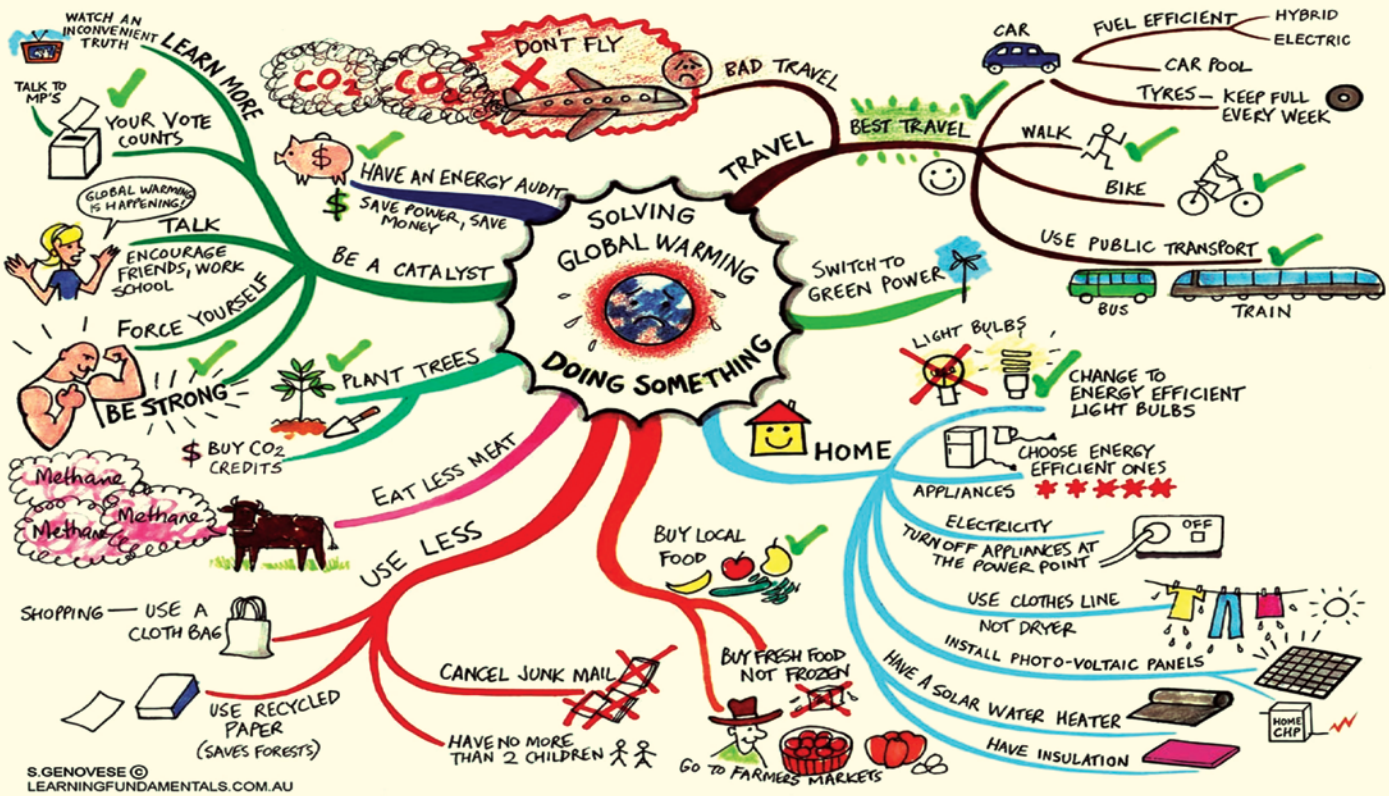

HVAC Industry's Mission for Sustainability and Green Buildings

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Climate change, global warming and energy issues are increasingly in the limelight during the past few years. They appear frequently in all forms of media. All sectors of energy consumption are naturally under the scanner, but apparently, none more so than air conditioning – at least, in so far as our country is concerned. The coverage extends to and focuses sharply on green buildings, sustainability and energy consumption. This way, public awareness in these burning topics of the day is promoted, and ample information and data are also conveyed. The information and data projected include write-ups on how energy can be saved in various ways in buildings - like passive architecture, natural cooling, natural ventilation, using the right kind of materials, providing insulation, optimizing use of glazing, applying solar energy, applying wind energy and applying geothermal energy – to mention a few.

HVAC Energy Consumption – Global vs Indian

Information and data furnished also contain and refer to statistics, particularly applicable to energy consumption and their patterns, but, information of this kind, specifically

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Country	Population - million	Per Capita Energy Consumption KWH	Total Energy Consumption KWH/10^9	Carbon Emissions - metric tons
USA	276	104304	28955	1518
European Union (EU)	375	48210	18082	900
Germany	82.8	49939	4074	24.64
France	59	50848	3019	106.2
Japan	126.5	50291	6360	303.6
Australia	19.2	73209	1377	94.08
India	1,014	3605	3575	253.5
Sudan	35	674	21	1.4
Nepal	24.7	674	15	0.04
Global Energy Consumption			**115820**	

Table 1 : Energy consumption in some select countries.
Source : US Energy Information Administration.

applicable to our country is very scanty and scattered. In such write-ups, it is commonly observed (by their authors), that out of the total global energy consumption, about 40-50% is due to buildings and further, that about 36% of that 40-50% is due to air conditioning. This pattern and the calculations based thereon, lead to a figure of 24-30% for the total annual consumption of building air conditioning. The pattern, it appears, is assumed to apply to our country also – it is either stated specifically or implied. This is the only context in which air conditioning appears in media coverage and it establishes the image of air conditioning as an energy guzzler and with nothing else to show for it.

It will be seen from this table that the US energy consumption is 8 times the consumption of India. Further, according to the same source, global energy consumption is 4 times the US energy consumption. It is based on this source that the value of global energy consumption - 115820×10^9 KWH has been derived in the above table.

The Indian HVAC industry consumption is less than 5% approximately of all India consumption and less then 1% of global consumption

The calculations below will help place the Indian consumption in a few perspectives.

The estimated value of air conditioning energy consumption of India - 64.40×10^9 KWH (as calculated by this author)

$$\text{Total Energy Consumption of India} - 3575\times10^9$$

$$\frac{\text{Air Conditioning Energy Consumption of India}}{\text{Total Energy Consumption of India}} = \frac{64.40\times10^9}{3575\times10^9} = 1.9\%$$

Keeping in view the lack of reliable data and scope for increasing the rigour of methodology and calculations, this figure is not likely to exceed 5%. It will thus appear that the contribution of air conditioning in India to total energy consumption in the country (5%) is much less than the global pattern, according to which it should have been in the range of 24-30%

$$\frac{\text{Air Conditioning Energy Consumption of India}}{\text{Global Energy Consumption}} = \frac{64.40\times10^9}{115820\times10^9} = 0.056\%$$

Observations made about the reliability of data and the scope that exists for improving the rigour of the calculations already made apply in this case also. Accordingly,, this figure can be raised to 0.1%

Global Warming - a Consequence of Energy Consumption

But then, why is energy so important? This is a big question – and it will be answered here only to the extent necessary for the purposes of this article. A large percentage of energy produced globally is from gas, oil and coal. All the three are fossil fuels. Between them, the three together constitute about 80% of total energy generated globally. Combustion of fossil fuel gives rise to *green house gases*. Carbon dioxide is the most widely known *green house gas*. Accordingly, burning of fossil fuel to produce energy means that vast quantities of carbon dioxide are being liberated. The carbon dioxide so liberated surrounds the earth. It interferes with the heat exchanged between the earth and the sun and impedes discharge of heat to the atmosphere. As a result, the temperature of the earth rises. The more the energy (from fossil fuel) consumed, the greater will be the concentration of CO_2 in the atmosphere and accordingly, the warmer will be the the earth (surface). This is what everybody knows these days as *global warming*. In a nut shell, it means - generating energy (from fossil fuel) gives rise directly to *global warming*.

Renewable Energy Sources

This problem of *global warming* - arising from energy generation and consumption, does not arise in the case of non-fossil energy sources or renewable energy sources - RES (well known RES are solar energy, wind energy, geothermal energy, tidal energy and hydroelectric power – to mention a few). A passing reference to nuclear energy needs to be made at this point. Obviously, it can not be categorized as fossil fuel energy - nor on the other hand,

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does it qualify as an RES. Hydro-electric power is the one amongst RES which has the minimum emission. Emission due to nuclear energy is only slightly greater than hydro-electric power. It is therefore regarded as a source of clean power. At the present time however, its contribution to the total energy generated is only about 15%. Only time will show, if it will be increasingly accepted as a major energy source.

Though renewable energy is available in so many diverse ways, the fact is that they are not easy to tap and use. This is reflected in the fact that energy derived from RES constitutes only about 10% of the global energy generation. If building air conditioning consumes unconscionably large amount of energy, immediately it becomes a major culprit from the point of view of *global warming*, because it derives most of its energy from non-renewable energy sources – as indeed most energy consuming sectors – transportation, aviation, and manufacturing industries – do today.

Global warming is one major issue in the environmental impact of air conditioning. The other is ozone depletion. This however, is a problem that has been effectively taken care of and therefore will not be referred to in the rest of the article.

Fossil Fuel Consumption (by HVAC Plants) – the Cause of GWP

It has already been seen that a large part of the energy consumed in today's scenario is derived from fossil fuel. Thus, it is now easy to see the link between *global warming* and the energy consumption of every sector – and that, of course, includes building air conditioning also.

Most of the new refrigerants come not just with zero or near-zero ODPs, but also with zero GWPs or near- zero GWPs also. Unfortunately, however, while the new refrigerants with zero ODPs or near-zero ODPs (and air tight machines) solved the ODP problem, their zero GWP or near-zero GWP properties did not solve the GWP problem. This is because GWP is due to two effects – the *direct effect* and the *indirect effect*. The former is a function of refrigerant GWP – The *direct effect* is therefore zero, if GWP is zero. The *indirect effect*, on the other hand is due to energy consumption itself. It is therefore the energy consumption that needs tackling. And that is not anywhere near so easy!

Reducing Energy Consumption

By raising energy efficiencies

There are two aspects to energy consumption. The first one is to reduce the use of energy itself. Something can be done about this to be sure – but not much! What can therefore be done is to minimize load (on the air conditioning plant) by focusing on it in all aspects of the work - as much as possible. The other involves a change of life style itself. This is more easily said than done – and in any case, and essentially - it is not just an air conditioning problem. Assuming therefore a given (and prevailing) life style, energy consumption can only be reduced by improving efficiency in energy generation and usage. And to be sure, when it is usage we are talking about, its about air conditioning and air conditioning only - at least, in so far as this article is concerned.

By selecting high efficiency chillers

Using high efficiency equipment is one obvious method. In medium capacity and large capacity air conditioning plants, the chillers happen to be the major source of energy consumption. A large majority of chillers being installed today – and for that matter – during the past decade is being imported. They have significantly higher efficiencies - as much as 25% - as compared to chillers about 25 years ago. The quest for raising their efficiencies is a never-ending-quest in the industry. Although, there are chillers of varying energy efficiency categories (like high efficiency, moderate efficiency and standard efficiency), generally speaking (as we have noted already), the efficiency of all chillers being installed today are acceptably high and they are rising – though not spectacularly – all the time.

Chiller efficiencies are enhanced by applying sophisticated, programmed DDC controls and by using variable speed drives for the compressors. Both these features are factory built and the machines come fitted and tested (in the factory). Large plants rarely work on single chillers. Multiple chillers configuration is the norm. The controls provided on individual chillers take care of the control of that particular chiller. Sequencing the chillers and issues related to operation of multiple chillers at various plant loads or system loads are handled by the Building Automation or Building Management System (BAS or BMS).

By raising system efficiencies

It has been noted that the chiller is often the largest consumer of energy in an air conditioning plant. Obviously then the plant consists of a number of other items of equipment, components, accessories and systems, all of which also consume energy. Typically they consist of cooling towers, air handling units, pump sets, hydronic (chilled water piping) systems, condenser water piping systems, air distribution systems (ducting, air outlets etc.), insulation for the building, pipes, ducts and also, some electrical work and control systems.

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By paying special attention to part-load efficiencies

HVAC plants, are typically sized to meet peak load requirements. However, peak loads prevail only for a small fraction of the total number of hours that a plant works. Accordingly, high peak load efficiencies – while important – do not by themselves govern the performance of the plant as far as energy consumption is concerned. A great deal of hard work goes into ensuring maximum possible efficiency at part loads also. This is achieved generally by taking special care of energy aspects while selecting the plant, equipment, accessories and by ensuring good system design. Typically, the air conditioning plant, involves three kinds of flows viz., the refrigerant flow (in chillers), chilled water flow, condenser cooling system water flow and air flow. In all these cases, the basic aim is to ensure that the flow falls - at least proportionately - with falling load. This is ensured by using VFDs. We have already seen that many modern chillers are available with factory mounted VFDs. The same approach serves fans (air) and pumps (water). Thus, VFDs are now increasingly used to vary the flow in response to fluctuations of air conditioning loads of the building.

Apart from the basic equipment like chillers, cooling towers, pumps and air handling units, there are other accessories like heat recovery condensers and heat recovery wheels, which recover energy and thus raise plant efficiencies, which, in turn, raise the efficiency of the entire system.

It has already been noted that chillers are mostly imported and that their efficiencies are acceptably high. Moreover, raising chiller efficiencies is something that the manufacturers take care of. On the other hand, the other components of the plants involved are usually manufactured in the country. Also, system design is in the hands of our engineers. In conventionally designed plants, the energy consumption of the components and the rest of the system excluding the chillers could be comparable to that of the chillers. It is here that our engineers focus on designing and installing air conditioning plants. Substantial energy saving may be achieved (say, up to 25% of the total energy consumption by careful and skillful engineering). This is being addressed during the last few years. Raising energy savings achieved is an unremitting and never-ending task for our engineers.

The selection of systems, equipments and accessories of an air conditioning plant depends on a number of factors. Not all kinds of equipment, systems and accessories find use in every plant. One of the elements of good design is selection of appropriate equipment, systems and accessories for each and every plant – and there are a variety of them. Often there are a number of options too. Calculations and optimization exercises invariably precede finalization of system and equipment selection. Use of software and spread sheets and other calculations methods are widely practiced in HVAC work. While these are "practiced", it is necessary to strive for making them more rigorous and all-encompassing.

High Performance Buildings

The design teams as they were

This is all about what the air conditioning engineer does on his own. But his involvement on a project usually starts much before the project reaches a stage, where the nitty-gritty of his own design work can start. Ideally, he is in the picture right from the time the owner and the architect conceive their philosophy for the building and the sketch schemes get under way. The entire design team gets into action right from the word 'go'. Beside air conditioning, there are several other services involved like, structures, civil work, water system, landscaping, and electrical work etc. The design teams include participation from all such disciplines. And the air conditioning engineer interacts with the rest of the members of the design team and makes contributions and value additions. To be sure, this approach is not new, but in today's scenario, this needs to be implemented more deliberately and meticulously. In a nutshell, he should keep doing better and better at what he is doing. Also, there are a few other disciplines involved too - and that is a recent phenomenon.

The additions to the design team

An *energy consultant* enters as a member of the team. He has the responsibility of examining the various energy saving strategies – sometimes contentious too - proposed for the building by the various service disciplines, analyzing the strategies and come up with an appropriate menu of strategies.

There are also some experts from *green building rating organizations*, these days. They look at all aspects of building design and not any particular set of factors - in particular, not just energy - and make appropriate recommendations to achieve the owners' brief - to build a certified green building or of a specified rating category of green building.

There is above all, of course, the architect. As in the past, the architect continues to hold the overall command on how the building is going to be built and to balance the various claims and contributions of different disciplines and experts, needed to achieve a *high performance building*.

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Many of these activities are not new; they have constituted an integral part of the functions and responsibilities of architects and design teams for centuries. But what distinguishes today's teams is that they have to do more of whatever field they were engaged in - and in addition, many things that they were not doing at all. The involvement of the *energy consultant* and *green building advisors* are two typical cases. These are very recent developments say, a few months to a couple of years.

Focus on Energy Driven by Sustainability

We have been considering – essentially – the energy aspects of air conditioning all the while in this paper. This is driven by *sustainability*, which can be regarded as the mother concept, from which follows the centre place accorded to considerations of energy aspects. The concepts of green building, ASHRAE Standard 90.1, ECBC and air conditioning, all play a key role in all the factors of *sustainability* noted above. Although, *sustainability* and *green buildings* are not all about air conditioning or indeed, all about energy either, for that matter, they do deal essentially and comprehensively with air conditioning as a whole with emphasis on factors like comfort, indoor air quality (IAQ) and energy aspects (as well as energy aspects of other building services).They do figure very prominently indeed in both *sustainability* and *green buildings*.

Energy Concerns Date from the Arab Oil Crises of the 1970s

Long before, *global warming* became an issue of great concern, energy had become a vital factor in all engineering - including, of course, air conditioning. It was the Arab oil crises in the early 70s which brought the energy issue into focus. At that time, the scarcity of energy was the driving force. Scarcity, no doubt was a cause for great concern, but today other aspects of energy consumption have become even more critically important. This criticality arises from considerations of *global warming* and *climate change* rather than shortage of energy sources. The energy scarcity in the 70s however, was itself a sufficiently grave cause for ASHRAE to come up with Energy Standard 90.1. Published as far back as the year 1975, it is a voluntary standard, but has been made mandatory in a large number of states in US. It is also been widely applied in several other countries.

ASHRAE Standard 90.1 – the Widely Known Energy Standard in Air Conditioning

This Standard covers building envelope considerations, equipment efficiencies, and energy recovery concepts – amongst several factors and also, aims to stipulate maximum permissible energy consumption values for (high-rise) buildings. This is known in the industry as "Energy Performance Index" (EPI) and is expressed in KWH/m^2/annum. With the advent of threats from *global warming*, the EPIs are getting continually lower.

Thus, the Standard is responding to the ever-changing energy scenario all the time. Though published in 1975, it is still arguably, the most important document in energy related issues in the field of air conditioning.

ASHRAE in India

ASHRAE is an international organization and its influence is strong in India. There are three ASHRAE chapters in our country. Further more, ISHRAE is an affiliate of ASHRAE. For decades, air conditioning in India has been generally following the lead guide lines of ASHRAE in all technical matters. Given such strong influence and given the increasing population of imported equipment (a large percentage of which is manufactured by internationally reputed American majors), it can be readily appreciated that equipment efficiencies, system efficiencies, installation practices etc in India are following international standards and trends closely – though not without a time lag during the past couple of decades at least.

ECBC–2007, Green Buildings and ISHRAE

With *global warming* and *climate change* being the ruling buzz words today, the Government of India has focused on legislating energy standards throughout the country. The ECBC – 2007 is a case in point. It is basically, ASHRAE Standard 90.1. ECBC-2007 was launched in May last. It is a voluntary standard at the present time but is due to go mandatory in a matter of an year or two. ISHRAE is also associated in the framing of this Code. ISHRAE and the industry are both gearing up to implement this Standard. ISHRAE is also focusing on how it can be made more and more closely relevant to Indian conditions and requirement. ISHRAE will stay engaged with the Code authorities to furnish feedbacks, views and recommendations for keeping the Code continually in an updating mode.

The green building movement is also growing from strength to strength. As we have noted before, there is more to green buildings than either just air conditioning or for that matter, just energy alone. Never the less, both these have a vital role to play in the achievement of a *high performance buildings* and also earning certificates or classification awards under the system put in place by the Green Building Council of India (which is an arm of the USGBC). Here again, the Green Building Council stipulations and requirements, as far as building energy consumption are concerned, do not just rest

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heavily, but do so entirely on ASHRAE Standard 90.1 and ECBC-2007. Infact, ASHRAE is a strong supporter and promoter of the green building movement. ASHRAE has come up with several guidelines and publications, the most important of which is the "ASHRAE Green Guide". It has been described by ASHRAE as "*An ASHRAE publication addressing matters of interest to those involved in Green or Sustainable Design of Buildings*". This was published in the year 2003. It is a veritable bible for all those involved in green building design especially, those in the services segment. It is unnecessary to dilate upon its importance to the air conditioning community itself.

Like on the energy front, ISHRAE's role will be proactive on the *green building* front also.

Introducing HVAC Engineer to the Emerging Concepts and the role of ASHRAE and ISHRAE

The concept of *sustainability* and energy considerations also brings with it concepts of natural cooling, passive architecture, earth air tunnels (EATs), geothermal energy, wind tower, solar energy . . . as applicable to thermal aspects of building construction and performance. Air conditioning engineers are set to play their due role in meeting this emerging requirement. They have to strengthen their existing knowledge of these technologies, which have not figured in their day-to-day work so far.

Professional bodies and organizations like ISHRAE, ASHRAE Indian Chapters and the Green Building Council have been organizing seminars and conferences to familiarize professional engineers, architects, contractors and manufacturers with these emerging concepts. In the HVAC field, it is ISHRAE and the ASHRAE Indian Chapters that are playing a major role in imparting training and also, promoting the objectives of *high performance buildings*, *sustainability* and *green buildings*.

It is heartening to note that there are over 70 green buildings of different categories already in the country. The progress in the years to come will be spectacular – as can only be expected. The estimated cumulative numbers (of green buildings) is expected to touch 100 by the end of the year or even soar above 1000 by 2012.

HVAC Industry on Alert and Geared Up

The efforts of the HVAC industry and its professional bodies are not getting adequate exposure. When they do, the focus has been on HVAC as an energy guzzler. It is time to view the HVAC industry in a more balanced perspective. Its performance and achievement till date need to be noticed, although, it has to go a long way and do better. The endeavor will not cease.