Module 8

GREEN BUILDINGS

- Prof. Rohan Dasgupta

Green buildings doesn't have to necessarily look like these:

So let's take a look at the top 10 green buildings of 2014

WAYNE N. ASPINALL FEDERAL BUILDING AND COURTHOUSE, GRAND JUNCTION, COLORADO

U.S. LAND PORT OF ENTRY, WARROAD, MINNESOTA

SUSTAINABILITY TREEHOUSE, GLEN JEAN, WEST VIRGINIA

SUNY-ESF GATEWAY CENTER, SYRACUSE, NEW YORK

THE DAVID AND LUCILE PACKARD FOUNDATION HEADQUARTERS, LOS ALTOS, CALIFORNIA

5

JOHN AND FRANCES ANGELOS LAW CENTER, BALTIMORE, MARYLAND

EDITH GREEN-WENDELL WYATT FEDERAL BUILDING MODERNIZATION, PORTLAND, OREGON

3

BUSHWICK INLET PARK, BROOKLYN, NEW YORK

2

BUD CLARK COMMONS, PORTLAND, OREGON

1

ARIZONA STATE UNIVERSITY STUDENT HEALTH SERVICES, TEMPE, ARIZONA

GREEN BUILDING

Green building (also known as **green construction** or **sustainable building**) refers to both a structure and the using of processes that are environmentally responsible and resource-efficient throughout a building's life-cycle: from siting to design, construction, operation, maintenance, renovation, and demolition.

Green building design involves finding the balance between homebuilding and the sustainable environment.

The Green Building practice expands and complements the classical building design concerns of economy, utility, durability, and comfort.

GREEN BUILDING: OBJECTIVES

Although new technologies are constantly being developed to complement current practices in creating greener structures, the common **objective is that green buildings** are designed to reduce the overall impact of the built environment on human health and the natural environment by:

- ✓ Efficiently using energy, water and other resources
- ✓ Protecting occupant health and improving employee productivity
- ✓ Reducing waste, pollution and environmental degradation

Goals of Green Buildings:

- ✓ Siting and structure design efficiency
- ✓ Energy efficiency
- ✓ Water efficiency
- ✓ Materials efficiency

- ✓ Indoor environmental quality enhancement
- ✓ Operations and maintenance optimization
- ✓ Waste reduction
- ✓ Cost and payoff

Siting and structure design efficiency:

- The foundation of any construction project is rooted in the concept and design stages.
- The concept stage, in fact, is one of the major steps in a project life cycle, as it has the largest impact on cost and performance.
- In designing environmentally optimal buildings, the objective is to minimize the total environmental impact associated with all life-cycle stages of the building project.
- However, building as a process is not as streamlined as an industrial process, and varies from one building to the other, never repeating itself identically.
- In addition, buildings are much more complex products, composed of a multitude of materials and components each constituting various design variables to be decided at the design stage.
- A variation of every design variable may affect the environment during all the building's relevant life-cycle stages.

Energy efficiency:

- Green buildings often include measures to reduce energy consumption – both the embodied energy required to extract, process, transport and install building materials and operating energy to provide services such as heating and power for equipment.

- Buildings built primarily with wood will have a lower embodied energy than those built primarily with brick, concrete, or steel.

Energy efficiency:

- Techniques to reduce operating energy:

✓ reduce air leakage through the building envelope
✓ high-performance windows and extra insulation in walls, ceilings, and floors
✓ passive solar building design
✓ orient windows and walls and place awnings, porches, and trees to shade windows and roofs during the summer while maximizing solar gain in the winter
✓ effective window placement
✓ solar water heating
✓ onsite generation of renewable energy through solar power, wind power, hydro power, or biomass

Water efficiency:

- The protection and conservation of water throughout the life of a building may be accomplished by **designing for dual plumbing that recycles water in toilet flushing or by using water for washing of the cars**.
- Waste-water may be minimized by utilizing **water conserving fixtures such as ultra-low flush toilets and low-flow shower heads**.
- **Bidets** help eliminate the use of toilet paper, reducing sewer traffic and increasing possibilities of re-using water on-site.
- **Point of use water treatment** and heating improves both water quality and energy efficiency while reducing the amount of water in circulation.
- The use of non-sewage and **greywater** for on-site use such as site-irrigation will minimize demands on the local aquifer.

Material efficiency:

Building materials typically considered to be 'green' include:

✓ lumber from forests that have been certified to a third-party forest standard,

✓rapidly renewable plant materials like bamboo and straw,

✓ dimension stone,

✓recycled stone,

✓ recycled metal

✓other products that are non-toxic, reusable, renewable, and/or recyclable.

✓For concrete a high performance or Roman self-healing concrete is available.

✓The EPA (Environmental Protection Agency) also suggests using recycled industrial goods, such as coal combustion products, foundry sand, and demolition debris in construction projects

Indoor Environmental Quality Enhancement

Indoor environmental quality deals with providing **comfort, well being** and **productivity** of the occupants by virtue of **indoor air quality, thermal quality** and **lighting quality.**

Indoor Environmental Quality Enhancement

Indoor Air Quality:

- ✓ Reduce volatile organic compounds (VOCs)
- ✓ Reduce microbial contaminants
- ✓ Provide adequate ventilation
- ✓ Control of moisture accumulation (dampness)

Thermal Quality:

- ✓ Personal temperature and airflow control
- ✓ Properly designed building envelope

Lighting Quality:

✓ Creating a high performance luminous environment through the careful integration of daylight and electrical light sources

Orperations and Maintenance Optimization

✓ No matter how sustainable a building may have been in its design and construction, it can only remain so if it is operated responsibly and maintained properly.

✓ The addition of new green technologies also falls on the O&M staff.

✓ Although the goal of waste reduction may be applied during the design, construction and demolition phases of a building's life-cycle, it is in the O&M phase that green practices such as recycling and air quality enhancement take place.

✓ O&M staff should aim to establish best practices in energy efficiency, resource conservation, ecologically sensitive products and other sustainable practices.

✓ Education of building operators and occupants is key to effective implementation of sustainable strategies in O&M services.

Waste Reduction

- ✓ Reduction of waste of energy
- ✓ Reduction of waste of water
- ✓ Reduction of waste of materials
- ✓ Reduce the amount of materials going to the landfill during construction
- ✓ Provide on-site waste solution like composting bins
- ✓ Consider wood recycling
- ✓ Extend the useful life of a building
- ✓ "Greywater", wastewater from sources such as dishwashing or washing machines, can be used for subsurface irrigation, or if treated, for non-potable purposes, e.g., to flush toilets and wash cars.
- ✓ Convert waste and wastewater into fertilizer

COST AND PAYOFF

✓The most criticized issue about constructing environmentally friendly buildings is the price.

✓ Photo-voltaics, new appliances, and modern technologies tend to cost more money.

✓ Most green buildings cost a premium of <2%, but yield 10 times as much over the entire life of the building.

✓ In regards to the financial benefits of green building, over 20 years, the financial payback typically exceeds the additional cost of greening by a factor of 4-6 times.

✓ The stigma is between the knowledge of up-front cost vs. life-cycle cost.

✓ The savings in money come from more efficient use of utilities which result in decreased energy bills. It is projected that different sectors could save $130 Billion on energy bills.

COST AND PAYOFF

✓ Higher worker or student productivity can be factored into savings and cost deductions.

✓ Broader benefits, such as reductions in greenhouse gases (GHGs) and other pollutants have large positive impacts on surrounding communities and on the planet.

✓ Confirming the rentability of green building investments, further studies of the commercial real estate market have found that LEED and Energy Star certified buildings achieve significantly higher rents, sale prices and occupancy rates as well as lower capitalization rates potentially reflecting lower investment risk.

LEADERSHIP IN ENERGY AND ENVIRONMENTAL DESIGN

Leadership in Energy and Environmental Design (**LEED**) is a set of rating systems for the design, construction, operation, and maintenance of green buildings, homes and neighbourhoods.

LEADERSHIP IN ENERGY AND ENVIRONMENTAL DESIGN

- Developed by the U.S. Green Building Council (USGBC), LEED helps building owners and operators be environmentally responsible and use resources efficiently.
- From 1994 to 2006, LEED grew from one standard for new construction to a comprehensive system of interrelated standards covering all aspects of the development and construction process. LEED also has grown from six volunteers on one committee to more than 200 volunteers on nearly 20 committees and nearly 150 professional staff.
- LEED standards have been applied to more than 7,000 projects in the United States and 30 countries, covering more than 1.5 billion square feet (140 km^2)

LEADERSHIP IN ENERGY AND ENVIRONMENTAL DESIGN

- **LEED Performance Credit System:**

The LEED performance credit system aims to allocate points based on the potential environmental impacts and human benefits of each credit.

Points are allotted for specific criterions like energy efficiency, waste reduction, indoor environment quality etc.

The addition of all those points provides the basis for the LEED certification which are as follows:

LEED Certified: 40 – 49 points
LEED Silver: 50 – 59 points
LEED Gold: 60 – 79 points
LEED Platinum: 80 points and above

LEADERSHIP IN ENERGY AND ENVIRONMENTAL DESIGN

- **Examples:**

✓ Phipps Conservatory & Botanical Gardens in Pittsburgh has multiple LEED certifications, including the world's only Platinum-certified greenhouse and a Platinum-certified and net-zero energy Centre for Sustainable Landscapes.

✓ Taipei 101 is the tallest and largest green building of LEED Platinum certification in the world since 2011.

✓ Abad Nucleus Mall at Maradu, Kochi, is India's first LEED certified gold-rated green mall.

Abad Nucleus Mall

Green Rating for Integrated Habitat Assessment

Bridging the gap between demand and supply of non-renewable and scarce resources through cost-effective interventions

by

The Energy and Resources Institute

GRIHA Self-Evaluation Guide

Sr. No.	Criterion	Points
1.	**Site Selection:** The site plan must be in conformity with the development plan/master plan/UDPFI guidelines (mandatory). This should comply with the provisions of eco-sensitive zone regulations, coastal zone regulations, heritage areas (identified in the master plan or issued separately as specific guidelines), water body zones (in such zones, no construction is permitted in the water-spread and buffer belt of 30 metre minimum around the FTL), various hazard prone area regulations, and others if the site falls under any such area (mandatory with no point allocation).	0
	The site should be located within ½ km radius of an existing bus stop, commuter rail, light rail or metro station and/or the proposed site must be a Brownfield site (to rehabilitate damaged sites where development is hindered by environmental contamination, thereby reducing pressure on undeveloped land)	1

GRIHA Self-Evaluation Guide

Sr. No.	Criterion	Points
2.	**Preserve and protect landscape during construction/compensatory depository forestation.**	
	Applicability Check 1 There are existing several mature trees on site that can be preserved	Yes
	Construction has been planned in a way that excavation/basement work, up to plinth level is not coinciding with rainy season and the site disruption is restricted to pre-designated areas	1
	Proper staging, spill prevention plan , sedimentation and erosion control systems in place.	1
	Trees are preserved and protected properly Note: Applicable if answer is yes in Applicability Check 1 above	1
	Compensatory forestation is applied on site Note: Applicable if answer is yes in Applicability Check 1 above	1

GRIHA Self-Evaluation Guide

Sr. No.	Criterion	Points
3.	**Soil conservation (post construction)**	
	Applicability Check 2: Top soil quality meets the quality standard of top preservation criteria as per criteria 3	Yes
	Top soil is fertile and properly laid for vegetative growth Note: Applicable if answer is yes in Applicability Check 1 above	1
	Measures taken for proper stabilization so soil Note: Applicable if answer is yes in Applicability Check 1 above	1
4.	**Design to include existing site features**	
	Building and site planning to minimize the disruption of natural ecosystems and to maximize benefits from prevailing micro-climate	4

GRIHA Self-Evaluation Guide

Sr. No.	Criterion	Points
5.	**Reduce hard paving on site**	
	Net Paved area on site under parking, roads etc. to exceed 25% of the site area (minus the building footprint) or the net imperviousness factor of the site should not exceed the net imperviousness factors prescribed in the NBC 2005, whichever is more stringent.	1
	Total surface parking not to exceed as permitted by the local building by-laws	0
	More than 50% of the total paved area to have pervious paving or open grid pavements or grass pavers or shading through the use of vegetated pergolas or covered with coating of SRI>0.5 OR More than 50% of the total paved area to have a combination of the above.	1

GRIHA Self-Evaluation Guide

Sr. No.	Criterion	Points
6.	**Enhance outdoor lighting system efficiency**	
	Luminous efficacy of 100% of lamps used in outdoor lighting to meet the corresponding lamp luminous efficacy as mentioned in Table 6.1, as per GRIHA	1
	Automatic controls to be installed for 100% of outdoor lights	0
7.	**Plan utilities efficiently and optimize on-site circulation efficiency**	
	Various transportation and service corridors shall be minimized and consolidated and the pedestrian walkways to be shaded.	1
	Aggregate utility corridors shall be used	1
	Utility corridors shall be consolidated along the previously disturbed areas or along new roads in order to minimize unnecessary cutting and trenching and ensure easy maintenance	1

GRIHA Self-Evaluation Guide

Sr. No.	Criterion	Points
8.	**Provide minimum level of sanitation/safety facilities for construction workers**	
	Ensure compliance with the NBC (2005) safety norms for providing the necessary safety equipment and measures for construction workers	1
	Provisions for drinking water, healthy and clean living conditions and sanitation facilities shall be provided for the workers	1
9.	**Reduce air pollution during construction**	
	Necessary measures to be taken on site to reduce air pollution for example providing site barricading to a height of 3 m on the site perimeter, carry out wheel washing of vehicles entering/exiting the site, sprinkle water on roads with loose dust etc.	2

GRIHA Self-Evaluation Guide

Sr. No.	Criterion	Points
10.	**Reduce landscape water demand**	
	If landscape water demand is reduced by up to 30%	1
	If landscape water demand is reduced by up to 40%	2
	If landscape water demand is reduced by up to 50%	3
11	**Reduce building water use**	
	Non Applicability condition: All faucets, which are installed in spaces with water head heights less than 15 feet (4.6 m), in a gravity fed systems, can be exempt for calculations in Criterion 11.	
	If building water demand is reduced by up to 25%	1
	If building water demand is reduced by up to 50%	1

GRIHA Self-Evaluation Guide

Sr. No.	Criterion	Points
12.	**Efficient water use during construction**	
	Efforts to be taken to reduce the use of potable water during construction for example use waste jute bags to cover columns and beams during curing, add admixtures to concrete which cause a reduction in the water required for curing etc.	1
13.	**Optimize building design to reduce conventional energy demand**	
	The WWR and/or SSR shall be limited to the prescribed levels as per Table13.1 (GRIHA Manual Introduction Volume-I) and all fenestration shall meet the SHGC requirements of ECBC 2007OR shading requirements as suggested in 13.1.4 OR 13.1.5, as per clause 13.2.3 to 13.2.5	2
	Minimum 25% of the living area shall be daylighted and shall meet the level of daylight prescribed in NBC 2005 (reference Table 13.2 GRIHA Manual Introduction Volume-I)	2

GRIHA Self-Evaluation Guide

Sr. No.	Criterion	Points
	If the total daylighted area>50% of the total living area and meets the prescribed level of daylight	1
	If the total daylighted area>75% of the total living area and meets the prescribed level of daylight	1
	Over-design of artificial lighting system shall be avoided and the lighting levels in indoor spaces shall be maintained as recommended in NBC 2005.	1
14.	**Optimize energy performance of building within specified comfort limits**	
	All mandatory compliance measures (for all applicable buildings) as recommended in the Energy Conservation Building Code 2007 of BEE shall be complied with.	6
	The thermal comfort conditions and at least 10% reduction from the benchmark EPI, specified in GRIHA, shall be met.	2
	If the reduction in energy consumption is $\geq$ 20% of the benchmarked figure and the thermal comfort criteria are fully met	2

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Sr. No.	Criterion	Points
	If the reduction in energy consumption is ≥ 30% of the benchmarked figure and the thermal comfort criteria are fully met	4
	If the reduction in energy consumption is ≥ 40% of the benchmarked figure and the thermal comfort criteria are fully met	6
	If the reduction in energy consumption is ≥ 50% of the benchmarked figure and the thermal comfort criteria are fully met	8
15.	**Utilization of fly-ash in building structures**	
	Replace 15-25 % of OPC by weight with fly-ash in structural concrete	1
	Replace more than 25% of OPC by weight with fly-ash in structural concrete	1
	100% of the building blocks shall have at least 40% fly ash (by volume)	2
	Replace 15-25 % of OPC by weight with fly-ash in masanory and plaster mortar	1
	Replace more than 25% of OPC by weight with fly-ash in masanory and plaster mortar	1

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Sr. No.	Criterion	Points
16.	**Reduce embodied energy of construction is reduced by adopting material efficient technologies and/or low-energy materials**	
	The embodied energy of the structural systems of the building shall be reduced by at least 2.5% for 100% of the structural system in the building.	1
	The embodied energy of the structural systems of the building shall be reduced by at least 5% for 100% of the structural system in the building.	2
	The embodied energy of the non-structural systems of the building shall be reduced by at least 5% for 100% of the structural system in the buildinguilding blockwork.	1
	The embodied energy of the non-structural systems of the building shall be reduced by at least 10% for 100% of the structural system in the buildinguilding blockwork.	2

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Sr. No.	Criterion	Points
17.	**Use low-energy materials in Interiors**	
	Minimum 70% of the total quantity of materials used for sub-assembly/internal partitions/panelling/false-ceiling/in-built furniture shall be low-energy materials	2
	Minimum 70% of the total quantity of materials used for flooring shall be low-energy materials	1
	Minimum 70% of the total quantity of materials used for door, windows and frames shall be low-energy materials	1
18.	**Renewable energy utilization**	
	The minimum size of the renewable energy system, installed on site, should be equal to 1% of the total connected load for artificial lighting and space conditioning loads ***The clause is optional if residential built up area is more than 80% of the total built up area of the project.**	2

GRIHA Self-Evaluation Guide

Sr. No.	Criterion	Points
	If the total energy generated by the renewable energy system is equivalent to 5% or more of the total annual energy consumption for artificial lighting	1
	If the total energy generated by the renewable energy system is equivalent to 10% or more of the total annual energy consumption for artificial lighting	2
	If the total energy generated by the renewable energy system is equivalent to 20% or more of the total annual energy consumption for artificial lighting	3
	If the total energy generated by the renewable energy system is equivalent to 30% or more of the total annual energy consumption for artificial lighting	4
	If the total energy generated by the On-site or Off-site, renewable energy system is equivalent to 100% or more of the total annual energy consumption for artificial lighting	2

GRIHA Self-Evaluation Guide

Sr. No.	Criterion	Points
19.	**Renewable energy based hot water system**	
	Applicability Check 3: The total hot water requirement is more than 500 litres per day	Yes
	If the renewable hot water system saves 20-50% of the annual energy required for hot water Note: Applicable if answer is yes in Applicability Check 3 above	1
	If the renewable hot water system saves 50-70% of the annual energy required for hot water Note: Applicable if answer is yes in Applicability Check 3 above	2
	If the renewable hot water system saves more than 70% of the annual energy required for hot water Note: Applicable if answer is yes in Applicability Check 3 above	3

GRIHA Self-Evaluation Guide

Sr. No.	Criterion	Points
20.	**Waste water treatment**	
	Applicability Check 4: The total waste water generation on site is more than 10kL per day.	Yes
	The treated waste water shall meet the BIS recommended disposal standards, as per table 20.3, GRIHA Note: Applicable is answer is yes to Applicability Check 4 above	2
21.	**Water recycle and reuse (including rainwater)**	
	Applicability Check 5 Ground water table is high and ground water recharge is not advisable as per Central Ground Water Board norms.	Yes
	If the project demonstrates 25% annual water reuse Note: Applicable is answer is yes to Applicability Check 4 above	1

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Sr. No.	Criterion	Points
	If the project demonstrates 50% annual water reuse Note: Applicable is answer is yes to Applicability Check 4 above	2
	If the project demonstrates 75% annual water reuse Note: Applicable is answer is yes to Applicability Check 4 above	3
	The surplus rainwater is recharged in to the ground after necessary filtration Note: Applicable if answer is yes to Applicability Check 5	2
22.	**Reduction in waste during construction**	
	Hazardous and inert waste shall be segregated during construction	1
	The segregated waste shall be recycled and/or safely disposed	1
23.	**Efficient Waste segregation**	
	Multi-coloured bins shall be provided to segregate waste at source	1

GRIHA Self-Evaluation Guide

Sr. No.	Criterion	Points
24.	**Storage and disposal of wastes**	
	Separate space shall be allocated for collection of waste before transfer for recycling	1
25.	**Resource recovery from waste**	
	Applicability Check 6 Organic solid waste generation on site is more than 100 kg/day	Yes
	Appropriate measures to be taken for zero-waste generation from site Note: Applicable if answer is yes to Applicability Check 6	2
26.	**Use of low-VOC paints/adhesives/sealants**	
	100% of all paints used in building interior shall be low/zero-VOC, as per Table 26.1, GRIHA Manual	1
	100% of all adhesives and sealants used shall be low/zero-VOC, as per Table 26.1, GRIHA	1
	100% of all composite wood products shall not use urea-formaldehyde	1

GRIHA Self-Evaluation Guide

Sr. No.	Criterion	Points
27.	**Minimize ozone depleting substances**	
	All insulation to be used in the building shall be CFC and HCFC free	1
	All HVAC and refrigeration equipment shall be CFC free	
	The fire-suppression systems and fire extinguishers shall be halon free	
28.	**Ensure water quality**	
	Water used for various purposes like drinking, irrigation etc. shall conform to the BIS standards (Table 28.3, GRIHA Manual)	2
29.	**Acceptable outdoor and indoor noise levels**	
	The measured outdoor noise levels on site conform to the standard set by the CPCB, Table 29.1, GRIHA	1
	The measured indoor noise levels inside the building meet the noise levels recommended by NBC 2005 (Table 29.2, GRIHA Manual)	1

GRIHA Self-Evaluation Guide

Sr. No.	Criterion	Points
30.	**Tobacco and smoke control**	
	Smoking is prohibited on site OR Necessary provisions shall be provided in the mechanical ventilation system by the HVAC consultant	1
31.	**Provide at least the minimum level of accessibility for persons with disabilities**	
	Buildings shall be designed in compliance with the NBC code in order to be disabled friendly	1
32.	**Energy audit and validation**	
	A mandatory energy audit shall be conducted by a BEE certified energy auditor	0

GRIHA Self-Evaluation Guide

Sr. No.	Criterion	Points
33.	**Operation and Maintenance**	
	Metering and seb-metering of energy as well as water will be carried out as per GRIHA claues	1
	An O & M protocol to be specified for operation and maintenance of the various systems in the building.	1


Thank you!