A monthly newsletter of
Indian Association of Energy Management Professionals

# THE URJA WATCH

February 2009, Vol. II/Issue 8

***It is about "Conscience Keeping on Energy Matters"***

## FOCUS ON
## AIR CONDITIONING

# FOCUS ON AIR CONDITIONING

## What's inside…

**From the Editor's Desk...**

# Keeping Cool in Hard Times

Dear Readers,

We will soon be entering into the traditional dog days' of summer. Get ready to face high temperatures, and some oppressive humidity. The easiest thing to combat the heat is to turn up the air conditioner. Sure, it feels good – but then, it is tough to keep cool in the present hard times of serious energy shortages and economic constraints.

Keeping cool has been a human preoccupation for thousands of years. Ancient homes and buildings were built with natural cooling in mind. Ceilings were high, walls were thick, porches were deep and shaded, and wall-openings were placed to permit cross-ventilation of natural air.

All that has changed over the last century. New homes and buildings have taken different shapes. They were built differently using steel and cement, with lower rooflines and ceilings, glass windows, electrical lighting, and ventilation systems. Office buildings got pretty looks, with glass sheets stretching all sides from ground level to the top floors. In short, Ventilation, Air conditioning and Refrigeration technologies changed most of our fundamental patterns of living. The introduction of air conditioning radically altered the architectural design of buildings. Today, building air conditioning systems are designed to provide a more productive, comfortable and safe environment for the occupants.

However, cooling comfort does not come easy and cheap. It involves planning, costs big money in terms of capital costs of air conditioning equipment, associated pumps and electrical systems, and running costs of energy and maintenance.

Air conditioning typically contributes more than half of the energy consumption in most commercial buildings. We can deduce that a lion's share of energy consumption in buildings goes towards air conditioning. We need to explore ways and means to save energy and cut our cooling costs.

Fortunately, market forces and other environmental concerns have driven many innovations. Air conditioning has come a long way since its first appearance on the market as a cooling device for buildings.

Designs have continuously improved to achieve better efficiency. As a result, most of the present day new air conditioners consume thirty to fifty percent less energy than models manufactured during the 1970s. More fine-tuning controls are now available to adjust comfort conditions and save energy too.

Over the last few years, many significant changes have been introduced in the design of buildings and the associated mechanical and electrical systems leading to the concept of “Green Buildings”. Energy-saving insulations, for example, significantly reduce the amount of energy consumed by a building. A building designed in the recent past years uses much less energy on a per-square-foot basis than a building designed three decades ago.

Today, buildings can include new technology that features distributed intelligence in the form of personal computers and alternative telecommunications systems. And new air-conditioning systems provide greater comfort to occupants at lower cost by allowing individuals to adjust their office environments to suit their own needs.

The systems-designing professionals also recognize the growing need to respond to environmental and "green" building concerns. These include, but are not limited to, energy conservation as an end in itself, indoor air quality, sustainable design considerations, and new technologies that will better address environmental issues.

Addressing these issues with technical expertise - and eventually getting success - gives engineering professionals like IAEMP members the satisfying sense of participating not only in energy conservation efforts but also in building a better living environment for fellow human beings.

In this issue, you will find some articles that provide interesting insights into improving the working of modern air conditioning systems. I welcome your comments on these articles.

As always, I am counting on your input, ideas, and enthusiasm to make “The Urja Watch” a continued success. I would be happy to help you to get involved in some way.

Energetically,

S.Subramanian
Editor

## Letters to the Editor

---

Dear Sir,

Hearty Congratulations! - For bringing us the Special Republic Day Issue (January 2009) on RENEWABLE ENERGY, which is quite informative and focusing mainly on the non-conventional energy sources available worldwide and in our country.

No doubt India is blessed with enormous renewable energy resources. If put to use it can wipe off the huge import bills on the conventional energies. In spite of this fact, our Government is not at all making full fledged efforts to explore and utilise these resources.

As cited by Mr. F. T. Kanpurwala, in his article on Geothermal Energy, the moment Australian scientists estimated that only one percent of the nation's untapped geothermal energy could produce 26,000 years worth of clean electricity, the Australian government immediately announced a A$50 million (US$43 million) project to help develop technology to convert geothermal energy into base load electricity. Such immediate actions are required in India, but unfortunately, our political & administrative system is so selfish, corrupt and hopeless that nothing is being done.

To cite an example, one of our friends has developed technology to produce ethylene from waste, which can be added to motor fuels. He started his plant at Buti Bori, near Nagpur. It could have been developed on a very large scale with government support, but because of government's apathy, negligence and non-cooperation towards such industry, he is unable to produce and his unit is on the verge of dying. This is the state of affairs in India. How can we expect energy self-sufficiency by 2010?

Looks very difficult!

Ulhas Vajre
BEE Certified Energy Auditor
Navi Mumbai

# ENERGY CONSERVATION
# IN AIR CONDITIONING AND REFRIGERATION

By Rakesh Sahay

Heating, Ventilation and Air Conditioning, popularly known as HVAC, has become a necessary evil. That's what everybody thinks. They consume over 50 percent of the energy requirements of a commercial building and can be as high as 65 percent. What is it that makes it consume so much of energy? Why is there so much consumption and yet so many complaints? There is hardly any building where the occupants are satisfied with their Air Conditioning system and feel that they get what they are paying for, both in terms of installation cost (first cost or as inbuilt in rental tenancy charges)? What is it that ails this power guzzler?

First very few consider this important service as important and hence have little knowledge about it. Those who have some knowledge about it, feel they know all about it and hence make lots of mistakes. Last but not the least for every one person who feels that something is wrong and they should "ring the bell", there are others who ignore the issue and leave it for someone else to take up and rectify the matter.

While conducting energy audits on HVAC, there are a number of issues which crop up. In a multi-tenancy building (where the landlord provides the HVAC and tenants only pay the rents), very few of the tenants actually know about what is the rental that they pay for the HVAC. What are the various terms and conditions for which they pay? Hence miss out on saving opportunities. Sometimes it becomes prudent for the client to get professional HVAC help in understanding the implication of the clauses put in the agreement before agreeing and signing the agreement.

Most of the tenants only negotiate on the base building rental and do not realize the total cost of tenancy and thus lose a lot of money as "extras" or "user charges".

By doing this, they not only reduce their monthly expense, but ultimately also reduce the main plant operating costs to the owner/ developer. Thus it becomes "win-win" situation for both the parties concerned.

Get all the tenants together in the same premise and add up the HVAC charge that each pays. This amount when converted to usage must make logical sense of usage, which in most cases, does not, for e.g. in one of the buildings the total usage or generation was an average of "X"TR, while the total billing was adding up to "1.2X"TR.

This way 20 percent saving can be achieved without any modifications, just by uniting and sharing the information within the same building.

In the land of non violence and “Gandhian Principles” where we feel proud about lecturing about strength in unity, can we not do this simple act of coming together and discuss at least once a month on such issues which affect all together.

Another thing that regularly comes up in audits is the effective utilization or operation of the Variable Air Volume (VAVs) and Variable frequency Drives (VFDs) in Air Handling Units (AHUs). While conceptually the VAV and VFD are designed and installed to reduce the air quantity to match the load requirement, it is rarely checked or audited, after commissioning whether it is doing so. There is tremendous opportunity to conserve in getting the same audited and cross checked regularly. In a couple of sites it has contributed up to 40 percent of the possible savings.

In terms of load management, it is also prudent to check after SIX months of occupation the actual load on the installed motors. In most of the cases the motors are loaded to less than 50 percent which results in the motors operating at very low efficiencies and also with very low power factor. This leads to the input power as well as higher maximum demand.

Unfortunately in most of the IT and ITES offices the Server and UPS rooms has been the worst managed locations that one can come across. The power for the servers, the loading of the UPS and the air distribution and air conditioning of such locations leaves so much to improve, but none of the organizations are willing to listen and improve. While it is understood that they are critical to the operations and lots of contractual obligations are dependant on such facilities, but it is crime to waste energy the way it is done.

UPS are loaded to only 15-20 percent which then takes 60 percent more power than is required by the computers or servers. Thus losing so much more to air condition the same ineffective area and system.

Similarly the server room air distribution is so poor that most of the time the cool air is sucked back by the air conditioners and the hot air gets sucked back into the servers. This results in server’s fans automatically demanding higher air quantity and consuming more power. Sensing and displaying higher temperatures. This makes the air conditioners to be operated at lower temperatures and for longer hours, which again adds to power consumed and wasted.

It is also estimated that for some large houses, the amount of energy wasted in server and UPS rooms is enough to condition the balance entire area of the IT and ITES offices.

The entire air conditioning system ultimately releases the room heat to the atmosphere using the cooling tower or the air cooled condenser. Hence the effectiveness of these parts of the systems needs to be audited very regularly and kept at their best to keep lower energy consumption of the entire Air Conditioning system. In one of the sites it has resulted in reduction of 12 percent of the total Chiller plant power consumption by improving the cooling towers.

In smaller factories and industries the refrigeration systems are great power guzzlers and also does provide for great opportunities in energy conservation. Most of such utilities are 24/7 operation for such refrigeration packages and thus give more scope for conservation drive. Again the effectiveness of the condenser and cooling towers are very important. Also operating the chiller at the optimum temperature makes lot of sense. Even 1$^{o}$C change in temperature results in 3-5 percent of energy difference.

These great energy guzzlers are like high blood pressure patients, which need more care, weekly check ups, every day monitoring and daily exercises. Hence regular audit and monitoring is a must for such systems. Upkeep and keeping fit are two mantras for air conditioning and refrigeration systems. One should also be aware that there are lots of people and organizations which sell gadgets claiming power savings. Beware of such people and gadgets, never fall prey to such claims…….

Simple measures can reduce lot of wastage in such systems and hence careful evaluation of operations and performance is a must. Careful regular monitoring of these is also required and gives much better results with minimum or no investment, rather than gadgets, and quack doctors.

---

***About the author***

*The Author Mr. Rakesh Sahay is a member of IAEMP and a certified energy auditor with specialization in HVAC and Heat Recovery. He runs a company called eQube.*

# HIGH DELTA-T CHILLED WATER SYSTEMS

By R. V. Simha

***Editor's Note:*** *This is a detailed technical article based on a paper presented by the author. This long article is published in its full form so as to preserve its vital contents without any distortion.*

***ABSTRACT***

*Conventional chilled water systems (in air conditioning plants) work on a ΔT of about 5°C. This is raised to 9 to 10°C in High-ΔT systems. The big advantage is, of course, the reduction in water flow rate / TR.*

*Although high ΔTs are desired, they are not achieved readily. It is necessary to keep all of the several factors involved all the time in focus viz., the Characteristics of cooling coil, Design & selection of the cooling coil, Control valve characteristics, Authority of the control valve, Design of the branch circuit (comprising Shut-off valves, Balancing valves, Strainers, piping etc.,) during design, planning & execution of the project. Amongst the several consequences of this failure, the most conspicuous, are perhaps, the inability to load all chillers to their full capacities and the inefficient use of chillers.*

*This article discusses all those vital considerations, which it is essential to address, in order to achieve targeted plant performance & efficiencies.*

---

## 1. What is a High-ΔT System?

In conventional air conditioning systems, the difference between entering and leaving temperatures across the chillers (ΔT) is about 5°C. It will, however be higher – at around 9 to 10 °C - in the case of High-ΔT chilled water systems. This High-ΔT needs to be achieved not only at chillers but also on low side terminals like Air Handling Units and Fan Coil Units.

For the normal ΔT of 5°C (9°F), the flow rate will be 0.16 l/s (2.5gpm/TR). In a High-ΔT system, on the other hand, the flow rate comes down to 0.09 l/s (1.5gpm/TR). The reduction in flow will therefore be in the ratio of 5 / 9 i.e., about 0.55.

## 2. Benefits of High-ΔT

The most important benefits are, of course, reduction in sizes of pipes, valves, fittings, control valves, balancing valves and pumps. Obviously, the insulation cost will also be lower; likewise, connected pumps power requirements will also be lower. It follows therefore that one of the main themes in today's air conditioning systems viz., conservation of energy, is well addressed in this system. It is needless to say that first cost of entire piping system will also be lower in this system.

The saving in connected power due to smaller pumps employed will be greater than any increase in power requirements of the chillers due to the larger range through which the chillers will be required to work. These advantages become increasingly significant as the plant capacities go up. For large plants, therefore High-ΔT systems are the first choice.

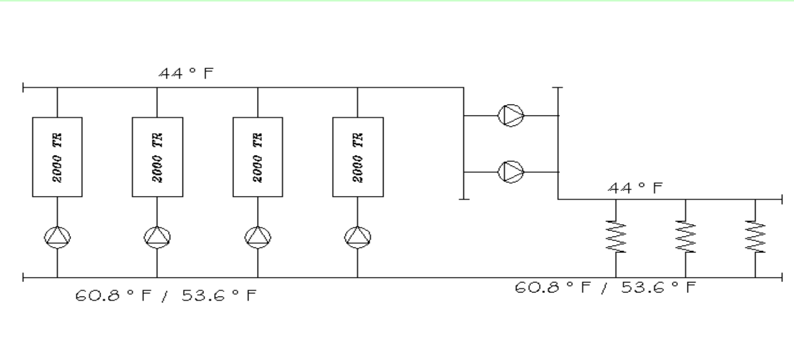
## 3. Low-ΔT Syndrome

The High-ΔT systems are not new, though they have come into vogue more recently than primary and secondary pumping for chilled water systems. High-ΔT systems are now accepted all over the world; nevertheless, there are, in fact, concerns about the difficulties / inability to achieve the high design ΔTs, so much so that the term "Low ΔT Syndrome" has gained widespread currency.

It is well to recall in this context, the history of primary – secondary systems of chilled water piping. The concept when it was introduced was readily accepted, - because of its obvious attractions. There were, many aspects of its design and performance that caused concerns; nevertheless, they did not deter the industry from accepting the system – the difficulties were merely addressed and solutions evolved – as indeed is being done even at the present time. Likewise, not withstanding the "Low ΔT Syndrome," High-ΔT systems have come to stay. And we need only to find solutions to tackle it.

What then are the several symptoms that constitute the "Low ΔT Syndrome"?

Figure 1 shows 4 nos. chillers each of 2000 TR capacity, so that the total plant capacity is 8000 TR at full load. A plant of this type may have to operate at loads as low as say 1500 TR (about 18% of full load). One would expect that it will suffice to run one chiller at partial load, to meet this load of 1500 TR. But, then such expectations are often believed.




$$TP_{\Delta T\,-16.2} = 2000 \times 1.5 \times 8.33\,(60.8 - 44.6) / 200 = 2000$$
$$TP_{\Delta T-\,9.0} = 2000 \times 1.5 \times 8.33\,(53.6 - 44.6) / 200 = 1150$$

*Fig 1 – Chillers cannot be loaded to their full capacity if ΔT is low*

Ideally speaking (in a High-ΔT system), the temperature of return water from the load should be around 16°C (61°F) for a supply water temperature of 7°C (44.6°F). The chiller in turn, will therefore cool from 16°C to 7°C. In practice, the return water temperature could be much lower - say about 12°C. It will deliver only 12 - 7 / 16 - 7 = 5 / 9 of 2000 TR i.e., 1100 TR. The chiller will continue to cool water to 7°C, but no lower. Its capacity will therefore be reduced to 1100 / 2000 x 100 i.e., 55%. Accordingly, two chillers will have to be on line (each delivering 750 TR approx) in order to deliver a capacity of 1500 TR. This is the situation at part load.

If the system had been designed for High-ΔT and it operates at lower ΔTs, the entire piping system including pumps, pipes, coils etc., it is obvious that it will turn out to handle the higher flow rates that the lower ΔTs will call for to meet the full load requirements. In effect, this is equivalent to under sizing of the plant.

## 4. Low-ΔT Syndrome compared to Low Power Factor Scenario

If then the High-ΔT Systems pose such serious problems how can they be tackled? It is perhaps easiest to start with an electrical analogy to gain a better understanding of the problem. That is because the Low-ΔT Syndrome is the equivalent of Low power factor in an electrical distribution system. Please see the comparisons below:

| | **Electrical Distribution** | **Hydronic Cooling** |
|---|---|---|
| Symptoms | ♦ High Current Demand<br>♦ High Voltage Losses In Conductors and Transformers | ♦ High Flow Demand<br>♦ High Pressure In Pipes and Heat Exchangers |
| Problems | ♦ Low Power Factor | ♦ Low Delta *T* |
| Root Cause | ♦ Large, Under-loaded Induction Motors | ♦ Improperly Designed, Operated and/or Maintained Cooling Coils. |
| Solution | ♦ Power Factor Correction at Induction Motors | ♦ Delta *T* Correction at Cooling Coils. |
| Benefits | ♦ Increased Power Distribution and Lower Current Demand and Lower Voltage Losses | ♦ Increased Cooling Distribution Lower<br>♦ Flow Demands Lower Pressure Losses |

## 5. Cooling Coil Design and Selection

Focusing again on the Hydronic Systems, it is obvious that the chilled water flow rate in a variable flow system should decrease as the load decreases – for otherwise, there would be nothing to commend it. This decrease does indeed occur, but how much should be the decrease?

First, we shall note that in a (cross flow) cooling coil, the standard conditions are 7°C entering chilled water temperature, 27°C mixed air entering temperature 12°C leaving air temperature and a water flow rate of 0.16 L/s (2.5 g/TR). One would assume – simplistically – that when the load falls to say 50%, so would the flow. The performance of such a coil would be "Linear". Unfortunately, cross flow coils do not have such characteristics, but instead, their performance is 'Non Linear'; thus, at 50% flow, the coil capacity is still 80% (and not 50%). Further, the flow required to produce 50% capacity is less than 30%). This can be seen from Figure 2 – which is taken from ASHRAE Hand Book Application Volume.

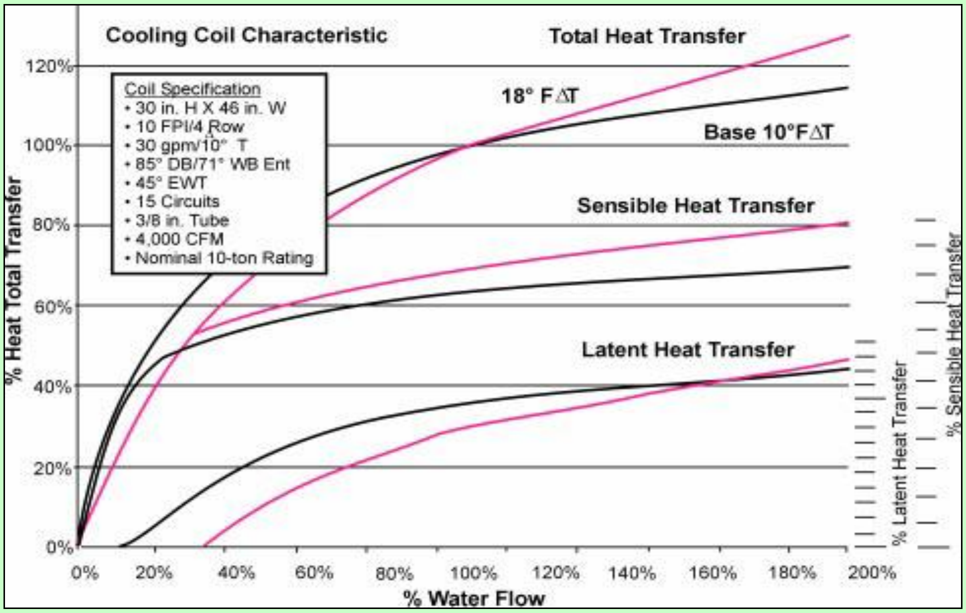



**Fig. 2 – Characteristics of Cooling Coil**

Saying that the coil capacity at 50% flow is 80% is the same thing as saying that the ΔT at 50% capacity should be 80 / 50 = 1.6 times the ΔT at 100% capacity. Thus if ΔT at full load is 9°C, it should be 1.6 x 9 = 14.4°C (2.6°F approx) at 50% capacity. (Incidentally this statement holds for the normal 5°C ΔT Systems also; in this case, the ΔT at 50% load should be 1.6 x 5 = 8°C).

### 5.1.1 Non-Linear Characteristics of Cooling Coil

Why is the coil characteristic non-linear?

We all know that a project engineer is invariably required to check a cooling coil section, when the manufacturer puts forward his submittal.

It is usual for him to fall back upon the following 3 equations.

$q_a = q_w = q$ = coil capacity - (1)

$q_a = Q_w \times \Delta h \times C_1$ - (2)

$q_w = Q_a \times \Delta T \times C_2$ - (3)

*Where,*

q = Coil capacity (given)

$q_a$ = coil capacity from air side calculations.

$q_w$ = coil capacity from water side calculations.

$Q_a$ = Air flow rate

$Q_w$ = Water flow rate

$\Delta h$ = Entering air enthalpy minus leaving air enthalpy.

$\Delta T$ = Leaving water temperature minus entering water temperature.

$C_1, C_2$ - are constants to take care of factors required to obtain results in desired units.

q = qw = qa

These checks are necessary and essential, but there is another equation and it is that which plays the vital role in understanding the low $\Delta T$ problem.

$q = q_a = q_w$ = A x U x LMTD - (4)

*Where,*

A = coil surface area.

U = Overall heat transfer co-efficient.

LMTD = Logarithmic Mean Temperature Difference.

In this equation, A is obviously constant for a given coil.

As the capacity falls at say 50% part load across the coil, if the chilled water also falls to 50% of full load flow, the heat balance between air and water would be neatly maintained. This would be simple. Unfortunately this is not how things work.

As the capacity changes, only U & LMTD can change (since A is constant for a given coil). U does decline with flow, but less rapidly than q, the capacity. Hence, at-say 50% air flow across the coil, the load will be 50% but U x A would have decreased by less than 50% - say about 40%. Thus the deficit must be met by a decrease in LMTD to balance equation 4.

Of the four temperatures that determine the LMTD, three stay essentially constant; the entering and leaving air temperatures do not change much – and likewise the chilled water supply temperature nearly constant. It is therefore only the chilled water return temperature that will act to increase (by means of reducing the chilled water flow rate) to reduce the LMTD in response to the reduced load.

The whole point is that ΔT increases at coil part load or alternately, the chilled water flow is reduced to a greater degree as load falls off.

### 5.1.2 Worked Example

A Worked example is presented below to support the above concepts.

***Coil data:***

100% air flow rate = 29250 cfm

A = face area = 62.5 sq.ft

Face velocity = 468 fpm (at full load)

***Nomenclature:***

a. GTD = Greatest Temperature Difference (°F)
= (Entering Air Temp.°F - Leaving water temp.°F)

b. LTD = Least Temperature Difference °F
= (Leaving Water Temp.°F - Entering air temp.°F)

c. LMTD = Log Mean Temperature difference °F

$$LMTD = \frac{GTD - LTD}{2.3 \log_{10} \frac{GTD}{LTD}}$$

d. U = Overall heat transfer co-efficient (btuh/sft/°F)

e. $\frac{Upl}{Ufl} = \frac{\text{U at part load}}{\text{U at full load}}$

f. TR = Tons Refrigeration

g. gpm = Water Flow Rate in gpm

h. LWT = Leaving Water Temperature °F

i. EWT = Entering Water Temperature °F

j. ΔT = LWT - EWT

***Procedure:***

a. Using 100% values (row-1) calculate LMTD.

b. Again using 100% values calculate `U' value.

c. Calculate LMTD for 75% value (row-2) assuming U = 0.9 times full load value.

d. Enter LMTD value from previous step in the LMTD equation & solve for LWT by trial & error

e. Determine ΔT from LWT & Chilled water supply temperature.

f. Determine the flow rate.

## Results of Calculations:

The table below furnishes the results of the calculations:

| | TR | ΔT - °F | Upl / Ufl | gpm | |
|---|---|---|---|---|---|
| | | | | Calculated Values | Manufacturer's Data |
| 1 | 92.8 | 16.3 | 1 | 137 | 137 |
| 2 | 74.6 | 19.7 | 0.9 | 91 | 110 |
| 3 | 54.2 | 22.8 | 0.8 | 57 | 80.4 |
| 4 | 30.3 | 26.2 | 0.6 | 28 | 45 |

***Calculations:***

Consider conditions corresponding to Row 2 (i.e., at 74.6 TR load)

a. Calculate LMTD for 100% values (Row-1)

$$\text{LMTD} = \frac{\text{GTD} - \text{LTD}}{2.3 \log_{10} \frac{\text{GTD}}{\text{LTD}}}$$

GTD = 78.6 - 60 = 18.6

LTD = 54.5 - 42.8 = 11.7

$$\text{LMTD} = \frac{18.6 - 11.7}{2.3 \log_{10} \frac{18.6}{11.7}} = 14.9\text{ °F } (9.50\text{°C})$$

b. Calculate U From Row 1 (100%) :

Using 100% load values:

TR x 12000 = A x U x LMTD

92.8 x 12000 = 62.5 x U x 14.9

$$U = \frac{92.8 \times 12000}{62.5 \times 14.90} = \frac{11136000}{931.3} = 1196 \text{ btuh/sft/°F}$$

c. Calculate LMTD for 75% values (Row-2) :

74.6 x 12000 = 62.5 x 1196 x 0.9 x LMTD

$$\text{Hence, LMTD} = \frac{74.6 \times 12000}{62.5 \times 1196 \times 0.9} = \frac{895200}{67259.35} = 13.3$$

LMTD required = 13.3 °F.

d. Calculate Leaving Water Temperature:

$$\text{LMTD} = \frac{(78.6 - \text{LWT}) - (53.3 - 42.8)}{2.3 \text{ Log}_{10} \dfrac{78.6 - \text{LWT}}{53.3 - 42.8}}$$

$$= \frac{(78.6 - \text{LWT}) - 10.5}{2.3 \text{ Log}_{10} \dfrac{78.6 - \text{LWT}}{10.5}} = 13.3°\text{F}$$

*Calculate LWT by Trial & Error from the above equation:*

Try LWT = 65

$$= \frac{\Delta\ (78.6 - 65) - 10.5}{2.3 \text{ Log}_{10} \dfrac{78.6 - 65}{10.5}}$$

$$= \frac{13.6 - 10.5}{2.3 \text{ Log}_{10} \dfrac{13.6}{10.5}}$$

$$= \frac{3.1}{2.3 \text{ Log10 } 1.295238} = \frac{3.1}{0.258} = 12.0°\text{F}$$

Since the discrepancy between the required value (13.3°F) and the calculated value (12.0 °F) is not acceptably small, repeat the calculation with different value of LWT. This procedure leads to a LWT value of 62.5 °F (for which LMTD is 13.1°F).

e. Determine $\Delta T$ = 62.5 - 42.5 = 20.00

$$\text{f. Determine flow rate} = \frac{24 \times \text{TR}}{\Delta T}$$

$$= \frac{24 \times 74.6}{20} = \frac{1790.4}{20.00} = 89.52 \text{ gpm}$$

***Notes:***

1. *U values shown at different loads are assumed values. They are not actual values, but the actual values will be proportional to them.*
2. *Calculations have been made on the assumption that the coil is handling only sensible heat load.*
3. *The calculations have been made to illustrate the concept. Actual coil selections should use U value calculations based on approved procedures and duly factoring Latent Heat loads.*

### 5.1.3 Example of Cooling Coil Selection

It will be useful to take a look at the Tables 1 & 2 below at this point.

***TABLE – 1***

***Table - 1a***

***Data of Manufacturer - 1 dated 23.08.2004***

| **Capacity %** | **Total TR** | **Flow** | | **ΔT** | | **LPS/TR** |
|---|---|---|---|---|---|---|
| | | **USGPM** | **LPS** | **Deg C** | **Deg F** | |
| 100 | 92.8 | 137.5 | 8.56 | 9.0 | 16.26 | 0.092 |
| 75 | 74.6 | 110.0 | 6.88 | 9.0 | 16.28 | 0.092 |
| 50 | 54.2 | 80.4 | 5.03 | 9.0 | 16.19 | 0.093 |
| 25 | 30.3 | 45.0 | 2.81 | 9.0 | 16.17 | 0.093 |

***Table – 1b***

***Data of Manufacturer - 1 dated 21.01.2005***

| **Capacity %** | **Total TR** | **Flow** | | **ΔT** | | **LPS/TR** |
|---|---|---|---|---|---|---|
| | | **USGPM** | **LPS** | **Deg C** | **Deg F** | |
| 100 | 92.8 | 137.5 | 8.59 | 9 | 16.2 | 0.093 |
| 90 | 83.3 | 115.7 | 7.23 | 9.6 | 17.28 | 0.087 |
| 80 | 74.1 | 98.8 | 6.17 | 10 | 18 | 0.083 |
| 70 | 64.8 | 83.1 | 5.19 | 10.4 | 18.72 | 0.080 |
| 60 | 55.6 | 68.0 | 4.25 | 10.9 | 19.62 | 0.076 |
| 50 | 46.3 | 54.2 | 3.38 | 11.4 | 20.52 | 0.073 |
| 40 | 37 | 41.5 | 2.59 | 11.9 | 21.42 | 0.070 |
| 30 | 28 | 30.1 | 1.88 | 12.4 | 22.32 | 0.067 |
| 20 | 18.7 | 18.8 | 1.17 | 13.3 | 23.94 | 0.063 |

# TABLE – 2

## DATA OF MANUFACTURER 1 & 2 COMPARED

**Table – 2a**

**Manufacturer – 1**

| Capacity % | Total TR | Flow | | ΔT | | LPS/TR |
|---|---|---|---|---|---|---|
| | | USGPM | LPS | Deg C | Deg F | |
| 100 | 92.8 | 137 | 8.56 | 9.0 | 16.2 | 0.092 |
| 75 | 69.45 | 91 | 5.69 | 10.2 | 18.4 | 0.082 |
| 50 | 46.3 | 54 | 3.39 | 11.2 | 20.1 | 0.073 |
| 25 | 23.35 | 24.37 | 1.53 | 12.9 | 23.1 | 0.093 |

**Table – 2b**

**Manufacturer – 2**

| Capacity % | Total TR | Flow | | ΔT | | LPS/TR |
|---|---|---|---|---|---|---|
| | | USGPM | LPS | Deg C | Deg F | |
| 100 | 84 | 125.1 | 7.81 | 9.0 | 16.2 | 0.093 |
| 75 | 62 | 78.7 | 4.91 | 10.6 | 19 | 0.079 |
| 50 | 42 | 45.9 | 2.86 | 12.1 | 21.8 | 0.069 |
| 25 | 21 | 20.0 | 1.25 | 14.0 | 25.2 | 0.060 |

This example serves to show how the ΔT at partial load has to increase over ΔT at full load. When this happens, the return water temperature goes up and the LMTD correspondingly goes down. Thus compensation for the inadequate drop in the U factor is achieved.

High return water temperature automatically means a high ΔT. To achieve this high ΔT, it is certain that precautions need to be taken while selecting the coil.

### 6.1.1 Coil - Control Valve as a Team

It is clear that the coil requires a flow that falls off steeply to begin with as the load falls from 100% load (valve in fully open position) but a flow that declines slowly as the valve nears its fully closed position. To achieve this, what is required is a valve which closes the flow ‘fast’ to begin with and only ‘gradually’ later as the capacity approaches zero. A valve with such a characteristic is a globe type (control) valve with equal percentage plug. Hence an equal percentage valve should be applied for proper flow control.

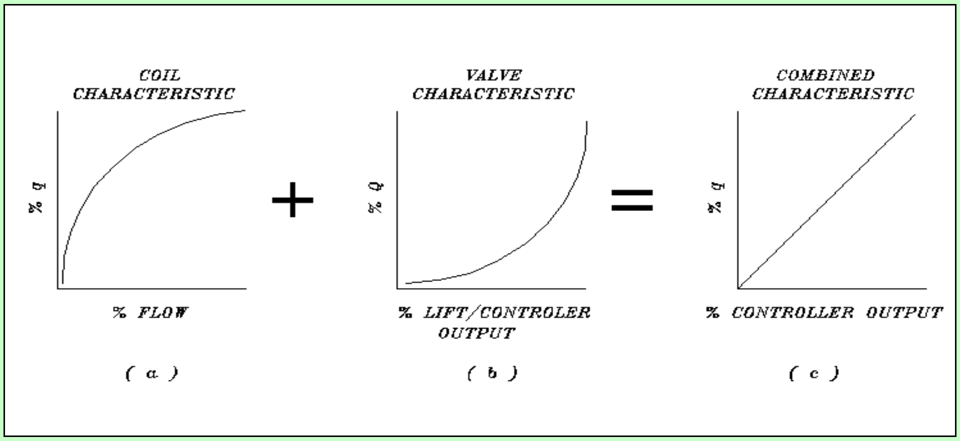



*Fig. 3 - Typical Coil & Valve Characteristic "Marriage"*

While Figure 3 is about the concept, Figure 4 shows it in a detailed and realistic manner.

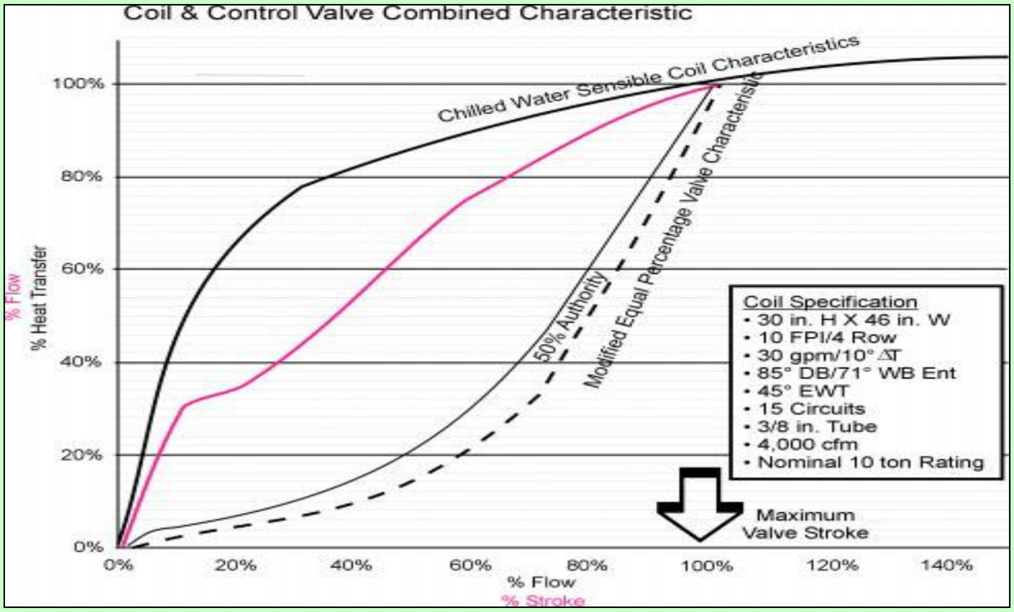



*Figure 4 – Typical Control characteristic with control valve.*
*The combined coil heat transfer characteristics for a cooling coil with a valve characteristic (valve Authority 50%) shown:*

In Figure 3a, the coil characteristic is shown. Figure 3b shows the valve characteristic. As already discussed, the former depicts the inadequate sensitivity of coil capacity for flow reduction to begin with i.e., as the valve starts closing and an improvement as the valve approaches the fully closed position. The valve characteristic (for equal percentage valve) shows 'fast' reduction in flow to begin with and a slow down as the valve approaches the fully closed position. The mutually complimentary nature of the characteristics results in a linear characteristic.

### 6.1.2 Valve Requirements

a. The valve should have a pressure drop that is large enough to ensure that its operation will have necessary impact on flow variation (control). An index of this aspect of valve performance is:

$$\frac{\text{Valve } \Delta P \text{ at 100\% flow}}{\Delta P \text{ of the branch circuit (in which the valve is operating)}}$$

This is called "Valve Authority". Its value should be 0.5 minimum.

b. The Rangeability of the valve (the ratio of flow at fully open position and minimum flow of the coil is likely to operate) should be not less than 50 to 1. This will ensure satisfactory modulation down to 1/50 of full flow.

c. The control valve should close tight against the highest differential pressure that the chilled water pumps can generate.

d. Valve actuators, valve cages, trim plugs & seals should be robust. Otherwise high velocities and throttling will cause deterioration of valve seats and permit chilled water leaks in valve closed position. A 50% safety factor is recommended.

See also Appendix - I for Definitions of Valve Terms.

## 7. Summary

Summarizing, it will be noted that the following points emerge:

a. Chillers should be specified for High-ΔT.

b. The chilled-water ΔT should be equal-to-design at full-load and greater-than-design at part-load in a variable –flow hydronic cooling system.

c. Chilled-water ΔTs are determined by a building's various terminal devices.

d. High chilled-water ΔTs result from proper design, installation, operation, and maintenance of cooling coils, control valves, control systems, distribution pumps and distribution piping.

e. More water chillers, larger chilled-water pumps, and/or larger chilled-water piping will not overcome the performance problems resulting from low/below-design chilled-water ΔTs.

## 8. Conclusion

Inspite of the "Low-ΔT Syndrome", High-ΔT systems are here to stay. Selection of chillers, coils, control valves and design of the rest of the system particularly piping system, has to be done to meet the demands of High-ΔT systems in a meticulous and professional manner. The designer should make sure that the coil and valve selections are carried out specifically to meet the stipulations. The supplier of coil and valves in particular should understand the requirements thoroughly and meet the requirements fully. The success of entire system will be assured and projected savings achieved, only if due attention is paid by detailed engineering.

---

Reference:


1. Kirsner. W, Trouble Shooting – Chilled Water Distribution Problems at the NASA Johnson Space Centre – HPAC Journal, February 1995 - Heating, Piping & Air-conditioning.
2. Fiorino D.P, Achieving High Chilled Water Delta *T*s – ASHRAE Journal, November 1999.
3. 2004 – ASHRAE Hand Book – HVAC Systems & Equipments – Chapter 42 – Valves.
4. 2003 – ASHRAE Hand Book – HVAC Applications – Chapter 37 – Testing, Adjusting & Balancing.


Bibliography


1. Kirsner, W, Low delta t central plant syndrome - – HPAC Journal, February 1995
2. Hegberg M.C, Control Valve Selection For Hydronic Systems – ASHRAE Journal, November 2000
3. Petit jean. R, 1997, Total Hydronic Balancing: A Handbook for Design and Troubleshooting of Hydronic HVAC Systems, Tour & Anderson Hydronics AB.


---

### *About the author:*

*Mr R.V.Simha, a veteran in the field of Heating, Ventilation and Air-conditioning (HVAC) has held the highest positions in ISHRAE and ASHRAE India Chapters. He has presented numerous papers in public forums. He has also served the committee which drafted the NBC-2005.*

## INNOVATIVE AIR CONDITIONING GADGETS

“Air Conditioned" Shirt

Plugging this shirt into the USB drive of your computer will pull in cool air to your body using fans positioned on the lower part of the back.

"Air Conditioned" Bed

This device will draw cool air in into the pad
and circulate it under your body while you sleep.

*Source: Internet*

# The Charm of a Ceiling Fan

By S. Subramanian

Having started my career in one of the oldest and highly-reputed fan-manufacturing companies in India, I cannot help talking about the virtues of the good old ceiling fan.

Despite awesome advances in air-conditioning technologies, one of the most sensible solutions to home comfort is the ceiling fan. A ceiling fan is a simple device and a charming supplement to home cooling. Compared to air conditioners, ceiling fans are a lot less expensive. They provide more value for your money as they consume much less energy and cost little to maintain. Where possible, it makes sense to install ceiling fans.

During the summer, using a ceiling fan in conjunction with an air conditioner will allow you to set the thermostat higher without a difference in comfort. You can call it a wind chill effect. A fan's breeze will make a 79-degree room feel more like 72 degrees. By raising the thermostat, you can save up to 30 percent on your air conditioning bills, depending on your home's construction and where you live.

How to choose a ceiling fan? Today, you can choose a ceiling fan from a range of staggering styles, configurations, sizes, materials, finishes, prices, and accessories. It is a difficult choice given the variety that is available in the market. However, high-quality fans have certain basic traits. I'll just mention a few:

1. First of all, it should have a strong heart - I mean a high quality motor. The best measure of motor quality is a company's history of market reputation. We do have fans that were manufactured in the 1950s by some reputed companies that are still running great.

2. They move air effectively through the room and noiselessly. You certainly do not want a fan with a motor that hums or buzzes.

3. Their parts are sturdy, well designed, made from high-grade materials that last longer. Watch for fans that come with flimsy components that may vibrate, rattle and have a short life.

4. They come in attractive and durable finishes with matching controls.

5. They are usually backed by a long-term warranty.

Good Luck in your purchasing decision and happy fan-cool times!

# Check List for Energy Conservation in HVAC

(Courtesy: M/Devki Energy Consultancy Pvt.Ltd.,Vadodara)

**1. Avoid Refrigeration & Air-conditioning to the Extent Possible**

* Use evaporative cooling for comfort cooling in dry areas
* Use cooling tower water at higher flows for process cooling

**2. Operate at Higher Temperature**

* Increase chilled water temperature set point if possible.
* Improve Air Distribution and Circulation
* Improve air Distribution in Cold Storages
* Measure and control temperature accurately

**3. Reduction in Air-conditioning Volume and Shift Unnecessary Heat Loads**

* Keep Unnecessary Heat Loads Out
* Use False Ceilings
* Use Small Power Panel Coolers
* Use Pre-Fabricated, Modular Cold Storage Units

**4. Minimise Heat Ingress**

* Check and Maintain Thermal Insulation
* Insulate Pipe Fittings
* Use Landscaping to reduce solar heat load
* Reduce Excessive Window Area
* Use Low Emissivity (Sun Control) Films
* Use low emissivity (sun control) films, revolving doors, air-curtains, PVC strip curtains etc
* Use Low Conductivity Window Frames
* Provide Insulation on Sun-Facing Roofs and Walls.
* Provide Evaporative Roof Cooling
* Building Structure Cooling
* Use High Speed Doors for Cold Storage

**5. Using Favourable Ambient Conditions**

* Use Cooling Tower Water Directly for Cooling in Winter
* Design New Air-conditioning Systems with Facility for 100% Fresh Air during Winter
* Use Ground Source Heat Pumps

## 6. Compressors

* Ensure correct charging of refrigerant and check seals regularly for leaks
* Avoid throttling of suction/discharge valves

## 7. Use Evaporators and Condensers with Higher Heat Transfer Efficacy

* Use Heat Exchangers with Larger Surface Area
* Install desuperheaters with heat recovery for applications requiring hot water.
* Use Plate Heat Exchangers for Process and Refrigeration Machine Condenser Cooling
* Avoid the Use of Air Cooled Condensers
* Evaporative Pre-coolers for Air-cooled Condensers
* Sub-cooling of liquid refrigerant is desirable by over-sizing of condenser.

## 8. Energy Saving Opportunities in Normal Operation

* Use Building Thermal Inertia
* Put HVAC Window Air Conditioners and Split Units on Timer or Occupancy Sensing Control
* Interlock fan coil units in Hotels with Door Lock or Master Switch
* Improve utilisation of outside air.
* Maintain Correct Anti-freeze Concentration
* Install a control system for multiple chillers.
* Optimise water/brine/air flow rates
* Defrosting
* Match the refrigeration system capacity to the actual requirement
* Monitor performance of refrigeration machines

## 9. Maintenance to Ensure Energy Efficient Operation

* Clean fouled heat exchangers
* Specify appropriate fouling factors for condensers
* Purging the condenser of air
* Do not overcharge oil
* Maintain compressor seals to avoid refrigerant leaks

## 10. Pumps/Fans/Blowers

* Optimise the performance of pumps, fans & blowers as the flow rates can have significant impact on the performance of the chilling package

## 11. Inter-fuel Substitution for Energy Cost Reduction

* In locations with process waste heat or waste heat from captive power plants, consider the use of absorption chilling packages.
* In locations with cheap fuel sources, like agro-waste, pit head coal or natural gas, consider the use of absorption chilling packages.
* Gas engine driven vapour compression packages can also be considered, especially when it is part of a cogeneration system.

## 12. System Design and Equipment Selection for Energy Efficient Operation

* Provide air conditioning only for specific areas when required for manufacturing process. Comfort air-conditioning should be minimised to the extent possible.
* Avoid over sizing to the extent possible – try to match the actual load, provide efficient method of modulation.
* Use larger heat transfer areas of evaporators and condensers.
* Sub-cooling of liquid refrigerant can be considered to reduce flashing of refrigerant in evaporator.
* Consider the use of vapour absorption machines when waste heat or other economical heat energy sources are available.
* Thicker insulation on pipes and vessels.
* Thicker insulation on the structure, provide building insulation.
* Use smooth, well-rounded air inlet cones for fan air intakes.
* Avoid poor flow distribution at the fan inlet.
* Minimise fan inlet and outlet obstructions.
* Use airfoil shaped fan blades.
* Use low slip or no-slip (timing) belts.
* Use variable speed drives for large pump and fan loads.
* Use energy efficient motors for continuous or near continuous operation.
* Eliminate or reduce reheat whenever possible.
* Purchase only high efficiency machines

# AIR CONDITIONING QUIZ

To tickle the brains of our esteemed readers, the editor has compiled a few questions on the basics of air conditioning. The questions are fairly simple. Just tick what you think are right and compare them with the right answers at the end. Don't cheat!

**1. How would a liquid react to an increase in pressure?**

A. It would change to a vapour
B. It would change to a solid
C. The boiling point would raise
D. The boiling point would lower

**2. Which heat causes a change of state?**

A. Sensible Heat
B. Specific Heat
C. Latent Heat
D. None of the above

**3. Which pressure opens the thermostatic expansion valve?**

A. Discharge Pressure
B. Equalizer Pressure
C. Evaporator Pressure
D. Thermal Bulb Pressure

**4. Which component meters refrigerant flow?**

A. Compressor
B. Evaporator Pressure Regulator
C. Thermal Bulb
D. Thermostatic Expansion Valve

**5. What will refrigerant absorb when left open to the atmosphere?**

A. Light
B. Moisture
C. Sound
D. Static Electricity

**6. In heating and cooling terms, 1 "Ton" equals:**

A. 1000 BTU/Hr
B. 5000 BTU/Hr
C. 10,000 BTU/Hr
D. 12,000 BTU/Hr

**7. Who discovered that Ammonia could chill air?**

A. Michael Faraday
B. W.H. Carrier
C. Thomas Alva Edison
D. W.H. Trane

**8. In which year was this discovery made?**

A. 1902
B. 1820
C. 1856
D. 1912

**9. A split air conditioners splits the:**

A. Condensing unit
B. Air handling unit
C. Hot and cold sides
D. Compressor unit

**10. COP is a term that refers to:**

A. Cooling Power
B. Compressor Performance
C. Coefficient of Performance
D. Condensor Performance

***Answers to Air-conditioning Quiz***

1.C, 2.C, 3.D, 4.D, 5.B, 6.D, 7.A, 8.B, 9.C, 10.D

**What is your score?**

8-10 correct: Wow! You are a real professional.
5-7 correct: Good! You need to polish up a bit.
Below 5: Cheer up! You can certainly learn more.

# IAEMP NEWS

## FIRST MEETING OF IAEMP-RAJASTHAN AT JAIPUR

### A report from Dharmendra K. Agrawal, Jaipur

On 8th February, 2009, the first meeting of IAEMP – Rajasthan Chapter took place at the premises of The Institution of Engineers, Jaipur. The meeting was attended by several enthusiastic IAEMP members. As this was the first meeting, the agenda was somewhat limited. After preliminary introductions of each other, activities covered the following topics:

1) Briefing about IAEMP and its activities.

2) Discussions on increasing the membership.

3) Discussions on Home Energy Management plan.

4) Forum to focus on energy issues to be taken up with the state authorities.

5) To contribute first-hand experiences in IAEMP publications.

6) To make IAEMP - Jaipur a self-sustainable forum.

7) Fixing up the date and venue for the next meeting.

We all look forward to a very meaningful association in future and take up important energy issues in a concerted way.

## NEW MEMBERS

### Mr Milind Chittawar,CEO of SEE TECH joins IAEMP

Mr Milind Chittawar,one of the most successful Energy Auditor in the country with international exposure has joined IAEMP. Based at Nagpur, he runs a successful BEE accredited ESCO company SEE TECH Solutions Pvt Ltd.( www.letsconserve.org)

# UPCOMING EVENTS

**BUSINESS INTERACTION MEET ON ENERGY EFFICIENCY, BHOPAL**
Indian Association of Energy Management Professionals
www.iaemp.org March 14-15,2009

---

ENVIROENERGY 2009, Chandigarh, India. March 19-21, 2009
International Conference on Energy and Environment
http://www.enviroenergy2009.org

---

U.S. Solar Energy Trade Mission to India March 22-27, 2009
http://www.buyusa.gov/pacificsouth/indiatrademission.html

---

ENERGY & LIGHTING EXPO-2009, Bangalore, India April 9 – 14, 2009
Palace Grounds, Bangalore
www.energy-09.com

---

WINDPOWER 2009 Conference & Expo, Chicago, USA May 4 -7, 2009
Organized by American Wind Energy Association
www.windpowerexpo.org

---

Clean Technology 2009. Houston, Texas, USA May 3-7, 2009
Energy, Water and Environmental Technologies
http://www.csievents.org/Cleantech2009/

---

World Renewable Energy Congress Bangkok, May19-22, 2009
WREC 2009 Asia, Thailand.
www.thai-exhibition.com/wrec2009asia/

---

PV America Conference & Exhibition, Philadelphia, USA June 8-10, 2009
Pennsylvania Convention Center,
www.seia.org

---

17th European Biomass Conference and Exhibition June 29-July 2, 2009
Conference Centre, Hamburg, Germany
www.conference-biomass.com

---

3rd Renewable Energy India 2009 Expo, New Delhi. August 10-12, 2009
Pragati Maidan, New Delhi, Organized by Exhibitions India Pvt. Ltd.
Supported by Ministry of New & Renewable Energy, Government of India
www.renewableenergyindiaexpo.com

---

## We Need Your Active Participation…

Do you have an area of expertise in energy management? Have you solved a difficult problem or have an interesting case study? Do you want to share a joke with others? Or just have a word of appreciation for this issue. Share your knowledge with others and promote yourself too, by writing to **The Urja Watch.**

You may also tell us about upcoming energy-related events in your area. Be sure to mention the title of the event, organizers, dates, venue, city, and contact information to get more details of the event.

Please note the following points while making your submissions:

- Articles must be original, in electronic version, 500 words or less. If you are using material from external sources, please acknowledge them.
- Please include contact information (full name, title/organization, phone numbers, and email ID) with your submission.
- Articles should be in MS word, single spaced, with easily readable font, preferably Arial size 12. Photos should be of high resolution.
- Please e-mail your submissions to Editor, "The Urja Watch" at tellsubi@gmail.com
- There are no deadlines for submissions. You may submit articles anytime.
- We reserve the right to edit, rewrite or reject any article.

## We Need Your Feedback Too!

Please write your views and suggestions to the editor at: tellsubi@gmail.com
Letters must include the writer's name, address, phone and email ID.

We appreciate your feedback and thank you for your support.