

Module 5: Green Buildings and Sustainable Energy Practices

Unit	Topic	Key terms
5.1	Green buildings	Definition, features, necessity
5.2	Benefits of green buildings	Environmental, economic, health, social
5.3	GRIHA rating system	TERI, MNRE, GRIHA Council, star rating systems
5.4	Energy performance	EPI, passive and active strategies

5.1 Green buildings

5.1.1 Introduction

Buildings are among the largest consumers of natural resources. Over their life cycle — extraction of raw materials, manufacture, transport, construction, operation, maintenance and demolition — they consume land, water, energy and materials, and release greenhouse gases, waste water and solid waste.

Globally, the building and construction sector accounts for roughly 35–40% of final energy use and close to 40% of energy-related CO₂ emissions (UNEP Global Status Report, approximate figures). In India, buildings consume over 30% of total electricity, and this share is rising rapidly with urbanisation. A large part of India's building stock for 2040 is yet to be built, so the way we design today locks in resource use for the next 50–100 years.

The green building concept responds to this challenge. It treats the building not as an isolated object but as part of a larger ecosystem, and asks how the building can deliver comfort and function while drawing the least from nature.

5.1.2 Definition

*A **green building** is one that is designed, constructed, operated, maintained and finally decommissioned in a manner that uses less water and energy, conserves natural resources, generates less waste, and provides a healthier and more comfortable environment for its occupants, as compared to a conventional building.*

In simple terms, a green building is **resource-efficient over its entire life cycle** and **healthy for the people inside it**. The term "sustainable building" or "high-performance building" is often used with the same meaning.

Three ideas underlie the definition:

- **Life-cycle thinking** — impacts are considered from material extraction to demolition ("cradle to grave"), not only during construction.
- **Reduce first, then supply green** — demand for energy and water is first reduced through design, and only the remaining demand is met through efficient systems and renewable sources.
- **Occupant well-being** — daylight, fresh air, thermal comfort and freedom from pollutants are treated as performance requirements, not luxuries.

5.1.3 Features of a green building

The main features of a green building are:

1. **Sustainable site planning.** Selecting a site that avoids ecologically sensitive land, preserving existing trees, top soil and natural drainage, and orienting the building to suit the sun path and prevailing winds.
2. **Energy efficiency.** Climate-responsive design, an insulated envelope and external shading reduce the energy load; efficient LED lighting and HVAC, along with on-site renewables such as rooftop solar PV, meet the remaining demand.
3. **Water efficiency.** Low-flow fixtures, rainwater harvesting, on-site treatment and reuse of waste water, and native, drought-tolerant landscaping.
4. **Material efficiency and waste management.** Use of local, low embodied-energy and recycled materials (fly-ash bricks, compressed stabilised earth blocks, blended cements, bamboo), with segregation, reuse and composting of construction and household waste.
5. **Indoor environmental quality.** Adequate daylight, natural ventilation and fresh air, thermal and acoustic comfort, and low-VOC paints, adhesives and sealants.

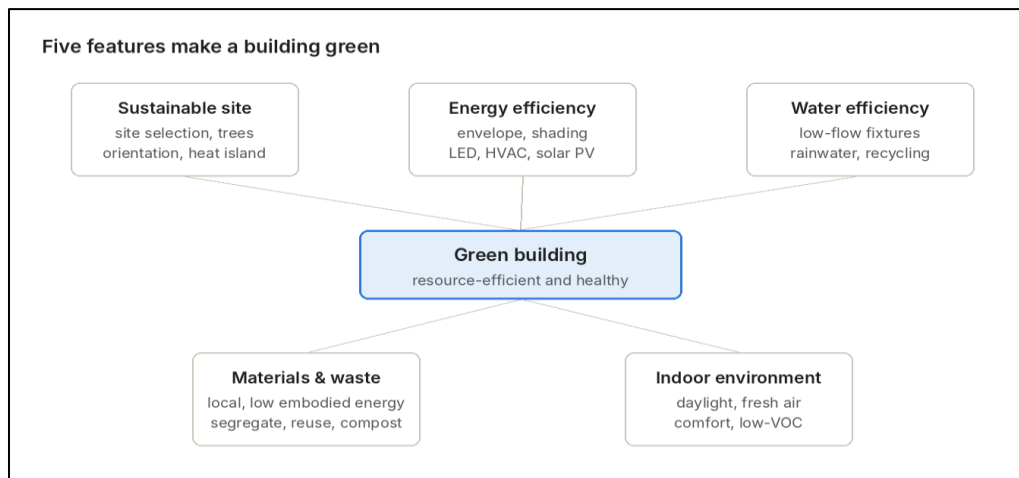


Fig. 5.1 · Five features of a green building

Comparison: conventional vs green building

Aspect	Conventional building	Green building
Design approach	Form first; services added to achieve comfort	Climate-responsive; loads reduced at design stage
Energy	High grid electricity use; mostly fossil-fuel based	30–50% lower energy use; part met by renewables
Water	Fresh water used for all purposes	30–50% lower; rainwater and recycled water used
Materials	Chosen mainly on first cost	Chosen on life-cycle cost and embodied energy
Waste	Mixed waste sent to landfill	Segregated, recycled, composted
Indoor environment	Often dependent on artificial light and AC	Daylit, well-ventilated, low-VOC
Cost view	Lowest initial cost	Lowest life-cycle cost

5.1.4 Necessity of green buildings

The need for green buildings arises from the following factors.

1. **Rising energy demand and climate change.** Building energy use is a major source of greenhouse gas (GHG) emissions. India has committed to reduce the emission intensity of its GDP by 45% from 2005 levels by 2030 and to reach net-zero by 2070. Buildings must contribute to these targets.
2. **Rapid urbanisation.** India's urban population is expected to rise from about 35% to over 50% by 2050. Housing, offices, hospitals and schools for this population will place huge demands on energy, water and materials.
3. **Depletion of natural resources.** River sand, stone, timber and clay for bricks are being extracted faster than they can be replenished. Sand mining, for example, damages river beds and ground-water tables.
4. **Water scarcity.** Many Indian cities face acute water shortage and falling ground-water levels. Buildings are major consumers of municipal water.
5. **Waste generation.** India generates very large quantities of construction and demolition waste annually, much of which is dumped illegally. Municipal solid waste is also rising.
6. **Urban heat island effect.** Hard, dark surfaces and reduced vegetation make cities 2–5 °C hotter than surrounding areas, increasing cooling demand.

7. **Health of occupants.** People spend nearly 90% of their time indoors. Poor ventilation, glare and chemical emissions lead to "sick building syndrome" — headaches, fatigue, irritation of eyes and throat.
8. **Economic reasons.** Rising electricity and water tariffs make operating costs a major part of a building's life-cycle cost; efficient buildings reduce these costs.
9. **Policy and regulation.** The Energy Conservation Building Code (ECBC 2017), ECO-Niwas Samhita (ENS 2018) for residential buildings, the National Building Code (NBC 2016, Part 11: Approach to Sustainability) and state-level incentives encourage or require green practices.

5.2 Benefits of green buildings

The benefits of green buildings are commonly grouped under the **triple bottom line** of sustainability — environment (planet), economy (profit) and society (people). For this course, they are discussed under environmental, economic, and health and social benefits.

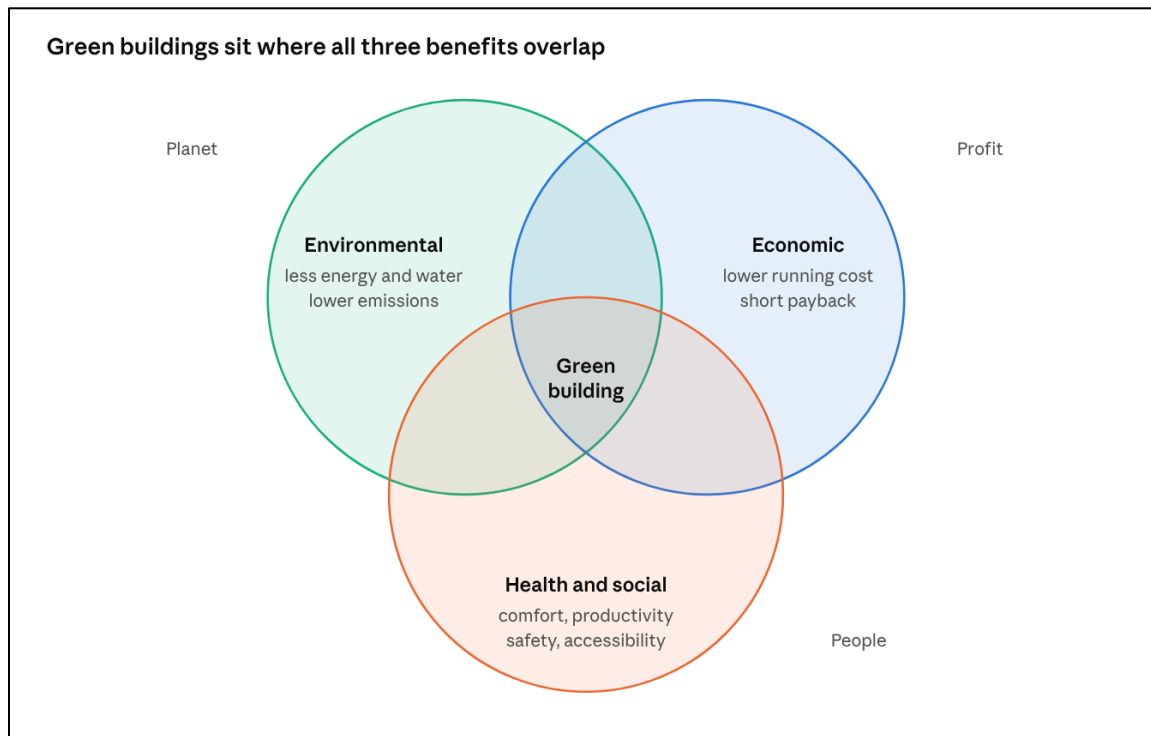


Fig. 5.2 · Triple bottom line of green buildings

A building is truly sustainable only when it succeeds on all three — Planet, Profit and People — at the same time.

5.2.1 Environmental benefits

1. **Reduced energy use and GHG emissions.** Green-rated buildings in India typically use 30–50% less energy than conventional buildings. Since most grid electricity comes from coal, every kWh saved avoids about 0.7–0.8 kg of CO₂.
2. **Water conservation.** Low-flow fixtures, rainwater harvesting and waste-water recycling cut fresh-water demand by 30–50% and reduce the load on municipal supply and sewers.
3. **Conservation of natural resources.** Use of fly ash, GGBS, recycled aggregates and local materials reduces quarrying, mining and sand extraction.
4. **Less waste to landfill.** Segregation, recycling and composting divert a large part of construction and operational waste away from landfills.
5. **Cooler and cleaner surroundings.** Green cover and cool roofs reduce the urban heat island effect, and protecting trees, top soil and natural drainage supports local biodiversity.

5.2.2 Economic benefits

1. **Lower operating costs.** Savings in electricity and water bills over the building's life far exceed the extra initial cost.
2. **Short payback period.** A green building typically costs about 2–8% more than a conventional building, and this extra cost is usually recovered within 3–6 years.
3. **Lower life-cycle cost and higher asset value.** Durable materials and efficient systems reduce maintenance costs, and green-rated buildings command higher rentals and resale value.
4. **Government incentives.** Many states and urban local bodies offer additional FAR, faster approvals or property-tax rebates for GRIHA/IGBC-rated buildings.
5. **Higher productivity.** Better daylight, air quality and thermal comfort improve occupant productivity; since salaries far exceed energy costs in offices, even a small gain is economically significant.

Simple payback period — the time required for savings to recover the additional investment:

Illustration: An office building costs ₹ 20 crore in conventional design. Green features add 5%, i.e. ₹ 1 crore. If annual electricity and water savings are ₹ 25 lakh, the simple payback = $1,00,00,000 \div 25,00,000 = 4$ years. Beyond this, the savings are a net gain for the remaining 40–50 years of the building's life.

5.2.3 Health and social benefits

1. **Better indoor air quality.** Adequate fresh air and low-VOC materials reduce respiratory problems, allergies and sick building syndrome.
2. **Thermal, visual and acoustic comfort.** Daylight, glare control, comfortable temperatures and noise control improve concentration, mood and sleep.
3. **Higher productivity and learning.** Daylit, well-ventilated offices and schools record fewer sick days, better performance and better test scores.

4. **Safety and accessibility.** Safe working conditions and sanitation for construction workers, and ramps, accessible toilets and signage for persons with disabilities, the elderly and children.
5. **Community benefits and green jobs.** Reduced pollution and heat improve the quality of life of the neighbourhood, and the sector creates jobs in energy auditing, solar installation and waste management.

Summary of benefits

Category	Key benefits
Environmental	Less energy, water, materials and waste; lower emissions; ecosystem protection
Economic	Lower operating and life-cycle cost; short payback; higher asset value; incentives
Health	Better indoor air; comfort; fewer illnesses; higher productivity
Social	Worker safety; accessibility; community well-being; awareness; green jobs

5.3 Green building rating system — GRIHA

5.3.1 Green building rating system

A **green building rating system** is a tool that evaluates the environmental performance of a building against a set of defined criteria, awards points for each criterion met, and certifies the building at a level (stars, or Certified/Silver/Gold/Platinum) based on the total score. It converts the broad idea of "green" into measurable, verifiable targets.

Major rating systems:

Rating system	Country	Developed by
GRIHA	India	TERI and MNRE; administered by GRIHA Council
IGBC	India	Indian Green Building Council (CII)
LEED	USA (used worldwide)	US Green Building Council
BREEAM	UK	Building Research Establishment

Rating system	Country	Developed by
Green Star	Australia	Green Building Council of Australia

5.3.2 Introduction to GRIHA

GRIHA stands for **Green Rating for Integrated Habitat Assessment**. The word *griha* in Sanskrit means "abode" or "home". GRIHA is the **national rating system of India** for green buildings.

- It was conceived by **The Energy and Resources Institute (TERI)**, New Delhi, and developed jointly with the **Ministry of New and Renewable Energy (MNRE)**, Government of India, in 2007.
- It is administered by the **GRIHA Council**, an independent not-for-profit society set up by TERI and MNRE.
- It is designed for Indian climates and building practices, and is aligned with Indian codes — NBC 2016, ECBC 2017, CPCB norms and MoEFCC guidelines.
- It is revised periodically by a Technical Advisory Committee. The current version for new buildings is **GRIHA V2019** (earlier versions: GRIHA 2007, V2015).
- Variants: GRIHA (new buildings), SVAGRIHA (small projects), GRIHA for Existing Buildings, GRIHA for Large Developments, GRIHA for Affordable Housing, GRIHA for Cities and others.

5.3.3 Purpose of GRIHA

GRIHA aims to minimise a building's resource consumption, waste generation and overall ecological impact to nationally acceptable limits, while ensuring occupant comfort. Its specific purposes are:

1. To provide a **national, objective yardstick** to measure how "green" a building is in the Indian context.
2. To **reduce consumption of energy, water and non-renewable materials** over the building's life cycle.
3. To **reduce waste generation and pollution** during construction and operation.
4. To ensure **health, comfort and well-being** of occupants and construction workers.
5. To promote **renewable energy** and **sustainable, locally available materials**.
6. To **verify actual performance** after occupancy, not just design intent.
7. To create **awareness** among designers, builders, owners and users, and support **national policy goals** on climate change.

5.3.4 Key highlights of GRIHA V2019

1. **Performance-oriented.** Points are awarded for meeting measurable benchmarks (energy use per m², water use per person), not merely for listing green features.
2. **Life-cycle approach.** It covers site selection, design, construction, operation and maintenance; V2019 adds life cycle cost analysis (LCCA) and life cycle assessment (LCA) of materials.
3. **Suited to Indian climates.** Benchmarks vary with India's five climatic zones, so a building in Mangaluru (warm–humid) is assessed differently from one in Jaipur (hot–dry).
4. **Mandatory criteria and verification.** Some criteria must be met for any rating; compliance is checked through documents, simulations and site visits, and the final rating is given only after performance monitoring.
5. **Social criteria and policy support.** GRIHA includes worker safety and sanitation, universal accessibility and staff facilities, and government buildings are required to achieve at least a 3-star rating.

5.3.5 Structure of GRIHA V2019

GRIHA V2019 has **30 criteria** grouped into **11 sections**. Ten sections together carry **100 points**, and the eleventh section, **Innovation**, carries **5 bonus points**, giving a total of **100 + 5 points**.

The ten main sections are Sustainable Site Planning, Construction Management, Energy Optimization, Occupant Comfort, Water Management, Solid Waste Management, Sustainable Building Materials, Life Cycle Costing, Socio-economic Strategies, and Performance Metering and Monitoring. The points carried by each section are given in the table in Section 5.3.6.

5.3.6 Point system with differential weightage

GRIHA does **not** give equal points to every criterion. Points are distributed according to the **relative environmental significance** of each aspect in the Indian context — this is called **differential weightage**. Energy and water, which have the largest impact and are scarce in India, receive the most points; aspects with a smaller impact receive fewer.

Section-wise weightage in GRIHA V2019

No.	Section	Maximum points	Share of 100
1	Sustainable Site Planning	12	12%
2	Construction Management	4	4%
3	Energy Optimization	18	18%
4	Occupant Comfort	12	12%
5	Water Management	16	16%

No.	Section	Maximum points	Share of 100
6	Solid Waste Management	6	6%
7	Sustainable Building Materials	12	12%
8	Life Cycle Costing	5	5%
9	Socio-economic Strategies	8	8%
10	Performance Metering and Monitoring	7	7%
	Total	100	100%
11	Innovation (bonus)	5	—
	Grand total	100 + 5	

Within sections, weightage also differs between criteria. For example, in the Energy Optimization section, *Energy optimization* (C7) carries 12 points, *Renewable energy utilization* (C8) 5 points and *Low ODP and GWP materials* (C9) only 1 point. In Water Management, *Rainwater management* and *Water quality and self-sufficiency* carry 5 points each, while *Water demand reduction* carries 3.

Observations on differential weightage

- Energy (18) + Water (16) together account for over one-third of the total score, reflecting India's energy and water stress.
- Site, occupant comfort and materials (12 each) form the next tier.
- Construction management (4) and life cycle costing (5) carry fewer points but some of their criteria are mandatory.
- Innovation points reward projects that exceed benchmarks, encouraging continuous improvement.

5.3.7 Star rating thresholds

The total points scored determine the GRIHA star rating. A project must also satisfy all mandatory criteria.

Points scored (out of 100)	GRIHA rating
25 – 40	★ (1 star)
41 – 55	★★ (2 stars)
56 – 70	★★★ (3 stars)

Points scored (out of 100)	GRIHA rating
71 – 85	★★★★ (4 stars)
86 and above	★★★★★ (5 stars)

Example: A project that meets all mandatory criteria and scores 73 points is rated **4 stars**. With 3 innovation points it reaches 76 — still 4 stars; it would need 86 for 5 stars.

(Note: in the older GRIHA 2007/V2015 systems, the minimum score for certification was 50 points, with bands of 51–60, 61–70, 71–80, 81–90 and 91–100 for 1 to 5 stars.)

5.3.8 GRIHA rating process

1. **Registration** of the project with the GRIHA Council (preferably at the concept design stage) and payment of fees.
2. **Orientation workshop** for the project team on the criteria and documentation.
3. **Design-stage compliance** — submission of drawings, energy and daylight simulations, specifications and calculations. Pre-certification may be awarded at this stage.
4. **Due diligence site visits** by GRIHA professionals during construction to verify on-site practices.
5. **Evaluation** of documentation by GRIHA evaluators and preliminary scoring.
6. **Commissioning and final submission** after construction, including performance data.
7. **Award of provisional rating**, followed by the **final rating** after verification of performance data from the occupied building (typically one year of operation).

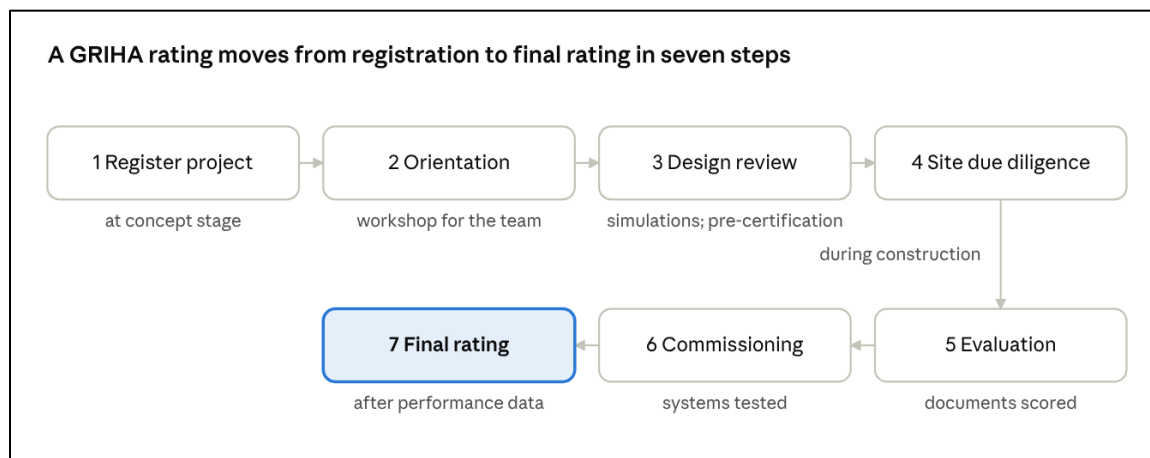


Fig. 5.3 · GRIHA rating process flowchart

The rating is earned in stages: design intent is checked first, and the final rating is confirmed only after the building's actual performance is verified.

5.4 Energy performance in green buildings

5.4.1 Concept of energy efficiency in buildings

Energy efficiency means using less energy to deliver the same (or better) level of service — lighting, thermal comfort, ventilation, hot water, vertical transport — that the occupants need. It is different from **energy conservation**, which may involve doing without a service (for example, switching off lights). An energy-efficient building provides full comfort while consuming the minimum energy.

Energy used in a building is of two types:

- **Embodied energy** — energy consumed in extracting, manufacturing, transporting and assembling the building materials (covered in Module 4).
- **Operational energy** — energy consumed during the life of the building for cooling, heating, lighting, fans, pumps, lifts and equipment. Over a 50-year life, operational energy is generally 80–90% of the total life-cycle energy of a conventional building, which is why operational efficiency is the main focus.

Typical breakdown of electricity use in an air-conditioned office building in India (approximate)

End use	Share of electricity
Air conditioning (HVAC)	55–60%
Lighting	20–25%
Equipment and plug loads	15–20%
Pumps, lifts and others	5–10%

Since cooling and lighting dominate, the **building envelope** (walls, roof, windows) and **daylighting** have the largest influence on energy performance.

Energy Performance Index (EPI) — the standard measure of a building's energy performance:

Lower EPI indicates better performance. Indicative values for day-use office buildings in India: conventional air-conditioned offices about 200–250 kWh/m²/year; ECBC-compliant 120–150; good green buildings below 90; some net-zero-ready buildings below 50 (BEE star-rating benchmarks, approximate).

Illustration: An office building of 5,000 m² built-up area consumes 6,00,000 kWh per year. $EPI = 6,00,000 \div 5,000 = 120 \text{ kWh/m}^2/\text{year}$.

5.4.2 Need for energy efficiency in buildings

1. **Growing demand.** Building electricity demand in India is rising rapidly because of urbanisation, rising incomes and the spread of air conditioners; room AC ownership is expected to grow several-fold by 2040.
2. **Climate change.** Most of India's electricity is generated from coal; efficiency directly reduces CO₂ emissions and helps meet national climate commitments.
3. **Energy security.** India imports a large share of its oil, gas and coal; lower demand reduces import dependence.
4. **Peak load and power shortages.** Cooling loads coincide with summer peaks; efficient buildings reduce peak demand and the need for new power plants.
5. **Cost savings.** Reduced electricity bills over the long life of the building.
6. **Comfort and health.** Well-designed buildings remain comfortable even during power cuts and in non-air-conditioned spaces.
7. **Long life of buildings.** A building's design decisions lock in its energy use for 50 years or more; it is far cheaper to get them right at design stage than to retrofit later.
8. **Regulatory requirement.** ECBC 2017 (commercial buildings with connected load ≥ 100 kW or contract demand ≥ 120 kVA) and ECO-Niwas Samhita (residential) set minimum energy-performance standards, adopted by many states including Karnataka.

Hierarchy of energy-efficient design — the order in which strategies should be applied:

1. **Reduce demand** through climate-responsive (passive) design.
2. **Meet the remaining demand efficiently** through efficient active systems and controls.
3. **Supply the balance from renewables** (solar PV, solar thermal).
4. **Monitor and manage** through metering, commissioning and maintenance.

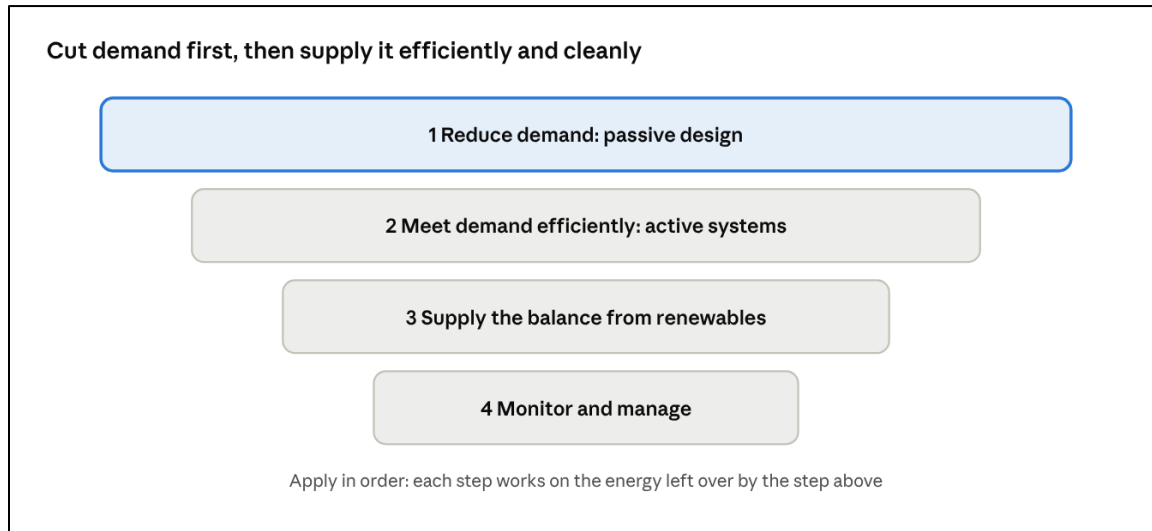


Fig. 5.4 · Hierarchy of energy-efficient design

The widest band gives the largest, cheapest savings: a kWh never needed is better than a kWh produced efficiently or from the sun.

A building that, over a year, generates as much renewable energy on or near site as it consumes is called a **net-zero energy building (NZEB)**.

5.4.3 Passive design strategies

Passive design uses the building's form, orientation, envelope and materials to achieve comfort by working with the local climate — sun, wind, daylight and ground — **without consuming mechanical or electrical energy**. Passive strategies cost little or nothing extra if adopted at the design stage, and they reduce the size of the active systems needed.

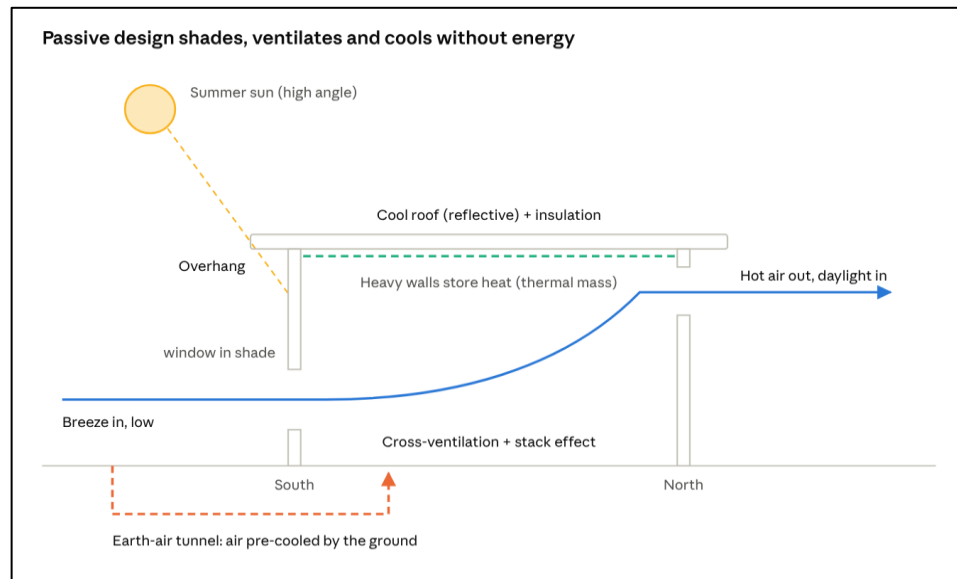


Fig. 5.5 · Schematic section showing passive design strategies

The overhang blocks the high summer sun; cool air enters low on the windward side, warms, rises and leaves through the high opening (stack effect); the cool roof and insulation cut heat gain from above.

1. **Orientation.** Longer facades should face north and south, and shorter facades east and west, because east and west walls receive intense low-angle sun that is hard to shade. The building should also be placed to catch prevailing breezes.
2. **Shading devices.** Overhangs and chajjas on south-facing windows, vertical fins on east and west windows, and verandahs, jaalis and trees keep direct sun off walls and glass.
3. **Building envelope.** Roof and wall insulation, cool (high-reflectance) roofs and the thermal mass of stone, brick or concrete reduce heat gain. Traditional examples are rat-trap bond walls, filler slabs and Mangalore-tiled roofs.

4. **Fenestration and daylighting.** A window-to-wall ratio of about 40% or less, low-SHGC glazing, and clerestories, skylights and light shelves admit daylight without excess heat, cutting daytime lighting energy by 30–60%.
5. **Natural ventilation.** Cross-ventilation through openings on opposite walls, and the stack effect, in which warm air escapes through high openings and draws cool air in at low level, keep spaces comfortable without fans or AC.
6. **Passive cooling.** Evaporative cooling using water bodies, earth-air tunnels that use the steady ground temperature (about 25–27 °C at 3–4 m depth) and night flushing with cool outdoor air.

5.4.4 Active design strategies

Active design uses mechanical and electrical systems that **consume energy** to provide comfort and services. In a green building these systems are selected for **high efficiency**, correctly sized for the loads that remain after passive design, and controlled so they operate only when and where required. Active strategies also include **renewable energy systems** that generate energy on-site.

1. Efficient HVAC systems

- o High-efficiency chillers and BEE 5-star-rated room ACs and inverter ACs; variable refrigerant flow (VRF) systems.
- o Variable frequency drives (VFDs) on pumps, fans and cooling towers.
- o Heat recovery wheels and energy recovery ventilators that pre-cool incoming fresh air using exhaust air.
- o Radiant cooling (chilled water in slabs or panels) and thermal energy storage (chilling water or making ice at night to use during peak hours).
- o Raising AC set-point to 24–26 °C (BEE recommends 24 °C as default) — each 1 °C rise saves about 6% of cooling energy.

2. Efficient lighting

- o LED luminaires; reducing lighting power density (W/m²) below ECBC limits.
- o Occupancy sensors, daylight-linked dimming, timers and task lighting.

3. Efficient equipment and appliances

- o BEE star-labelled fans (BLDC fans use about half the energy of conventional fans), pumps, motors and transformers.
- o Efficient lifts with regenerative drives.

4. Building automation and controls

- o **Building Management System (BMS)** to monitor and control HVAC, lighting and pumps from a central point.
- o Smart meters and sub-meters for each end use; energy dashboards for occupants.

5. Renewable energy systems

- o **Rooftop solar photovoltaic (PV)** panels to generate electricity; net metering allows surplus to be exported to the grid.

- o **Solar water heaters** — mandatory in many Indian cities for residential and hostel buildings.
- o Building-integrated PV (BIPV) on facades, wind–solar hybrid systems, biogas from organic waste.

6. Commissioning, energy audit and maintenance

- o Commissioning verifies that all systems perform as designed before handover.
- o Periodic energy audits identify waste and opportunities for savings.
- o Regular maintenance (cleaning of filters, coils, solar panels) sustains efficiency.

5.4.5 Passive vs active strategies — comparison

Aspect	Passive design strategies	Active design strategies
Principle	Use climate and architecture to provide comfort	Use mechanical/electrical systems to provide comfort
Energy use	No operating energy	Consume energy (efficiently) or generate renewable energy
Stage applied	Mainly at concept and design stage	Design, construction and operation
Initial cost	Low or nil if planned early	Moderate to high
Maintenance	Very little	Regular maintenance required
Life	Lasts the life of the building	Equipment life 10–25 years
Dependence	Depends on climate and occupant behaviour	Reliable, controllable comfort
Examples	Orientation, shading, insulation, cool roof, daylighting, cross-ventilation	Efficient AC, LED lighting, VFDs, BMS, solar PV, solar water heater

The two are **complementary**: passive design reduces loads first, so that smaller and fewer active systems are needed; active systems then meet the remaining demand efficiently. The best green buildings combine both — this is called the **integrated design approach**.

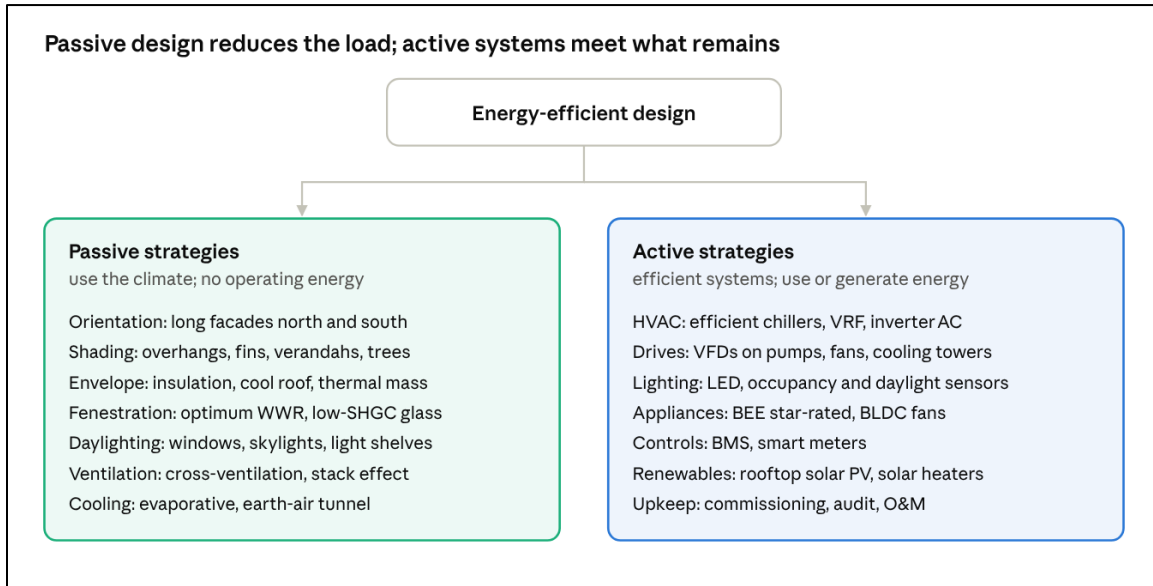


Fig. 5.6 · Classification of energy-efficient design strategies

A quick test: if the strategy works with the power switched off, it is passive; if it needs electricity (or produces it), it is active.

5.4.6 Indian case examples

- **Indira Paryavaran Bhawan, New Delhi** — Ministry of Environment, Forest and Climate Change office; GRIHA 5-star and designed as a net-zero energy building. Uses a central courtyard, shading, insulation, chilled-beam cooling and a large rooftop solar PV system.
- **CII-Sohrabji Godrej Green Business Centre, Hyderabad** — among India's first green-rated buildings; uses courtyards, wind towers, roof gardens and daylighting.
- **TERI Retreat (RETREAT), Gual Pahari, Gurugram** — demonstrates earth-air tunnels, solar passive design and renewable energy integration.
- **Suzlon One Earth, Pune** — large corporate campus with extensive daylighting and on-site wind and solar energy.

Key technical terms

A. General and life-cycle terms

Term	Meaning	Unit / example
Green building	Building that uses less energy, water and materials, produces less waste and gives a healthier indoor environment over its life cycle	GRIHA / IGBC rated buildings

Term	Meaning	Unit / example
Sustainable development	Development that meets present needs without compromising the ability of future generations to meet theirs (Brundtland, 1987)	—
Triple bottom line	Evaluating performance on environment, economy and society together (planet, profit, people)	—
Life cycle assessment (LCA)	Quantifying environmental impacts of a product or building from raw-material extraction to disposal (cradle to grave)	kg CO ₂ -eq
Life cycle cost analysis (LCCA)	Total cost of ownership: initial + operation + maintenance + replacement + disposal, in present value	₹
Embodied energy	Energy used to extract, manufacture, transport and install building materials	MJ/kg, GJ/m ²
Operational energy	Energy used to run the building — cooling, lighting, equipment	kWh/year
Carbon footprint	Total greenhouse gas emissions caused by a building or activity	t CO ₂ -eq
Greenhouse gases (GHG)	Gases that trap heat in the atmosphere — CO ₂ , CH ₄ , N ₂ O, HFCs	—
Global warming potential (GWP)	Heat trapped by a gas relative to the same mass of CO ₂ over 100 years	CO ₂ = 1
Ozone depletion potential (ODP)	Ability of a substance (e.g. refrigerant) to destroy stratospheric ozone, relative to CFC-11	CFC-11 = 1
Simple payback period	Extra initial cost ÷ annual savings	years

B. Site and environment terms

Term	Meaning	Unit / example
Urban heat island (UHI)	Cities being warmer than surrounding rural areas due to hard, dark surfaces and less vegetation	2–5 °C warmer

Term	Meaning	Unit / example
Albedo	Fraction of incident solar radiation reflected by a surface	0 (black) to 1 (white)
Solar reflectance index (SRI)	Combined measure of a surface's reflectance and emittance; higher = cooler roof	White roof $\approx$ 100
Rainwater harvesting (RWH)	Collection and storage of rainwater, or recharge of ground water	Roof-top RWH
Grey water / black water	Waste water from basins, showers, kitchens / from toilets	Grey water reused after treatment
Construction & demolition (C&D) waste	Debris from construction, renovation and demolition	Concrete, brick rubble
Low-VOC materials	Paints, adhesives and sealants that release few volatile organic compounds	g/L of VOC
Sick building syndrome (SBS)	Discomfort and illness of occupants linked to time spent in a building with poor indoor air	Headache, eye irritation
Indoor environmental quality (IEQ)	Overall quality of indoor air, light, temperature and sound	—

C. Rating system terms

Term	Meaning
GRIHA	Green Rating for Integrated Habitat Assessment — India's national green building rating system (TERI + MNRE)
GRIHA Council	Independent society that administers GRIHA ratings
SVAGRIHA	Simple Versatile Affordable GRIHA — version for small projects
Criterion	A specific requirement against which points are awarded (30 in GRIHA V2019)
Mandatory criterion	Criterion that must be met to be eligible for any rating
Differential weightage	Allotting different points to criteria according to their environmental importance

Term	Meaning
Innovation points	Bonus points (up to 5) for exceeding benchmarks or using new technologies
Pre-certification	Provisional recognition at design stage, before construction is complete
Commissioning	Systematic testing to confirm that building systems perform as designed

D. Energy and building-physics terms

Term	Meaning	Unit / example
Energy efficiency	Providing the same service with less energy	—
Energy Performance Index (EPI)	Annual energy use per unit built-up area	kWh/m ² /year
Thermal conductivity (k)	Rate of heat flow through 1 m thickness of a material per unit area per °C	W/m·K
Thermal resistance (R)	Resistance of a layer to heat flow = thickness ÷ k	m ² ·K/W
Thermal transmittance (U-value)	Heat flow through 1 m ² of an element per °C difference; $U = 1/\Sigma R$	W/m ² ·K
Thermal mass	Capacity of heavy materials to store heat and release it later	Stone, brick, concrete
Time lag	Delay between peak outside temperature and peak inside surface temperature due to thermal mass	hours
Window-to-wall ratio (WWR)	Glazed area ÷ gross external wall area	≤ 40% (ECBC)
Solar heat gain coefficient (SHGC)	Fraction of incident solar heat that passes through glazing	0 to 1; lower is better in hot climates
Visible light transmittance (VLT)	Fraction of visible light passing through glazing	0 to 1
Daylight factor (DF)	Indoor illuminance ÷ outdoor illuminance under overcast sky	%

Term	Meaning	Unit / example
Cross-ventilation	Air movement through openings on opposite walls driven by wind	—
Stack effect	Vertical air movement as warm, lighter air rises and exits high, drawing cool air in low	—
Evaporative cooling	Cooling of air by evaporation of water	Desert cooler
Earth-air tunnel	Buried pipes that pre-cool (or pre-warm) incoming air using stable ground temperature	3–4 m depth
Coefficient of performance (COP)	Cooling output ÷ electrical input of a refrigeration system; higher is better	COP 3–6
Energy efficiency ratio (EER)	Cooling capacity (W) ÷ power input (W) for air conditioners	BEE star label
Variable frequency drive (VFD)	Device that varies motor speed to match load, saving energy in pumps and fans	—
Building management system (BMS)	Computer-based system to monitor and control building services	—
Net metering	Billing system where surplus solar power exported to the grid is offset against power drawn	—
Net-zero energy building (NZEB)	Building that generates as much renewable energy as it consumes over a year	Indira Paryavaran Bhawan
ECBC	Energy Conservation Building Code (BEE, 2017) for commercial buildings	—
ENS	ECO-Niwas Samhita (2018) — energy code for residential buildings	—
BEE	Bureau of Energy Efficiency, Ministry of Power — runs star labelling and ECBC	—