RESEARCH ARTICLE OPEN ACCESS

Comparative Analysis of HVAC System Based on Life Cycle Cost Analysis

Jignesh M. Barot
PG student, A. D. Patel Institute of Technology, New V. V. Nagar, Anand, Gujarat, India

ABSTRACT
A heating, ventilating, and air conditioning (HVAC) system is designed to satisfy the environmental requirements of comfort or a process, in a specific building or portion of a building and in a particular geographic locale. Efficient design of heating, ventilating and air-conditioning (HVAC) systems is a primary concern in building projects. The objectives of the HVAC system design are to provide a thermal comfort, good indoor quality and energy conservation. For the typical commercial building projects, it is not difficult to acquire the reference settings for efficient operation. However, for some special projects, due to the specific design and control of the HVAC system, conventional settings may not be necessarily energy-efficient in daily operation. The HVAC system design and equipment selection for a commercial building (376 TR) is included as a case study in this paper. The outcomes of this paper are efficient design of HVAC system with minimum energy consumption and equipment selection based on operating and life cycle cost analysis.
***Keywords*–** HVAC system, Life cycle cost analysis

I. INTRODUCTION

A heating, ventilating, and air conditioning (HVAC) system is designed to satisfy the environmental requirements of comfort or a process, in a specific building or portion of a building and in a particular geographic locale. Designers must understand a great deal beyond basic HVAC system design and the outdoor climate. They must also understand the process or the comfort requirements. In addition, designers must understand how the building is (or will be) constructed and whether that construction is suitable for the stipulated use of the space. It is also necessary to understand the use of the building and in most buildings the use of each part. How does this use affect occupancy, activity level, humidity, temperature, and ventilation requirements? Designers must have answers to these and many other questions before they can design a suitable HVAC system.

Every HVAC design involves, as a first step, a problem-solving process, usually with the objective of determining the most appropriate type of HVAC system for a specific application. It is helpful to think of the problem-solving process as a series of logical steps, each of which must be performed in order to obtain the best results. Although there are various ways of defining the process, the following sequence has been found useful:

1. Define the objective. What is the end result desired? For HVAC the objective usually is to provide an HVAC system which will control the environment within required parameters, at a life-cycle cost compatible with the need. Keep in mind that the cost will relate to the needs of the process.

More precise control of the environment almost always means greater cost.

2. Define the problem. The problem, in this illustration, is to select the proper HVAC systems and equipment to meet the objectives. The problem must be clearly and completely defined so that the proposed solutions can be shown to solve the problem.
3. Define alternative solutions. Brainstorming is useful here. There are always several different ways to solve any problem. If remodelling or renovation is involved, one alternative is to do nothing.
4. Evaluate the alternatives. Each alternative must be evaluated for effectiveness and cost. Note that ‘‘doing nothing’’ always has a cost equal to the opportunity, or energy, or efficiency ‘‘lost’’ by not doing something else.
5. Select an alternative. Many factors enter into the selection process-effectiveness, cost, availability, practicality, and others. There are intangible factors, too, such as an owner’s desire for a particular type of equipment.
6. Check. Does the selected alternative really solve the problem?
7. Implement the selected alternative. Design, construct, and operate the system.
8. Evaluate. Have the problems been solved? The objectives met? What improvements might be made in the next design?

II. COMPARISON OF ALTERNATIVES

Parameter	Unit	Option I	Option II	Option III	Option IV
System Brief		Water Cooled Screw Chiller	Air Cooled Screw Chiller	All DX Conventional Split Ac Units	Air Cooled VRF System
Non Diversified Cooling Load	TR	376	376	376	376
Total Installed Non Diversified Capacity (Low Side)	TR	376	376	414	414
Diversified Installed Capacity High Side @ 80% Diversity (Chiller/VRF ODU/DX ODU)	TR	301	320	414	338
System Connected Load Chiller	KW	226	336	538	423
System Connected Load - Plant Room Equipment Excluding Chiller	KW	48	48	0	0
System Connected Low Side AHU	KW	75	75	0	0
Total Connected Load	KW	349	459	538	423
Operating Load (At 90% Loading)	KWH	326	425	484	381
Power Consumption (Per Hr)	KWH	326	425	484	381
Power Consumption (Full Load 12 Hrs)	KWH / Day	3915	5103	5807	4568
Power Consumption (Per Year @ 75% Usage Time)	KWH / Year	1071698	1396854	1589651	1250600
Power Consumption Rs. / Year (@ 6rs./Unit)	Rs. L / Yr	64	84	95	75
Operating And Maintanance Cost Rs./ Year	Rs. L / Yr	8.5	9.4	7.2	8.3
Make Up Water Cost Rs./ Years (@ 5 Paisa / ltr)	Rs. L / Yr	4.9	0.0	0.0	0.0
Total Operating Cost Rs./ Years	Rs. L / Yr	77.7	93.2	103	83.3
Capital Cost Of HVAC System Installation	Rs. L	252	244.4	139	248
System Life	Years	18 -20 years	15 Years	10 Years	12 Years
Space Requirement		Chilled Water Plant Room At Utility Room In Basement , Cooling Tower At Roof Level Or In Open Yard	Chiller At Roof With CHW Pump Room	Required To Locate Some 150 Condensing Unit Of Conventional Split Ac Units Within 7.5 mtr Distance Of The IDU	All VRF ODU Can Be Placed On The Roof / Ground / Chhajja
Redundancy		Very Good	Very Good	Partial	Partial

Comparison of alternatives based on operating cost and life cycle cost

Total Non Diversified Cooling Load							376	TR
Total Diversified Cooling Load For Chiller Selection @ 80% Diversity							301	TR
Chiller Selection = 150 Tr X 03 Nos. (2 W + 1 Standby)							300	TR

HVAC Power Demand - Plant Room							Operation	Emergency KW
Plant	TR /USgpm	Head Mt.	BKW	Motor KW	**Qty**			
					Working	SB	KW	
Water Cooled Screw Chiller	150			112.5	2	0	225	
Pr. CHW Pump	360	10	2.8	3.5	2	1	7	
Sec. CHW Pump On VFD	501	15	5.8	6.5	2	1	13	
Cooling Water Pump	600	15	7.0	7.5	2	1	15	
C. Tower - CTI Approved	Suitable For 28.5 Deg WBT/880 US gpm Flow / 150 TR Chiller / 32 Deg C Out Let / 36 Deg C Inlet Temp.			5	2	0	10	
Plant Room Ventilation				3			3	
CHW Plant Room						KW	273	

HVAC plant room equipments

Notes and assumptions for comparison of alternatives

- Electrical unit rate @ RS. 6 per kwhr
- Chiller operating power consumption is calculated based on the input McQuay
- Power consumption is assumed with 90% compressor loading
- Cost of operating @ RS. 500 / TR is considered in operating head

Calculation for water cooled screw chiller

- Total TR: 376 TR
- Non diversified cooling load: 376 TR
- Assume 80% diversity due to commercial building, therefore
  Diversified TR = 376 X 0.8 = 301 TR
- System connected load chiller = 301 X 0.75 = 226 KW (0.75 KW/TR: Power consumption in KW)
- System connected load chiller (Plant room equipment excluding chiller) = 48 KW
- System connected low side AHU = 376 X 0.2 = 75 KW
- Total connected load = 226 + 48 + 75 = 349 KW
- Operating load = 349 X 0.9 = 326 KWH
- Power consumption (Per hour) = 326 KWH
- Power consumption (Full load 12 hrs) = 326 X 12 = 3915 KWH/Day
- Power consumption (Per year @ 75% usage time) = 365 X 3915 X 0.75 = 1071698 KWH /yr
- Power consumption Rs. /year (@ 6 RS. /unit) = (6 X 1071698) / 100000 = 63 Rs. L /yr
- Operating and maintenance cost RS. / year = (2250 X 64) / 100000 = 8.5 Rs. L /yr
- Make-up water cost Rs./yrs (@ 5 Paisa/ltr) = (301 X 12 X 10 X 365 X 0.75 X 0.05) / 100000 = 4.9 Rs. L /yr
- Total operating cost Rs. / yr = 64 + 8.5 + 4.9 = 77.7 Rs. L /yr
- Capital cost of HVAC system installation = 376 X 0.67 = 252 Rs. L

III. CONCLUSION

Based on comparative analysis of alternatives with operating cost and life cycle cost, a chilled water
system (water cooled screw chiller) with counter flow induced draught cooling tower is selected for a particular project of 376 TR.

RERERANCES

[1] MaQuay chiller product catalogue
[2] www.stcpl.com
[3] ASHRAE Hanbook 2012
[4] ISHRAE Handbook - HVAC applications