

ENERGY SAVINGS IN HEATING, VENTILATION & AIR CONDITIONING (HVAC) SYSTEMS

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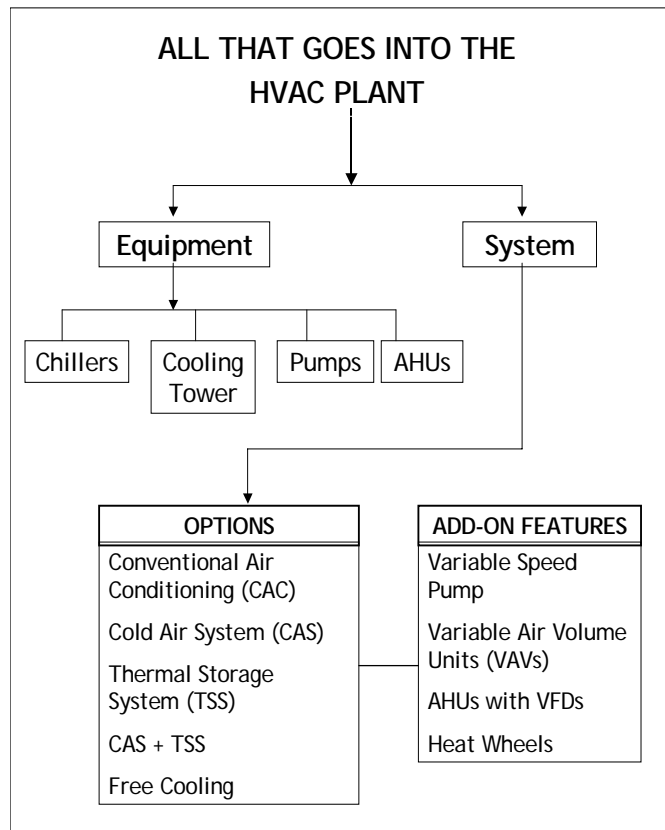


Fig. 1

1.0 Chillers :

1.1 In on-going efforts to improve equipment efficiency the focus in HVAC Industry has been - naturally - on Chillers over the past 25 years. Chiller efficiencies have gone up by as much as 40%.

Efficiencies of chillers vapour compression cycle have improved from 0.85 KW/TR in last 3-4 decades to less than 0.5 KW/TR today. This is in the Water Cooled Chiller category. In Air Cooled Chiller category - improvements are from about 1.4 to about 1.2 KW/TR.

Table - 1

Type of Chiller	Size Range - TR	Typical operating power - at Full Load	COP Watt/watt
Reciprocating-Water Cooled	5 - 240	0.75 KW/TR	4.1
Reciprocating - Air Cooled	5 - 450	1.2 KW/TR	2.93
Screw - Water Cooled	125 - 675	0.6 - 0.7 KW/TR	5.86 - 5.0
Screw - Air Cooled	100 - 300	1.1 KW/TR	3.1
Centrifugal Water Cooled	150 - 2000	0.5 - 0.7 KW/TR	7.0 - 5.0
Absorption - Single Stage	200 - 1500	18 lbs/TR-hr	-
Absorption - Two Stage	200 - 1500	9 lbs/TR-hr COP = 1.0	-
Direct Gas Fired - Absorption	200 - 1500	COP = 1.0	-

For chiller selection, one of the important criteria is whether the chiller should be Air Cooled or Water Cooled.

There are Pros & Cons applicable to Water Cooled Chillers and Air Cooled Chillers.

Another criterion that arises sometimes is whether VCM (Vapour Compression Machines) should be used or whether VAM (Vapour Absorption Machines) should be used.

Obvious attraction in the VAM is that it requires very little electrical power as compared to VCMs. As far as total energy requirement is concerned. However, VAMs actually consume more of it. The only difference is that the energy consumed by it is by the way of heat energy. But one should note that even the source of heat energy is nothing but fossil fuel. It means therefore, that VAMs contribute more to Global Warming Effect than the VCMs. Since, however minimizing energy consumption - however important it is - is not the only criterion or sometimes not even a major criterion in selecting a chiller, pros & cons need to be examined.

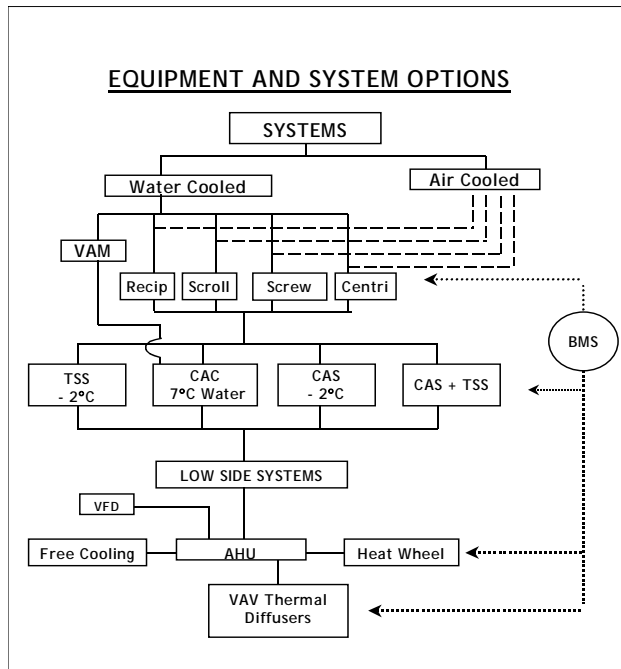


Fig. 2

1.2 Provide Heat Recovery Chillers & save power for reheat :

In Industrial Applications, keeping down the RH within limits is important. One of the most commonly employed methods is to employ re-heat. This may work out to as much as 0.8 KW/TR. Obviously, re-heat is a wasteful method; infact, the well known ASHRAE Standard ANSI/ASHRAE/IESNA Standard - 90.1 1999 - Energy Standard for Buildings Except Low Rise Residential Buildings, forbids use of external source of energy for RH control of this kind. A solution to this problem is readily available, i.e., buying Chillers with Heat Recovery Condensers (HRCs). This way the heat that would be normally rejected to the atmosphere either directly - as in an Air Cooled Condenser (or via a Cooling Tower in Water Cooled System) is trapped and used to provide the necessary reheat to the supply air. It is not that this concept is new in our country. We have several such installations, which have been working satisfactorily for years and keeping RH under control without consuming a single watt of extra power. The point here is that it deserves to be implemented more often than is being done today.

With energy engaging everybody's attention the way it is, the quest for raising chiller efficiencies can only get more & more intense.

2.1 Using Variable Water Flow & Air Flow :

The use of Variable Flow Pumping for chilled water systems is well known, but, while the concept is unexceptionable, its implementation holds the key to realization of the much sought-after energy savings. In other words, attention to detail is essential. Even in the United States and other developed countries, the debate on the details of applications of Variable Flow Pumping continues and the search for better ways of doing it is never-ending - even though variable flow pumping has been in vogue there for more than 3 - 4 decades.

In our Country, this development has occurred only a few years ago. It is now picking up; one needs to keep learning more & more about how to implement the concept to realize - in full measure - the expected savings. Many installations of variable flow system have failed to satisfy the user. Thorough analysis of flow patterns and detailing of the system prior to taking a decision to go for this system is a must.

Variable Flow Pumping has long been understood to mean variable flow on the secondary side and just that. It was the general perception that the Chiller flow (on the primary side) should be constant. Today however, Chillers for Variable flow are being offered by several chiller manufacturers like Carrier, Trane, York, Dunham Bush, etc.. Coupled with this availability and with more reliable and sophisticated controls, variable flow systems with just one circuit for the entire chilled water piping system viz., the primary circuit, are being increasingly accepted. Doing away with the secondary circuit cuts down the system KW/TR and also brings down the cost of the plant, which naturally has a cascading effect on the energy consumption - and the first cost too.

Use of VAVs & variable airflow system involving use of variable speed drives (for the fan) is another popular concept. In this case, typically the power consumed (by chilled water pumps as well as AHUs) works out to about 0.3 KW/TR. If Variable Speed operation is not incorporated, this power is consumed more or less all the time the plant is running, regardless of the load (While the Chiller is controlled to match its capacity to the load, this does not happen to the AHUs & Pumps). If we look at a 400 TR Plant for example, the power required for the Pump & AHUs together is about 120 KW. Trying to save energy for this kind of load is well worth it. However, the remarks we have already made while discussing Variable Flow Pumping, apply in this case also i.e., study, analyze & only then, implement. That is the key.

Example - 1 : 10/5 Operation :

A. Air Distribution by Conventional Method with Constant Air Volume AHUs

AHU Cooling Capacity of 55 TR, air flow rate of 21000 cfm.

Power consumption of AHU - 8.8 KW

Energy Consumption for the AHU for 10/5 operation.

$$\begin{array}{ccccccccc} \text{KW} & & \text{Hrs} & & \text{Days} & & \text{Months} & = & \text{KWHr} \\ 8.8 & \times & 10 & \times & 22 & \times & 12 & = & 23232 \end{array}$$

$$\text{Energy Cost / KWHr - Rs. 5.5} \qquad \text{Rs.} = 127776$$

B Air Distribution with Variable Air Volume (VAV) Systems and AHU with Variable Frequency Drive (VFD)

	AHU cfm	Speed rpm	Load %	AHU - KW	Hrs		Days	Months	KW-Hr
Summer (March - June)	11000	850	50	3.85	0800-1200	4	22	4	1355
	21000	1120	100	8.8	1200-1800	6	22	4	4646
Monsoon (Jul - Oct)	7500	810	100	3.3	0800- 1200	4	22	4	1162
	7500	810	100	3.3	1200-1800	6	22	4	1742
Winter (Nov - Feb)	7500	810	100	3.3	0800-1200	4	22	4	1162
	7500	810	100	3.3	1200-1800	6	22	4	1742
AHU - KWHr									11810
Energy Cost / KWHr - Rs. 5.5									64952.8

Summary of Energy Cost

A. Air Distribution by Conventional Method with Constant Air Volume AHUs Rs. = 127776

B. Air Distribution with Variable Air Volume (VAV) Systems and AHU with Variable Frequency Drive (VFD) Rs. = 64952.8

Saving in Energy Cost p.a Rs. = 62823.2

Extra Investment for VAV System (8 Nos. VAVs+ VFD) Rs. = 300000

Hence, pay back will be about 4 Years and 7 Months.

Example - 2 : 24/7 Operation :

A. Air Distribution by Conventional Method with Constant Air Volume AHUs

AHU Cooling Capacity of 55 TR, air flow rate of 21000 cfm

Power consumption of AHU - 8.8 KW

Energy Consumption for the AHU for 24/7 operation.

$$\begin{array}{rcl}
 \text{KW} & & \text{Hrs} & & \text{Days} & & \text{Months} & = & \text{KWHr} \\
 8.8 & \times & 24 & \times & 30 & \times & 12 & = & 76032 \\
 \text{Energy Cost / KWHr - Rs. 5.5} & & & & & & \text{Rs.} & = & 418176
 \end{array}$$

B Air Distribution with Variable Air Volume (VAV) Systems and AHU with Variable Frequency Drive (VFD)

	AHU cfm	Speed rpm	Load %	AHU - KW	Hrs		Days	Months	KW-Hr
Summer (March - June)	11000	850	50	3.85	0800-1200	4	4	30	1848
	21000	1120	100	8.8	1200-1800	6	4	30	6336
	11000	850	50	3.85	1800-0800	14	4	30	6468
Monsoon (Jul - Oct)	7500	810	100	3.3	0800-1200	4	4	30	1584
	7500	810	100	3.3	1200-1800	6	4	30	2376
	7500	810	100	3.3	1800-0800	14	4	30	5544
Winter (Nov - Feb)	7500	810	100	3.3	0800-1200	4	4	30	1584
	7500	810	100	3.3	1200-1800	6	4	30	2376
	7500	810	100	3.3	1800-0800	14	4	30	5544
AHU - KWHr									33660
Energy Cost / KWHr - Rs. 5.5									185130

Summary of Energy Cost

C. Air Distribution by Conventional Method with Constant Air Volume AHUs	Rs. = 418176
D. Air Distribution with Variable Air Volume (VAV) Systems and AHU with Variable Frequency Drive (VFD)	Rs. = 185130
Saving in Energy Cost p.a	Rs. = 233046
Extra Investment for VAV System (8 Nos. VAVs+ VFD)	Rs. = 300000

Hence, pay back will be about 15 Months.

2.2 Variable Speed Fans in Cooling Tower :

Energy saving in Cooling Towers can be achieved in cooling tower also, by taking care to select the right tower (with the right airflow rate) to begin with (not necessarily the tower with the lowest cost). Fans can be run at reduced speed during part load conditions.

2.3 Free Cooling :

In conventional air conditioning plant, OA provided is minimum - or recommended OA and it cannot be increased. During periods of mild weather however, OA can be raised to - up to 100% - to provide 'Free Cooling'. This is a strategy that is easy to apply and also, has the potential to provide spectacular energy savings - they are so spectacular that focus on it should be first and it should be sharp.

While it is easy to apply, acceptance & enthusiastic (!) application of the strategy, will be greatly enhanced, if the HVAC Engineers can produce credible calculations of the savings in advance and stand by their indicated figures. Such credible calculations are indeed possible today, since requisite data is available & computerization is possible.

3.1 Cold Air System (CAS) Benefits :

As we all know, conventional air Conditioning design is based on a chilled water flow rate of 2.4 gpm/TR, with a temperature rise of 8° F (4.5°C); there is however nothing sacrosanct about either the 2.4 gpm/TR or the 4.5°C rise. On the other hand, selecting the chilled water flow system for about 1.2 gpm/TR will reduce flow rate by half. This does not adversely affect the chiller performance to any significant extent - in fact, all major manufacturers of chillers now offer machines, which will operate at such low flow rates.

In addition, lower pumping power demand, lower costs of pump, piping, pipe insulation etc., are a big bonus. More importantly and more relevant to the context, is the energy saving that halving the flow rates implies.

Similar considerations also apply to the airside. Conventional systems go for supply air of 55°F (12.7°C) to maintain Room at 75.2°F (24°C) using Chilled water at 7°C; here again, there is nothing sacrosanct about these figures; one may as well go for supply air temperature at 40°F (4.4°C) and water temperature of 35.6 °F (2°C), while maintaining the room at 24°C or may be even 26°C (Higher DBs are acceptable with lower RHs - typically, say 78°F db (25.5°C) and 35 to 40% RH - since the comfort levels at 23°C & 55% RH and at 26°C and 35 - 40% RH are about the same). One would imagine that a temperature of about 4°C would call for brine (typically, ethylene glycol), but today chillers are available to deliver water at about this temperature continuously and all this - at low flow rates (say 1.2 gpm/TR).

This significant lowering of the supply air temperature for the same room temperature (or even higher room temperature) results in a reduction of air flow rate by as much as 40 - 50%. This is a spectacular reduction & immediately leads to smaller AHUs, reduced ducting, lower noise levels, better indoor air quality, competitive first cost, lower fan power requirement, etc.. Incidentally, this system is called the Cold Air System (CAS).

The lower RHs, which come with CAS will also help achieve better IAQ since, bacteria find it harder to survive at lower RHs. Also. The occupants will find the air more crisp & fresh at lower humidities. Another significant gain that lower humidities restore is that the mold & fungus problem is tackled in a forthright manner (and at no extra cost as compared to a Conventional Air Conditioning).

3.2 Heat Wheels :

Heat Recovery Wheels use the cooling energy of the air in the conditioned space to cool (and dehumidify) warm & moist- outside air that needs to be supplied to the air conditioned space to meet ventilation requirements. Stale (but cool & dehumidified) air from the conditioned space is exhausted through one half of the wheel while outdoor air is drawn through the other half in a counter flow pattern. At the same time, the wheel is rotated slowly (approx. 20 rpm). Sensible heat is transferred as the metallic substrate cools down & stores cool energy as it comes into contact with the cool (and dry air) stream and parts with it to the incoming warm and moist incoming ventilation (outside) air. Latent heat is transferred as the mixture is absorbed by the cool & dry desiccant layer from the warm humid ventilation air and released into the cool dry desiccant.

Heat Recovery Wheel advantages are -

- a. Helps to meet ventilation requirements without raising energy cost.
- b. Maintains humidity conditions at no additional cost.
- c. Allows reduction in system capacity by about 70 to 80% of ventilation air load.

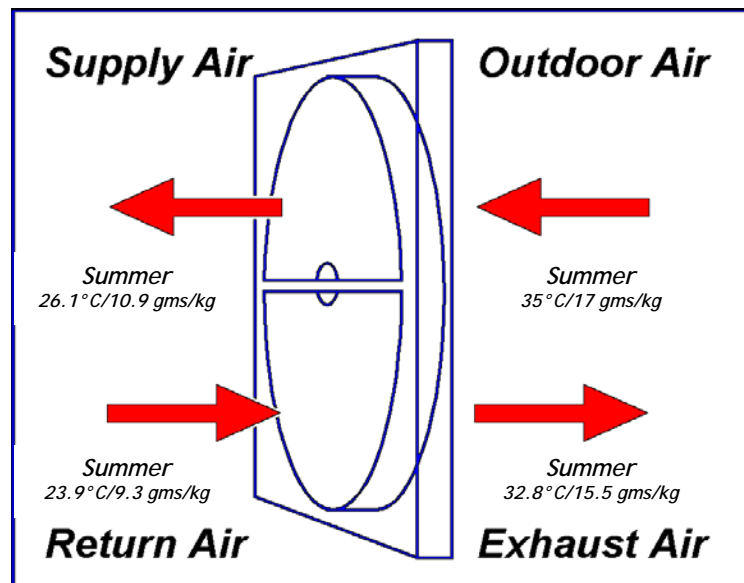


Fig. 3

Example :

Area air conditioned	-	1250 sqm
Occupancy - Nos.	-	175 Nos.
Outside Air at 20 cfm/person	-	3500 cfm
Total Load without HRW	-	52.0 TR
OA Load	-	16.5 TR
Recovery at 70% efficiency	-	11.5 TR
Installed capacity (52-11.5 TR)	-	40.5 TR

Heat Recovery Wheels are quite commonly in use in our country today - particularly in the context of higher ventilation flow rates that acceptable IAQ is held to demand. They reduce the plant capacity requirements by as much as 70% to 80% of the total ventilation load. Thus for a 50 TR plant capacity, calculated in the conventional manner (without HRW), the reduction in plant capacity due to use of HRW is about 20%.

Thus it will be appreciated, that there is a very substantial reduction in capacity, which naturally translates into reduction of connected power requirements & spectacular energy savings.

3.3 The Ozone Systems :

The Ozone system essentially involves of injecting ozone into the supply air stream of an air conditioning plant to eliminate Volatile Organic Compounds (VOCs)- like formaldehyde for example. By removing the air of VOCs in this manner, the OA flow rate required to maintain acceptable IAQ can be reduced below the mandated flow rate in the International Standards. The adequacy of quantity of ozone injected is achieved in the system by ensuring that there will be a surplus of ozone after it has burnt the VOCs completely. This surplus ozone has to be kept within the minimum specified limit since ozone is also a contaminant when it is present in the air in larger concentrations. This hazard is one of the reasons why it has not won greater acceptance.

3.4 Thermal Storage System (TSS) :

In the Conventional Plant the Chillers are selected for peak load. Consider for example - a plant of 1500 TR, which also represents the peak load on the building. The capacity of the Chillers can be reduced to 300 TR from 500 TR.

The peak load however prevails only for few hours in a year - let us say about 70 hours. (Even during a peak summer day, the third machine may work only for about 4 hours.) During the rest of hours in the year, cooling is still required, though the load will be less than 1500 TR. Most of the time two chillers will be capable of handling the load and the third chiller will be idle. Infact, it could be that on a substantial no. of days, even more than one chiller will be idle. In other words, no chiller will work more than 12 hours a day, any time of the year for a typical commercial building; and during parts of the year when weather is milder, even 2 out of 3 Chillers may not work for 10 hours a day. Thus a large part of the installed capacity and investment will represent wasted assets. To overcome this situation a Thermal Storage System (TSS) can be installed. In this system, the installed capacity will be about 50 - 60% of the peak load. The Chillers will now work upto 20 hours or more a day. During night hours, when cooling is not required, the Chillers will produce ice & store cooling energy therein. During the day, the deficit in cooling capacity in peak hours (afternoon hours) that will be experienced with 2 chillers working, will be met by melting of ice (releasing of latent heat) produced during the night hours.

In this system, the Energy consumption will not be spectacularly lower than when large Chillers are used. The benefits, however, are many. TSS will bring down the cost of all electrical work, which includes the following :

- a. Installed capacity is lower.
- b. Connected power is lower.
- c. HT Panel.
- d. Substation
- e. LT Panel
- f. Cables
- g. DG Sets, etc..

TSS will also bring down the demand on the utilities at peak load conditions with obvious benefits to the consumers at large. The utilities can generate and offer more energy to the consumers with the same installed generating capacity.

In the prevailing scenario, in our country, multiple tariffs are not yet in vogue. But they are inevitable sooner or later - and when they do materialize, multiple tariffs, will be significantly lower cost for energy consumed during off peak hours. The TSS have been perceived to be advantageous even in the absence of the props that multiple tariffs offer, but then backed by multiple tariffs, they (the advantages) will be much more visible.

TSS will require space for the Ice storage. This will be in the form of MS or SS Tanks of adequate capacity. They are usually circular - like tankers and are installed vertically or horizontally. They can be located either on ground, with or without shelter or below ground.

There are many TSS Plants in the Country, but to the extent that there is enormous scope for increase in their nos. of such plants may be regarded as a Recent Advance or an Emerging Trend.

3.5 CAS + TSS :

From what has been said above, it is clear that while both CAS & TSS are attractive on their own, the attraction is all the greater when they combine - for each props - up the other.

4.0 Combined Heating, Cooling & Power Plants (CHP) :

Another emerging trend today is what is called Combined Heating, & Power Plants (CHP). It is well known that the efficiency of generation by thermal power is under 40%. This is because the waste heat generated by the power plant is usually not put to any use. Waste heat recovery potential exists in exhaust gas heat & in the jacket water. This potential is exploited to run the VAMs. The Heat Recovery VAMs (HR VAMs) can use steam or high temperature hot water (at about 190°C) from exhaust gas and hot water (90°C) from jacket water. With this system, it is possible to extract 1 TR of cooling capacity for every 4 KW (5 KVA) of DG Capacity.

The data required for calculations include the power requirements of the building for load other than air conditioning as well as of course the air conditioning plant capacity by the building caused for.

An example is shown below :

Air Conditioning plant capacity required	500 TR
Chiller power (Air Cooled) at 1.3 KW/TR	650 KW
Low side power - AHUs, Pumpsets, etc.	195 KW
Total power for Air Conditioning	845 KW
Total building load at 1.65 times of Air Conditioning Load	1408 KW

System configuration using CHP:

Selected DG Set Capacity (without CHP)	1408 KW
DG Set capacity	1120 KW
Reduction in DG Set capacity required (1408 KW - 1120 KW)	288 KW
DG Set capacity reduction	20.45 %

The 20% reduction in capacity shown above is for the total power requirement of the building. If the data chosen is the power requirement of the of the Air Conditioning plant instead, the reduction in total power requirement (of the building) works out to 33% approx.

The DG set capacity selected and the break-up of 500 TR Capacity between VCMs & VAMs and other related parameters can be calculated by Trial & Error procedure.

As of now, gas supply is not available in Karnataka, but it is expected to be in 2 - 3 years' time. The exhaust gas from gas turbines is a much cleaner than from Diesel Engines. This confers the advantage that the exhaust gas from the turbines can be passed directly through the generators of the VAMs rather than provide an exhaust gas boiler or HRU (Heat Recovery Unit) - which is the prevailing practice when waste heat is derived from diesel engines.

5.0 Building Management System (BMS) :

DDC (Direct Digital Control), BAS (Building Automation System), BMS (Building Management System) & EMS (Energy Management System) are the various terms used; out of them, BAS & BMS are the most popular in the HVAC. This technology is about 2-3 decades old. But, in our Country, it entered the scene in mid 90's. BMS is now an integral part at an HVAC System of any considerable size and / or complexity. Infact, even Package Units are available today with Microprocessor based controls.

BMS helps in many ways -

- i. Operation of Plant.
- ii. Control of Environmental conditions.
- iii. Dynamic representation of Flow Diagrams.
- iv. Graphics
- v. Data Acquisition
- vi. Historic Trends
- vii. Scheduling

While these benefits, are great the system is often sold on basis of the energy saving that BMS offers with short payback periods (1 to ½ years). This is a case of revolutionary Technology Advances in related branches of Engineering & Science other than HVAC (rather than in HVAC itself) impacting on HVAC.

Computerization has brought changes in several other ways too. Computer systems backed by necessary sophisticated & powerful soft ward have changed the approach and way of working in HVAC - Heat load calculations, equipment selections, detailed engineering of hydronic systems, air conveying & distribution systems for example. The acute need for visualization of available options (and what-if options), close analysis required for all these exercises, could not have been possible manually. This is another instance of the impact of revolutionary & technology advances in relating to Engineering & Science.

6.0 The many options :

Engineers often have many options to assess - as to both (a) Equipment and (b) Systems for any given project. Amongst equipment, the available options are -

- Water Cooled Chillers,
- Air Cooled Chillers,
- Centrifugal Machines,
- Screw Machines,
- Scroll Machines,
- Absorption Machines.

In Systems, choices available are -

- 7° C Water System.
- Thermal Storage System
- Cold Air Distribution System
- Thermal Storage System + Cold Air Distribution System
- Variable Air Volume Systems.
- Variable Flow System.

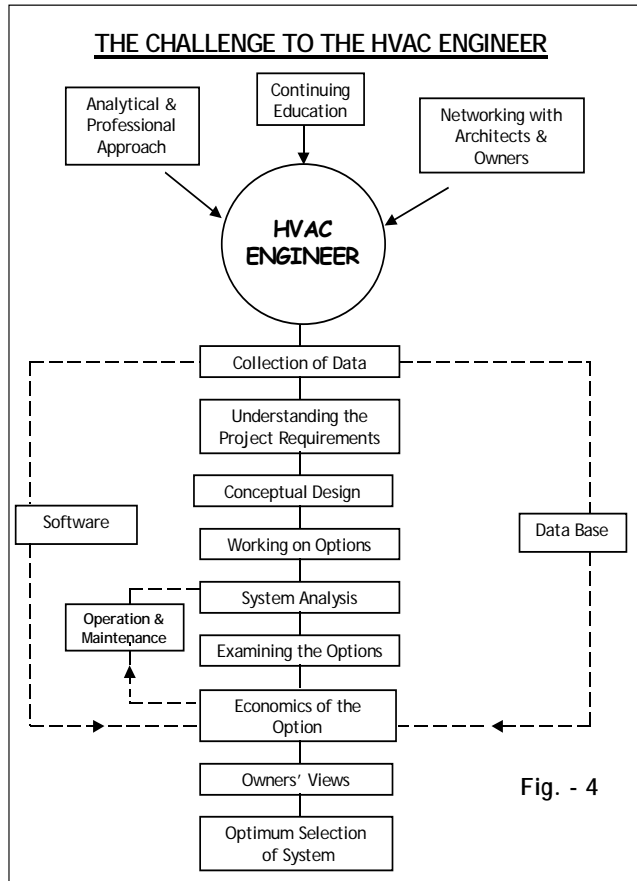
This complex scenario keeps getting more & more so all the time. The engineer needs to be abreast it of in real time. Networking with Architects, Owners & other Agencies and working with an analytical & professional approach are essential.

The diverse equipment & system options available and duly noted in this article, are by no means exhaustive; moreover, options available will keep increasing as equipment manufacturers & design engineers are always on the look-out for innovative products, features & systems to achieve their goal.

The quest for keeping abreast of developments and - applying them in real time may be regarded as an "Advance" that is the need of the hour. Let us then take a closer look at what this "quest" demands in real time.

- Understanding the project requirements
- Database for Equipment
- Database for Weather
- Ability to set up alternatives
- Software for using data & analytical power effectively.
- Analyze the System.
- Analyze the options.
- Vie the Economics of the options, including first cost & owning cost.

The requisites & design process involve are shown graphically in Fig. 4 below :



7.0 Focus on Building Energy Consumption

We have so far looked at the "Available option in Energy Saving in HVAC Plants" with particular focus on Equipment and Systems used in Air Conditioning. We shall now specifically look at how they impact on the air conditioning of buildings but, why then, buildings and not some other application ? There are a couple of good reasons. The first - it is building air-conditioning that has established the image of air conditioning amongst the public. The other is more solid. In many of our buildings as much as 60% of all energy consumed is by air conditioning. It is therefore well worth our while to shift our focus to this application.

Cooling load for buildings is a function for several parameters :

- a. Building Envelope
- b. Heating, Ventilation & Air Conditioning.
- c. Power.

- d. Lighting.
- e. Other Equipment.
- f. Method for Building Envelope Trade-off options.
- g. Climate Data.

In the conventional design procedures, the HVAC Engineer had nothing to do with any of the above factors during the design process of building. By & large, this is true even today, though there are, to be sure, exceptions. The Architects usually finalize all the drawings and pass them on to the HVAC Engineers. The HVAC Engineers then design the plant. Interaction would be limited to the provision of space requirements and aesthetics aspects. But the trend is changing. Hopefully, the day when we can say "it is not true any longer" is not too far away.

The Architects - again, generally speaking - have a free and unfettered hand and have no ceiling on power demands or building energy consumption to contend with. Today, once the application, nature, type of building etc., is known, a ceiling on the max. Power & Energy requirements would also be stipulated. It is upto the Architect & - design team to see how the scheme will stay within the imposed limits. The inputs from the design team required are, of course, not confined to just HVAC but they are needed from other services too. The emphasis is not on the efficiency on air conditioning plant, but more importantly, on the entire building itself. The stipulation of ceilings on the individual services as to their power, water, . . . should be regarded as guidelines. The goal is set - and the Design Team has to achieve it.

The entire design team therefore needs to make a concerted effort. The team should optimize consumption of various services so as to stay within the grand total ceiling, while retaining the architectural concepts of the building in tact at the same time. Trade-offs between the services Architectural & interior aspects could occur in this context.

To give an example of how Optimization and Trade-off can occur. The Architects can increase the fenestration in the building. This would result in a greater cooling load but, at the same time, would also reduce the insulation values of the building surfaces, which will have the effect of increasing the heat gain. He can go outside the shell of the HVAC, employ more day lighting from the increasing fenestration and reduce lighting load. This is just an example of how advantage can be derived out of flexibility.

In Energy there are many factors that go into building design. Energy is a new entrant into this domain (Post 1973 as we have seen), but being new, does not mean that it has no voice or that it is faint. Its voice can be pretty loud and calls for attention and gets it. Though there are, no doubt, other Energy consuming building services, like lighting & plumbing for example, HVAC consumes as much as 60% of the total energy budget. Hence, the focus on HVAC in Building Services, particularly, for Energy conservation point of view is necessarily sharp and un-renting.

This has been realized duly & ASHRAE has come out with following widely known Standards.

- a. Energy Efficient Design of New Buildings except low rise Residential Building - American Society of Heating, Refrigerating & Air Conditioning Engineers (ASHRAE) and Illumination Energy Society of North America (IESNA) 90.1 1999.
- b. Energy Efficient Design of Maximum Low Rise Residential Building ASHRAE - 90.2 1993.
- c. Energy Efficient Design in Energy conservation in Energy Building - ASHRAE 100 - 1995.

Of this the first is the most important, as it applies to large buildings, institutional buildings, commercial buildings, etc., The Standard is comprehensive & covers many aspects of an “Energy Efficient Buildings”.

Apart from ASHRAEs’ initiatives in “Energy Efficient Buildings”, a major player is The US Green Building Council. This organization viz., US Green Building Council has instituted a Green Building (Leadership in Energy & Environmental Design - LEED for short) Certification Programme or LEED Certification Programme. The LEED Certification Programme duly recognizes that there is more to Energy Efficient Buildings than the HVAC Plant or Electrical Work or Plumbing or for that matter, any other building services. Its scope is much broader, as will be evident from its focus on a wide range of parameters.

Green Building Rating involves ratings for:

- Site Characteristics
- Efficiency of Water
- Usage
- Energy & Atmosphere
- Material & Resources
- Indoor Environmental Quality &
- Innovations & Design Process

Each of these parameters is allotted a no. of credit points. The Certification Levels available are listed below :

Certification Level	Points
Certified	26to 32
Silver	33 to 38
Gold	39 to 51
Platinum	52 or more (max. 69)

To be sure there are several parameters, like for example, Site Characteristics, Efficiency of Water, Usage, Material & Resources, which are not in the control of the HVAC Engineer, though their impact on the design & performance of the HVAC Plant is often significant. At the same time, it should also be noted that for the Platinum Building over 30% out of the 52 or more points are within the purview of the HVAC plant design This is not a small fraction.

There are already a few Green Buildings in our Country. The best known is, of course, the CIIs’ Green Building in Hyderabad. It is, infact, a Platinum Building.

Owners are showing a deep & growing interest in Green Buildings. More Green Buildings can therefore be expected to be on the way.

It therefore now only remains for the HVAC industry to start applying the ASHRAE & Green Building Council criteria & practices. Sooner it is done, the better it is.

8. Getting ready to cope with the Ever-Advancing Technological Environment.

8.1 Application of Software

Software can no doubt be imported (manly from US), but they are made to suit American Conditions. They are not suitable for our conditions and our engineers do not find them sufficiently user-friendly.

Even design procedure & calculations outlined in literature originating from US & other countries are not readily convertible to design information tools for applications in our scenario.

These two considerations point to the necessity for improvising or creating software required ourselves in the country after Indianizing the concepts.

8.2 About the mind-set

Given the requisite tools that we have already discussed and the necessary change in our mind-set, the HVAC Engineer can deliver the following :

- Set up goals.
- Draw appropriate detailed & focused specifications to meet the goals.
- Indianize applications of technology.
- Seek to combine all relevant technologies to achieve the goal.
- Conceptualize, analyze and generate hard numbers, adequate to facilitate decision making on systems, equipment (make, model, etc) and award of work.
- Execute work competently.
- Ensure that the operation of the plant is in line with specifications and design goals.

This is more easily said than done.

What is required is increased levels of professionalism, strong motivation and willpower. This is the challenge facing the industry in our Country today.

DISCLAIMER CLAUSE :

The authors believe that the facts and suggestions presented in this paper to be accurate. However, applicability of any one or more of the options presented shall thoroughly be analyzed before implementation. The author disclaims any responsibility for actions taken based on the material presented in this paper.

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