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HVAC OF GREEN BUILDINGS

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The starting point will be to look at "what is green?" and “what is a green building?”

The voluntary pursuit of any activity which encompasses concern for energy-efficiency, environment, water conservation and use of recycled products and renewable energy, can be defined as "green" .

It is clear that "green" is a great deal about concern for energy-efficiency, environment, and water conservation. Concerns about these parameters – happily – also happen to be the current concerns of the HVAC industry. Any building which factors such concerns in design and execution becomes a "green building".

From what follows in the rest of this article, it will become clear that these points are being addressed by the industry, but more importantly, there is another point that emerges equally clearly – that there is scope for a great deal of improvement in implementation of the various strategies and methods that are available today. Being constantly on the lookout for new strategies is, of course, an on-going process.

We shall, in this article, look at various elements of the HVAC systems – element wise and also, the various systems themselves – of which, these elements form a part. See **Figure 1.**

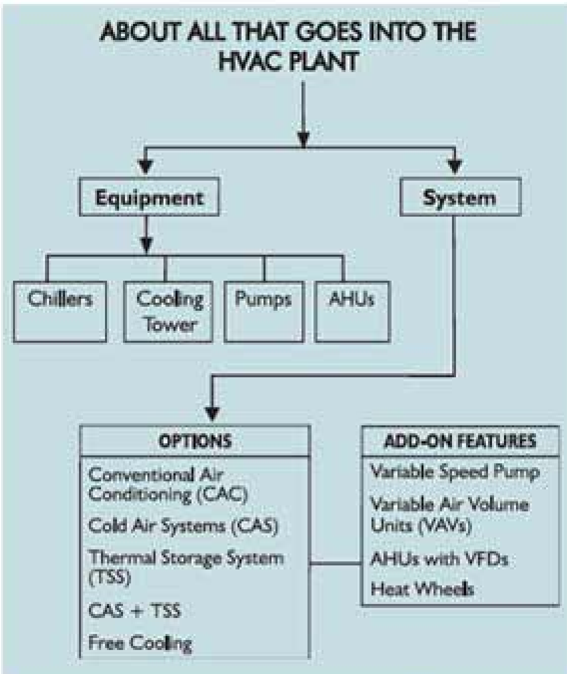

Figure 1: Various elements of the HVAC system.

Environmental Impact of Chillers

The ODP problem. The chiller is the heart of an air conditioning plant. In a typical water-cooled chiller plant, it accounts for as much as 62% of the total HVAC power requirement. See **Figure 2a, 2b and Table 1**. It is even higher (at 82%) in an air-cooled chiller plant. That, it is this element of the plant that contributes most to the plant's environmental impact should not therefore occasion any surprise.

As far as "environmental impact" is concerned, the problem of Ozone Depletion Potential (ODP) has been associated with chillers via the refrigerant charge contained in them over the past few years. However, it is no longer an issue. The war against ODP has been won by a two - pronged attack. The first was to do away with CFCs. This is a widely known strategy. Not so many are familiar with the second, which has to do with leak tightness of chillers.

Table 1: Air-Cooled and Water-Cooled Chiller Plant - kW/TR

Sl. No.	Description	Water-Cooled kW/TR	%	Air-Cooled kW/TR	%
1	Chillers				
	a. Water-Cooled Chiller	0.65	62.5		
	b. Air-Cooled Chiller			1.2	82.2
2	Condenser Water pumps	0.094	9.0		
3	Cooling Tower Fans	0.037	3.6	0.078	4.8
4	Chilled Water pumpsets	0.078	7.5	0.181	11.2
5	Air Handling Units	0.181 1.039	17.4	1.459	

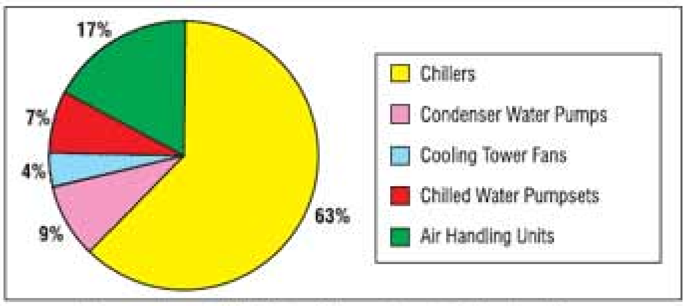

Figure 2a : kW/TR – Water-Cooled Chiller Plant.

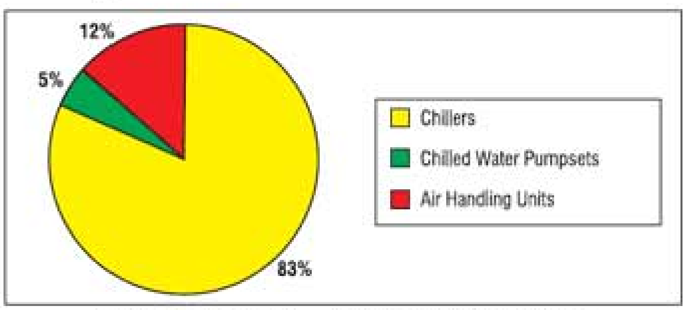

Figure 2b : kW/TR – Air-Cooled Chiller Plant.

In the mid 80's, chiller leakages of 25% were common. The leakage rate of today's machines is down to 0.05% per annum; infact, we are close to zero-leakage or nearzero leakage machines. The implication is that if the refrigerant does not find its way into the atmosphere, it cannot do any harm, no matter what its ODP is. Today's refrigerants however, are not only, not permitted to leak, but, in any case, they also have lower ODPs.

Table 2: Refrigerant ODPs.

Refrigerants	Atmospheric life (years)	ODP
11	45	1.000
12	100	0.820
22	11.8	0.034

134a	13.6	0.000
123	1.4	0.012

The problem of ODP has thus been taken care off.

The GWP (TEI and TEWI) problem. GWP is the term that is commonly talked about, but it should rather be the TEI (Total Environment Impact) and TEWI (Total Environmental Warming Impact) instead. TEI is the sum of ODP and TEWI. TEWI, in turn, is the sum of Direct and Indirect Effects. Since the ODP is no longer a problem, it is the Direct and Indirect Effects that we should be focusing on. Direct Effect is due to refrigerant leakages. Some refrigerants do have relatively high GWPs, but this is not particularly relevant, because, as we have just seen, today's machines are near-zero leak machines.

Table 3: Refrigerant GWPs.

Refrigerants	GWP (100 yr Integral Time Horizon)
11	3500
12	7300
22	1500
134a	1200
123	120

The Indirect Effect is due to emissions generated by fossil-fuelled power plants, which produce electricity to operate chillers. This Indirect Effect is quite large compared to the Direct Effect, contributing more than 96% to 99% of the Global Warming Gas Emissions – also, more widely known as Green House Gases (GHGs). The magnitude of this figure is largely due to excellent gains made in reduction of Direct Emissions. Obviously, the tighter the machines, the closer this value i.e., 96-99% will approach 100%. Thus, the 25% emissions in 1985 that we have already noted were due to this Direct Effect (chiller leakages), is now less than 4% today. It is therefore futile to invest on resources to tackle the "less than 4%" of the problem – and even this 4% will keep falling. We need therefore to focus instead on the Indirect Effect, which means concentrating on raising chiller efficiencies.

Turning to chiller efficiencies therefore, we find that compared to 20 years ago, they have improved by as much as 40%. Chillers in middle 80's, which were routinely consuming 0.7 to 0.8 kW/TR, are today available at 0.6 to 0.7 kW/TR and at even below 0.5 kW/TR. The higher efficiencies (lower kW/TR's) are associated with large chillers – particularly, centrifugals and screws. The centrifugals come into play for plant capacities of 500 TR and above.

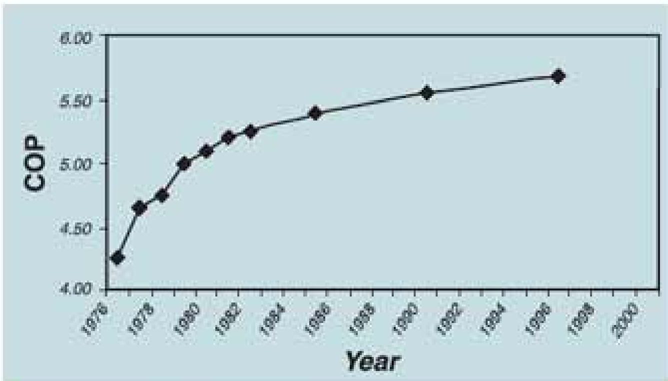

Figure 3 : Improvement in chiller efficiences over the years.

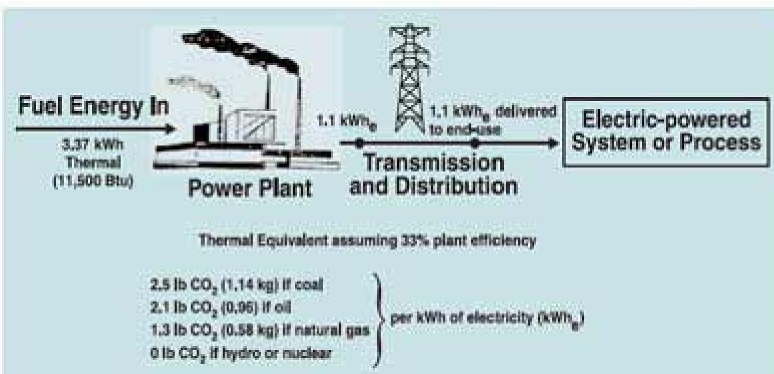

Figure 4 : Conceptual illustration of CO_2 emissions from electric end-uses of energy.

Lower kW/TR is good for the user and good for everybody too, since it brings down the environmental impact. The reduction is in direct proportion to the improvement in efficiencies.

That raising chiller efficiencies has been the subject of industry's sustained attention for the last 2- 3 decades is clear from **Figure 3.**

VAMs have high TEWIs. We have just looked at VCM chiller efficiencies and seen that kW/TR values are in the range of 0.5 to 0.65 kW/TR. This will however correspond to 2.16 kW/TR (for 0.65 kW/TR chiller) when losses in generation of electrical power from fossil fuel, transmission and other losses are taken into account (See Box next page and also **Figure 4**). The Vapour Absorption Machines (VAMs) on the other hand, while they consume very little electrical power, require relatively large energy inputs in the form of heat energy instead. It is only heat energy, no doubt, but it is energy all the same. The total power requirement (i.e., electrical power + heat power) for VAM turns out to be something like 2.8 kW/TR for a Double-Effect Machine.

In a word, what emerges from the above picture is that VAMs consume 30 to 80% more power and consequently, that they generate 30 to 80% more green house gases also, than the VCMs generate. This observation does not apply, where waste heat is available, like in co-generation plants and in some industries.

Water economy. It will be remembered that conservation of water is another element of the 'green' approach. Both air-cooled and water-cooled machines are available in the vapor compression machine category, whereas VAMs are just water-cooled machines. Aircooled VAMs are not available commercially, except in the smallest sizes. Moreover, the heat rejection of VAMs is 50% higher than that of VCMs. This means that water consumption is higher for VAMs as compared to VCMs.

Legionnaires needs to be taken care off. In watercooled systems, heat rejection occurs to water flowing in the heat exchangers (condensers); the hot water is then conveyed to the cooling tower. In the cooling tower, part of the water evaporates into the air stream, cooling the rest of it i.e., water. Water goes out of the tower and into the outdoor environment, not only in vapour form but also as aerosols. The aerosols could carry Legionnaires bacteria, which thrive in the warm water that the "cold water" basin of the tower houses. The "cold" water could be in the neighbourhood of 30–35°C in our kind of climate and it offers the bacteria just the ideal conditions under which they thrive. This is not to say that cooling towers, and therefore, by implication – water-cooled machines should not be used. Even if the HVAC industry can cut down on use of cooling towers, there are other industries, which have no option but to live with them. Moreover, the extent of cooling tower usage in the HVAC industry is pretty small compared to that in other areas like, for example, power plants, petro-chemical industry, oil refineries, etc.. Hence, one must realize that cooling towers are in use and will continue to remain in use. The point that is being made here is that when it has to be used in an HVAC plant, one needs to take care of this threat to the environment – consciously and professionally – and provide chemical treatment, ongoing monitoring (of the water quality), good maintenance and so on.

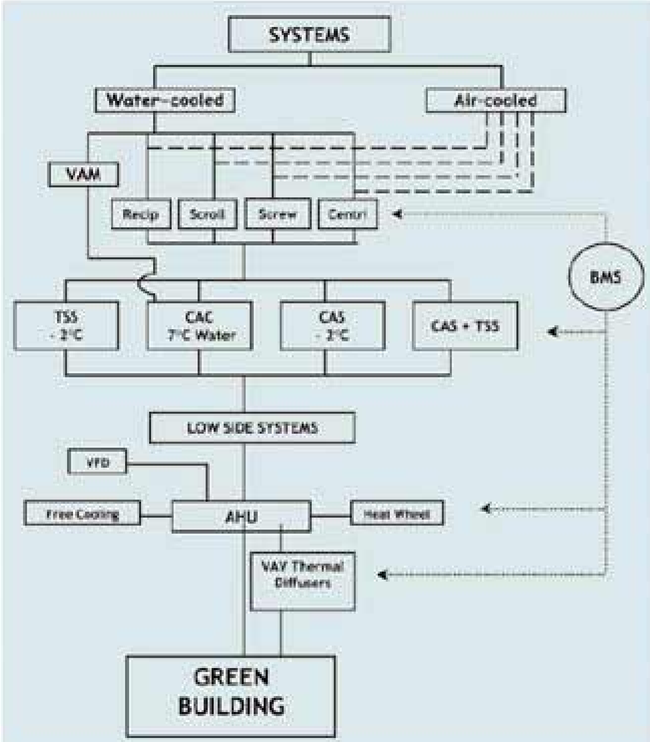

Figure 5: Equipment and system options.

TEWI Calculations for VCMs & VAMs

Furnished below are TEWI calculations for Chillers - both Vapour Compression Machines (VCMs) and Vapour Absorption Machines (VAMs).

Definitions :

We start with some necessary definitions :

TEI = ODP + TEWI

Where TEI is Total Environment Impact.
ODP is Ozone Depletion Potential
TEWI is Total Environmental Warming Impact.

All the terms are expressed in kgs of CO_2 liberated to the atmosphere.

The above equation simplifies to :

TEI = TEWI

since, as we have already seen, the problem of ODP has been taken care of by selection of :

a. Low ODP refrigerants
b. 'Zero' Leak or 'Near Zero Leak' machines.
Hence, ODP is equal to zero.

TEWI, in turn, can be expanded to :

TEWI = Direct Effect + Indirect Effect

The Direct Effect is due to emission of refrigerants to the atmosphere; the Indirect Effect is related to machine efficiency–rather the machine inefficiency!

TEWI for Vapour Compression Machine (VCM)

Consider now the example given below :

Given :

Type of Chiller	Vapour Compression Machine (water-cooled)
Refrigerant	R-22
Refrigerant Charge	58 kg
GWP (of R22)	1500 kg of CO_2 per kg of refrigerant
TR	150
Average Load	0.7 x Peak Load
kW/TR	0.65 (water-cooled chillers)
μ - kg of CO_2 / kWh of elec. power	0.67
Usage	16 hrs/day, 300 days in the year
Equipment Life	15 years

Required to calculate TEWI :

The calculations are shown below :

TEWI = (58 × 1500) + (150 × 0.7 × 0.65 × 0.67 × 16 × 300 × 15)
= 87000 + 32,92,380
= 33,79,380 kg of CO_2 per annum

The above calculations are for water-cooled chillers. By repeating the procedure, but using a kW/TR value of 1.2 in lieu of 0.65, the TEWI for air-cooled chillers can be obtained.

The same way, TEWI values for R-12 chillers can be calculated using GWP value of 7300 kg of CO_2 in lieu of value of 1500 kg of CO_2 applied for R-22.

It will be seen that in the above calculations, the Direct Effect is figured as occurring at the time of the ultimate disposal of the refrigerant at the end of the useful life of the machine. This is equivalent to assuming "zero leakage". However, even if one considers loss of 2 or 3 refrigerant charges, still the Indirect Effect will continue to remain predominant. This will be more emphatic, the longer the life of machine.

The above goes to show that ODP & GWP of the refrigerant are not major players in the selection of a machine. They are important but they constitute only two amongst the several performance parameters that need to be considered in the selection of a chiller. The Indirect Effect is a function of the machine efficiency and the operating pattern. Controlling the operating pattern is not exclusively in the hands of the engineer. It is therefore the chiller efficiency that he should be looking into. Moreover, because of its impact on energy consumption, the part load and ambient weather – dependant performance of the chiller will become the primary considerations.

TEWI of Vapour Absorption Machines (VAMs)

TEWI can be calculated for VAMs also.

In this case, its readily seen that the ODP is necessarily zero, since water is the refrigerant for Lithium Bromide / water machines.

Considering TEWI - again, the Direct Effect will be zero for the same reason i.e., the Global Warming Potential of the refrigerant (i.e. water) is zero. Thus, once again :

TEWI = Indirect Effect.

Here is an example :

Given :

Type of Machine	: Direct Fired Double Effect
Fuel used	: Oil (HSD), Gas
Fuel Consumption – kg/hr/TR	: 0.27 (from Thermax specification sheet for Eco Chill + fuel driven VAMs)
kg of CO_2 liberated per kg of fuel burnt	: 3

Required to calculate TEWI :

Kg of CO_2 liberated per TR = 0.27 x 3
= 0.81

TEWI = 0.81 × 150 × 0.7 × 16 × 300 × 15
= 61,23,600 kg per annum

It is, of course, not necessary to calculate TEWI for the VAM, if the necessary heat energy is available as waste heat.

Conclusion

The table below summarizes the results of all the calculations :

TEWI – kg of CO_2

Type of Machines	VCM Refrigerant - R-22	VCM Refrigerant - R-12	VAM
Air-cooled chillers	63,25,855	66,03,854	–
Water-cooled chillers	33,79,380	36,57,380	–
VAM (water-cooled)	–	–	61,23,600

It will be seen that TEWI of air-cooled Vapour Compression Machines and Vapour Absorption Machines are about the same, but the (TEWI) value for VAMs is about 80% higher than for water-cooled Vapour Compression Machines.

Equipment and Systems

Besides chillers, there are other elements of equipment too in an HVAC system. We need to look at them also to see how they consume energy and what can be done to enhance their efficiencies. The same applies to the several systems of which the elements form a part.

Using Variable Water Flow and 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 and 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.

Use of VAVs and variable airflow systems 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 0.4 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 and pumps). If we look at a 400 ton plant for example, the power required for the pump and AHUs together is about 160 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 and only then, implement. That is the key!

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.

Provide Heat Recovery Chillers and 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 an 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 a 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.

Select the right type of fan for AHUs. Fans incorporate several types of fan blades – forward curved, backward curved, aerofoil blades, etc.. The engineer should always be vigilant to make sure that he selects the kind of fan that has the best efficiency to offer for the project he is handling. More specifically, it means that he should be alive to the need to look for backward curved fans, to see if it suits him better – rather than to go with forward curved blade fan – as if, by default.

Variable speed fans in cooling tower. Energy saving in cooling towers can be achieved 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.

Free cooling. In a 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 and enthusiastic application of the strategy, will be greatly enhanced, if 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 and computerization is possible.

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 – infact, 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 a 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 and 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 and 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 and fresh at lower humidities. Another significant gain that lower humidities restore is that the mold and fungus problem is tackled in a forthright manner (and at no extra cost as compared to a conventional air conditioning).

Heat Wheels. 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 100 ton plant capacity, calculated in the conventional manner (without HRW), the reduction in plant capacity due to use of HRW is about 30%. (This indication is based on assumed values of 20m2/ TR; 5 m^2/person, 7 L/s/person at a OADB of 35°C, OAWB of 28.3°C and room DB of 24°C and 55% RH).

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

Thermal Storage System (TSS). Then there is also the Thermal Storage System (TSS). The CAS requires water (or brine) temperature as low as 2°C or even less. That the

CAS manages even that requirement and stays competitive all by itself is another matter, but, in the TSS, water in any case is already available at about that temperature, so that the two systems can go hand-inhand. Thus, we see that while the TSS reduces installed capacity of the plant by about 40- 50%, a further reduction of about 7 -10% is contributed by the CAS. It's easy to see that the reduction in plant capacity and the reduction in connected power requirements, which they translate to, is one of the great attractions of TSS.

The TSS, as we have seen, reduces plant capacity by about 30 to 40% with a corresponding reduction in connected power requirement. Its not that TSS saves energy as such in any big way, but it shifts the consumption from – typically, the peak hours of the day to some other part of the 24 hour-day – typically again – to the off-peak hours. To the owners, it yields plenty of benefits, viz., lower first cost on electrical work, furnishes a tool to fight powercuts, shut-downs, etc., takes advantage of multiple tariff structure where available and so on. But that is not all; there are other benefits too. To the power generating companies, it means that the peak load on their plants is reduced – which enables them to generate more energy, with the same installed capacity. To put it more briefly, more kWh is generated for the same kW installed.

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

BMS (Building Management System). We have now looked at a number of technologies and energy saving strategies like Variable Flow Air and Water Systems, Heat Recovery Chillers, CAS, TSS and Free Cooling. They are by no means exhaustive as equipment manufacturers and design engineers are always on the look out for more innovative products, features and systems to achieve the goal.

Many of them can be applied on the same plant, but to make them all work for us, BMS is essential.

Energy Costs Enter Into the Picture

There can be no two opinions about the fundamental requirements :

1. Energy conservation is a must.
2. Strategies for achieving energy consumption are available, but we are not really exploiting them.

Almost every plant buyer wants to minimize the operating cost. An overwhelmingly large part of the operating cost is the energy cost. In this scenario, it is worth noting that the HVAC plant often accounts for as much as 60% of the total building energy consumption. While buying a plant, the most frequently adopted criterion is the lowest first cost. This may not, however, always yield a lower running cost, for the plant with lower first cost, may cost somewhat more to operate. At the same time, neither is it always that a plant with a higher first cost will necessarily yield a lower owning cost; all it means is that in a majority of cases there could be an extra first cost to be factored in to achieving lower energy costs.

Energy consumption calculations. For establishing such derivable benefits, detailed energy calculations are essential. For carrying out energy calculations, in turn, the essential pre-requisites are :

1. Performance of chiller and other auxiliary elements at various ambient air conditions and part-load conditions.
2. The usage pattern of the building.
3. Variation of load due to the ambient conditions (weather).

These are available today, though the engineer has to seek them consciously. Availability of weather data – in forms suitable for HVAC work – had been an issue for decades, but the situation has eased with the publication of *Weather Data and Design Conditions for India* brought out by ISHRAE and ASHRAE India Chapter in 1999.

Chiller performance is obviously crucial since, as we have seen, it accounts for 60 to 80% of all connected power requirements of the plant. Manufacturers typically furnish computer selections showing the value of parameters at duty conditions. For energy calculations however, it is necessary to have partial load performance and performance covering the range of ambient conditions that the chillers will encounter at the given project location. These data could be tabulated as shown in **Table 4.**

Table 4 : kW/TR vs. % load and condenser EWT.

Condenser EWT °C					
% Load	**30.83**	**28.5**	**23.5**	**20.9**	**18.3**
100	0.644	0.589	0.493	0.455	0.427
90	0.622	0.564	0.461	0.416	0.376
80	0.633	0.558	0.445	0.394	0.348
70	0.654	0.582	0.448	0.389	0.336

60	0.678	0.597	0.447	0.388	0.334
50	0.726	0.63	0.459	0.392	0.338
40	0.818	0.709	0.499	0.424	0.357
30	0.989	0.849	0.592	0.492	0.405

The tabulated data has been shown graphically in **Figure 6.** The table and graph serve to highlight that the performance parameters – in winter for example, will differ from those applicable to summer – at the same part load (on the chiller). It will also bring the energy calculations closer to reality – the way APLV and IPLV cannot do.

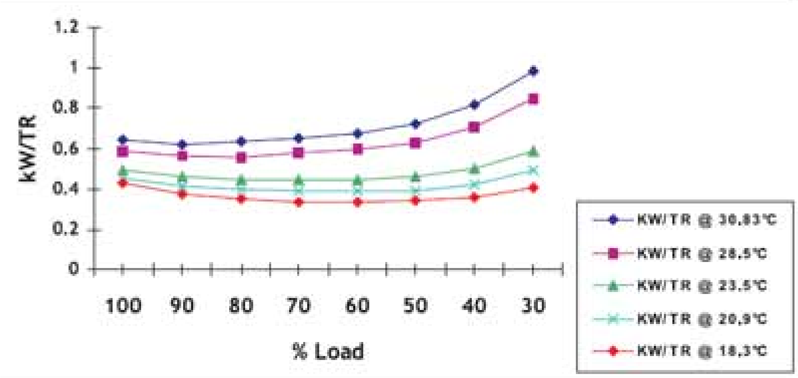

Figure 6 : kW/TR vs. % load & condenser EWT (for water-cooled screw chiller).

Detailed energy calculations – the way described above for example – should be made in the initial stages of the project. The purpose of making them is to be able to leverage on the results (of the calculations) to select appropriate systems, appropriate equipment (makes and model, etc.) and appropriate equipment configuration. Some of these are obvious and do not require elaborate calculations, but quite often, application of judgement alone is not adequate. Recourse must then necessarily be made to detailed studies. This way, the owner will have hard numbers also, besides assessments based on judgement, in making buying decisions.

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 system

• Variable flow system.

As we have noted already, a buyer wants minimum first cost as well as minimum operating cost (energy cost). The engineer needs to analyze all the considerations listed above in order to arrive at the right choice of the equipment and system.

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

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

Keeping abreast of developments in real time requires continuing education.

What the HVAC Engineer Needs to Do ?

The wherewithal to accomplish this task comprises many steps and items such as :

• Understanding the project requirements

• Database for equipment

• Database for weather

• Ability to set up alternatives

• Software for using data and analytical power effectively

• Analyze the system

• Analyze the options

• Weigh the economics of the options, including first cost and owning cost

In today's scenario, decisions are not made on individual judgements – however competent and knowledgeable the engineer is – but on analyses and the resulting hard numbers. System optimization, analysis, credible energy consumption calculations and so on – are a must. The engineer should be in a position to convince the customer about the benefits of adopting energy saving strategies because even though first cost of plants incorporating such strategies may be higher, the life cycle costs will be lower. More over the more important purpose is served – i.e., energy saving, conserving fossil fuel and containing global warming. Please see **Figure 7.**

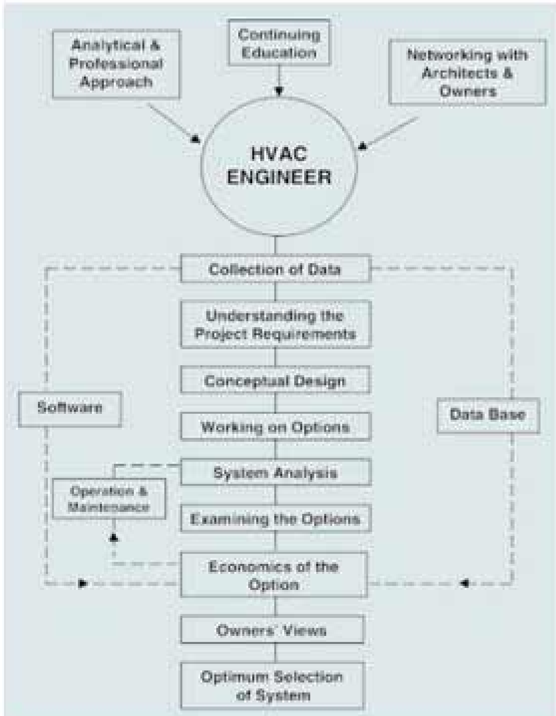

Figure 7 : The challenge to the HVAC engineer.

The Need for Software

Software can no doubt be imported (mainly 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 procedures and calculations outlined in literature originating from US and 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.

What the HVAC Engineer Can Deliver ?

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 and 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 strong motivation and will power.

Conclusion

Everything that has been said in this article has to do something or other with either energy or water or environment – all of which are tied up closely with the task of making a building "green". We have seen that the HVAC industry is seized of the problem – unveiling new refrigerants, raising chiller efficiencies, making chillers tighter, introducing system technologies like CAS and TSS, incorporating system features like Variable Flow Pumping, VAVs and VSDs (for AHUs), applying a variety of energy saving strategies, putting BMS to good use and so on. Focused engineering, exploiting the computing capabilities of a computer, developing necessary software for carrying out the elaborate calculations required and the need for employing and building adequate database have all been identified as crucial to the success of endeavour in promoting “green building” practices. The HVAC engineer has to be more professional in his approach, more focused on ensuring that the design concepts and goals are fully realized.

He has a job ahead of him and a challenge to takeup.