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# Green Building HVAC – A Look at the Hazy Scenario

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## **Abstract**

*Starting with the way energy and climate change are driving air conditioning these days, this article takes the reader from concepts and related aspects of Adaptive Comfort, the ingestion of Adaptive Comfort Systems into Standard 55-2010, the Standards that relate to Green Building, the admission of low energy cooling systems to tackle whole-building cooling requirements as well as to participate in Mixed Mode Systems (MMS), the importance of temperature differences of cooling media across the coils, the importance of exit temperature differences of the cooled media, ASHRAE's initiative in taking over responsibility for creation of the Green Building in totality, the rising perception of dissatisfaction with Green Building performance amongst their users and investors, ASHRAE's aim to provide leadership for everything that has to do with Sustainability and Green Buildings. It ends with comments and suggestions on what is good for our country and sounds a wake-up call to all stake holders to take cognizance*

*of the lagging response in this country to developments the world over in the Sustainability and Green Building scenario.*

## **Introduction**

The need to do something different for Building HVAC became insistent from the year of the Arab oil crisis way back in 1973. Energy consumption of air conditioned buildings was viewed as a legitimate requirement regardless of how much it was – one did not pause to consider whether it was reasonable or too high. But 1973 changed all that. An energy crunch ensued and building energy consumption came under intense scrutiny. This was followed by the ODP issue, and the now familiar intractable problems, viz. global warming and Total Environmental Impacts leading eventually to climate change. The concept of sustainability emerged and soon its commercial avatar, the Green Building, entered the scene. In the mean time, studies and researches, equipment efficiency rise and innovations, evolving energy saving solutions and strategies,

generating Guidelines, Codes & Standards, the coming into being of regulatory bodies and legislation – were occurring. That brings us to today – a scenario that is littered with questions and throws challenges at our industry.

## **Features of the Current Scenario**

The complexities of the scenario contain technical as well as administrative and commercial aspects. We shall begin by noting the technical aspects.

- Introduction of the concept of Adaptive Comfort.

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## **About the Author**

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- Bringing NC (Naturally Conditioned) spaces into *Standard 55-2004* and pushing it more and more centre stage.
  - Introducing enhanced air movement and elevating its status almost to that of DB and RH as a tool to deliver comfort.
  - Providing SET\* (*Standard Effective Temperature*) as the basis for calculation of cooling effect of Room Air Movement. [\*SET, defined as the equivalent air temperature of an isothermal environment at 50% RH in which a subject, wearing clothing standardized for the activity concerned, has the same heat stress (skin temperature  $t_{sk}$ ) and thermoregulatory strain (skin wettedness  $w$ ) as in the actual environment.]
  - Opening up of the third compliance path into a rejuvenated *Standard 55-2010*, via ACS.
  - The ingestion of *Standard 55-2010* into *Standard 189.1*, thus linking comfort directly with energy.
  - The emergence of ANSI/ASHRAE/USGBC/IESNA – 189.1-2009 – *Standard for the Design of High-Performance Green Building Except Low-Rise Residential Buildings* as a comprehensive single standard for Green Buildings.
  - ASHRAE taking the lead role in Green Building Movement and changing its brand and tag-line.
  - Emergence of sustainability and climate change as the trade mark symbols of today's predicament.
  - Green Building Organizations.
  - Green Building Rating Systems: LEED (IGBC), GRIHA (TERI & MNRE), ECBC and Green Globe (US).
- It is easy to see that this scenario stems from considerations

of sustainability on which, perhaps, the heaviest impact is from energy. The significance of several of the points noted has been covered, especially the technical aspects, in detail in the References and Bibliography. *Figure 1* depicts developments and – to some extent – indicates the interplay of various factors involved.

### The Emerging Technical Aspects and Challenges

From the technical stand point, inclusion of NC spaces in *Standard 55*, emphasis being laid by ASHRAE on Adaptive Comfort to provide low energy cooling solutions for mainstream HVAC as well as for natural cooling, in applications for both MMS and whole building coding (in case of natural systems) offer points of interest and indeed engineering challenges.

An important point that has emerged in the past few years is the realization that passive cooling systems, though they are ancient in their origin, can be used to modernize current technologies. A few examples will serve to illustrate this point.

The current norms are based on room temperature of 24°C, RH of 50 to 60%, SHF of 0.8 to 0.9 and SAT of 13°C, dehumidified air flow rate of 190 to 235 l/s/TR and water flow rate of 0.16 l/s/TR. Likewise, there are conventional norms that are applied to widely used temperature differences, viz. temperature drops across cooling coils and exit (or leaving) temperature approaches. The latter typically apply to (a) refrigerant and air (DX coils), (b) refrigerant and water, (c) water and air, and (d) room to supply air and such parameters. All indications are that they are not necessarily valid in today's engineering and technological environment, since the

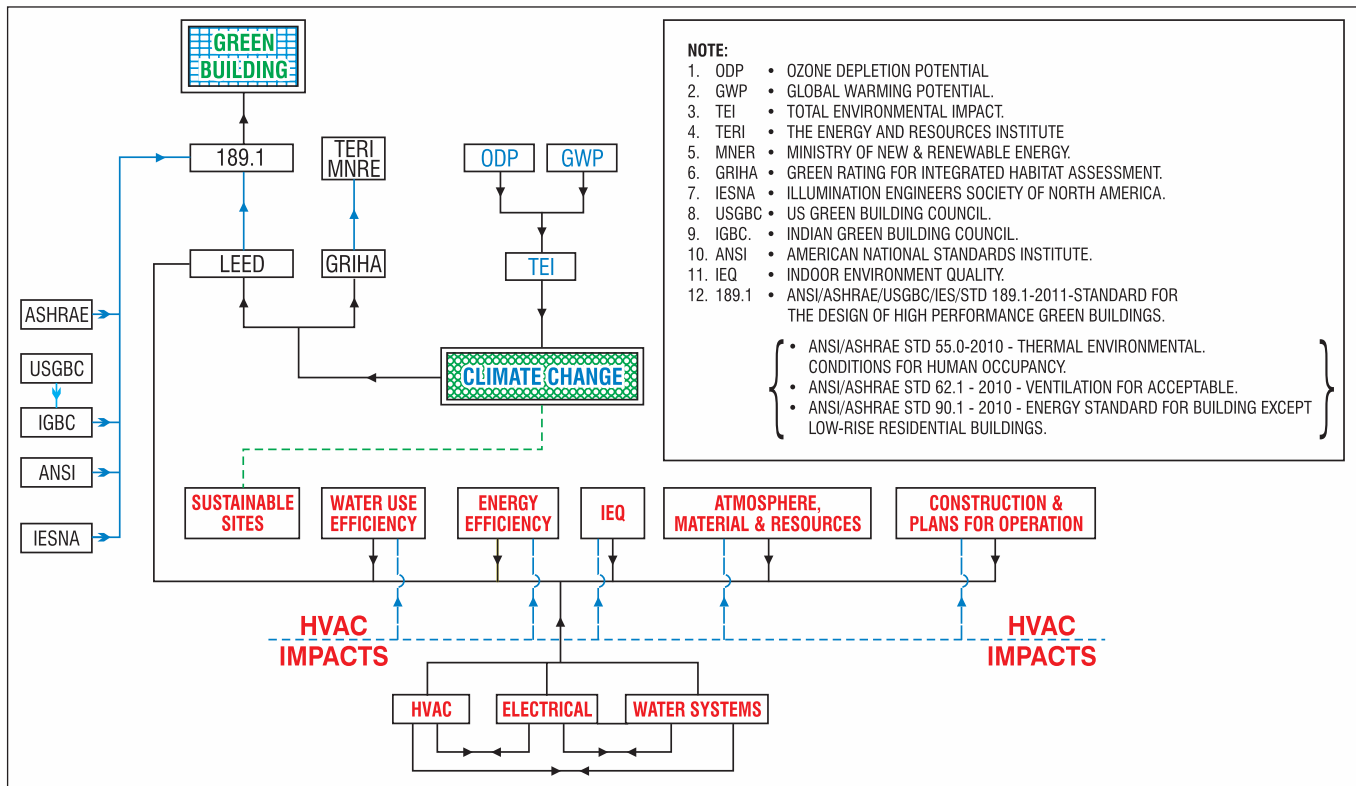


Figure 1: Development and interplay of various factors in the Green Building Model

### What is Standard 189.1 About?

Standard 189.1 provides minimum requirements for high performance; green buildings. (Note that “High Performance”, “Green Buildings” and “Multi-storied” all mean the same thing. This can be seen from the title of the standard itself). The standard is not a guide; nor is it a rating system, built on ASHRAE Standards 62.1, 90.1 and 55. Standard 189.1 prescribes compliance paths and also three levels of implementation, viz. *mandatory* (required for all projects), *prescriptive option* (simple option, very few calculations) and *performance option* (more options, but more effort). Goals for Standard 189.1 include establishing mandatory criteria in all topic areas, providing simple compliance options and complementing Green Building rating programs.

Topic areas of Standard 189.1 are sustainable sites, water use efficiency, energy efficiency, indoor environmental quality, and building’s impact on the atmosphere, materials & resources, construction and operations plans.

The topic area *sustainable sites* comprise site selection, measure for reducing heat island effect, reduction of light pollution and site development. Under *building’s impact on the atmosphere*, the topics covered include; construction waste management, wood products, refrigerants, storage and collection of recyclables and discarded goods, use of reduced impact materials, and life cycle assessment calculations.

Mandatory provisions for water use efficiency cover; site water usage, building water use, and water metering. *Water use efficiency* also deals with energy efficiency requirements.

current norms have evolved from considerations of convenience; they do not necessarily maximize either comfort or minimize first cost or operating cost. Nevertheless, they are deeply ingrained in today’s HVAC practice – and continue to be applied in day-to-day work. The trend however, is that conventional standards are being questioned insistently with the result that high-end design is gradually finding its way to increasingly large number of projects. While this observation applies to mainstream HVAC, the need for the trend to set-in in alternates to air conditioning – especially in passive cooling and evaporative cooling, is even more acute and immediate.

Worked examples over the years in ASHRAE hand book chapters on evaporative cooling do not consider ambient WB temperatures

It usually calls for higher efficiencies compared with Standard 90.1 requirements.

Under *energy efficiency* highlights, higher levels of performance are stipulated; Standard 90.1 provides the benchmark. The features include; electric peak load reduction, renewable energy provisions and energy measurements for performance verification.

Energy measurement requirements for various systems are stipulated.

Building envelope requirements are specified for roof and wall insulation, air barrier, fenestration and SHGCs. Minimum equipment efficiencies and economizer cycles for Package Units are stipulated.

Duct seal level requirements, raised fan efficiency requirements, exhaust air energy requirements; IAQ and thermal environmental quality (Standard 62.1) stipulation are all covered.

Annual energy cost, annual carbon dioxide equivalent (CO<sub>2</sub>e), peak electric demand and related topics come under *energy efficiency performance* topic area.

Indoor environmental quality - IAQ (62.1), thermal environmental conditions (Standard 55) and acoustical controls are covered.

Construction and operation requirements include plans for construction, building acceptance testing, building commissioning, erosion and sediment control, IAQ construction management, moisture control and construction activity pollution prevention. Commissioning includes activities – pre-permit, pre-occupancy and post-occupancy.

beyond 24°C. Further, room to supply air temperature differences can be as low as 3°C; even 2°C is not overruled, while ASHRAE repeatedly uses 5°C. Both are too restrictive.

The remarks made in the above paragraphs apply with equal force to day time ventilative cooling, night ventilative (convective cooling) and night sky radiative cooling (which can produce water temperatures of the order of 20°C in summer – in our country, when night skies are clear).

In all evaporative cooling (also called wet bulb technology), the ambient WB temperature is of crucial importance. Underestimating the WB temperature by even 1°C is liable to result in inadequate cooling. Likewise, consequence of overestimating by 1°C will mean the plant is over-sized and therefore, uneconomical – and

### Green Building Rating Systems

Indian Green Building Council (IGBC) is a part of CII-Godrej Green Business Centre, which is actively involved in promoting the Green Building movement in India. The council is represented by all stakeholders of construction industry comprising corporate, government and nodal agencies, architects, product manufacturers, institutions, etc. The council is industry-led, consensus-based and member-driven.

LEED India is the indigenized version of the LEED rating system and is administered by the Indian Green Building Council (IGBC) under license agreement with USGBC.

GRIHA has been conceived by TERI. (It has been developed jointly by TERI and Ministry of New and Renewable Energy, Government of India). It is a green building ‘design evaluation system’, and it is claimed that it is suitable for all types of buildings in the five climatic zones of the country. CPWD buildings are required to be compliant with grade-3 of GRIHA. It may be expected that all buildings in the public sector will be eventually covered under this requirement.

Developers, builders and owners in the private sector can exercise any available option if, like IGBC, other Green Building rating organizations establish their presence in the Indian market.

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the design will not be sold. Thus, a WB temperature which is not accurate to say,  $\pm 1^\circ\text{C}$  can affect a design either favorably or adversely. The techno-commercial fallouts are too well-known to the engineers and the industry to need elaboration.

Comfort temperatures for India could be selected using Adaptive Comfort Approach but they should be based on comfort votes exercised by inhabitants of our own country and in our own climate and cultural setting. Our participation in further evolution and application of Adaptive Comfort Approach should be meaningful (to us) and pro-active.

The COPs of mainstream air conditioning vary over a range. The values in the lower part of the range are around 3. They cover small commercial equipment, particularly in the unorganized market. They do not make it to the minimum requirements of *ASHRAE Standard 90.1* (and USGBC 189.1). Big plants using 0.5 to 0.6 kW/TR efficiencies (capacity 900 kW approximately) reach COPs of around 5. It has taken over 30 years for chiller efficiency to rise by about 40%. The rate of rise droops with rising efficiency. On the other hand, in passive cooling, COPs of the order of 10 and higher are achieved routinely. Passive cooling enters Standard 55-2010 in a conspicuous manner through compliance path 3 - for Naturally Conditioned areas. One should expect to see a trend towards pushing more and more comfort applications to Natural Conditioning to reap the benefits of achieving higher COPs at lower energy cost and rupee costs as well. Here again, it is unnecessary to elaborate on this theme.

### **The Techno-commercial Scenario**

Applications of passive cooling systems - like night time (convective) ventilative cooling, night sky radiant cooling – shifting thermal mass applications, earth-connected systems (e.g., Earth Air Tunnel) and so on call for more effort design engineers. Assuming that such efforts will be forthcoming, the approach and procedure would be to start with maximizing applications of the system with lowest energy cost and reaching in steps to increasingly more and more sophisticated systems, till a situation is reached when even the most sophisticated system in that category will not be able to maintain the requirements of the upper limit of the comfort proposed. It will then be time to think of more powerful and sophisticated systems (involving mechanical refrigeration) entailing higher energy cost leading eventually to the next category. This process will continue till all available natural cooling systems are tried one after the other. At each category, the endeavor will be to raise the bar for the best performance obtainable in that category.

### **Focus on the Third Compliance Path – ASHRAE Standard 55-2010**

The *ASHRAE Standard 55-2010* helps arrive at the design comfort temperature for Naturally Conditioned spaces (compliance path 3). It is possible that the upper comfort temperature limits so arrived at will be lower than those that will be acceptable in at least some tropical regions of the world. Provision may therefore be made in the Standard to accept higher comfort temperatures where desired, while still retaining the comfort model of *Standard 55*

intact. In fact, the adaptive approach may be more meaningfully applied by permitting each community to evolve its own comfort temperature values, while retaining the methodology and other procedures contained in *ASHRAE Standard 55-2010* for measurement or/and processing the measured values.

*ASHRAE Standard-55* has three compliance paths:

- 1) Graphic Comfort Zone Method
- 2) Computer Model Method
- 3) Adaptive Approach

The first two paths apply to conventional air conditioning (main-stream air conditioning) design systems. The design solutions to meet compliance requirements in paths 1 and 2 are available readymade in the industry, having evolved continually over several decades in a scenario of increased levels of expectation of comfort and matching design solutions developed to meet them, more or less on-line and also, with matching revisions in standards. Such a (relatively) happy situation does not prevail in the case of compliance path 3 (for Naturally Conditioned spaces). Here, design solutions together with evolved and accepted methodologies are not yet available. This is not an encouraging situation. (It exists even in North America, though not with the severity we perceive in our country). Work must start right from creating awareness amongst engineers. Increased knowledge levels and skills are to be imparted to the engineers (and others in the industry as well) to cope with this situation.

The demarcation line between main-stream HVAC and low energy cooling may become fainter and fainter and eventually cease to be noticeable. Additional knowledge and learning become essential for HVAC engineers if they are to tackle the situation. It is not clear at this point as to who will do it. There is ample concern about such issues in the US and action is being taken all the time. In our country, HVAC engineers may be content to leave the burden of additional knowledge and learning to LEED, GRIHA and such other rating and certification bodies; however, those bodies, it seems, are also not equipped adequately to play this role effectively. In US, ASHRAE talks about these needs. In our country ISHRAE does not, and nobody else does either. There is an immediate need to eschew the learning-lethargy that prevails.

### **HVACR Engineers Need to Acquire New Knowledge, Technical Expertise and Skills**

Involvement of HVACR in energy performance and Indoor Environmental Quality is obvious enough and is a known fact, but issues relating to other factors viz., Buildings' Impact on the Atmosphere, Material & Resources, Construction and Operations Plans are less so. In *Standard 189.1*, HVACR engineers inevitably need to interact with a larger number of disciplines even to do just their own work and many of them are relatively new to them. The HVACR team alone and by itself – even if it concerns only HVAC work – cannot determine energy issues anymore; it needs to take into account impacts made by other disciplines also. All processes which normal HVACR work involves, like design, choice of system, preparing schemes and tender document, execution of

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work, commissioning & operation and performance & validation – exhibit complexities not experienced hither to. Indeed, the infrastructure of the HVACR industry itself, as it exists today, will face demands and situations never before encountered. This can also be seen from the observations made by Kent W. Peterson, Chair, ASHRAE Standard Project Committee 189.1 (which produced *Standard 189.1*), in his presentation “Standard for the Design of High-Performance Green Buildings”.

### About Green Buildings Organization in U.S

ASHRAE takes responsibility for entire building and just not HVAC alone.

*Standard 189.1* is sponsored by four parties, but it is ASHRAE that has taken all the initiatives on its own. It is not just performance in HVACR that they now plan to provide, but the sustainable building itself in which HVACR is but one of the several factors and disciplines involved. ASHRAE – and by implication – the HVACR industry is responsible for the entire *Standard 189.1*. The challenge for the HVACR industry is all the greater. Therefore, Peterson asks a crucial question, and provides the answer too.

‘What is Your Best Path Forward?’ he asks — ‘*Begin to understand the impact of these new requirements on your business and technical expertise. Identify what requisite skills and knowledge you will need once this standard and green codes are implemented*’; is his answer.

The responsibility of delivering performance for the whole building rests with HVACR. From the fore-going couple of paragraphs, it is clear that HVAC is going to have to do more for less. ASHRAE has been contemplating several initiatives but their adequacy remains to be seen. For us the implications are even graver because this situation has not yet been recognized.

### Increased Demand for Air Conditioning Raises Heat for India and China

Nevertheless, it is clear that the issue has been receiving due attention – in North America, advanced countries in Europe and rest of the world but not India and some other countries mainly in Asia, Africa and Southern America. It is therefore disconcerting to come across a report of this kind:

#### Increasing Use of AC Heating Up Climate Change Worries

MUMBAI, India – Air-conditioning sales are growing 20% a year in China and India as the cooling needs of increasing populations grow. The potential cooling demand of Mumbai, India, alone has been estimated to be a quarter of that of the United States. According to an article in *The New York Times*, as air conditioners sprout up across the world, scientists are becoming increasingly alarmed about the impact their refrigerant gases have on climate change. This includes modern refrigerants in use as a result of the Kyoto Protocol. Researchers recently calculated that if all the equipment entering the world market uses the newest gases currently used in air conditioners, up to 27% of all global warming will be attributable to those gases by 2050.

– From ASHRAE’s weekly eNewsletter of June 28, 2012

A related development which is about one of the most important strategies to combat the environmental impacts - renewable energy – strikes a comparatively cheerful note.

#### Renewable Energy Investments Growing Around the World

NAIROBI, Kenya—Total investment in renewable power and fuels last year increased by 17% to a record \$257 billion, according to two new reports on renewable energy trends by the United Nations Environment Programme (UNEP) and the Renewable Energy Policy Network for the 21st Century (REN21). The REN21 report found that renewable energy use continued to grow strongly in 2011 in all end-use sectors: power, heating and cooling, and transportation. Renewable sources supply 16.7% of global energy consumption. According to the UNEP report, in 2011, the United States closed the gap with China as the top renewable energy investor. U.S. investments grew 57% to \$51 billion. China, which has led the world for two years, recorded renewable energy investment of \$52 billion, up 17%.

– From ASHRAE’s weekly eNewsletter of June 28, 2012

#### USGBC and LEED Face Stiff Competition in the US USGBC’s LEED v.12, GBI’s Green Globe

We can now turn to look at how the solutions evolved to the technical problems are being implemented in the field. A few points that follow will throw light on the scenario.

USGBC - and by implication LEED too – is facing stiff competition for its position as the No. 1 Green Building organization in the US. It is losing ground to its closest rival – Green Globe, a product of a Canada-based organization “Green Building Initiatives” which happens to be extremely active in the US. *Green Globe claims that its system incorporates features which are not available in LEED*. It is going all out to position itself as an alternative to LEED with the GSA (General Services Administration of the US Government), and is apparently succeeding.

ASHRAE’s tie-up with USGBC is close. ASHRAE is amongst the sponsors, and co-sponsors *Standard 189.1* along with USGBC and IESNA. It owns the *ANSI/ASHRAE/USGBC/IESNA - 189.1-2009*. This Standard is approved by the Board of Directors of ASHRAE (it also carries the approval of the USGBC Board of Directors, IESNA Board of Directors and ANSI). ASHRAE holds the copy right to this Standard.

ASHRAE is playing an active role in Sustainable Design. It espouses “Sustainable Policy”. Amongst its Strategic Plan Directives listed is – “ASHRAE will lead the advancement of sustainable building design and operations”. (See *Reference 1.*)

#### LEED v.12 Launch Postponed to June 2013

LEED is developed by USGBC. The USGBC is working over the past 3 years to launch LEED v.12 but have failed to do so. The president of USGBC has announced that its launch is put-off to June 2013. The delay is due to the number and variety of responses that the drafts (of LEED-12,) issued for public review, evoked. USGBC has not been able to field the clarifications sought

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and queries raised. Thus, LEED itself is in confusion. Excerpts from the recent announcement from Rick Fedrizzi, President, CEO & Founding Chairman, USGBC in the matter may be seen below.

*...they (the stake holders) need more time to absorb the changes we're proposing and to get their businesses ready to take the step with us...*

**Author's comment:** Are we giving ourselves any time for such study at all?

*...Our team believes that a simpler rating system nomenclature is more conducive to continuous improvement and maintaining clear communications throughout development. We're also committing to a fifth public comment...*

**Author's comment:** Looks like there is no organized way of evoking any comparable, meaningful public debate in our country.

Some of the sample responses to Rick Fedrizzi's message of June 4, 2012 given below help us to get an idea of the nature of these comments and the kind of flux that various views of LEED are presently in.

*The delay in the launch of LEED 2012 is a wise move on the part of USGBC and allows it to educate and inform the users and the public more fully about the proposed improvements to the LEED Rating System. It will also give USGBC a chance to hone the system that will support LEED v4 so hopefully it will not experience the type of growing pains and problems that have been experienced with LEED 2009. Brave move USGBC!*

– Anonymous

*Implementing a LEED building has proven to be expensive & frustrating for most of my customers; many will never do the certification again but will allow some of the principals. Please look clearly at the cost & political fallout of implementing more strict & complicated procedures. You are pushing the construction industry away for the sake of minimal long term savings with large up-front costs - Balance is needed.*

– Anonymous

**This is good news.. some of us are still working on v2.2 projects!** I would advocate for a 5-year release schedule, especially if major changes are being implemented.

– Nick

### **ASHRAE Changes its Brand, Logo and Tagline – HVAC makes way for Sustainability and Green Buildings?**

ASHRAE has changed its brand - logo and tagline as well. A few sentences from a recent mailer addressed to all members by President (2011-2012 ) Ron Jarnagin will hopefully suffice to give readers a helpful glimpse of an ASHRAE that is in transition.

*"...As time and technology have changed, so has ASHRAE, moving from focusing solely on HVAC&R to providing guidance for total building design, reconstruction, construction and operation..."*

*"...We are doing business as "ASHRAE" vs. using our full legal name of the American Society of Heating, Refrigerating and Air Conditioning Engineers. Use of ASHRAE reflects our*

*global membership and that our services will continue evolving globally..."*

### **Conclusion**

Developments and changes are taking place in the United States - and obviously in many other advanced countries too. Eventually, they will no doubt find appropriate solutions. It should not be assumed however, that solutions would be appropriate in our context also. This may be attributed to two factors - (1) India is a monsoon country and still a developing country. (2) We have not yet taken notice - not in an organized way in any case - of the problems we encounter. Validity of the solutions evolved in the US to "our context" is something which we can assess only after we have understood "our context". Many countries which are small, poor and weak have their own National Green Building Organizations and they are not necessarily or invariably aligned with such organizations in other countries, bigger and stronger than their own. Some of them were established even earlier than in UK, which did so only as late as in the year 2008. They had to encounter the harshest impact today of climate change - floods and erosion resulting in starvation, loss of vast areas of fertile and cultivable land, loss of property, mass evacuations, loss of life... on a large scale, something like a decade ago. They could not afford to wait. While we should continue to learn from advanced technologies from wherever they are available, we should not wait but work to stand on our own legs. Some of our problems, viz. need for having our own labs, raising knowledge levels and acquiring new learning, dealing with the emergence of Adaptive Comfort Approach, finding design solutions, acquiring or developing software... are known. The overarching requirement however, is a well drafted agenda and engineering will power to implement it. There has been no worthwhile debate as yet on initiating anything along those lines. It is time to make amends and start a debate forthwith to mount the effort.

### **References**

1. *Understanding Standard 189.1 for High-Performance Green Buildings*, by Tom Lawrence at ACREX 2010 at Mumbai
2. *Standard for the Design of High-Performance Green Buildings*, by Kent Peterson, PE, FASHRAE, LEED®AP, P2S Engineering, Inc.

### **Bibliography**

1. *Impact of Standard 55-2010 and Standard 189.1-2009* – on Air Conditioning - the Discipline, ASHRAE and the Industry, article by R.V.Simha – Published in April-June 2012 issue of ISHRAE's AC&R Journal.
2. *Looking at Standards 189.1-2009, 90.1-2007, 55-2010- all together, for Creating High Performance Buildings And/or Green Buildings*, presented by R.V. Simha at AcreConf-2012 in January 2012 at New Delhi.
3. *A Survey Of The Adaptive Comfort Approach & Its Impact on Alternates-to-Air Conditioning*, article by R.V.Simha, published in ISHRAE's AC&R Journal (Part-1 in Oct-Dec 2011 issue and Part-2 in Jan-March 2012 issue). ❖