



Only commissioning can ensure that an owner's goal of a green building is achieved.

# The Importance of Commissioning Green Buildings

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Until recently, commissioning of HVAC systems in a building meant swinging a sling psychrometer and recording area-wise temperature and humidity. For the average construction engineer, it was a process mostly carried out to get a completion certificate from the consultant and claim the final payment of the HVAC contract. Today, a well-defined commissioning process is required, especially for green buildings, where the first cost is incrementally higher, but it is paid back in terms of energy savings during operation and maintenance. Such savings will not be achieved if commissioning is not done.

## What is a Green Building

The term 'green building' is not new anymore and is the most important subject for designers all over the world today. Though several definitions exist, a green building is

best described as a building that has been designed, constructed and operated so as to have a benign impact on the environment, thus meeting the needs of the present without having to draw on the

future's ability to sustain itself.

## Why is it Called Green

A green building is all about sustainability of ecology, biodiversity, materials, energy, water and IAQ.

Computer aided tools assist in quantifying and ascertaining the greenness of a building. A recent study was done by Greenpeace, to check for energy losses through leakages by taking thermographs.

## About the Author

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Photo 1 : Thermographs of three different buildings, showing the leakage of cold air in blue. Note the building on the extreme left shows virtually no leakage (Source: www.greenpeace.org/ India/ press release)

Photo 1 shows thermographs of three different buildings. The blue color shows the air leaking out of the building. As can be seen the building to the left, the green building has the least cold air leakage and the one to the right has the most leakage.

Experience has shown that a well-designed green building can bring down the energy consumption of a building to 120 to 140 kWh/m<sup>2</sup>/annum, nearly 40% down from the conventional figure of 200 kWh/m<sup>2</sup>/annum.

It is no wonder then that, more and more buildings are opting for going green.

**What is the LEED Rating System**

Several rating systems exist for green building certification. However, the LEED or Leadership in Energy and Environmental Design rating system is the most widely accepted in India and is the basis of this article.

**LEED and IGBC**

The Indian Green Building Council IGBC was constituted in 2007 and it formed the Indian LEED rating system for buildings in India, on the same lines as the USGBC LEED rating system. The rating system is based on codes such as the ECBC (Energy Conservation Building Code) and ASHRAE 90.1. Thus a green building has energy efficiency built into it because of the benchmarking to these standards. Any additional enhancements and green features entitle it to additional credits.

To date, there are 230 projects registered in India for the certification program covering 133 million ft<sup>2</sup>.

Table 1 lists the maximum number of points that can be scored under different green features, when a building is getting itself rated for greenness.

The LEED India rating system has separate sets of guidelines for:

- New Construction – a building which is constructed

	New Construction		Core & Shell	
	Pre-req.	Credit	Pre-req.	Credit
Sustainable Sites	1	14	1	14
Water Efficiency	NIL	6	NIL	6
Energy & Atmosphere	3	17	3	14
Material & Resources	1	13	1	11
Indoor Env. Quality	2	15	2	11
Innovation & Design and Leed Accredited Professional		5		5
<b>TOTAL</b>	<b>7</b>	<b>69</b>	<b>7</b>	<b>61</b>

Table 1 : Green features and maximum awardable points for green buildings under LEED India.

and to be used by the owner, for example, a corporate constructing a building for its own use

- Core And Shell – a building which is constructed to be leased out, for example a developer constructing a building and leasing to different clients.
- Homes – These set of guidelines were recently launched in May 2008 and are in their basic form.

As can be seen from the table, the maximum points to be scored by a ‘new construction’ building are 69 and for a ‘core and shell’ building are 61. Out of these, scoring 7 points, under the heads given in Table 1 is compulsory or a pre-requisite. Any added green features help the building to score additional points or ‘credits’ and it is the total of the two figures, that classifies the merit ranking of the green building as platinum, gold, silver or certified. Table 2 shows the cut-off marks for each category.

Rating	New construction	Core & Shell
Certified	26-32	23-27
Silver	33-38	28-33
Gold	39-51	34-44
Platinum	52-69	45-61

Table 2 : Rating levels for green buildings.

**Agencies Involved in Green Building Certification**

The process of getting a project certified green and more importantly rated platinum or gold or silver must start even before the building plans are drawn. The project team, besides the various contracting agencies must appoint the following consultants:

**Facilitator**

This agency helps



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in guiding the project team through the entire journey of certification. It is a hand holding exercise, where time to time inputs on various aspects of the rating system are given to the project team. The facilitator carries out a feasibility study for the project to find out the eligibility for certification and what level of certification it can achieve.

**Energy & Lighting Simulator**

This agency models the building on the following lines.

- a. It ensures that the building complies with ASHRAE 90.1.2004 for minimum energy performance. Incidentally, this is a pre-requisite for all green buildings.
- b. It evaluates the percentage of energy savings over and above ASHRAE 90.1.2004. This feature fetches additional points in optimized energy performance. (2 points are mandatory in C&S projects)
- c. Lighting simulation facilitates in calculation of daylight and views credit.

**Commissioning Agent**

Commissioning is the third and most important pre-requisite for any building wanting to get itself rated through the LEED India rating system. It is the commissioning agent who facilitates the integration of systems in a building and ensures that the systems operate as intended in the original design. The following paragraphs cover this aspect in greater detail.

**What is Commissioning**

Commissioning can be defined as a process that verifies that the facility and its systems meet the owner's project requirement. It is a planned, systematic quality control process that involves the owner, users, occupants, operation and maintenance staff, design professionals and contractors.

It addresses the dynamic systems in a building. Dynamic systems are those systems that have a significant impact on energy efficiency in the building like the HVAC system, which consists of chillers, pumps, cooling towers, air handlers, domestic pumping system, lighting system etc. Table 3 describes the features of commissioning.

Commissioning bridges the gap..... 'possibility' & 'reality'	
• Verifies design is .....	met
• Monitors construction compliance with .....	intent
• Assures systems operate as.....	intended
• Validates & calibrates performance.....	measurements
• Training to operational staff	
• Value addition to project from past experience	

Table 3 : Salient features of the commissioning process.

**What Commissioning Means to the Owner**

- It ensures savings to the owner
- It captures the owner's brief and documents his functional requirement
- It ensures reporting to the owner on pending issues post commissioning such as set points, monitoring, operation etc.



- It is one of the pre requisites for qualifying for LEED rating system.

**Roles and Responsibilities of the Commissioning Agent**



The commissioning agent or CA, who carries out this process is an independent agency or individual appointed directly by the owner. For the process to be free of vested interests, the CA, is neither a part of the design and construction team nor related to them. A CA has a mechanical or electrical engineering background with expertise in mechanical and electrical systems as well as operation and maintenance. It often also has expertise in indoor air quality and may be qualified in areas involving envelope insulation and glazing, which are used to improve system efficiency.

Although its experience with issues such as water quality, environmentally sustainable materials and low toxicity materials may be limited, a conventional CA is experienced in coordinating a systematic process of seeing that design concepts from multi-disciplinary teams are clear and well-documented and that the specified performance criteria are realized. This puts it in the best position to orchestrate the commissioning process even when the design and construction phase is on. In short, it works with various design and construction agencies to realize a common goal.

The HVAC consultant along with the building owner's project team addresses selection of energy efficient equipment/ systems. The contractor or the OEM supplier takes care of installation. The commissioning agent does the design / construction reviews, facilitates integration and efficiency analysis of the system, imparts training to the facility manager, ensures documentation of the system manual and prepares quick reference guides for chillers, VFDs etc. He also ensures a check and balance on selection of appropriate equipment/ technologies conforming to ASHRAE 90.1.2004. In addition, he conducts a cross verification of technical documentation/ submittals of equipment with respect to design intent, tender specifications and actual equipment at site.

**The Commissioning Process**

Beginning at the design phase and extending through the typical warranty period, commissioning is a

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systematic process of ensuring that all building systems perform interactively according to the design intent, the facility staff are properly trained and that adequate documentation has been provided. It is an integrated process for “new construction” as well as for “existing buildings”, which ensures the systems designed are integrated to perform as intended.

There are two aspects to commissioning of green buildings as per the LEED system:

- Fundamental building commissioning – this is a pre-requisite, to be complied with compulsorily. The time line for this activity covers the pre-design / design phase, construction phase and acceptance phase.
- Enhanced commissioning – this activity earns extra credit in the evaluation process. This activity covers the warranty phase of the project.

Usually there is a single commissioning agency (CA) that takes care of both, fundamental and enhanced commissioning of the building. The entire process is illustrated for the easy reference of readers in *Figure 1*.

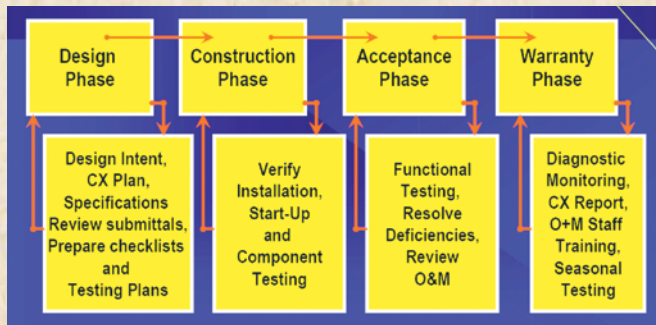


Figure 1 : The commissioning process.

### Pre-Requisites and Credits Associated with Commissioning in the LEED System

The LEED design guide on green building ratings describes the system for awarding points to a green building is explained in the earlier part of the article. It describes ‘fundamental commissioning of the building energy systems’ as a pre-requisite to any green building. Credits associated with the Commissioning Agent (CA) in the LEED rating system are:

a. Enhanced commissioning	Credit 3 in Energy & Atmosphere
b. Measurement & verification (M&V)	Credit 5 in Energy & Atmosphere
c. Construction IAQ management plan	Credit 3.1/ 3.2 in Indoor Environmental Quality. The CXa facilitates the project team in making and implementing the construction IEQ management plan during construction and post occupancy.
d. Thermal comfort verification	Credit 7.2 in Indoor Environmental Quality

### Why is Commissioning so Important for Green Buildings

The concept of ‘green building’ is relatively new, especially in india and because of this, the ‘sustainable’ and ‘green’ features in building design may not be completely understood and incorporated by many designers and installers. Being scarce, green products and features are also susceptible to substitution with cheaper and less appropriate alternatives. That said, even if the products and techniques are correct, yet if they are poorly or incorrectly installed, they will end up negating the good features and will not ensure a truly green building. The commissioning agent is equipped with the necessary knowledge, being a trained agency/people and they can ensure that such lacunae do not exist, and hence are extremely important to a green building.

### Benefits of Commissioning

After having detailed the entire process, it is necessary now, to summarize the benefits that a detailed commissioning process can offer to a green building;

- Reduced energy use and lower operating costs, that are part of green building design are translated into reality
- Facilitates the project management process
- Value addition, by way of technical inputs, sharing of experiences from other projects
- Smooth start-up for equipment
- Co-ordination between various agencies for integration of the entire system
- Systematic documentation helps the facility staff in maintaining the building
- Improved occupant comfort resulting in increased productivity- a feature of green buildings.

### What is Retro Commissioning

Commissioning of existing buildings is known as retro commissioning. It is an event in the life of a building that applies a systematic investigation process for improving and optimizing a building’s operation and maintenance. Retro commissioning however occurs after construction, as an independent process and its focus is usually on optimizing energy-using equipment such as HVAC system, lighting and related controls. *Table 4* lists the fundamental differences between commissioning of new and existing buildings.

### Is Commissioning Applicable Only to Green Buildings?

Whether it is a new building or existing building, the ultimate aim of commissioning the systems in a building is to achieve and ensure operational savings, ongoing

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New-construction commissioning	Retrocommissioning (Existing equipment)
<b>1. Conception or pre-design phase</b> a) Develop commissioning objectives b) Hire commissioning provider c) Develop design phase commissioning requirements d) Choose the design team	<b>1. Planning phase</b> a) Develop commissioning objectives b) Hire commissioning provider c) Review available documentation and obtain historical utility data d) Develop retrocommissioning plan
<b>2. Design phase</b> a) Commissioning review of design intent b) Write commissioning specifications for bid documents c) Award job to contractor d) Develop commissioning plan	<b>[No design phase activities]</b>
<b>3. Construction/installation phase</b> a) Gather and review documentation b) Hold commissioning scoping meeting and finalize plan c) Develop pre-test checklists d) Start up equipment or perform pre-test checklists to ensure readiness for functional testing during acceptance	<b>2. Investigation phase</b> a) Perform site assessment b) Obtain or develop missing documentation c) Develop and execute diagnostic monitoring and test plans d) Develop and execute functional test plans e) Analyze results f) Develop Master List of deficiencies and improvements g) Recommend most cost-effective improvements for implementation
<b>4. Acceptance phase</b> a) Execute functional tests and diagnostics b) Fix deficiencies c) Retest and monitor as needed d) Verify operator training e) Review O&M Manuals f) Building/retrofit accepted by owner	<b>3. Implementation phase</b> a) Implement repairs and improvements b) Retest and remonitor for results c) Fine-tune improvements if needed d) Revise estimated energy savings calculations
<b>5. Post-acceptance phase</b> a) Prepare and submit final report b) Perform deferred tests (if needed) c) Develop recommissioning plan/schedule	<b>4. Project hand-off and integration phase</b> a) Prepare and submit final report b) Perform deferred tests (if needed) c) Develop recommissioning plan/schedule

Table 4 : New Construction commissioning v/s Retro commissioning.

accountability of energy use in the buildings and IAQ management. Most conventional buildings do not have any energy management agenda and even if they have one, such programs focus on installing energy efficient technologies with very little emphasis on efficient operation. Efficient operation of the systems in the building is the least understood and can offer the highest potential for savings.

## The Importance of BMS in Green Building Commissioning

The HVAC system consists of high side and low side. The high side includes chillers, primary / secondary pumping system with pump logic controller and cooling towers with two speed motors or VFDs. The low side includes AHUs, AHU controls like modulating/ control valves for chilled water and VFDs to modulate the AHU's motor speed. Design and selection of the equipment and systems is carried out keeping in mind best practice

manuals/codes. The key lies in proper integration of all the equipment to work in tandem resulting in an energy efficient system. Energy efficiency analysis of the equipment/ system post installation gives us an insight for further fine tuning for optimization and defines the baselines for future reference.

BMS is very good tool to visualize, monitor and control the operations of various systems in the building. BMS also facilitates capturing of energy performance of the systems in the building, which in turn can help the facility staff to manage the building systems more efficiently. BMS is not a panacea for all operational problems. The key lies in analysis of the data arising out of BMS and interpreting it to take necessary corrective action.

Many problems are noticed only when a catastrophic failure or a visible consequence occurs. One example is Demand Control Ventilation (DCV). Correct modulation of the fresh air damper is crucial element in DCV. Malfunction of the fresh air damper will result in intake of excess quantity of fresh air than desired. This will result in increasing the heat load that will result in wastage of energy. The entire matter will go unnoticed but for BMS, which will display the status of the damper and change in temperature. With BMS, the key lies in action, which will only happen if the person operating the BMS is vigilant and trained to interpret the readings displayed.

Each of these problems can have sizable effect on the economics of owning and operating a building. Not only can energy costs become prohibitively expensive but also capex invested for energy efficient technologies may cease to provide returns.

A lot of data gets generated from the HVAC / electrical system through the BMS. For effective utilization of BMS the key lies in interpretation and analysis of the same. Effective representation of data by means of informative screens can be of great help to the facility staff.

## Case Study

As an example, in the design / construction review of the technical submittals of primary secondary chilled water pumps, the commissioning process includes :

- a. document the basis of design of pump selection and check for the design efficiency. (Pump performance curve is a vital document for evaluating and computing

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efficiency of the pump when commissioned),

b. calculate the HP/ kW of the pump motor

c. compute the design system efficiency of the pump selected

d. cross check the electrical single line diagram (SLD) and ensure that it is in line with the motor selected. In many cases, discrepancies arise due to design changes that have taken place at the HVAC end and the same is not communicated to the electrical end, resulting in wrong switchgear being ordered,

e. check for motor details like IP-protection, insulation class, efficiency as per ASHRAE 90-1-2004,

f. crosscheck and verify the electrical control circuit with respect to the BMS I/O summary. For example, BMS on/ off command (digital output, DO) to VFD and trip status monitoring (digital input, DI) requires potential free contact (PFC). Invariably when the electrical drawing is reviewed either the PFC is missing or the contact is not potential free,

g. ensure that the electrical panel manufacturing is taken up only after points a to f above are addressed, otherwise the panel has to be modified to accommodate these changes, resulting in re-work and wastage of time

and energy,

h. cross-check for control logic operation by energizing the control circuit once the panel is ready and installed at site. The power circuit is tested only after this is found healthy.

Thus, if these commissioning procedures are followed, the start up of equipment/ systems is smooth and without any hiccups and hassles. This becomes very important during the final stages of the project as the project completion date is announced and all the contractors have dead lines to adhere to. At that point, discovering anomalies comes as a rude shock and can disrupt the harmony in the team comprising HVAC, Electrical and BMS contractors.

### **Conclusion**

At present, in India, commissioning is a 'blip on the radar' of commercial and institutional building professionals. Determining of energy efficiency is important to green buildings as it has a significant impact on energy cost and adds value to occupant comfort. In the US, this activity is rapidly gaining importance and more and more architectural and engineering firms are including commissioning services as a core business concept. ❖

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