High Performance Design and Sustainability for Healthcare Facilities

Apollo Hospital, Navi Mumbai

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Introduction

Energy efficiency and the green bug have caught on globally, and many projects and buildings are now seeking improved energy performance and green building certification. While commercial buildings started this trend, in the recent times high energy-intensive buildings such as laboratories, healthcare facilities and various industrial buildings have started embracing energy conservation and sustainability in a big way. This trend is true especially in recent times with the healthcare sector, and why not? After all, the healthcare sector is the second largest energy-intensive sector, second only to commercial food service industry. *Figure 1* illustrates the energy consumption and intensity for various types of buildings, and as can be seen the healthcare industry is a highly energy-intensive industry, thereby prompting large hospitals and healthcare facilities to embrace various energy conservation measures and ultimately go green.

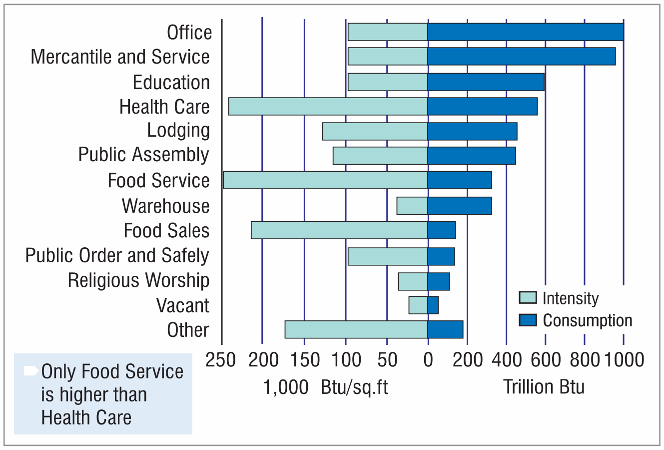

Figure 1: Energy consumption and intensity based on building type

What is a High-Performance Building?

Based upon the needs of the building owner, the term 'high performance design'

About the Author

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could mean different things. Defining it is certainly not easy. A commonly used definition of a high-performance building is one with energy, economic, and environmental performance that is substantially better than standard practice. It is far more energy efficient and saves money and natural resources. It is a healthy place to live and work in, and has relatively low impact on the environment. There is an inherent conflict in some of the above goals and it is imperative that we find the sweet spot for each project building holistically and cohesively.

Energy Performance – What is the Goal?

How energy efficient should a high-performance building be? The *LEED for New Construction* system does not specify. A building can be anywhere from 10 to 48 percent more efficient than *ASHRAE 90.1-2010* base requirements, with a minimum mandatory requirement of 10%, to be rated as LEED certified. While this is definitely a good start, it has been observed that several projects do really very little for energy conservation beyond their standard practices and the mandatory 10% energy savings. So what should be the benchmark for a high performance building? Should it be LEED Silver? Or should it be LEED Platinum? The new *ASHRAE Standard 189.1-2011, Design of High-Performance Green Buildings Except Low-Rise Residential Buildings* suggests that a building that is not at least 30% more efficient than the minimum requirements is not truly a high-performance building.

So, that leads to the next major question: what should buildings really do to meet and better such high energy efficiency goals? Many buildings today do have high performance glass, roof insulation and even reflective roof tiles or paint, utilize reasonably high COP (coefficient of performance) chillers, variable frequency drives for secondary pumps and AHUs and heat recovery systems, and have realistic lighting power designs.

One thing that comes out clear is that we need to definitely go beyond usual measures, if we are to achieve this 30% saving over already stringent benchmarks. This requires, in principle, a completely different approach to building and systems design. One of the first key steps, is to look at an Integrated Design approach for all healthcare buildings for energy efficiency and inclusive sustainability. This means there needs to be a highly collaborative approach among all the design team members, and the key aspect of integrated design is inclusion of construction and operations in the key decision making process. Typically, in conventional hospital design, architects and various consultants work within their respective disciplines and success is often narrowly framed in the terms of profit and being on-budget for a particular task rather than in overall success of the final product. In the integrated approach, the entire team works to ensure optimal and efficient design and planning, construction and operation of the facility from beginning to end. This approach not only saves money, but also helps design high performance buildings that are significantly better than conventional buildings.

Energy Conservation Measures

For energy savings in large healthcare facilities, we need to look beyond standard designs and approaches. Some of these measures are not new and are definitely being followed by many professionals, but what needs to be done is to commercially adopt these ideas and explore new yet proven technologies to arrive at the right balance. Most energy conservation measures relate to building envelope, lighting, HVAC and controls.

Building Envelope

Building envelope design has a key role to play when looking at energy efficiency in hospitals. The building envelope includes the opaque components i.e. the wall and roof, and the fenestration. Of this, fenestration design has a very important role to play, not just in energy efficiency, but also in the health and well-being of occupants. There are several studies that confirm that there is a significant positive improvement to a patient viewing the outdoors, especially nature. However, sufficient attention needs to be given to fenestration design such that the facility can harvest natural light and provide patients with view to the outdoors while keeping

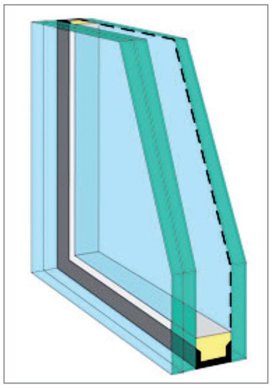

Figure 2: High performance double glazing

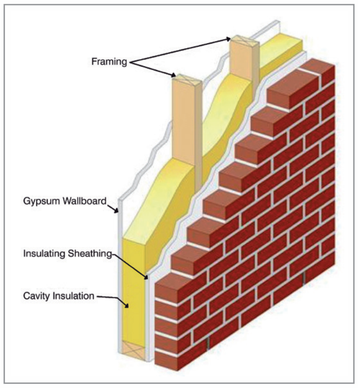

Figure 3: Typical insulated wall section

the heat out. That means we need to provide the right amount of fenestration at the right locations. Additionally, selection of glazing such as high performance, low-e coated glazing etc., as indicated in *Figure 2*, can help reduce heat ingress even further. Hence, designing the envelope with an optimum window-wall-ratio (WWR) is very critical and in India, typically, it would be prudent to restrict the overall WWR to less than 40% to reduce heat ingress while allowing natural light inside. Other energy saving approaches include insulated walls (see *Figure 3*) and roof, and even cool and high reflective roofs that reduce heat ingress. Most recently, many large healthcare facilities have started paying more attention to passive techniques such as external shading on the east, west and south facing façade that not only reduces heat, but also adds to the elevation design and aesthetic element of the hospital.

Natural and Artificial Lighting

A well-designed building orientation and form can definitely help bring natural lighting into the building and reduce the usage of artificial light during the day. This not only conserves energy, but also enhances occupant comfort. Natural lighting, wherever possible, is a great way to reduce the overall energy consumption. In many modern health care facilities, the focus on design to harvest maximum daylight is becoming very critical. Especially daylighting can be easily considered for many non-clinical spaces

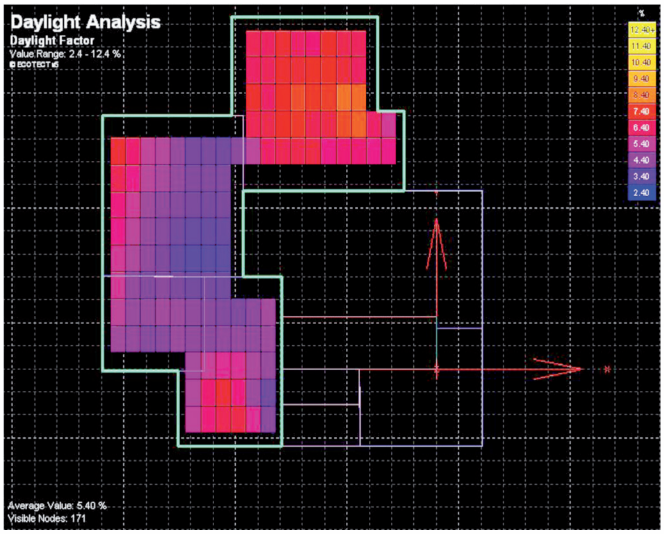

Figure 4: Daylighting simulation indicating the percentage of daylight within a space

such as consultant rooms, waiting areas, cafeteria, lounges and similar spaces. These areas are often occupied all the time and do not have any specific lighting requirements, so it would be good to plan and locate these areas to harvest maximum daylight. Today, simulation software are available, which can simulate and indicate the percentage of daylighting or even lux level of the daylight penetration into each space. *Figure 4* shows a daylight simulation for a space showing the % of the daylighting within the spaces with the areas shaded in blue having around 2.4% daylight (which is around 240 lux) and the areas shaded in red having upto 6-7% of daylighting within the spaces. Sophisticated simulation tools can help designers cleverly design buildings and façade to ensure sufficient penetration of daylight and optimize window sizing to enable it.

Artificial Lighting

Figure 5: T5 lamps

Where daylighting is not possible, artificial lighting is a must. The main area to focus in lighting design is to restrict the overall connected lighting power so that sufficient illumination is provided without overlighting. The effort is to design for the lowest overall lighting power density (LPD), defined as the total lighting power (wattage) divided by the space area and measured in watts/sq ft. Reductions in LPD value can be done by going in for high-performance lighting including T5 lamps (*Figure 5*) and LEDs (*Figure 6*) with electronic ballasts to ensure the required luminance is achieved but at minimum wattage.

Figure 6: LED spotlights and LED Strips

Additionally, many areas such as closed consultation rooms can be provided with occupancy sensors to turn off lighting, when not occupied. For areas that are capable of harvesting maximum daylight, one can provide daylighting sensors to turn off artificial lights, where there is sufficient natural light. These occupancy and daylighting sensors (*Figure 7*) can help reduce over 20% of the total lighting energy and also have typically, less than 2 years of payback.

Figure 7: Occupancy cum daylight sensors

Controllability of Systems

Another energy conservation measure that can help us achieve notable savings is the controllability of systems. Most areas have centralized lighting with very little control for occupants, thereby increasing significantly the overall energy usage even at part occupancies. Individual adjustable lighting, especially for all consultation rooms, wards, and patient rooms can definitely help reduce the fixed intensity general lighting systems. They can be coupled with user-adjustable lighting levels and automatic shutoff switching for maximum savings.

HVAC

The HVAC system is the most critical component of the healthcare facility. While providing thermal comfort for all the spaces, it is also critical for the HVAC system to provide the necessary air quality and filtration. There are several HVAC systems and measures that can be adopted for large healthcare facilities to reduce energy consumption, while not compromising on thermal comfort or air quality. Traditional HVAC energy efficiency measures include; high COP (coefficient of performance) chillers, VFDs for pumps and AHUs, heat recovery wheels to pre-cool incoming fresh air, etc. These are now being used commonly in many hospitals.

Innovative HVAC systems

Some of the newer and more innovative measures to achieve energy savings in HVAC include; displacement ventilation, FCUs with Dedicated Outdoor Air Systems (DOAS), mixed-mode ventilation for non-clinical spaces, demand control ventilation, ground source heat pumps and geothermal systems, among others. Of these innovative measures, FCUs with DOAS, demand control ventilation are common measures that many of the newer generation and green hospitals are already adopting. Mixed mode ventilation systems for non-clinical areas are quite common in healthcare facilities in the West. However, in India, with most of the cities having harsh ambient conditions, natural ventilation is not so commonly adopted, especially in healthcare facilities where dust and infection are areas of concern.

Demand Controlled Ventilation

Fresh air is a critical requirement for all areas especially in healthcare facilities for better indoor environment. While pumping

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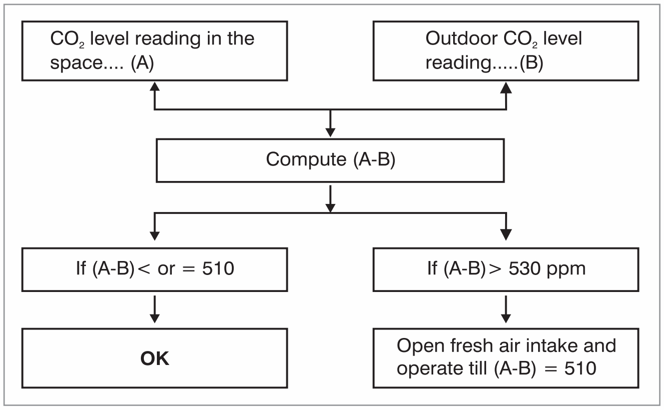

Figure 8: Demand controlled ventilation

in fresh air is good, and the more the better, so long as it does have a huge effect on the overall energy consumption with loads increasing significantly. Demand controlled ventilation is a concept that brings in fresh air but also keeps comparing the indoor fresh air CO_2 levels with the outdoor CO_2 levels, and in case the indoor levels are lower than or even the same as outdoor levels, no more fresh air is brought in until the indoor CO_2 levels reach about 530 ppm higher than outdoor levels. This is done through a motorized damper arrangement, which modulates the incoming quantity of fresh air based on CO_2 levels. This ensures that sufficient fresh air is brought in whenever needed, but also kept out if not needed to balance indoor air quality with energy consumption. This is usually done for non-critical areas such as waiting, consultation areas, patient rooms etc. but still can help reduce the overall energy consumption significantly while not compromising on indoor air quality. *Figure 8* indicates the schematic of a typical simple demand control ventilation arrangement.

Displacement Ventilation

Another HVAC measure that is known to provide good energy savings, but not so commonly used in Indian conditions is displacement ventilation (refer *Figure 9*). Again, these are for the non-clinical areas, where displacement ventilation can not only conserve energy, but also provide most occupants the ability to control their own thermal comfort by providing local diffusers at floor, desk or overhead levels.

Geothermal Systems

Geothermal and ground source heat pumps are the newest innovative systems that are currently being used in healthcare as well as other facilities in the West. While these are known to be effective for heating systems, there are successful examples of installations for cooling purposes as well. However, the lack of measured data for most cities in India as well limitations on the ability to install and maintain such systems are the deterrents to these systems being adopted in India currently. While a few experimental systems have been installed in some areas and projects, mainstream adoption of such techniques has still not happened and we will have to wait and see how they evolve with time.

Energy Conservation vs. Energy Generation

All the above-mentioned concepts are not new to most of us, and may be incorporated in our buildings as well. What high performance buildings are focusing more on are technologies that not only conserve energy, but actually generate energy to improve the overall performance of buildings. As Albert Einstein once said, "We cannot solve problems by using the same kind of thinking we used when we created them". We need to explore new and innovative ways for energy efficiency and conservation.

Net Zero Energy Buildings

This brings us to what are now being referred to as Net Zero Energy Buildings (NZEB). A net zero energy building produces as much energy as it uses over the course of a year (*Figure 10*).

NZEBs are very energy-efficient buildings, with the remaining low energy needs typically met through the use of on-site renewable energy. NZEB advantages include reduced total cost of ownership due to improved energy efficiency, isolation from future energy price increases and safeguards from future legislative restrictions including carbon emission tax that is being seriously considered by several nations.

On-site solar PV systems are probably the most commonly used technology to generate energy. There are several buildings world-wide including healthcare facilities that already utilize solar PV panels to generate on-site energy. Other energy sources such as micro wind turbines are also being explored in a big

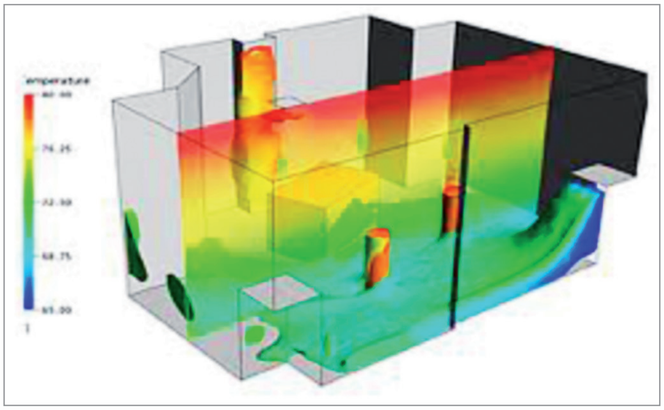

Figure 9: Displacement ventilation

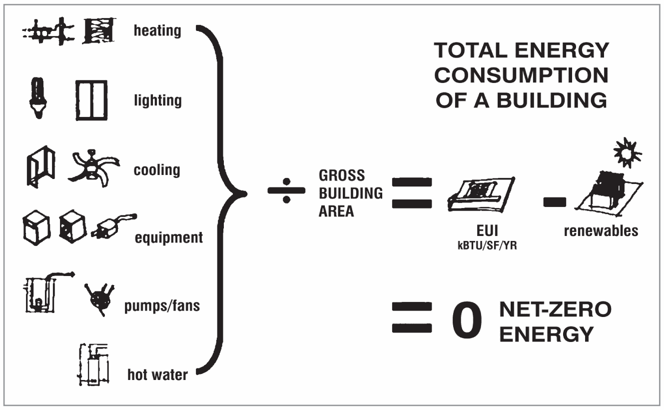

Figure 10: Net Zero Energy Building concept

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way world-wide, while biogas and biomass systems are still developing.

Importance of Measurement & Verification

While designing and installing these systems and measures is critical, equally important, if not more, is the measurement and monitoring of these systems on a real time basis to sustain these energy savings. It is imperative to develop and establish performance metrics and verification methods for high-performance buildings, systems and products that provide sustainability. For energy, the need is for facility executives to do a better job measuring and verifying energy. We have seen in several instances all these meters and complex ways to measure energy, but people easily forget or they just do not want to measure. What should be the key metrics and measurements? How do we simplify this to make it second nature in building operations and maintenance?

It is common sense that measurement and verification (M&V) and energy go hand in hand, but not necessarily everyone in the construction industry sees it that way. In fact, M&V helps to objectively define high-performance buildings and helps different stakeholders of the industry to meet the definition. Facility executives need better feedback on actual energy performance, and they need to be empowered to take action on that data. One would tend to agree that the measurement and verification of energy performance goals is generally not well implemented. Most property owners do not meter or sub-meter their buildings well from an energy performance standpoint. Understanding where the energy is being used is difficult, if not impossible.

Improving operations to improve energy performance is really the key to success of high performance buildings. Energy-saving strategies can only be implemented if building owners and operators know how. Educating and having knowledgeable operators is the key. An incremental operational improvement is a vastly underutilized energy efficiency strategy.

Design is certainly a good place to focus your initial efforts. The vast majority of buildings that are being built today will exist for decades to come. So, it is extremely important that we look at reducing energy in existing buildings through operational improvements and education. It is important to carry out specific studies on the energy performance of high-performance buildings over time. We need comparisons of actual building performance with respect to the intended performance.

As the level of awareness and education improves amongst building operators, the long-term drop-off in building performance will not be prominent. Retro-commissioning is important for preventing that drop-off. Building information modeling (BIM) is a tool for returning equipment to its original specifications. BIM gives you a permanent record of how systems are supposed to function. Currently, BIM is being used primarily by architects as a design tool, but there is real value in facility executives and building operators learning the software and incorporating it as part of their building operations management.

Inclusive Sustainability

Irrespective of the size, usage or budget, every project can

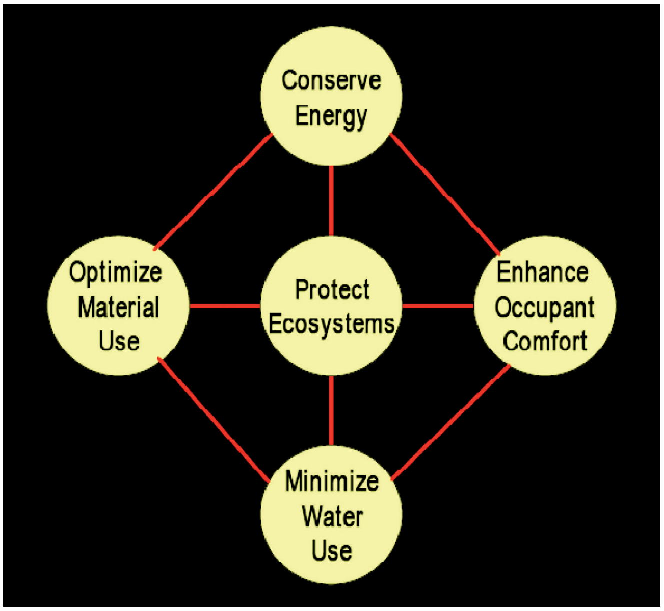

Figure 11: Holistic sustainability

make a sustainable difference to the environment. We just need to find the right balance and how to effectively and efficiently apply concepts of sustainability to every project. This also means an opportunity for research and development in new technologies. Every project can achieve any or all of the outcomes listed in *Figure 11*.

These can be achieved through smart site planning, efficient building design and strategic materials and systems selection, while recognizing regional environmental priorities.

The Cost of Not Going Green!

The costs of not going green and high performance are gaining significance in today's context. Two factors that profoundly change the way we view sustainable buildings are energy and water. With issues of global warming and climate change being brought to the forefront, we are not only going to be looking at just initial and operating costs, but also international issues such as carbon emissions tax. Add the increasing cost of energy, and this can be a double sided pressure that makes it impossible to ignore green and high performance buildings.

In Summary

Green and high performance design should not be viewed as additive to regular building design and operations and should not be conceived as a separate feature with an add-on cost. Contracting and facility management teams need to view sustainability and high performance buildings as potential opportunities and not as an additional price burden. This will happen in tandem with education. In a densely populated country like India, it is critical that sustainability initiatives are not restricted to a few large developments, but reach out to every small tenement and become embedded into the DNA of the industry and part of national culture and lifestyle. After all, India was one of the greenest societies on the planet several centuries ago, when these concepts were not even verbalized!