

“ENERGY EFFICIENCY IN BUILDINGS AND BUILDING CODES”

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Energy Efficiency in Construction.

World over, today the major thrust and Focus is on constructing environment friendly buildings. The concept is slowly spreading across various other countries across the globe, including India. Construction Industry in India is growing at a stunning 30 %. If this growth is to be sustainable, adoption of energy efficient housing sector is a necessity. This would go a long way in addressing the national priorities of water conservation and energy efficiency.

Boom in Real Estate in our Energy starving country is again imposing high power and energy requirements threats, to over come this threat we need to design energy efficient buildings, selection and use of energy efficient equipments to be installed inside the building as Major chunk of power is shared by high rise commercial complexes, institutional buildings and malls which are flourishing all around now a days.

Building Energy Saving

The Building Envelope

The building envelope consists of the walls, windows, doors, roof, floor and foundation. This exoskeleton does much more than simply contains the conditioned air for the comfort of the occupants. It is also a major contributor to the heating and cooling load. Heat moves through each of these elements, into the building in the summer and out of it in the winter. The higher the temperature difference the greater the flow of heat. The quantity of heat is also dependent on the quality of the insulation: better insulation increases the thermal resistance of the building envelope. Many projects focus on this principle of building design as a cheap, effective way to lower energy consumption.

- **Windows & Glass Facades**

Windows have the lowest insulation value of any element of the building envelope. They also permit radiant energy to enter a space, as opposed to conduction through the walls and roof. Thermal radiation accounts for a large portion of the energy in natural sunlight. Closing curtains or blinds will reduce the radiant contribution of the light and also reduce the conduction of thermal energy through the window. Double paned windows with blinds are ideal for all seasons. The insulation is needed in all seasons to retard the heat flow out in the winter, and vice versa in the summer. The blinds can either block or enhance the flow of solar radiation.

- **vestibules**

A vestibule is an elegant architectural feature of a building entrance that can also be a practical and effective energy saver. The double set of doors reduces a major portion of the building load attributed to the envelope: exfiltration and infiltration. These are, respectively, the passage of conditioned air out of the building and the movement of unconditioned air into the envelope. Busy building entrances can lose much energy, approaching losses from a door open to the exterior all the time.

The double set of vestibule doors greatly reduces the flow of air through an entrance. Automatic operation prevents a clear passage for air flow, since one set of doors is always closed. Also, the volume of air trapped between the portals acts as a buffer to the transfer of heat through the vestibule. When there is no traffic the trapped volume of air is an effective insulator that increases the thermal resistance of the passageway. Otherwise the glass vestibule can be a source of high energy loss.

- **Increase use of available day lighting**

The ideal lighting for any visual activity is natural light. It is best for color rendition, and it is a boost to the attitude and performance of the people within a space. Artificial lighting can only approximate the real thing, and then only a narrow band from the whole spectrum. It is always prudent to make the most of available day lighting, since it is not only the most healthy but also the cheapest light source.

Few offices can get by on day lighting alone. A common compromise is the use of multiple level switching. The perimeter offices of a building with outside exposures can have some lamps in each fluorescent ceiling fixture on one switch and the balance on another. For three lamp fixtures this permits four levels of lighting (off, one, two and three lamps) that can be used to supplement the available daylight. In large open offices, exterior hallways or classrooms with perimeter day lighting the outermost row of lights can be switched separately, or turned on by a photocell when the daylight is inadequate. The small additional initial installation cost will be compensated many times over by the savings and the occupant's comfort.

- **Increase insulation thickness if it is less than R-10**

Older buildings were designed at a time when energy was inexpensive and it was not economical to provide an effective amount of insulation. A good portion of the envelope losses are through the ceiling and the floor of a building if it not slab on grade. These areas are usually accessible and it is easy to increase the amount of insulation. Areas with colder winters and hotter summers should strive for at least R-10 insulation. A practical way to determine the ideal quantity of insulation is to survey local contractors to determine what they install in new buildings.

- **Install shading devices on south & west facing windows**

The highest heat gain of buildings in the northern hemisphere is from the south and west exposures. The energy consumption profile is reduced when windows facing these directions are shaded. Internal shading with curtains or blinds is one method, external shades are another. The application of solar film on the windows is also effective. The solar film has the benefit of reducing the radiation component of the glass - thus a big portion of the heat gain - without blocking the light that is itself often an energy saver. A final solution is solar screens for the south and west windows.

- **Plan landscape shading with fast growing trees**

The critical exposures of a building in the northern hemisphere are those facing south and west. They receive the most direct sunlight in the summer and account for a majority of the building's heating load. Shading of windows with blinds or awnings will reduce this heat gain somewhat, but trees will do this and more: they can shade the walls and even the roof of small structures.

Deciduous trees, in addition, will lose their leaves in the winter to expose the building to the warming sunlight.

Landscaping has another benefit. A portion of the heat striking the lower walls of a building arrives indirectly, reflected from rocks, sidewalks and parking lots or re-radiated from these surfaces. Shrubs, grass and ground cover reduce this heat gain by blocking the heat transfer path or dissipating the thermal flow. Shrubs are quite effective if they shed their leaves in the winter or can be trimmed to open the thermal path to the south and west facing building walls.

- **Unoccupied operations**

Good design practice requires separate air conditioning systems for areas that are regularly eight hour occupancies and those that are 24 hour occupancies. This applies to hospitals, schools, factories and other facilities on an extended work schedule. If the business offices, for example, are on a different unit from the factory floor then either area can operate after hours without having to provide air conditioning to other large spaces that are not in use.

Controls

The ultimate objective of any serious energy conservation program for a sizeable facility is a central, computer automated electronic controls system. This integrated system of remote sensors and control devices permits the optimum use of energy in all areas while simultaneously providing the best environment for building occupants.

- **Optimized start/stop of air handling units**

This is a more sophisticated use of the on/off controls of all the air handling units in a building. Instead of a complete cut off of power to a unit the variable frequency drive setting is setback at night and on weekends. The advantage over full on/off controls is that when units are turned off all night they must work extra hard to return the space to the comfort zone in the morning. This is especially important during the heating season, when the peak load often occurs shortly after the office opens in the morning.

Operation of the equipment to maintain a nominal space temperature all night reduces the energy needed to start up, so the equipment can be sized to satisfy a smaller peak load. This, in turn, translates into less expensive air handlers and ones that operate nearer their most efficient, full load condition.

- **Demand limiting**

The demand limiting philosophy is to begin turning off pieces of equipment as the electrical use approaches the peak. The software, already programmed with a prioritized list of items to be turned off, simply follows the list until the energy use curve is leveled off and the peak load passes. Clever programmers will make use of the building mass to provide some thermal momentum during these periods, extracting or rejecting heat to the building while the HVAC is turned off to always maintain a comfortable environment.

- **Peak load shifting**

Some systems accomplish demand limiting by shifting the building load to off peak hours. One way to do this is to run the chillers during the night to chill water that is stored in large tanks on the premises. Then during the peak building load the following day the chillers are turned off and the ready-made chilled water is circulated to the building loop. Other systems make ice in the night and melt it later to chill the loop water.

Keep in mind that the peak load that the system is designed to handle typically lasts only a couple of hours. Use of the aforementioned dynamic elements, eg letting the temperature and humidity drift upward in the process, will greatly reduce the daily peak load. Also, since this load is usually at the end of the work day the entire system will be shut down soon and no additional energy will have to be input to make up for the excesses permitted, since the building will equalize with its environment through the night, possibly aided by artificial circulation of outside air.

- **Load leveling**

A plot of a typical day will indicate several peaks and spikes. A peak will show a gradual increase to maximum of, for example, the HVAC system as the building approaches the maximum load. Spikes may indicate the operation of the laundry or kitchen for an hour of intense activity, when copious quantities of hot water are used and generated rapidly, and electric equipment operates at high loading conditions.

The use of energy to complete the necessary daily functions at the facility cannot be avoided. However, the timing is often flexible. Instead of operating the laundry in the middle of the afternoon, for example, when the HVAC is approaching its peak, the laundry can be done earlier in the day. This will not affect the actual energy used, but it will reduce the peak load because the baseline is lower. The lower daily peak, in turn, will reduce the demand fee charged by the utility.

Saving Energy in the Lighting

Most of this lighting is used in stores, offices, warehouses and factories. It is strange, then, that conserving energy with lighting projects is not a high priority for most businesses. They assume lighting is a fixed overhead item that cannot be substantially reduced as an expense.

One mistake businesses make is to concentrate on first cost and purchase the cheapest lamps. They do not bother to consider the life cycle cost of these lamps. This can be a big mistake, given the 20,000 hour life of a typical fluorescent lamp. Installation of more efficient lamps can pay for their modest extra cost many times over. Industries that ignore this reduce their own competitiveness by operating under an escalating overhead, increasing with the electric rate.

Any modifications to the original lighting design at a facility should be done so that the quality of the lighting environment is not diminished. Exact illumination levels have been established to be maintained for specific tasks in the workplace. A number of inexpensive projects can be done, however, that do not significantly affect the light levels. They can be implemented by the maintenance staff, often without engineering design or approval required.

- **Use fluorescent lamps for interior lighting**

Fluorescent lamps are much more efficient than incandescent lamps and should be used where possible, including task lighting and down lights. Compact fluorescent lamps are available that can

be screwed directly into incandescent sockets. Thus they provide inexpensive lighting without sacrificing the convenience of incandescent lamps.

High intensity discharge (HID) lamps are more efficient than incandescent flood lights and should be used in their stead. HID lamps are best suited for large interior spaces with a high ceiling such as lobbies and atriums. They are also ideal for locations that are hard to access, such as mechanical rooms or auditorium with high ceilings. HID lamps have a longer lifetime than either fluorescent or incandescent bulbs and do not have to be changed as often. Incandescent light sources are still best for some applications, such as pipe basements, housekeeping closets and other areas with special requirements such as darkrooms, photo labs and studios. Limited use of incandescent lamps in conference rooms and dining areas that need lamps to be dimmed is common, although fluorescent dimming systems are becoming more competitive and commonplace.

- **Limit decorative lighting**

Lighting in special areas such as conference rooms, lobbies, auditoriums and waiting rooms should be kept simple and functional. Special treatment for architectural purposes should use efficient fluorescent or HID lamps and should, where possible, double as general illumination. Decorative lighting of the building exterior should only be done if it is incidental to a functional lighting system.

- **Control exterior and parking area lighting**

Exterior lighting of walkways and building entrances can remain on during daylight hours or at other unnecessary times. If these lights are on a dedicated circuit they can be turned on and off independently by an electromechanical timeclock. Work hours do not always coincide with the hours of darkness. Often the exterior lights will burn when in is light out either before or after business hours. The time clock will automate this function and save the staff the trouble. It will have to be reset periodically, though, as the seasons pass. A photocell connected in series with the time will resolve this problem and further reduce the time the lights are in use.

Lighting for parking lots and parking garages will benefit from these controls as well, to insure the lights operate only when needed. Further savings are possible from circuiting the luminaires in logical groups that can be cycled on and off during the night. For example, a multi-level parking garage can leave only one level on during the off hours. This will work especially well for buildings with an integral garage. Such facilities often have only a single access door after close of business, so most parking will be near this entrance anyway. Parking lots can follow the same method, security needs notwithstanding.

- **Use separate work station switching**

Large work spaces with individual work stations separated by partitions are common in laboratories and business offices. When a single person works late the entire space must be lit. An energy efficient alternative is to switch the lights so that one level will provide area lighting, then other switches at each logical work area will activate overhead lighting specific to that area.

- **Maximizing Use of Day lighting**

Any room with outside windows has day lighting available to supplement the artificial luminaries. There are three types of daylight that can enter a conditioned space: direct, indirect and reflected. Direct light is the least desirable because it can cause problems from glare and it also has the highest contribution to the cooling load for a space. Reflected light can have similar consequences unless it is carefully controlled.

Some architectural features can be enhanced to increase the natural lighting available to a space. Reflective sills and properly angled Venetian blinds can be used to amplify the flow of light through windows or opaque openings such as glass brick walls. Even directing the light straight up to a light colored ceiling will help, as the reflected light from this ceiling will reach deep into the room.

Landscape features are also helpful to direct more natural light through windows. A reflective area on the ground beneath a ground level window - of gravel, a light colored wood or concrete - will direct more diffuse light through nearby wall openings. Carefully trimming shrubs, trees and ground covering around windows will also help. These plantings may be desirable around windows facing south or west in the summer, however, to prevent direct light from heating up the building excessively in the late afternoon. Many people will trim the plants anyway and use blinds or shutters when direct lighting is a detriment.

Another factor of daylighting to consider is that windows with closed blinds or curtains have a higher insulation value. This is offset by the fact that the lights in a room also generate a portion of heat that must be removed by the air conditioning. This may be as much as ten percent of the total load. With the exception of direct lighting, though, it is generally an energy saver to take advantage of the daylight and pay the small penalty in higher air conditioning cost.

The electricity savings made possible by increased use of daylighting can take several forms. In a space that can turn off all lights when outside conditions are favorable, the total lighting cost can be considered the net savings. Even though the available natural light varies through the day and from season to season, the annual electricity savings could be as much as 60% of the lighting bill.

Each of these systems will permit immediate savings, depending on the type of controls used and the extent to which the present switching must be modified. The cost and payback calculations can be complex, and will be detailed in the forthcoming section on controls.

- **Reducing Illumination Levels**

Use of task lighting can reduce the footcandle levels in a space and reduce the electrical energy demand by 20% - 50%. Good areas to consider for this M & O are large open office areas where each workstation has a desk lamp, such as an engineering office that provides each drafting table with a lamp. In such instances the overhead lighting is no longer used to provide a task-specific illuminance, but serves only to supplement local light sources at each desk.

Light levels can also be safely reduced in non-critical areas such as hallways, lobbies, waiting rooms, storerooms, mechanical rooms and restrooms. There are a number of ways to reduce the illumination levels. The best method to use depends on the type of lamps to be modified, incandescent or fluorescent. The energy saved will be in direct proportion to the reduction in wattage.

Architectural Concepts

This section will discuss projects which are normally in the realm of the architect's to decide upon and to implement as space planning measures or aesthetic embellishments. However, each has a bonus of reducing energy usage. For the architect struggling to build a pleasant edifice with a few niceties to make it stand apart, the ability to recognize and quantify energy savings makes it easier to persuade a thrifty client

to spend the extra amount now for savings later. Engineers will also learn something from this section. They will find that many subtle architectural features impact the energy using characteristics of a building.

- **Roof and wall colors**

The color of the roof and walls can have an impact on the energy use characteristics of a building. In a region with a long and demanding cooling season it is advantageous to have a light colored, reflective roof that reflects solar energy before it is absorbed into the structure and imposes a load on the air conditioning system. The same applies to the walls, especially those facing south and west. The opposite is true of buildings in colder latitudes, which benefit from darker roofs and north facing walls, to enhance the absorption of sunlight in the heating season.

- **Optimum space temperatures**

Many people have the mistaken impression that all the rooms in a building need to be kept at the same temperature all the time. When the idea of conserving energy by changing the variable frequency drive setting makes the rounds, most people think they have to be uncomfortable to save energy. The following table will prove even the skeptics wrong.

- **Selected wind breaks**

Many locations experience strong winds for much of the year. This can cause extreme infiltration, especially near entrance areas or service doors. Any project to stifle the force of these prevailing winds will reduce the load on the air handling system, caused by the outside air infiltration. Trees and shrubs as a wind break are an aesthetic solution. Other architectural elements can be carefully integrated into the landscape, such as opaque screens, wood fencing with alternating slats or even transparent glass block walls. Careful placement of any of these windscreens can greatly improve infiltration control.

- **Interior design aspects**

The advantages of daylighting have already been discussed, as beneficial to the morale and attitude of occupants. Having a nice view can also be a boost to productivity. These are not strictly energy saving options, but intangible benefits of a conservation project that should be tallied on the positive side of a project. Spaces with these features can demand a higher lease fee, so the value is not altogether immaterial.

Another often unnoticed feature of a room is the wall color. The reflectance of the floor and walls have a great impact upon the ambient light level in a space - the lighter the color and the more reflective the surface the higher the footcandle level for a given fixture. This means a room with dark paneling will need up to twice the lumens from the lighting than the same room with light colored walls. The same variance applies to the use of dark carpeting versus light, semi-reflective tile or linoleum floor covering

Use of Variable Frequency Drives for Optimum Energy Saving

Introduction

Many electric motor-driven devices operate at full speed even when the loads they are serving are less than their capacity. To match the output of the device to the load, some sort of part load control is in use for the majority of their life. Examples include pumps, blowers, fans, conveyors, compressors and chillers.

Many part load control strategies waste energy. The most efficient method of part load control, resulting in minimal wasted energy, is the variable frequency drive (VFD).

VFDs accomplish part load control by varying electric motor speed. Energy savings of 50 percent or more over other part load control strategies are common.

Fluid flow control

The majority of variable frequency drive applications are for centrifugal pumps, blowers and fans. The savings potential for these devices is the largest since the theoretical input power varies with the cube of fan/pump speed and volume.

For example, a fan operating at half speed will require only about 13 percent of full speed power. Losses in the variable frequency drive will reduce savings somewhat, but the savings are still very impressive.

Air and water flow control is accomplished by either of several methods, including recirculating a portion of the flow, throttling, variable inlet vanes, and variable frequency drives.

Variable inlet vanes apply only to fans and blowers, not pumps. Inlet vanes control flow by pre-spinning the air entering a fan wheel or compressor impeller in the direction of rotation, which effectively varies its capacity.

Variable frequency drives can also be applied to what are called constant torque loads. Unlike the fan and pump power which varies with the cube of speed, constant torque applications vary power in direct proportion to speed. This results in lower savings for a given reduction in speed but there are still significant savings available in some applications.

Variable air volume systems

Variable air volume systems should always have a variable frequency drive installed to control volume. A variable frequency drive serving a variable air volume system operating for a typical 3,000 hours per year will pay for itself in two to five years for a return on investment of roughly 20-50 percent. Variable frequency drives on larger motors will offer a higher return on investment.

For "custom" applications associated with process fans or pumps, almost any scenario where the flow is being reduced to 90 percent or less of full volume for 4,000 hours per year or more is a good candidate for a variable frequency drive. Variable frequency drives installed to reduce flow significantly can easily pay for themselves in under a year for a return on investment of over 100 percent.

Circulating pumps for hot water heating systems

Circulating pumps for hot water heating systems are a good application for variable frequency drives, provided the hot water temperature is not reset according to building heating loads or outdoor air temperature.

Hot water temperature reset is an automatic lowering of water temperature when the heating loads on the building decrease. When this happens more flow is required to meet the heating

demands of the zones in the building. This keeps the required flow higher, which reduces variable frequency drive savings.

It should be noted though that disabling hot water temperature reset is not advised to achieve pumping savings. Hot water reset results in lower heating costs and allows the temperature controls to work considerably better which provides a more comfortable building.

Chilled water circulating pumps

Chilled water circulating pumps provide good opportunity for savings for variable frequency drives. Although the cooling season in the Midwest is fairly short, in most cases the pumps run continuously, including during light cooling loads outside normal business hours.

To achieve variable flow savings, the valves will need to be converted to two-way valves so that reduced pumping volume can result during periods of low cooling loads.

Additionally, a primary/secondary chilled water system may have to be established to maintain the required minimum flow through the chiller.

Geothermal heat pump systems

Almost without exception, variable frequency drives should be installed on circulating loop pumps for geothermal heat pump systems. The long hours of annual operation, particularly at low heating and cooling loads, provide lots of savings potential even for small pumps less than five horsepower.

Cooling towers

Cooling towers can be a good application for variable speed drives. The savings for cooling towers are generated by operating the fan(s) at lower speeds for longer periods of time as opposed to cycling the fans on and off at full speed. This reduces the energy consumption and in some periods may reduce billed demand.

Some chilled water applications that use a cooling tower may have condenser water temperature reset where the condenser water temperature is lowered during periods of low wet bulb temperature (or dewpoint). This saves chiller energy and although the tower fan will have to run faster to achieve lower condenser water temperature, the chiller savings more than offset the extra tower fan energy.

Use of Double Glazing for Optimum Energy Saving

An integrated system, By that, we mean each of the sub-systems such as lighting and heating is designed to work with each other sub-system so that benefits and savings accrue. This approach is followed through in the way the building deals with heat and light.

Each aspect builds on the next to achieve a total energy saving of 65% compared with a typical commercial building of the same size.

1. Reduce thermal loads

The internal thermal load of the Building is reduced 53%:

2. Widen the thermal control band

The building has been designed to operate between internal temperatures of 19° and 26°. This reduces heating and cooling energy use by 41% by using natural, fresh air ventilation when the outside temperature is between 19° and 26°.

3. Use daylighting

Encouraging daylight to enter the space reduces the electricity consumption for artificial lighting 52% below the (already lower) demand management savings identified above. Further savings are realized because the reduced internal load does not have to be removed by mechanical air conditioning plant.

4. Natural ventilation

Allowing fresh air to flow down through the light wells, across the tenancies and up into the atrium to be vented into the atmosphere through the thermal chimneys. Exposing internal thermal mass (bricks and concrete surfaces) provides a thermal store and lower radiant surface temperatures. A little over 50% of the ceilings are exposed for this purpose. The use of 'night purge' when the overnight outside air temperature is below 24°. This cools the building structure and reduces the need for mechanical (active) cooling during the next day.

5. Low E double glazing

Double glazing and the use of 'low E' window coatings reduces heat loss in winter. This type of glazing also causes the inside surface of the window to be closer to the internal air temperature thereby improving the radiant temperature felt by the occupant. That is, it is more comfortable to sit near one of these windows.

Use of Renewable Sources of Energy

Solar panels can be used on the roof of buildings for power generation to meet the peak demands of power and also for hot water generation for heating applications. Even though the capital cost for installing the panels is higher the energy available is free of cost.

The captive power generation facilities of the buildings must be designed in combined cycle mode wherein the waste heat of the flue gases of the generating units is recovered for the production of chilled water. This heat energy can be utilized either in the form of steam or can be directly fired in the Vapor absorption machines to produce chilled water which in turn can be used for air-conditioning. This not only increases the efficiency of the power plant but also cuts down the overall electrical energy requirement of the facility.

This way we can effectively deal with the shortage of energy available in the form of power, heating, ventilation, air- conditioning etc.