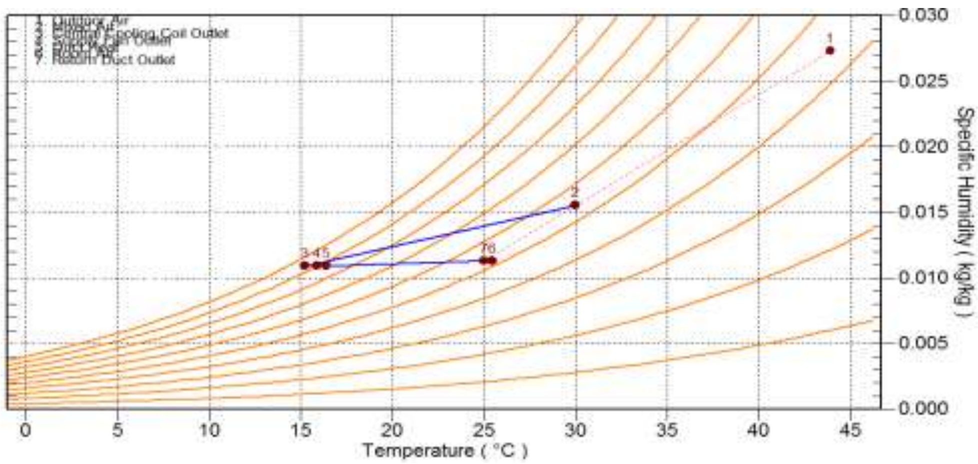

Fig. 9: Psychometric Chart for the Conference Room in Semera

It is also shown that the air conditioning loads are affected by many factors. These are building orientation, room area, number of occupants, material to which the room is made up of, the floor to which the room is located, the outside color of the wall and the roof, the coil bypass factor, the internal loads and the presence of partitions inside the room.

a) Orientation

Orientation is the position of the building in relation to its exposure to the sun light. As it is explained so far the building can be north, north east, east, south east, south, south west, west or North Westoriented. But from the results it is observed that orientation have a vital effect for the room air conditioning load. Especially for rooms with small area the effect is more. It is dependent on the geographical location of the room. The variation in cooling load for different locations is shown below. Generally when the room is west oriented (or when most doors and windows parts of the building are in the direction of west) there will be high AC load relative to North oriented building. For example the cooling loads in w/m^2 for hotel bedroom and conference hall are shown bellow. For N-orientated bed room in Addis Ababa it is 81.9w/m^2 and 98.9w/m^2 forthat of west orientated.

Table 13: The Effect of Orientation on Cooling Load for West and North

	Hotel bed room				**Conference hall**			
Locations	(a.a)	(B/Dar	(D/Dawa)	(Semera)	(a.a)	(B/Dar)	(D/Dawa)	(Semera)

Summer design DB(°c)	28	32.2	37.6	43.8	28	32.2	37.6	43.8
w/m² (N-orientation)	81.9	100.7	149.2	187.7	198.9	304.2	326.6	469.6
w/m² (W-orientation)	98.9	130.1	165.6	206.0	200.9	307.8	327.4	472.6

Graphically the results for the case of Addis Ababa can be shown as bellow.

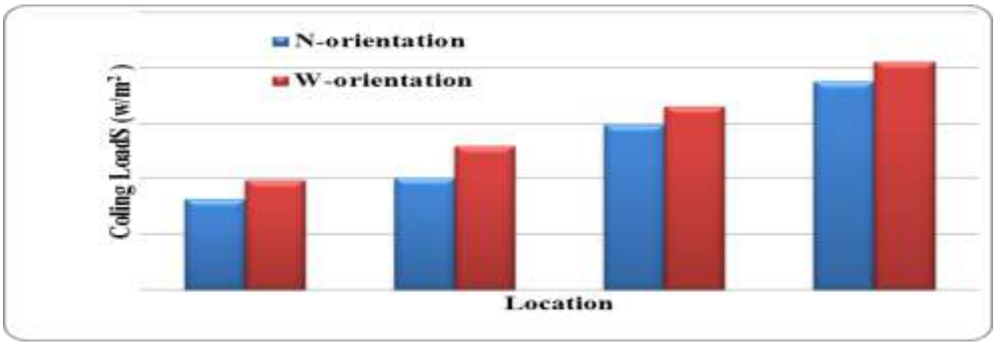

Fig. 10: The Effect of Orientation on Cooling Load for Bedroom

The cooling load for all the major orientation is shown below for each selected areas.

Table 14: Effect of Orientations on Cooling for Bedroom Located in Addis Ababa

Orientation	N	NE	E	SE	S	SW	W	NW
Cooling load (w/m²)	96.2	94.3	98.2	95.0	98.1	108.6	117.5	110.6
RH%	50	50	50	52	49	53	50	50

For Addis Ababa the NE orientation has the lowest cooling load, followed by SE then N orientation. West has the highest cooling load. Hence for building which are going to be constructed in Addis Ababa these are best orientations.

Table 15: Effect of Orientations on Cooling for Bedroom Located in Bahr Dar

Orientation	N	NE	E	SE	S	SW	W	NW
Cooling load (w/m²)	104.8	108.2	109.4	105.7	114.8	122.7	130.1	125.5
RH (%)	48	48	48	48	47	47	47	47

In this case N orientation has lowest cooling load whereas W orientation has the highest cooling load. Bhir-Dar represents Northern parts of Ethiopia. So for those areas North orientation is the best one.

Table 16: Effect of Orientations on Cooling for Bedroom Located in Dire-Dawa

Orientation	N	NE	E	SE	S	SW	W	NW
Cooling load (w/m²)	149.1	145.4	145.4	137.4	148.1	155.7	165.6	167.3
RH (%)	51	52	51	52	51	51	51	51

In this location E orientation has lower cooling load following the SE orientation, then major N orientation. It located in the Eastern part.

Table 17: Effect of Orientations on Cooling for Bedroom Located in Semera

Orientation	N	NE	E	SE	S	SW	W	NW
Cooling load (w/m²)	199.8	200.1	199.0	187.9	183.4	195.5	215.2	219.0
RH (%)	48	48	48	48	50	49	48	47

For Semera South orientation has the lowest cooling load. Semera is in the NE part.
For western parts Gambella is selected. As shown below North orientation has lowest cooling load keeping other parameters constant. Hence it is the best option for northern parts.

Table 18: Effect of Orientations on Cooling for Bedroom Located in Gambella

Orientation	N	NE	E	SE	S	SW	W	NW
Cooling load (w/m²)	64.1	66.1	65.5	67.1	76	81	77.2	75.9
RH (%)	53	53	52	52	53	53	53	53

b) Room Area

Rooms with different areas will have different cooling loads, keeping other parameters constant. For example the following table shows the variation of cooling load for various areas for bed room at Addis Ababa.

Table 19: Effect of Room Area on Cooling load for Bedroom Located in Addis Ababa

Bed room area(m^2)	30	34.3	40	45
Cooling load(w/m^2)	104.2	96.2	88.5	82.4

Form these areas 34.3m^2used in this paper from the existing buildings. It is observed from the figure that the cooling load decreases as the room are increases. This principle applies for all types of rooms.

c) Number of People

While the number of occupants inside the room is increasing it is clear that the heat inside the room will also increase. And to compensate that the cooling load is also increases. The following table shows this by taking the case for conference hall located in Addis Ababa.

Table 20: Effect of Number of People on Cooling for Bedroom

Number of people	100	200	300	400	500	600
Cooling load (w/m^2)	143.7	176.5	207.5	235.2	265.5	295.9

The room having a capacity for 500 people is taken for the analysis.

d) The Floor to Which the Room is Located

The room that requires AC may be located at the ground floor, at the intermediate floor, at the corner floor or at the roof floor.

Table 21: Cooling load for Different Room Locations for Bedroom @N-orientation for AA

room type	Room above un-conditioned	Room flip @90	Intermediate floor	Corner room	Roof floor room
Cooling load(w/m^2)	74.0	77.1	81.9	89.5	128.1

The results show that air conditioning loads at the roof floor are higher than the rooms at other floors. Thus AC engineers should also take this in to consideration.

e) Coil Bypass Factor

This is the property of the cooling machine. The coil bypass factor ranges from 0.02 to 0.1. The machine having a coil bypass factor nearly 0.02 will need lower cooling load for the same other effects. But it may have high capital cost in relative to those with higher coil by pass factor. In this work the coil bypass factor of 0.1 is used.

f) Outside Surface Color

The outside color of the roof and floor may be light, medium or dark. This will highly affect the air conditioning load. If the outside surface is dark the absorptivity will be high enough. It will need high w/m^2. And also it will affect the relative humidity of the room.

g) Internal Loads

The internal loads to the room are varied for according to the function of the room. As the internal loads get higher and higher it is obvious that the cooling load will be higher. For example for rooms located at Addis Ababa, the cooling load for conference hall=265.5 w/m^2, for hotel bed =96.2w/m^2, for shop=231.4 w/m^2, for office=112.6 w/m^2 and for bank room=370 w/m^2.

As far as cooling load is concerned in addition to type of application that the room is used for, the geographical location also has a vital effect. From the result it is observed that for the same room and internal loads and other factors the cooling load in Semera is the highest, followed by Dire-Dawa, then Bahir Dar and finally Addis Ababa. So the need for AC is much higher in hot areas of the country.

1) 5.2.1. Cooling Load for Different Types of Room in the Selected Locations

In the above discussion it is clearly presented that North orientation has the lowest cooling load in most of the areas of Ethiopia, hence the cooling loads obtained for different types of rooms in different parts of the country are taken as a standard accordingly. The following table summarizes the results.

Table 22: Cooling Load for Different Room in the Selected Locations

Room type	**Cooling load (w/m^2)**			
	Addis Ababa	Bahr-Dar	Dire-Dawa	Semera

Bedroom	96.2	104.8	149.2	199.8
Bank lobby	525.2	629.8	664.2	956.2
Conference Hall	256.5	304.2	326.6	469.6
Office	106.6	132.9	171.3	227.9
Shop	243.8	289.3	350.8	482.4

These standards are based on the parameters discussed so far like room area, number of occupants, and the like. So to use these standards one should take the parameters in to consideration.

VI. CONCLUSION AND RECOMMENDATION

Almost all areas of Ethiopia need cooling. Hence the air conditions are designed for cooling. To design the air conditioner for, specifying the cooling load is satisfying the comfort condition for that room is the main task. After the cooling load is specified then the equipment satisfying that condition will be selected.

The cooling load is dependent on many factors. Geographical location is the main factor. For example the cooling load for Semera is almost 2.3 times that of for Addias Ababa. The paper covered the all temperature zones of the country. That is Semera for very hot temperature areas, Dire-Dawa for hot temperature areas, Bahir-Dar for warmer areas and Addis Ababa for relatively moderate temperature areas of the country. Therefore the design of the rest areas can be based on these areas. The cooling load for various locations and rooms of different applications is calculated in w/m2. Hence by multiplying these values with the area of the room one can get the cooling load required by a particular room.

As illustrated so far orientation of the building highly affects the cooling loads. Even if there are areas lower cooling load in orientations other than north, like eastern parts which have lowest cooling load in east, almost all locations have lowest cooling load in north orientation. Hence north orientation of the building is the best option to minimize the cooling load. West orientation is the one with the highest cooling load.It is observed that the cooling load in the west orientation is almost 1.3 times that of north orientation for those rooms with less population number.

The number of occupants, room area, and internal loads are also the major factors affecting the cooling load. As the number of occupants and internal loads increases, the cooling load also increases. If the room area increases the cooling load will decreases. The parameters also vary depending on the type of room to which the air condition is designed for. Hence the designer should take these in to consideration while taking these parameters, so as to have a standardized AC system and local based air conditioning.

ACKNOWLEDGMENT

I take this opportunity to express my profound gratitude and deep regards to my advisor Dr. Ing. Demiss Alemu for his exemplary guidance, monitoring and consistent encouragement throughout the course of this paper, as well as for providing necessary information regarding the project.

I also take this opportunity to thank the national metrology agency for giving the valuable data that I need for the accomplishment of this paper.

At last but not least I would like to thank Engineer Yonas Wbe, for giving me the valuable information and supplying the necessary data by scarifying his working time and my ankle Mr. Nigussie Hassen for his progressive encouragement and advice so that I will have an initiation towards the paper.

REFERENCES

[1]. Abiy Zegeye, Alemayehu Worku, Daniel Tefera, Melese Getu and Yilma Sileshi (september 2009),Introduction to Research Methods,Addis Ababa University

[2]. Air Conditioning, (September, 2010), Retrieved 2013, from http://en.wikipedia.org/wiki/Air_conditioning.

[3]. Arlan Burdick IBACOS, Inc. (June 2011), Strategy Guideline: Accurate Heating and Cooling Load.

[4]. ASHRAE Inc. (2001), ASHRAE Handbook ofFundamentals

[5]. ASHRAE (2005), Technical Data Cooling Load Check Figures, USA.

[6]. ASHRAEInc. Standard 55, Human Comfort and Health Requirements.

[7]. ASHRAE, Inc.Cooling and Heating Load Calculation Manual, US Departement of Housing and Urban Developement.

[8]. Building Energy Software Tools Directory, Retrieved 2013, from http://apps1.eere.energy.gov/buildings/tools_directory/subjects.cfm/pagename=subjects/pagena.

[9]. Carrier Corporation, Software Systems Network, (1998-2002), HAP Quick Reference Guide/HAP Tutorials, USA.

[10]. Comfort air (2013), Retrieved 2013, from http://comfortair.software.informer.com/.

[11]. Ministry of workers and Developments, (1995). EBCS-11 (Ethiopian Building Code Standards), Addis Ababa, Ethiopia.

[12]. Lawrence E. McCabe (2004), Heating Ventilation and Air Conditioning.

[13]. Elite Software Development, Inc. (2013), Elite Software Development, Retrieved from http://www.elitesoft.com/.

[14]. Energy, Mines and Resource Canada, Heating Ventilation and Air Conditioning, Energy management, for industry.

[15]. M.Gestwick (June 2011), Strategy Guideline: Accurate Heating and Cooling Loadcalculation.

[16]. Guidance on U-Values from Domestic Heating Design Guide, Retrieved from www.heattrain.ltd.uk.

[17]. Heat transfer coefficient, Retrieved 2013, from http://www.engineeringtoolbox.com/overall-heat-transfercoefficient.
[18]. Mechanical, electrical, and plumbing engineering (2013), Retrieved 2014, from http://www.autodesk.com/industry/architecture-engineering-construction/mep-engineering.
[19]. P.N, Ananthanarayanan (2006), Basic Refrigeration and Air Conditioning (Third. Edition,)
[20]. Power consumption of household appliances (2005), Retrieved 2013, from http://www.wholesalesolar.com/StartHere/HowtoSaveEnergy/PowerTable.html.
[21]. S. S. Wane and M. B. Nagdeve (2012), Design of Air Coolig System forJournal of Environmental Research and Development.
[22]. Standards, Bureau of Indian, B. o. (2005), Indian building code.
[23]. Teklay, W. (2004), Design of energy efficient building for hot areas of Ethiopia with. Addis Ababa: Addis Ababa University.
[24]. S.Treado, The Effect of Building Envelopes on Cooling Loads Due to Lighting.
[25]. TSI, Incorporated (2013), HVAC assessment hand book,a practical guide to performance measurements in mechanical heating, ventilation and air conditioning systems.
[26]. S. K.Wang, Hand book of air conditioning and refrigeration (2nd. Edition)
[27]. A. R. Trott and T. Welch, Refrigeration and Air-Conditioning, (3rd. Edition)