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Green Retrofitting of Educational Complex

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Abstract

Objectives: To carryout green audit in existing educational complex and provide suggestions for green retrofitting using IGBC rating system. **Methods/Analysis:** The green building movement has gained tremendous momentum during the past 3-4 years. The present building stock is substantively huge and denotes one of the largest chances to decrease energy waste and control air contamination and worldwide warming. This paper presents detailed green audit carried out for an existing educational complex along with the recommendation for Green Retrofitting of the building. The parameters considered are site and facility management, Energy consumption, Water consumption, indoor environmental quality and Innovation. The data has been collected for the green retrofitting of existing educational complex and the measures and cost analysis has been carried out for implementation of suggested measures for the green retrofitting. Also the payback period of the investments has been calculated. The green building rating as per IGBC rating system has been evaluated for the educational building considering its present status and also after implementation of suggestions for green retrofitting for the building. **Findings:** The building gains 35 points at present and 76 points after implementation of suggested measures for green retrofitting. Payback period for energy retrofitting is in the range of 3 to 5 years. **Applications/Improvement:** Green retrofitting of the considered building will have benefits for the owner as well as users in the form of more comfortable and hygienic environment. The exercise carried out in this work can be applied to any other existing buildings to achieve green certification. The present work will serve as basis for implementation of 'Green Retrofitting' to existing buildings wherein the findings of this work will motivate stakeholders to carryout Green Retrofitting.

Keywords: Energy Efficiency, Green Building, Performance, Retrofitting, Sustainability

1. Introduction

Green building refers to a structure and using process that is environmentally responsible and resource efficient throughout the building life cycle, form sitting to design, construction, operation, maintenance, renovation and demolition. This requires close co-operation of the design team, the architects the engineers, the client at all project stages. The green building practice expands and compliments the classical building design concerns of economy, utility and comfort. Green building is a new concept for us so that it will help us in a new learning's. IGBC green existing buildings O&M rating system is a voluntary and consensus based programme. The rating is focused on sustained performance of buildings with respect to the green features. The overarching objective of this rating system is to facilitate building owners and facility managers in implementation of green strategies, measure their impacts and sustain the performance in the long run. IGBC green existing buildings O&M rating system is fundamentally designed to address national priorities of resource conservation while providing quality of life for occupants. The rating programme uses well accepted national standards and wherever local or National standards are not available, appropriate international benchmarks have been considered[1]. Cities in developing countries frequently suffer from poor water quality. Thus, the ability to make informed decisions on the current state of urban water quality, as well as on rehabilitating or implementing new infrastructure, is necessary. The purpose is to assess the water quality

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state of urban systems and to explore suitability of treatment scenarios[2]. Sustainable Building (SB) has emerged as an innovative approach to minimizing the resource consumption of buildings. To promote the market uptake of SB, innovative Business Models (BMs) are needed[3]. All proposed in the construction of green buildings differs from that of traditional buildings in terms of the design, materials, and processes. The barriers to the development of green buildings, such as the high cost and project delay, further indicate that the productivity of green building construction needs to be tackled[4]. The Sustainable design covers not only environmental considerations, but also integrates environmental issues with cost, schedule, operations, maintenance, and worker/employee considerations. The system focus on recent studies reported the need for and significance of improving the sustainability of existing buildings to stabilize and reduce their greenhouse gas emissions and minimize their negative environmental impacts[6]. This can be accomplished by integrating sustainable upgrade measures in existing buildings to improve their energy efficiency, water consumption, material recycling, waste reduction, lifecycle, and indoor environment. These upgrade measures include energy-efficient lighting and HVAC systems, renewable energy systems, water-saving plumbing fixtures, and sustainable management of building solid waste[5]. A green building is characterized by its efficient use of energy, water and materials as well as providing a comfortable living and working environment for the occupants. From the above, it suggests that sustainable design is not an option but a necessity; because sustainable community repairs, reserves, and improves environment and values for the advantage of all life present-day and upcoming. A diverse and healthy environment is basically valuable and important to a healthy community; but today, people are seriously corrupting the environment and the environment is not sustainable[6]. A proposed in other words, they must be aware of interior architectural finishes, lighting, millwork, cabinetry, plumbing, and the entire interior design details; the conventional ones and their sustainable alternatives. This awareness must not only include the main furniture but also the artwork and accessories, to create interior spaces that are aesthetically attractive and functionally and environmentally successful. As in all the sustainable approaches, there are rating systems created to evaluate interior design success. For residential buildings, there is IGBC for homes, it has many categories. It is not basically for interior design however, the water efficiency part covers the indoor appliances while the Energy and Atmosphere covers the heating and cooling systems. Also, the materials and resources could cover the internal finishing materials, and the indoor environmental quality is used for reducing air pollution. In general, there is always the fear that using a rating system can make the designer focus on some points that look easier to achieve more than on the points that will lead to creating a better building[7]. The Government elected at the center wants to make in India. Lot of publicity has been carried out in this regard. Many programmers have been jointly sponsored by Make in India mission with CII, ASCHOM, SIAM, etc., The Prime Minister of the country is continuously inviting industries from the developed countries to manufacture in India. 5S is an approach in the work place for the improvement of various aspects such as efficiency, productivity through an organized manner. 5S denotes: seiri (sort), seiton (set in order), seiso (shine), seiketsu (standardize), and shitsuke (sustain)[8]. Renewable energy is generally defined as energy that comes from resources which are naturally replenished on a human timescale such as sunlight, wind, rain, tides, waves and geothermal heat 26. Renewable energy resources that are naturally replenishing but flow limited. They are virtually inexhaustible in duration but limited in the amount of energy that is available per unit of time. Most of the cities in the global are consuming almost 70%-80% energy. Smart cities will make a radical shift as the urban utility and environmental resources will be optimally used. Masdar City will also have a sustainable, zero-carbon and, zero-waste ecology[9]. The proposed in the indoor environmental quality generally concerns in six factors which are a ventilation rate, a carbon dioxide level, a concentration of dust, air speed, temperature, and humidity. These factors can be controlled within limits by using an air conditioning system and a filtered ventilation system. But how to control them within acceptable standards and at minimum operation costs is not known. Researches shows that poor Indoor Air Quality IAQ) in school buildings can cause a reduction in students' performance assessed by short-term computer-based tests; whereas good air quality in classrooms can enhance children's concentration and also teachers productivity. High levels of CO_2 have been

shown to cause a negative influence consumption of non-renewable resources on large scale in order to meet the increasing demand of human race is creating a stress on the available resources[10]. The energy retrofitting of buildings is in demand for promoting green and clean technology. Reduction of lighting will reduce the building cooling needs while increasing its mechanical heating requirements. It is evident that these steps are part of a complex system and it is extremely difficult to quantify the impact of their interactions. It is also well established that the outcome of different steps are not additive and the product of sum is smaller than the sum of products of individual steps[11]. According to the USGBC, with an upfront investment of 2% in green building design, the resulting life savings is 20% of the total construction costs. Along with this increase in monetary savings, green building and architecture has been proven to make the occupants more productive. Studies have shown a link between improved lighting design and a 27% reduction in the incidence of headaches. Also, students with the most day lighting in their classrooms progressed 20% faster on math tests and 26% faster on reading tests in one year than those with less day lighting[12]. A recent study by World Bank has highlighted the increasing rate of environmental degradation of air and water pollution, deforestation and natural disasters leading to climate change globally. However, it can be justified that green entrepreneurship is nothing short of a movement and a viable solution to various issues, be it ethical, social or environmental in nature. Major part of India falls in composite climate where heat gain from roofs and walls is a main problem. The diurnal temperature variations are as large as 35 to 220C[13]. The high summer day time temperature is between 39− 450 C, summer time low is 27−32 0C, winter time high temperature is 10−25 0C, and low 3 −10 0C with mercury touching around 10C[14]. Given the pace of Urbanization, it is predicted that nearly 70% of the world populations will be living in the cities by 2050 and India is no exception. Currently 31% of the Indian population stays in the cities and contributes about 65% to the national GDP (World Bank Data). The increase in Urbanization will exert immense pressure on the existing infrastructure, food supplies, water supplies, traffic management, waste disposal systems, sustainability and on the overall quality of life. According to Guidelines issued by Ministry of Urban development the strategic components in building a smart city would be city improvement (Retrofitting), City Renewal (Redevelopment), City extension (Greenfield development) Pan City[15]. The need for proactive green buildings awareness among the public could lead to their demand for more environmentally friendly buildings[16].

2. Methodology

An Indian Green Building Council (IGBC) Existing Building O&M Rating System has been followed for the Green Retrofitting of building. An IGBC Green Retrofit promotes mainly energy efficiency, water efficiency and green building practices for residential and commercial retrofit projects.

There are major five parameters to be considered for Green Retrofitting:

- Site and Facility Management.
- Water Efficiency.
- Energy Efficiency.
- Health and Comfort.
- Innovation.

Waste audit should be undertaken to find out the total amount of waste the building generates and also how much of this is being recycled and how much is sent to incineration and landfill. This knowledge will help to find opportunities to increase recycling efforts and reduce the amount of waste sent to incineration and landfill. A condition audit is intended to determine the current condition and expected remaining economic life of a building's components. It is a vehicle for producing a complete inventory of a building (including equipment) that identifies deficiencies. Typical areas to be examined will include the structure, external walls and roof, mechanical, electrical and IT systems, hazardous materials (asbestos, lead, etc.), security and a review of safety issues. Also many existing buildings have a poor indoor environmental and/or air quality (IEQ/IAQ). IEQ e-compasses, thermal comfort, air quality, lighting levels and noise levels. Audit of each of these should be done to find out how they currently perform and where improvements can be made.

The green existing buildings O&M rating system addresses the most important national priorities which include water conservation, energy efficiency, handling of waste, reduced use of fossil fuels, lesser dependence on usage of virgin materials and health and well-being of occupants.

2.1 Water Conservation

Most of the Asian countries are water stressed and in countries like India, the water table has reduced drastically over the last decade. Green existing buildings O&M Rating System encourages use of water in a self-sustainable manner through reducing, recycling and reusing strategies. By adopting this rating system, green existing buildings can save potable water to an extent of 15–30. Most of the Asian countries are water stressed and in countries like India, the water table has reduced drastically over the last decade %.

2.2 Handling of Consumer Waste

Handling of waste in existing buildings is extremely difficult as most of the waste generated is not segregated at source and has a high probability of going to land-fills. This continues to be a challenge to the municipalities which needs to be addressed. IGBC intends to address this by encouraging green existing buildings to segregate the building waste.

2.3 Energy Efficiency

The building sector is a large consumer of electrical energy. Through IGBC Green Existing Building O&M rating system, buildings have scope to reduce energy consumption through energy efficient-lighting, air conditioning systems, motors, pumps etc. The operational energy savings that can be turn to 15-30% by these ratings.

2.4 Reduced Dependency on Virgin Materials

The rating system encourages projects to use recycled materials, and discourages the use of virgin wood during renovation, thereby, addressing environmental impacts associated with extraction and processing of virgin materials.

2.5 Health and Well-being of Occupants

Health and well-being of occupants is the most important aspect of Green Existing Buildings. IGBC Green Existing Buildings O&M Rating System ensures minimum ventilation aspects, occupant well-being facilities which are critical in a building. The rating system also recognizes measures to minimize the indoor air pollutants.

3. Green Retrofitting of Educational Building

A case study has been undertaken and entire procedure of Green Retrofitting was applied on existing college building. While selecting case study, the main concern was, lots of data, which is required for carrying out the work. Hence the 8 storied educational complex of Dr. D. Y. Patil Institute of Technology has been selected as a case study for the project work. The Green Retrofitting for this organization will be value addition to the institute.

Dr. D. Y. Patil Institute of Technology, Pimpri, Pune (DIT), all the eligible programmes have been accredited by the National Board of Accreditation (NBA). The Institute has been awarded 'A' grade by the Government of Maharashtra (India). The Institute is an ISO 9001:2008 certified institute. The college is located at Pimpri in the heart of Pimpri-Chinchwad industrial belt, which is one of the biggest industrial belts in Asia. The college has been awarded as a best college and best principal in Pune University. The campus has well ventilated, spacious classrooms, seminar rooms, laboratories, library, administrative block and conference Figure 1 shows the photograph of educational complex.

- **Name of Project:** DIT College (C Block) Pimpri, Pune.
- **No. of Stories:** Basement and G+8.
- **Total Building Area:** 251333.33 sq/ft.
- **Total Built up Area:** 122805.45 sq/ft.

Figure 1. Dr. D. Y. Patil Institute of Technology, Pimpri, Pune (DIT).

3.1 Action Plan

Basically retrofitting is recommended for building which older than 20–25 years. But need to consider some points like old buildings also have other drawbacks such as lack of security and maintenance services, absence of common facilities like gymnasium and society office, unavailability of proper open area for children in the compound, leakage problems, absence of elevators, poor interior planning of rooms and low resale value due to the poor condition of the buildings.

The building and the practices were studied according to the parameters discussed. For each parameter, following points are discussed in next section:

- The requirement as per (IGBC EB O&M) rating system.
- The available facilities or existing practices of the Institute (DIT).
- Recommendation or suggestion for improvement.

Table 1 shows DIT Educational complex Credit Points and Reasons of points for Site and Facility Management.

Table 2 shows DIT Educational complex Credit Points and Reasons of points for Water and Energy Efficiency.

Table 3 shows DIT Educational complex Credit Points and Reasons of points for Health and Comfort.

Table 1. DIT (C Block) credit points for certification and reasons of points for site and facility management

SR No.	Credit Name	Points Available	Possible Points	Not Possible Points	Reason of Points
Site & Facility Management					
SF MR 1	Green Policy	Yes	**Y**	-	As per IGBC rating system, In DIT College the required clearances from all regulatory bodies are in place.
SF MR 1	Waste Collection & Disposal	Yes	**Y**	-	Presently, biodegradable and non-biodegradable waste is segregated and it is sent to PCMC. Further it is suggested to segregate plastic, metals, and paper waste at the institute itself.
SF CR 1	Eco-friendly Commuting Practices: 25%, 50%	4	2	2	At present, due to location advantage, public transport is being used by students and staff to some extent. It is suggested to carry out some awareness programmes and motivate stakeholders so that the percentage of people using public transport/ecofriendly transportation increased.
SF CR 2	Eco-friendly Landscaping Practices: 50%, 75%	2	1	1	Natural landscaping with local plants is maintained in the campus. Institute has been suggested to have policy to use only organic fertilizers and grow native and adaptive plants in future.
SF CR 3	Heat Island Reduction, Non-roof: 50%, 75%	4	4	0	The Institute already has existing tree canopy and enough shading in campus
SF CR 4	Heat Island Effect: Roof 50%, 75%	4	4	0	It is suggested to install High Solar Reflective Index (SRI) tiles on entire roof area of building.
SF CR 5	Outdoor Light Pollution Reduction	2	2	0	Not much outdoor light pollution observed and suggested to do necessary arrangement of external lights to avoid this pollution.
SF CR 6	Building Operations & Maintenance	2	1	1	The Institute will have 1 point for doing green audit every 3 years and also have water and energy meters and the buildings having less than 50% of occupied area as air conditioned So, no need to install HVAC System and BMS.
		18	**14**	**4**	

Table 2. DIT (C Block) credit points for certification and reasons of points for water and energy efficiency

Water Efficiency					
WE MR 1	Water Efficient Fixtures	Yes	**Y**	-	The Institute has been recommended to use water efficient fixtures whose flow rates less than the baseline criteria, individually or in aggregate.
WE CR 1	Water Efficient Fixtures: 20%, 30%, 40%	6	4	2	The Institute will replace all the fixtures of WC, Taps, Faucets to low flow fixtures and no need to replace Urinal and Jet Spray.
WE CR 2	Rain Water Harvesting: 25%, 50%	4	4	0	The Institute will save 50% of Rain water from Roof and Non-Roof area from total runoff volume 109 cubic meter of DIT.
WE CR 3	Waste Water Treatment: 100%	4	4	0	The Institute already have existing STP of Capacity 200 KLD
WE CR 4	Waste Water Reuse, 75%,100%	4	4	0	The Institute reuses STP water for landscaping and flushing.
WE CR 5	Water Metering	4	4	0	The Institute have water meter and also will upgrade if needed.
WE CR 6	Turf Area: 50%, 25%	4	2	2	The Institute has Turf Area of 50% as a Percentage of Total Landscaped Area.
		26	**22**	**4**	
Energy Efficiency					
EE MR 1	Eco-friendly Refrigerants and Halons	Yes	**Y**	-	The Fire suppression & AC systems used in the institute are free from halons or other ozone depleting substances & suggested to check it.
EE MR 2	Minimum Energy Performance	Yes	**Y**	-	The Institute has been recommended to have annual minimum energy consumption of energy systems by LED retrofitting in the building to achieve the EPI limits.
EE CR 1	Improved Energy Performance	14	14	0	The Institute has already EPI below 40% and also will get innovation credit after Green Retrofitting.
EE CR 2	On site Renewable Energy: 2.5%, 5%, 7.5%	6	6	0	The Institute will Generate more than 7.5% On site Renewable Solar Energy after Green Retrofitting and also will get innovation credit in it.
EE CR 3	Off Site Renewable Energy: 25%, 50%, 75%	6	0	6	There are no such arrangements for purchasing off site renewable energy as on today and also presently no need.
EE CR 4	Energy Metering	4	4	0	The Institute already has energy meters. Need to upgrade by installing Sub-Meters for every building.
		30	**24**	**6**	

Table 3. DIT (C Block) credit points for certification and reasons of points for health and comfort

Health and Comfort					
HC MR 1	Tobacco Smoke Control	Yes	**Y**	-	In the Institute, Smoking is strictly prohibited in the entire campus. And has been recommended to install signage.
HC MR 2	Fresh Air Ventilation	Yes	**Y**	-	In The Institute, as per IGBC rating system the fresh air ventilation already exists and also there is enough open space as per requirement. Also institute has been suggested to use as per requirement.
HC CR 1	Carbon dioxide Monitoring & Control	2	0	2	As Classroom & Seminar halls are well ventilated. So this system may not require at present.
HC CR 2	Isolation of Polluting Equipment & Systems	2	0	2	Change in position of existing equipment is not feasible, also not required and there are exhaust fans, wherever necessary.
HC CR 3	Eco-friendly Housekeeping Chemicals	2	2	0	The Institute will replace all the normal housekeeping chemicals to Eco-friendly Housekeeping Chemicals.
HC CR 4	Thermal Comfort, Indoor Temperature and RH	2	0	2	At present no such system is installed.
HC CR 5	Facilities for Differently Abled People	4	4	0	The Institute already has lifts and other facilities. It is suggested to upgrade facilities for differently abled people as per requirement.
HC CR 6	Occupant Well-being Facilities	2	2	0	The Institute already has facilities, like outdoor sports and yoga and also will upgrade occupant well-being facilities as per requirement.
		14	**8**	**6**	

Table 4. DIT (C Block) credit points for certification and reasons of points for innovation category

Innovation Category					
ID CR 1.1	Credit 1-1 Innovation in Design	2	2	0	The Institute will retrofit high SRI tiles for roof more than 95% area.
ID CR 1.2	Credit 1-2 Innovation in Design	2	0	2	Here 30% of water will be only saved by water fixtures, which is less for qualifying as innovation.
ID CR 1.3	Credit 1-3 Innovation in Design	2	2	0	The Institute will achieve more than 14 point EPI after Green Retrofitting for qualifying as innovation.
ID CR 1.4	Credit 1-4 Innovation in Design	2	2	0	More than 7.5% energy will generated by on-site solar energy after Green Retrofitting for qualifying as innovation.
ID CR 1.5	Credit 1-5 Innovation in Design	2	0	2	At present no need to buy off-site energy.
ID CR 2	Credit 2: IGBC AP	2	2	0	IGBC AP will be a part of implementation of Green Retrofitting.
		12	**8**	**4**	
Possible Points:		**100**	**76**	**24**	**National Excellence**

Table 4 shows DIT Educational complex Credit Points and Reasons of points for Innovation Category.

Table 5 shows Energy Consumption of DIT Educational complex.

Table 6 shows LED Unit savings (Daily).

Table 5. Energy consumption of DIT educational complex

Light bill Total	Unit Consume Total	Rate /Unit	Total Bill Amount
	290000	8.73 (Average)	25,26,345.00 Per Year Used

Table 6. LED unit savings (Daily)

Description	Single LED Light unit consumed	Double LED Light unit consumed	Passage Big. 2ft LED Light unit consumed	LED Lamp in Lobby and Seminar Hall unit consumed	Wash Room LED Lamp unit consumed	SUPER FANS Celling Fans of 3 Wings unit consumed
Replacing Watts	20wt	40wt	40wt	6wt	6wt	40wt
Total Units Post Retrofit	82.38	166.56	19.68	4.4	4.56	187

3.2 Lighting Stimulation

Total consumption in units before and after Green retrofitting is provided in Figure 2**.**

The total units consumption per day = 466.58 kWh.

The total units consumption per year = 168000 kWh.

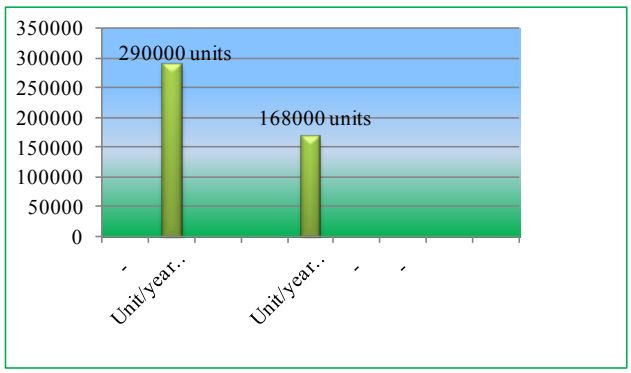

Figure 2. Lighting retrofit.

3.3 Solar Calculation

3.3.1 Solar Installation Cost

- Roof area for solar installation = 5000 sqft.
- Space required for 1 KW Panel = 70−80 sqft
- Hence, 5000 / 80 = 62.5 KW = 60 KW.
- 60 KW on grid system charges = 3894000.
- Net meter charge =85000.
- Installation charge (including fabrication) = 55000.

Total cost (3894000 + 85000 +55000) = 40, 34,000

Sunny days yearly = 325 days

So, the effective energy units produced per day = 60kw * day hours (effective sun)

= 60 KW * 4.5 hrs

= **270 kwh.**

Cost comparison has been presented in Figure 3.

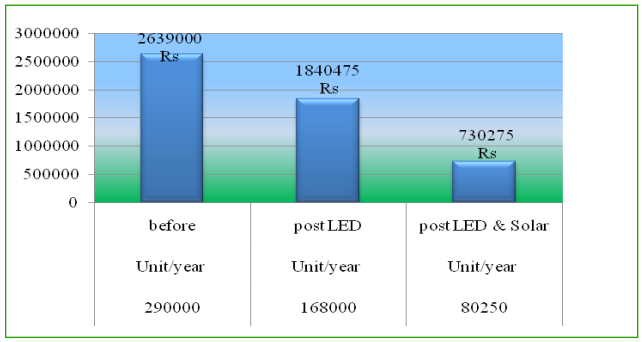

Figure 3. Solar retrofit.

3.3.2 Before LED Retrofit

Therefore, annual energy bill savings = energy units generated per day * Sunny days yearly * Rate of Units

= 270 * 325 * 9.1

= 87750 * 9.1

= 798525 Rs.

3.3.3 Payback Period

= Total set up cost of solar / annual energy bill saving with solar

= 40, 34,000/ 79852

= 5.05 Years

3.4 Water Consumption and Cost Calculation

Water consumption of our college DIT building (C block) is 80−100 TON per Day including Tank and PCMC water.

One unit = 1000 litter

Table 7 shows Water consumption bill.

Table 7. Water bill

Total Water Bill	Avg. 210 Tank per year used (Rs. 950 per tank approx.)
Rs. 114130	**Rs. 199500**

Therefore water consumption in Rs = Total PCMC Water Bill + Tank Bill

= 114130+19950= 313,630

=Avg. Rs. 315000

Table 8 shows Retrofitting of Plumbing Low-Flow Fixtures and its Cost Calculations.

Table 8. Plumbing low-flow fixtures cost calc

Sr. No	**Type of Plumbing Fixtures To be Retrofitted**	**Flow Rates**	**Cost**
1	Wash Basin faucets	2.5	Rs. 73710
2	Tapes	4	Rs. 32000
3	Water Closets dual flow	2	Rs. 51450
Total Cost of Plumbing Fixtures:			**1,57,160**

Total installation Charges= 50,000 Rs. approx

Therefore the total Plumbing fixtures for Retrofitting

= Total Cost of Plumbing Fixtures + Installation Charge

= 1, 57,160 + 50,000

= Rs. 2, 07,160.

Table 9 shows Rain water harvesting and its Cost Calculation

Table 9. Rain water harvesting cost calculation

Sr. No.	**Types of Area**	**Total sq.m. Area**	**Total Cost**
1	Roof Area	1300	2,80,000
2	Non-Roof Area	6250	23,54,625
Total harvesting cost:			**2634625/-**

Now, 1 Unit = 1000 Litter = Rs 2.5.

And 1 Cubic Meter = 1000 Litter

Now, the Total Runoff Volume = 109 cubic meter

So, to harvest 50% of Rain Water = 109 *50/100

= 55 Cubic Meter.

Now, 55 Cubic Meter= 55000 Litter

Therefore Total Cost Saving

= 55000 Litter * 2.5 Rs.

= Rs. 137500

3.5 High SRI Tiles Cost Calculations

High Solar Reflective Index (SRI) Tiles are white tiles which reflect the solar heat and reduce heat island effect.

Table 10 shows High SRI Tiles and its Cost calculation.

Table 10. High SRI tiles cost calculation

Sr. No.	**Design**	**Area**	**Total cost**
1	300 × 300 10mm cool roof SRI Tiles	14000 sq.ft.	742000/-

Total Calculation = 18% GST + Local Transportation + installation charges + other charges (5%) + Actual cost of Tiles

= 133560 + 5000 Approx. + 150000 + 37100 + 742000

= 10, 67,660

= Avg. Rs. 10, 70,000.

3.6 Eco-Friendly Chemicals Cost Calculations

These chemicals are used in place of housekeeping chemicals and will not harm to environments.

Table 11 shows Eco-Friendly Chemicals and its Cost Calculations.

Therefore total cost per year = total cost per month * 10 Month = **267400=Avg. Rs. 2, 68,000.**

Table 11. Eco-friendly chemicals cost calculations

Sr.No.	**Chemical Name and Description (HAYLIDE)**	**Rate Per Unit**	**Total Cost**
1	**APC-F GREEN** All - in -one Heavy Duty Cleaner for all types of Floors, Glass, Metallic, Laminated Furniture & all other Hard Non Porous Surfaces **(With Fragrance)**	529/-	7935/-
2	**Sterix A Super GREEN (Bio-degradable Acidic) Benzalkonium Chloride (0.5%) Bathroom Cleaner (Sinks -Tiles - Fittings - Glass etc.)** For Hard Water Marks & Highly Stained Heavy Usage Bathrooms (HCl Free) (**Not for Marble Floors**)	680/-	3400/-
3	**WC GREEN (100% Bio-degradable Acid Based) Heavy Duty WC & Urinal Cleaner** For Hard Water and Organic Stain Marks and Highly Stained Heavy Usage Bathrooms*	659/-	9885/-
4	**Fresh Hands LQ GREEN Clear Gel Hand Wash** (Economical Soap Free + Aloe Vera + Glycerin)	552/-	5520/-
	Total Cost per Month:		**Rs. 26740**

4. Result and Discussion

Detailed assessment carried out for the educational building has three aspects, Green Ratings, cost analysis for carrying out Green Retrofitting and pay-back calculations.

At Present calculations the building gains 35 points for the present status and after implementation of the recommendation suggested in this work, the same building will score 76 points. Hence after carrying out Green Retrofitting, the building will be awarded 'Gold certificate by IGBC.

Figure 4 shows the cost calculation which will be required for implementation of the suggested measures. For the above cost, pay-back period has been calculated which is presented in Figure 5.

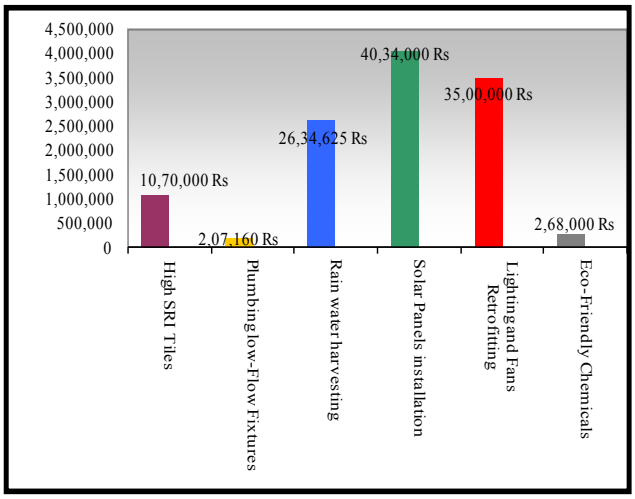

Figure 4. Cost analysis.

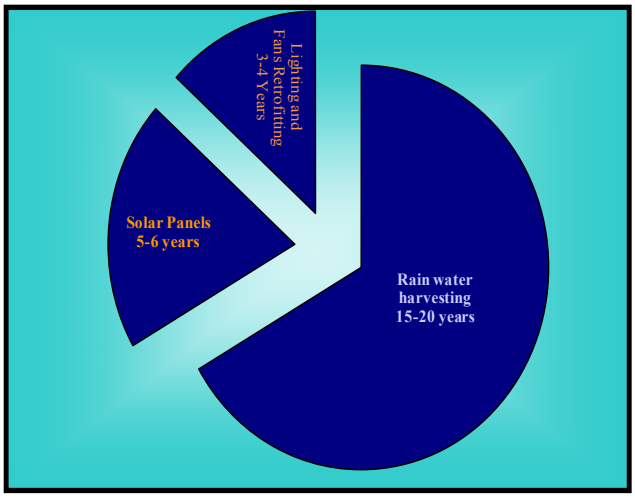

Figure 5. Payback period.

Table 12 shows DIT Rating Points for IGBC Certification.

Table 12. DIT rating points for certification

SR No.	Credit Name	Points Available	Points at present	Possible Points after Retrofitting
1.	Site & Facility Management	18	4	14
2.	Water Efficiency	26	12	22
3.	Energy Efficiency	30	14	24
4.	Health and Comfort	14	4	8
5.	Innovation Category	12	1	8
TOTAL CREDIT		**100**	**35**	**76**

Table 13 shows IGBC Certification Level.

Table 13. IGBC certification level

Certification Level	Points	Recognition
Certified	50–59	Best Practices
Silver	60–69	Outstanding Performance
Gold	**70–79**	**National Excellence**
Platinum	80–100	Global Leadership

Hence, total points obtained after green retrofitting will be **76.**

Hence, the building will fall under "**GOLD**" category.

5. Conclusion

In India some world class Green Building are constructed in past years, but a large investment of existing building need to be Green Retrofitted. The fast paced growth in economic and human activity across the global has put environmental resources under tremendous pressure thereby becoming a cause for irreversible damages to the environment at large and putting the quality of life of future generations to unknown risks. The increasing apprehension towards the environment is pushing the policy makers to seek sustainable solutions, leading to the origin of the theory of green buildings.

In the present work, 'Green Retrofitting' concept is studied in detail. A case study of existing educational complex has been carried out and IGBC rating for the same has been determined. Also, the existing facilities and the recommen-

dation are given point wise, considering IGBC guidelines cost analysis for implementing the Green Retrofitting to the selected educational complex has been carried out.

Following are the major conclusions derived:

- Green Retrofitting is very much essential and the awareness among all stakeholders is required to be created.
- IGBC rating of existing green buildings rating system has been studied and 76 credit of rating has been given to this selected case study.
- On the basis of IGBC credit ratings "Gold Certificate" has been decided for this building.
- As per recommendation suggested 30% of portable water has been saved from Low flow plumbing fixtures and 50% of rain water harvested from roof and non-roof areas which heads to concrete sayings.
- As per recommendation suggested 122000 kwh i.e., Rs 11,10,200 has been saved annually from LED Retrofitting and 87750 kwh i.e. Rs 7,98,525 has been saved annually from Renewable Solar Panels energy which is very good Energy Efficiency for this educational complex.
- Total Investment for "Green Retrofitting" of DIT building is 1,17,13,785 Rs.
- The Pay-back period of "LED Retrofitting" and "Renewable Solar Energy" is 3−4 years and 5−6 years which is very cost effective institute.

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7. Reference

1. IGBC Green Existing Buildings O&M. Available from: greencleanguide.com/igbc-green-existing-buildings-rating-system/
2. Rodríguez- Jeangros N, Camacho LA, Rodríguez JP, McCray JE. Integrated urban water resources model to improve water quality management in data-limited cities with application to Bogotá, Colombia. ASCE Journal of Sustainable Water in the Built Environment. 2018; 4(2):1–1. Crossref.
3. Çıdık MS, Boyd D, Thurairajah N. Innovative capability of building information modeling in construction design. Journal of Construction Engineering and Management. 2017; 143(8):1–34.
4. Hwang BG, ASCE M, Zhu L, Ming JTT. Factors affecting productivity in green building construction projects: The case of singapore. Journal of Management in Engineering. 2017; 33(3). Crossref.
5. Abdallah M, ASCE AM, El-Rayes K. Multi objective optimization model for maximizing sustainability of existing buildings. ASCE Journal of Management in Engineering. 2016; 32(4). Crossref.
6. Bashir FM, Ahmad MH, Sale AU, Abdullahi A, Aminu AS. Fundamental elements for sustainable design. Indian Journal of Science and Technology. 2016; 9(46):1–2.
7. Reham MM, Eldin M. Sustainable interior design for homes. Indian Journal of Science and Technology. 2017; 10(15):1–7. Crossref.
8. Anushan SCS, Anbarasu P, Antony ANJ, Selva Pandi K. Model of make in India possibilities: An Indian operations dream. Indian Journal of Science and Technology. 2016; 9(27):1–2.
9. Madakam S, Ramaswamy R. Sustainable Smart City: Masdar (UAE) (A City: Ecologically Balanced). Indian Journal of Science and Technology. 2016, 9 (6) pp. 1−3. Crossref.
10. Taemthong W, Sirikulyanon W. Improving indoor air quality in university buildings in Thailand. Indian Journal of Science and Technology. 2015; 8(29):1–8. Crossref.
11. Makarechi S. Shades of green technologies: Identification of significant parameters affecting the performance of green technologies in buildings. International Journal of Environmental Policy and Decision Making. 2010; 1(1)1–2. Crossref.
12. Retrofitting of an existing building into a green building. Available from: https://www.wbdg.org/.../retrofitting-existing-buildings-improve-sustainability-and-en
13. Mathur S, Tandon N. Green entrepreneurship: The emerging paradigm for sustainable growth and development in India-A study of the millennials. Indian Journal of Science and Technology. 2016; 9(45):1–3. Crossref.
14. Kumar A, Chani PS, Deoliya R. Green retrofit potential in existing research laboratories and demonstration of energy efficient and sustainable technologies: Case study. International Journal of Science, Engineering and Technology Research (IJSETR). 2014; 3(3):400–2.

15. Vadgama C, Khutwad A, Damle, Patil S. Smart funding options for developing smart cities: A proposal for India. Indian Journal of Science and Technology. 2015; 8(34):1–3. Crossref.

16. Nimlyat PS, Kandar MZ, Zango1 MS. Green building and environment sustainability: A retrofit of chemical engineering pilot plant building Universiti Teknologi Malaysia [UTM]. Indian Journal of Science and Technology. 2016; 9(46):1–2. Crossref.