Indoor Environmental Quality Credits in Green Buildings in India

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Abstract: A critical component of a green building is its indoor environment. Maintaining good IAQ requires enhanced ventilation, increased consumption of energy and thus higher operating costs. Reducing ventilation rates to save energy increases indoor generated VOCs and small particles by an amount that may pose health risks [1]. To strike a balance between the two, integrated design approach towards IAQ and energy is used in green buildings. The study focuses on how to make the rating system more adaptable, where the potential planner is able to understand the rating system and integrate the knowledge to identify the hindrances and how can they overcome the same to attain credits in the rating system. Further for higher adoption of the rating system in India, new aspects that can be included in the rating system and how to make credits easier to attain have been seen. Also in the LEED for India NC/CS rating system there have been India specific changes and the study is warranted to understand how it has been perceived by the users and take their suggestions for improvement of the rating system.

The study was carried out in six buildings which were developed as case studies. Four buildings have been certified under LEED India NC, one under LEED India CS and one is pre certified under LEED India CS. The study revealed the catalysts and hindrances associated with attaining credits under IEQ category. Some of the catalysts were gains in productivity, occupant comfort and wellbeing and improved indoor air quality. Some of the hindrances faced were high implementation cost of technology, amendment in the design of the building and difficultly to coordinate with the MEP, architect and project manager. The study also highlights the suggestions of stakeholders towards making credits under IEQ category easier to attempt and attain. Some of the suggestions were to reduce the threshold value for day lighting from 75% to 50%, exclude individual controls in commercial buildings and restricting CO_2 monitoring to AHU level.

***Keywords*:** Catalysts; Green Buildings; Hindrances; Indoor Environmental Quality; LEED for India.

Introduction

Buildings form an indispensable part of development. The environment and the deteriorating resource base cannot be overlooked when we talk about development. Hence, development needs to be sustainable so that the future generations can readily meet their needs. The Indian Construction Industry was approximately US$157 billion in size in FY14, as against an estimated US$ 153 billion in FY13 which indicates that the industry is growing profoundly [2]. Real estate continues to form a key ingredient for the success of India's rising economy. According to the economic survey 2013-2014, the real estate and ownership of dwellings contributed to about 5.9 percent of India's GDP [3]. This shows that the real estate and construction sectors are playing a crucial role in the overall development of India's core infrastructure.

The environmental impact of the building industry is significant. In India, buildings are responsible for 40 % of the energy use, 30 % of the raw material use, 20 % of water use, and 20 % of land use in cities. At the same time, they cause 40% of the carbon emissions, 30 % of solid waste generation, and 20 % of water effluents [4]. The building construction sector has been poorly regulated despite being a major resource predator. The building sector is responsible for more than one-third of global resource consumption annually, including 12% of all fresh water use and 10% global energy supply due to manufacturing [5]. The built environment accounts for some 40% of world

GHG emissions [6]. To reduce or eliminate negative environmental impacts and improve existing unsustainable design, construction and operational practices, green building practices have been evolved. As an added benefit, green design measures also reduce operating costs, enhance building marketability, increase worker productivity and reduce potential liability resulting from indoor air quality problems [7].

Green Building movement in India has gained tremendous impetus. With a sluggish beginning of 20,000 square feet green built-up area in the country in the year 2004, as on January 2015, more than 3,003 Green Buildings projects with a footprint of over 2.63 billion square feet are registered with the Indian Green Building Council, out of which 572 green building projects are certified and fully functional in India [8]. India currently has two major rating systems: LEED India, run by the Indian Green Building Council; and Green Rating for Integrated Habitat Assessment (GRIHA), a system developed by The Energy and Resources Institute and the Ministry of New and Renewable Energy, India. The GRIHA rating system is slowly strengthening its impact alongside LEED India and currently has green building footprint of 19 million sq. m. [9]. Table 1 shows total projects and registered space of various green building rating systems in India [10].

New buildings which are certified green can have tremendous benefits, both tangible and intangible. The most tangible benefits are the reduction in water and energy consumption right from day one of occupancy. The energy savings could range from 20 - 30 % and water savings around 30 - 50%. The intangible benefits of green new buildings include enhanced air quality, excellent day lighting, health & well-being of the occupants, safety benefits and conservation of scarce national resources [11].

According to a study taken up by Mc Graw Hill Construction, green building movement is accelerating as they are viewed as a long-term business opportunity. Fifty-one percent of the architects, engineers, contractors, owners and consultants participating in the study anticipated that more than 60% of their work will be green by 2015, up from 28% of firms in 2012 [12]. The growth of green buildings is spreading throughout the global construction market place with no limitation to any one geographic region.

Table 1: Total Projects and Registered Space of Various Rating Systems in India

	Projects in India	**Total of Registered and Certified Space**
LEED	405	6.9 gross square meters
LEED FOR INDIA	1,928	833 million square feet
TERI-GRIHA	550	20 million square feet

Indoor Air Quality is one of many factors that determine building functionality and economics. On an average, majority of people spend 90% of their time indoors where levels of pollutants maybe two to five times and occasionally more than 100 times higher than outdoor levels [13]. A person's daily exposure mainly comes through inhalation of indoor air. These pollutants can cause health reactions in people who suffer from asthma and who have allergies, thus contributing to millions of days of absence from work [14]. Indoor environmental Quality affects building occupants and their ability to conduct their activities. When the quality of indoor air is bad, occupants can find themselves devoting considerable resources to resolving unnecessary complaints. When IAQ is good, buildings are more desirable places to work [15].

IAQ directly affects occupant health, comfort and productivity. Widespread health impacts include increased allergy and asthma from exposure to indoor pollutants particularly those affected by building dampness or mold, colds and other infectious diseases that are transmitted through the air, and sick building syndrome symptoms due to prominent indoor air pollutants as well as other indoor environmental conditions. There is a huge potential of the impacts to affect a large number of building occupants and they are associated with significant costs due to health care expenses, sick leave, and lost productivity [16].

Indoor Environmental Quality forms a major part of the rating system of any green building. It provides owners an opportunity to earn 15 possible points under LEED for India 2011. Hence, it becomes important for organizations to exploit this category in the best possible way to achieve maximum points under these credits. Indoor air quality directly impacts the health and wellbeing of the occupants. The present study therefore focuses on the technologies and strategies being implemented in the selected buildings for each of the Indoor Environmental Quality credits. The following graph shows the points division in various categories that form the LEED-NC rating system. Indoor Environmental Quality forms a major part of the rating system after Energy & Atmosphere. Hence, it is an important

criteria and the study will focus on the technologies and strategies used to implement the Indoor Environmental Quality credits in the selected buildings and the hindrances and catalysts associated with the same.

The objectives of the study are as follows. (a) To make case profiles of selected LEED rated commercial buildings (b) To take a detailed account of the technologies and strategies used to implement the Indoor Environmental Quality credits as per the LEED rating system(c) To understand the catalysts and hindrances associated with Indoor Environmental Quality credits in the selected buildings (d) To take suggestions from selected stakeholders to make Indoor Environmental Quality credits easier to attempt and attain.
However, for the present paper only the third and fourth objective will be discussed.

Review of Literature

Many studies have been done related to the Indoor Environment of the built environment. Some relevant studies have been summarized below.

Fisk (2000) did a study on health and productivity gains from better indoor environments and their relationship with building energy efficiency [17]. The study elucidated that there is relatively strong evidence that characteristics of buildings and indoor environments significantly influence the occurrence of communicable respiratory illness, allergy and asthma symptoms, sick building symptoms, and worker performance. Chappels and Shove (2007) in the study debating the future of comfort: environmental sustainability, energy consumption and the indoor environment focused on actively promoting debate about the indoor environment and associated ways of life [18]. The discussion concluded that the indoor comfort of a building is likely to depend on the different interests and institutions involved in the construction process, and on the types of building science that are developed thereafter.

Frontczak and Wargocki (2011) in literature survey on "How Different Factors Influence Human Comfort in Indoor Environments" emphasized on the results of a literature survey which aimed at exploring how the indoor environment in buildings affects human comfort [19]. The results of the survey suggested that when systems for controlling the indoor environment are developed, the type of building and outdoor climate, including season, should be taken into account. In addition, providing occupants with the option to control the indoor environment improves thermal and visual comfort as well as satisfaction with the air quality. Lee and Guerin in a study on Indoor environmental quality differences between office types in LEED-certified buildings in the US compared IAQ, thermal quality, and lighting quality between 5 different office types in LEED certified buildings in relation to employees' environmental satisfaction and their job performance [20]. The study found IAQ enhanced worker's job performance in enclosed private offices more than both high cubicles and low cubicles.

Steemers and Manchanda (2009) in a study on Energy efficient design and occupant well-being: Case studies in the UK and India have demonstrated the relationships between sustainable building design and occupant well-being [21]. The study demonstrated that increased energy use in the buildings is primarily associated with increased mechanization (e.g. centralized air conditioning) and reduced occupant control. This reduced control relates to reduced occupant comfort and satisfaction. It was also reported that health conditions of occupants correlates strongly with their levels of satisfaction.

Jain, Mital and Syal (2013) in a study on LEED-EB implementation in India: An overview of catalysts and hindrances throws light on the hindrances and catalysts associated with LEED-EB as a tool for greening of existing buildings in India [22]. The study suggested that the two major catalysts were increased prestige and image and reduction in operational costs. Catalysts with medium and minor importance were better rental value, social responsibility, providing improved indoor environmental quality (IEQ) and pioneering green building movement in India. The study also indicated some of the hindrances associated with greening of existing buildings as the areas which need to be worked upon. One of the major areas of concern that has been brought forth by the study is difficulty in meeting some of the prerequisites.

The existing literature clearly shows that Indoor Environmental Quality of a building is of paramount importance. The technologies adopted while certification of a building plays a very important role in terms of the occupant health and productivity post the occupancy as well as the productivity gains from the same. Hence, effective and energy efficient technologies should be adopted keeping in view the nature, size and operations performed inside the building. Further, it becomes very important to understand the catalysts and hindrances associated with acquiring the credits under Indoor Environmental Quality so that in future the hindrances can be worked upon and catalysts can be used as strengths to achieve the credits. This will bring out clear quantifiable results of occupant comfort and wellbeing in a green building as compared to a conventional one. In addition, a general view about making the

credits easier to attain and understand would encourage more participation of stakeholders and accelerate the green building movement further. Keeping this in mind, the study has been conceptualized.

Materials and Methods

The population size of the buildings certified under LEED for INDIA –NC/CS is significant. These buildings were contacted as per their willingness to take part in the study. Six commercial buildings certified under IGBC –NC/CS were selected. Four buildings have been certified under LEED India NC, one under LEED India CS and one is pre certified under LEED India CS. The sample consisted of stakeholders who are involved in the process of building construction and have contributed to make the building achieve this certification. This included Building managers/owners involved in the process of taking the certification; Engineers or Architects of the buildings; Sustainability Consultants of the selected buildings; Sustainability consultants of green buildings not selected for the study.

As 6 buildings are studied, the sample consists of 6 building managers, 6 engineers/architects of the buildings and 6 sustainability consultants. In addition, 10 other sustainability consultants of LEED buildings not selected as case studies are a part of the sample to take a wider view of the catalysts and hindrances they face while going for IGBC certification. A total of 28 stakeholders will form the sample.

A questionnaire was developed to sketch a profile of the buildings in terms of the LEED certification and to know about the catalysts and hindrances associated with IGBC certification and suggestions to make the rating more feasible. A checklist was prepared to identify in detail the credits achieved under the rating system with emphasis on Indoor Environmental Quality. The sustainability consultants involved in the process of taking the LEED certification were contacted to elicit this important information. Three separate questionnaires were developed for the building managers/owners; architects/engineers and sustainability consultants. Apart from this, one questionnaire was developed for the sustainability consultants not involved in the buildings selected for the study. The ranking method had been used while calculating the responses in various discussions to get a clear understanding by ranking the options.

Results and Discussion

The responses obtained from the owner/manager, architect/engineer and sustainability consultant of the specific projects as well as other sustainability consultants who were not part of the specific projects chosen but have associated with other IGBC- NC/CS projects are as follows.

Catalysts perceived by stakeholders

Table 2: Ranking of Catalysts Perceived by the Stakeholders

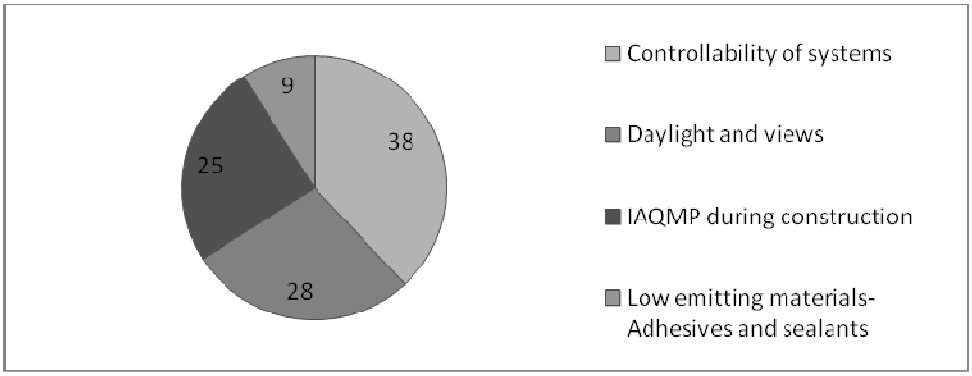
S. No	Catalysts	Rank scores (N= 28)
1.	Improved indoor air quality	3.82 **[3rd]**
2.	Better utilization of daylight	3.17 **[4th]**
3.	Better ventilation	2.42 **[6th]**
4.	Efficient lighting	1.75 **[7th]**
5.	Improved acoustics	2.60 **[5th]**
6.	Occupant comfort and wellbeing	4.25 **[2nd]**
7.	Gains in productivity	5.25 **[1st]**

[Figures in brackets denote ranks]

Maximum number of stakeholders opined that gain in productivity is the major catalyst associated with IEQ and hence gave it rank 1. They felt that good IEQ improves employee heath and performance by increasing their concentration and capacity to work for long hours. Occupant comfort and wellbeing scored rank 2 and the stakeholders felt that it improves employee's health and productivity. Rank 3 was given to improved indoor air quality which is also a catalyst while going for the credits under IEQ. According to the stakeholders efficient lighting was given rank 7 suggesting that it is a minor catalyst and is not a serious driving force to achieve credits under IEQ category.

Hindrances in relation with the credits

Figure 1: Credit/s under IEQ Posing a Hindrance to Achieve the Rating as Desired



Thirty eight percent of the respondents opined that the credit on controllability of the systems is the credit which in most cases is not approved by the council or the building team does not want to pursue the credit. This is because it was felt that individual controls of systems is not required in the building and leads to a heavy additional cost to the owner at shown in fig. 1

Twenty eight percent of the stakeholders felt that daylight and views posed a hindrance as no accurate simulation and modeling can be done for the building before it is constructed. Twenty five percent felt that IAQ during construction also posed a hindrance as the rating has not taken into account the Indian settings of a construction site whereby there is no air conditioning during the construction phase in the building. Hence, MERV 8 filters are of no use and the owner feels inappropriate to install the same. Nine percent of the stakeholders were of the opinion that it became difficult to convince the owners for using paints and adhesives which are prescribed as they come for a cost higher than the normal paints, adhesives and sealants.

Table 3: Ranking of Hindrances Perceived by Stakeholders

S. No	Hindrances	Rank scores (N= 28)
1.	High implementation cost of technology	4.89 **[1st]**
2.	Amendment in the design of the building	4.46 **[2nd]**
3.	Acceptance of technology	2.39 **[6th]**
4.	Training of the workers	2.67 **[5th]**
5	Difficult to coordinate with the MEP, architect and project manager	3.67 **[3rd]**
6.	Improper climatic, geographical and regional factors	2.85 **[4th]**

[Figures in brackets denote ranks]

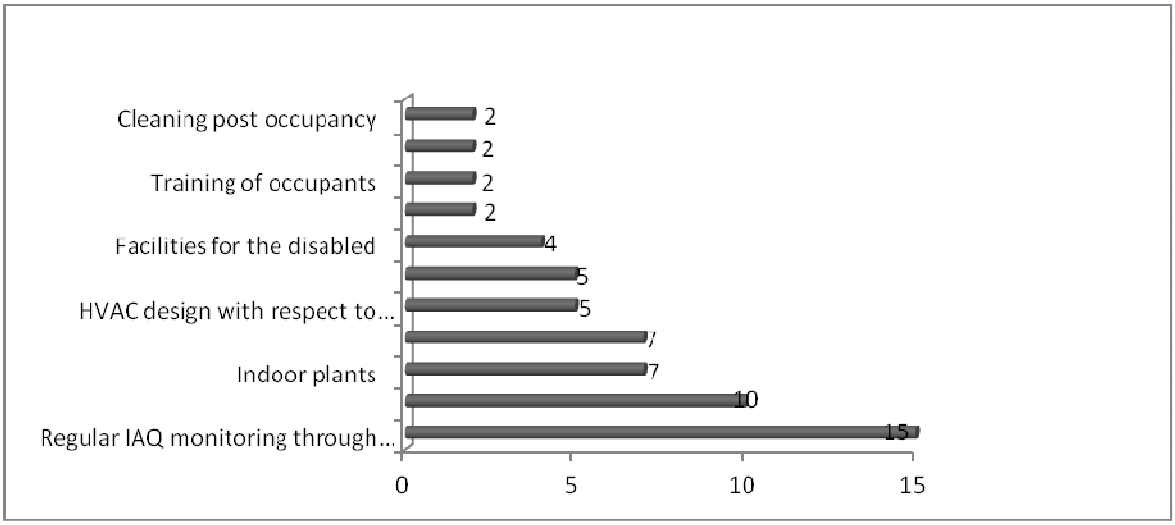
When asked about the hindrances faced by the stakeholders while going for IEQ credits, maximum respondents felt that high implementation cost of technology was the biggest hindrance they faced and gave it rank 1. As the technologies adopted for IEQ are energy efficient and come for a cost, this becomes a hindrance in achieving the rating as desired. CO_2 sensors, MERV filters and low emitting materials are technologies which are new and comparatively more costly than the existing ones.

Amendment in the design of the building was ranked 2. There are various changes that happen over the period when the building is pre certified or if the design is on paper to the actual project construction. Rank 3 was given to difficulty in coordinating with the MEP, architect and project manager. As credits under IEQ category involve the input from all the departments of engineering that is mechanical, electrical, plumbing, the architect as well as the project manager, a lot of time is wasted as the coordination is difficult leading to delay in the project completion. According to the stakeholders, acceptance of technology was ranked 6 suggesting that it is a minor hindrance under

IEQ category. Usually the technology employed in a building depends on the cost the owner is ready to invest in. Hence, once the technology is employed it does not take much time for the staff to accept the technology.

Aspects that can be included in the rating system

Figure 2: Responses of Stakeholders on Aspects to be Included in LEED for India Rating System



On analysis it was found that there are various aspects according to the stakeholders which need to be included in the rating system so that the rating becomes more authentic and easy to attain. Some of the aspects have already been addressed in the new ratings ahead of LEED for India 2011. Fig. 2 represents the responses of stakeholders to be included on the rating system.

One fourth of the consultants, 25% were of the opinion of including regular IAQ monitoring through a third party. They felt a need to regularize IAQ monitoring post occupancy as after certification the building might not follow the prescribed set of rules for the operations and maintenance of the building and hence compromise on the indoor environmental quality of the building. In line with this, 16% of the stakeholders opined that the former aspect will only be possible if there is IAQ management plan post occupancy. By doing this, the building will have set guidelines for the regular monitoring and hence will work towards its maintenance and upkeep.

Noise/ acoustics is the aspect which 12% of the stakeholders felt was necessary to be addressed in the rating system as a major part of indoor environmental quality comprises of noise reduction for productive gains. Twelve percent of the stakeholders also said that the use of indoor plants is extremely beneficial as they help improve the air circulation inside the building. Hence, forming a credit will bring this into practice.

Eight percent of the stakeholders were of the opinion to amend the HVAC design with respect to improved IAQ. After the building becomes operational, there are energy savings from the improved indoor air quality based on the credits of the rating system. Here, there can be amendments in the HVAC design with respect to lowering down the load initially calculated as per the standards as in practice the building might require a reduced load. Seven percent opined that there should be facilities for de-stressing for the disabled. There should be a separate entrance ramp for the disabled and facility of wheel chair, separate washrooms etc for them. Further, facilities such as a gymnasium; play room etc should be included for the employees. This aspect has already been addressed in the new rating system, IGBC for new buildings, 2014.

Other aspects such as carpeting, training of staff, and easy access to equipments, cleaning post occupancy were opined by 3% of the sustainable consultants each. These are aspects which need to be taken care of by individual facility managers of the building for a healthy environment within the enclosed space.

Level of difficulty in achieving credits

Table 4: Ranking of the Level of Difficulty in Achieving Credits by the Stakeholders

S.No	Credits	Rank scores (N=28)
1.	Daylight and views- Daylight	5.10 **[1st]**
2.	Controllability of systems	3.85 **[2nd]**
3.	Increased Ventilation	3.07 **[4th]**
4.	Indoor chemical and pollution	2.89 **[5th]**
5.	Outdoor Air Delivery	3.32 **[3rd]**
6.	Low-emitting materials	1.89 **[6th]**

[Figures in brackets denote ranks]

Maximum stakeholders were of the opinion that day light and views is the credit which is the most difficult to achieve under IEQ and hence gave it rank 1 in terms of level of difficulty in achieving credits. This is because any amendments that are made in the design of the building during construction, furniture alterations, and the calculation for the direct line of sight which is the method to attain the credit keep on changing. According to stakeholders rank 2 was given to controllability of systems which also posed a hindrance because it becomes difficult to decide the type of control to be provided and this credit has direct relation with the extra cost the building puts in to employ energy efficient features. Lastly, the stakeholders opined that it is difficult to achieve the credit on increased ventilation as the regular space is already designed keeping in mind 30% leverage in ventilation. This credit further justifies that to increase the ventilation rates by 30%, it is an additional cost that the company has to bear with low or nil benefits.

Maximum stakeholders opined that indoor chemical and source pollution control was fairly an easy credit to earn and hence gave it rank 5. There are set guidelines provided to achieve this credit which are easy to implement. Rank 6 was given to low emitting materials suggesting that it was the easiest credit to earn and the strategies to earn the credit are easy to implement.

Perception of stakeholders on making credits easier to attain

Table 5: Ranking of the Perceptions of Stakeholders on how to make Credits Easier to Attain

S. No	Strategies	Rank scores (N= 28)
1.	Reducing the threshold value for day lighting from 75% to 50%	2.03 **[2nd]**
2.	Exclude individual controls in commercial buildings	1.64 **[3rd]**
3.	CO_2 monitoring should be restricted to AHU level	2.21 **[1st]**

[Figures in brackets denote ranks]

When asked to rate the strategies to make credits under IEQ easier to attain, maximum respondents opined that CO_2 monitoring should be restricted to AHU level only giving it rank 1. In the present credit scenario, CO_2 monitoring has to be done in all densely occupied areas which increase the cost to install the CO_2 sensors in the building manifold. Air exchanges take place at the AHU level, if the monitoring is restricted to the AHU, the CO_2 level in the building will remain low itself.

Maximum stakeholders felt that humidity and temperature should have defined standards seeing the Indian climatic conditions giving it rank 2. Till now the rating system is using the ASHRAE and SMACNA guidelines to maintain the indoor air quality. But depending on the climatic conditions of India, there is an urgent need to put in place Indian air quality standards.

Rank 3 was given to exclude individual controls in commercial buildings to attain the credit of controllability of systems- Lighting. Every building has adopts different methods to meet their lighting requirements and hence it may not be necessary to employ individual task lighting for every work station. In many cases it only adds up to the cost of the fixtures bought for the building. Other strategies according to stakeholders which could make credits easier to

attempt and earn include preplanning of CO_2 credits and fresh air requirements, reduce compulsion to adopt multiple options under indoor chemical pollutants, introduce floor score rating for India, remove the criteria of task lighting, humidity and temperature should have defined standards seeing the Indian climatic conditions etc.

Conclusion

An unsaid truth is that the built environment has a vast impact on the natural environment, human health, and the economy. By adopting green building strategies, we can maximize both economic and environmental performance. Hence, green construction methods should be integrated into buildings at from the earliest stages of a building project [23]. It is estimated that 70% of the building stock that will be there in 2030 is yet to be built in India and the livability in the cities will be severely affected if no resource efficiency measures are employed [24].

A sustainable building project largely depends on the Indoor Environmental Quality as the eventual purpose of built environments is to support better quality of occupant's lives within an ecological system. The quality of indoor environments affect occupants most directly, therefore determines the success of a sustainable building project. To summarize, table 6 gives a clear idea about the hindrances and catalysts associated with each credit under IEQ category.

Table 6: Compilation of Catalysts and Hindrances Associated with each Credit under IEQ Category

Strategies to attain credits under IEQ	Reasons to select a particular strategy (Catalysts)	Reasons to reject a particular strategy (Hindrances)
Prerequisite 1- Minimum Indoor Air Quality Performance		
Ventilation Rate Procedure as per ASHRAE 62.1-2004	Mandatory credit. Hence the HVAC system has to comply with the ASHRAE standards	
Indoor Air Quality Procedure	Mandatory credit. Restricts contaminant concentrations to acceptable levels.	Additional aspect to the credit
		Increases cost as filter and pre filters have to be installed
Prerequisite 2- Environmental Tobacco Smoke (ETS) Control		
Prohibit smoking in the building	Only requires declaration of "No smoking" from the owner"	
	Inexpensive as no technology involved	
	Mandatory credit under IEQ	
Locate exterior smoking areas at least 25 feet from the entries and control its ventilation	Incase smoking zone has to be provided, this is the only strategy	Additional cost
		Difficult strategy as room has to be kept in negative pressure
Credit 1- Outdoor Air Delivery Monitoring		
Install CO_2 and airflow measurement equipment and trigger corrective action using BAS/HVAC system	Automated system, no need of manual arrangements	Expensive technology
	Installing a BAS helps achieving other credits in IEQ as well. One time investment for many automations in the building	Installing sensors in all regularly occupied areas is not understood by the owner
		Acceptance of technology
Using measurement equipment to trigger alarms	Inexpensive	A manual process.
	Easily understood by management	Time consuming
		Leads to inaccurate results as handled manually.
Credit 2- Increased Ventilation		
Use heat recovery to increase breathing zone above 30% rates	Only strategy available as per ASHRAE standards.	Expensive to install heat recovery wheels

required by ASHRAE		Difficult to explain the purpose of increased ventilation to owner
Credit 3.1- Construction Indoor Air Quality Management Plan—During Construction		
Meet or exceed the recommended SMACNA guidelines in design approach	Easy to comprehend	Elaborate set of guidelines which requires a check by the facility manager
	Minimum use of technology	
	Less expensive to administer	
Protect stored/absorptive materials from moisture damage	Easy to attempt	Additional storage space is required
	Less expensive	Manual inspection has to be done for mould formation
Filtration media of MERV 8 should be used in case of air handlers	Easy approach	Temporary
Credit 3.2- Construction Indoor Air Quality Management Plan—Before Occupancy		
Minimum 2 week building flush out with MERV 8 filters	Removal of all contaminants before occupancy	Third party commissioning is required
	Improved air quality	Can be expensive
Replacing filters by MERV 13 after flush out	Easy to administer	Very expensive
	Keeps contaminants in acceptable limits	Need constant replacement
	Improved air quality	
Credit 4.1- Low-Emitting Materials—Adhesives and Sealants		
VOC content of adhesives and sealants shall comply with the requirements of the reference standards	Only strategy to earn the credit	Difficult to procure adhesives and sealants with permissible VOC content
		Material cost increases
Credit 4.2- Low-Emitting Materials—Paints and Coatings		
Paints and coating used in the interiors shall comply with the requirements of the reference standards	Only strategy to earn the credit	Difficult to procure paints with permissible VOC content
		Material cost increases
Credit 4.3- Low-Emitting Materials—Flooring Systems		
All carpet installed in the building interior must demonstrate equivalence to the emissions test criteria of the CRI Green Label Plus Carpet Program	Easy approach to follow	Difficult to procure carpets with Green label certificate
		Cost increases
Select a product for which testing has been done by qualified independent laboratories in accordance with the appropriate requirements.	Difficult to procure carpets with Green label certificate	Third party testing required
	Contract given to a third party. No responsibility of the owner	Material cost increases
Credit 4.4- Low-Emitting Materials—Composite Wood and Agrifiber Products		
Wood and agri- fiber products should not contain added urea-formaldehyde resins	Only strategy to earn the credit	Difficult to procure paints with no added urea-formaldehyde resins
		Material cost increases
Laminating adhesives for field and shop-applied assemblies should contain no added urea-formaldehyde resins	Only strategy to earn the credit	Difficult to procure paints with no added urea-formaldehyde resins
		Material cost increases
Credit 5- Indoor Chemical and Pollutant Source Control		
Design facility cleaning and maintenance areas with isolated	Provides separate space for storing chemicals	Separate exhaust system has to be provided

exhaust systems for contaminants	Inexpensive strategy	Training of workers
	Utilization of manpower	Difficult to make the owner understand the strategy
Maintain physical isolation from the rest of the regularly occupied areas of the building	Provides separate space for storing chemicals	Separate exhaust system has to be provided
	Inexpensive strategy	The room has to be kept in negative pressure
	Utilization of manpower	Difficult to make the owner understand the strategy
Install permanent architectural entryway systems such as grills or grates	Easiest approach to achieve the credit	Does not look good in case the building is known for its aesthetics.
	Inexpensive	
	Easily understood by the owner	
Install high-level filtration systems in air handling units processing outside supply air (MERV 13)	Improves the air quality	Very expensive
	Enhances efficiency of the HVAC system	Not understood by the owners
Credit 6.1- Controllability of Systems—Lighting		
Provide individual lighting controls for 90% (minimum) of the building occupants	Increases concentration and work ability of employees	Expensive to employ
	Meets individual task requirements	Difficult to make the owner understand the need
		Difficult to achieve the threshold
Provide lighting system controls for all shared multi-occupant spaces	Meets the task requirements	Not needed in case individual lighting controls are provided
	Inexpensive as compared to the other strategy	
Credit 6.2- Controllability of Systems—Thermal Comfort		
Provide individual comfort controls for 50% (minimum) of the building occupants	Occupant comfort and well being	Expensive
	Gains in productivity	Difficult to make the owner understand the need
		Difficult to achieve the threshold
Provide comfort system controls for all shared multi-occupant spaces	Occupant comfort and well being	Acceptance of technology
	Inexpensive as compared to the other strategy	
	Gains in productivity	
Credit 7.1- Thermal Comfort—Design		
Design HVAC systems and the building envelope to meet the requirements of ASHRAE Standard 55-2004	ASHRAE standards are well defined and easy to comprehend	Expensive
	Standards are used to achieve other credits as well	Acceptance of technology
		Difficult to make the owner understand about the monitoring and corrective action
Demonstrate performance by using a local standard that has equivalent requirements to ASHRAE Standard 55–2004		ASHRAE standards are well defined and easy to comprehend
		Acceptance of technology
		Difficult to make the owner understand about the monitoring and corrective action
		Expensive

Credit 7.2- Thermal Comfort—Verification		
Provide a permanent monitoring system to ensure that building performance meets the desired comfort Criteria	Automated system, no need of manual arrangements	Expensive
	Installing a BAS helps achieving other credits in IEQ as well. One time investment for many automations in the building	Difficult to make the owner understand the need of the credit
		Acceptance of technology
Conduct a thermal comfort survey of building occupants within 6 to 18 months after occupancy.	No technology involved	Difficult in case the building is going for CS certification
	Inexpensive to carry out a survey	Difficult to make the owner understand the need to do a survey
	Talks about employee wellbeing in quantitative terms	
Credit 8.1- Daylight and Views—Daylight		
Demonstrate through computer simulation that the applicable spaces achieve daylight illuminance levels as described	Inexpensive as no technology is used.	Alterations happen if there are amendments in the design
	An expert in simulation can easily pull it of	Difficult to achieve the threshold of 75%
Use a combination of side-lighting and/or top-lighting to achieve a total day lighting zone that is at least 75% of all the regularly occupied spaces.	Easy if done by an expert	Alterations happen if there are amendments in the design
	No cost is involved	Difficult to achieve the threshold of 75%
Using records of indoor light measurements achieve minimum daylight illuminance levels	Easy if done by an expert	Alterations happen if there are amendments in the design
	No cost is involved	Difficult to achieve the threshold of 75%
Using combination of above calculation methods	Easy if done by an expert	Alterations happen if there are amendments in the design
	No cost is involved	
Credit 8.2- Daylight and Views—Views		
Achieve a direct line of sight to the outdoor environment via vision glazing	Only strategy to earn the credit	Alterations happen if there are amendments in the design

Table 7 throws light on how the strategies and technologies in credits under IEQ category in LEED India can be made simpler so that they are easier to attempt and attain. Researcher during the course of study has also come up with suggestions to make the credits easier to attain which have been presented alongside the suggestions taken in from the stakeholders.

Table 7: Compilation of Suggestions to make the Credits causing Hindrances Easier to Attempt and Attain

Strategies to attain credits under IEQ	Reasons to reject a particular strategy (Hindrance)	Suggestions of Stakeholders	Suggestions of researcher
Prerequisite 1- Minimum Indoor Air Quality Performance			
Ventilation Rate Procedure as per ASHRAE 62.1-2004, Indoor Air Quality Procedure	Mandatory credit Increases cost as filter and pre filters have to be installed	The ASHRAE standards very stringent and it is a task to design the HVAC accordingly. The owner does not understand the ASHRAE standard which is a hindrance in making them go for the prerequisite.	As the credit is a prerequisite, the ASHRAE standards should be such that the ventilation rate threshold is easily met.

Prerequisite 2- Environmental Tobacco Smoke (ETS) Control			
Prohibit smoking in the building	No hindrance	Easiest credit to achieve	Smoking being a potent cause for indoor particulate contamination has been addressed in the rating system very well.
Locate exterior smoking areas at least 25 feet from the entries and control its ventilation	Additional cost Difficult strategy as room has to be kept in negative pressure	This strategy is used rarely as owners usually prefer prohibiting smoking in the premises	
Credit 1- Outdoor Air Delivery Monitoring			
Install CO_2 and airflow measurement equipment and trigger corrective action using BAS/HVAC system	Expensive technology Installing sensors in all regularly occupied areas is not understood by the owner Acceptance of technology	CO_2monitoring should be restricted to AHU level. It is challenging to install CO2 monitors in densely occupied areas. It requires separate ducting which increases the overall cost.	As the fresh air enters any building through the AHU, CO_2 monitoring should be restricted to the AHU only.
Using measurement equipment to trigger alarms	A manual process. Time consuming Leads to inaccurate results as handled manually.	Measurement equipment is difficult to administer and time consuming. Pre planning should be done during the design stage for fresh air requirements.	Measurement equipment needs to be monitored manually at different times. This is a tedious process. So, strategy 1 should be used as BAS has multi purposes uses in energy as well as IEQ credits.
Credit 2- Increased Ventilation			
Use heat recovery to increase breathing zone above 30% rates required by ASHRAE	Expensive to install heat recovery wheels	More R&D has to be done on technology that can be used to achieve this credit as heat recovery wheels are expensive to install.	The space is already designed for 30% more ventilation than the requirements. Rarely more is required. More points should be allotted to this credit as it's expensive to earn
Credit 3.1- Construction Indoor Air Quality Management Plan—During Construction			
Meet or exceed the recommended SMACNA guidelines in design approach	Elaborate set of guidelines which requires a check by the facility manager	These guidelines should be diligently followed by the concerned authority. Progressive points should be given if a project employs more than one strategy.	A third party evaluator should be given the duty of inspection of the guidelines on the site, whether they are being followed or not. An extra point should be given if an inspector is deployed for the same.
Protect stored/absorptive materials from moisture damage	Additional storage space is required Manual inspection has to be done for mold formation		
Filtration media of MERV 8	Temporary		

should be used in case of air handlers	Difficult to explain the owner as HVAC is not used during construction in India		
Credit 3.2- Construction Indoor Air Quality Management Plan—Before Occupancy			
Minimum 2 week building flush out with MERV 8 filters Replacing filters by MERV 13 after flush out	Third party commissioning is required Can be expensive Need constant replacement	HVAC system is not used during construction in India. The ducts can be kept covered by some method other than MERV 8 filters.	Either MERV 8 or MERV 13 filter can be installed only once before occupancy. Incase both types of filters are used; the project should be eligible for an additional point.
Credit 4.1- Low-Emitting Materials—Adhesives and Sealants			
VOC content of adhesives and sealants shall comply with the requirements of the reference standards	Difficult to procure adhesives and sealants with permissible VOC content Material cost increases	It is important to make the vendors aware about the low VOC content in materials. Low VOC products can be 1.5 times more costly than normal products.	The production of low VOC products should be increased to bring down the cost of the product. Third party assessment should be done in case of the building goes for refurbishment.
Credit 4.2- Low-Emitting Materials—Paints and Coatings			
Paints and coating used in the interiors shall comply with the requirements of the reference standards	Difficult to procure paints with permissible VOC content Material cost increases	Constant testing of materials should be done post occupancy so that the building adheres to the standards set.	
Credit 4.3- Low-Emitting Materials—Flooring Systems			
All carpet installed in the building interior must demonstrate equivalence to the emissions test criteria of the CRI Green Label Plus Carpet Program Select a product for which testing has been done by qualified independent laboratories in accordance with the appropriate requirement	Difficult to procure carpets with Green label certificate	Floor score rating should be introduced in India. In addition to the options given by LEED, flooring systems with low embodied energy and recycled materials should be included in the strategies to earn the credit.	In case of carpets, care should be taken that they are cleaned at regular intervals and emit less dust as possible.
Credit 4.4- Low-Emitting Materials—Composite Wood and Agrifiber Products			
Wood and agrifiber products should not contain added urea-formaldehyde resins	Difficult to procure paints with no added urea-formaldehyde resins Material cost increases	Constant testing of materials should be done post occupancy so that the building adheres to the standards set.	

Laminating adhesives for field and shop-applied assemblies should contain no added urea-formaldehyde resins	Difficult to procure paints with no added urea-formaldehyde resins Material cost increases		
Credit 5- Indoor Chemical and Pollutant Source Control			
Design facility cleaning and maintenance areas with isolated exhaust systems for contaminants Maintain physical isolation from the rest of the regularly occupied areas of the building Install permanent architectural entryway systems such as grills and gates	Separate exhaust system has to be provided Training of workers Difficult to make the owner understand the need	Reduce compulsion to adopt multiple options under the credit. No separate generator rooms, plant room are provided as these rooms are clubbed with providing facilities for storing chemicals. Hence, on regular usage of the room, the building compromises on the acoustics.	In case the project is using more than one option; progressive points should be allotted for the same. Cleaning post occupancy should be given importance. The products used for cleaning and custodial training to the staff should be given so that the cleaning agents contribute to minimum deterioration of the air quality.
Install high-level filtration systems in air handling units processing outside supply air (MERV 13)	Very expensive Not understood by the owners		
Credit 6.1- Controllability of Systems—Lighting			
Provide individual lighting controls for 90% (minimum) of the building occupants Provide lighting system controls for all shared multi-occupant spaces	Expensive to employ Difficult to make the owner understand the need Difficult to achieve the threshold Not needed in case individual lighting controls are provided	The criteria of task lighting should be removed from commercial buildings.	In many buildings, both the strategies are being used to attain the credit. An additional point should be given in this case.
Credit 6.2- Controllability of Systems—Thermal Comfort			
Provide individual comfort controls for 50% (minimum) of the building occupants Provide thermal system controls for all shared multi-occupant spaces	Expensive	There needs to be standards for humidity and temperature seeing the Indian conditions.	The study shows that this credit has been attempted by less than 50% of the buildings. Seeing the hindrances associated, the number of points allotted to the credit should be increased.
Credit 7.1- Thermal Comfort—Design			
Design HVAC systems and the building envelope to meet the requirements of	Expensive Acceptance of technology	The ASHRAE standards are very stringent and it is a task to design the	Standards should be made according to the Indian standards.

ASHRAE Standard 55-2004	Difficult to make the owner understand about the monitoring and corrective action	HVAC accordingly.	
Demonstrate performance by using a local standard that has equivalent requirements to ASHRAE Standard 55–2004	ASHRAE standards are well defined and easy to comprehend		
	Acceptance of technology		
	Difficult to make the owner understand about the monitoring and corrective action		
	Expensive		
Credit 7.2- Thermal Comfort—Verification			
Provide a permanent monitoring system to ensure that building performance meets the desired comfort Criteria	Expensive	The owner does not understand the ASHRAE standard which is a hindrance in making them go for the credit.	The study shows that the buildings have opted for thermal comfort survey as the strategy to earn the credit. In case of CS buildings, the approach can be changed.
Conduct a thermal comfort survey of building occupants within 6 to 18 months after occupancy			
	Difficult to make the owner understand the need to do a survey		It is difficult to assume when the building would be occupied by the tenant. Hence, the project may lose on the credit point. So, strategy 1 should be employed.
Credit 8.1- Daylight and Views—Daylight			
Demonstrate through computer simulation that the applicable spaces achieve daylight illuminance levels as described	Alterations happen if there are amendments in the design	The threshold should be reduced from 75% to 50%. There needs to change in the limits of lux level to be achieved to make the credit easier to attain.	TThe study shows that this is the credit which has been least attempted. Therefore, modifications need to be made for this credit to become easy and attainable. The threshold can be reduced or 1 point should be given for a minimum threshold and 2 points if the project achieves 75%.
	Difficult to achieve the threshold of 75%		
Use a combination of side-lighting and/or top-lighting to achieve a total day lighting zone that is at least 75% of all the regularly occupied spaces.	Alterations happen if there are amendments in the design		
	Difficult to achieve the threshold of 75%		
Using records of indoor light measurements achieve minimum daylight illuminance levels	Alterations happen if there are amendments in the design		
	Difficult to achieve the threshold of 75%		

Using combination of above calculation methods	Alterations happen if there are amendments in the design		
Credit 8.2- Daylight and Views—Views			
Achieve a direct line of sight to the outdoor environment via vision glazing	Alterations happen if there are amendments in the design	Early planning during design stage should be done. Minimum alterations should be done when the project is in the construction phase.	

Overall, this study sees the catalysts and hindrances associated with LEED for India NC and CS. Apart from this, the study gives suggestions from stakeholders as well as of the researcher about overcoming the hindrances associated with IEQ credits and to make them easier to attempt and attain. Though modifications and revisions are done with new versions of the rating, this study gives a larger picture to overcome the hindrances and accelerate the growth of green buildings in India.

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