

Energy Conservation and Green Building (315316)

MSBTE Diploma · K-Scheme · Model Question Paper — Set C · Model Answers

How to use: Answers are written point-wise in MSBTE model-answer style. Facts about rating systems (GRIHA, IGBC, LEED), codes (ECBC/ECSBC) and government schemes change from time to time — they are given as on Oct 2026; points marked 'check current version' should be verified from the official website before quoting exact numbers.

Q.1

a) Importance of energy conservation.

2 M

1. World energy demand keeps rising with population and urbanisation, while most energy still comes from fossil fuels which are limited.
2. A unit of energy saved is cheaper than a unit of new energy generated (no new power plant, no transmission loss).
3. Less fuel burning means less CO₂, SO_x, NO_x and particulate pollution.
4. Buildings use a large share of electricity (lighting, fans, air-conditioning), so conservation in buildings gives large savings.

(Any two, 1 M each)

b) Define green building; two examples in India.

2 M

Green building: A green building is a building which, in its design, construction, operation, maintenance and demolition, uses less energy, water and materials, produces less waste and pollution, and provides a healthy and comfortable indoor environment for its occupants, thereby reducing its overall impact on the environment.

Examples: CII-Sohrabji Godrej Green Business Centre, Hyderabad (widely cited as India's first LEED Platinum building, 2003); Indira Paryavaran Bhawan, New Delhi (MoEFCC office building, GRIHA 5-star).

(Definition 1 M, two examples 1 M)

c) Two salient features of green building.

2 M

1. **Proper orientation and passive design** — long sides facing North–South, shading devices, cross-ventilation.
2. **Energy-efficient envelope** — insulated roof/walls, high-performance glazing, cool roof.
3. **Renewable energy** — roof-top solar PV and solar water heater.
4. **Efficient lighting and equipment** — LED lights, daylight sensors, star-labelled appliances, efficient HVAC.

(Any two, 1 M each)

d) Four parameters of IEQ.

2 M

1. Indoor air quality (fresh air, CO₂ level, VOCs from paints and adhesives)
2. Thermal comfort (temperature, humidity, air movement)

3. Visual comfort (daylight, glare-free artificial light)
4. Acoustic comfort (noise control)
5. Views to outside and occupant control of lights / fans

(Any four, ½ M each)

e) Four green building materials.

2 M

1. Fly-ash bricks
2. AAC (autoclaved aerated concrete) blocks
3. Bamboo
4. Recycled plastic lumber
5. Cross-laminated timber
6. Low-VOC paints

(Any four, ½ M each)

f) Define green building audit; scope.

2 M

Green building audit is a systematic, documented examination of a building to assess how efficiently it uses energy, water and materials, how it manages waste, and the quality of its indoor environment — comparing actual performance with green building standards/benchmarks and recommending improvements.

Scope: Energy (electricity, fuel, renewable energy); Water (consumption, leakage, rainwater harvesting, recycling); Waste management; Indoor environmental quality; Materials, site and landscape.

(Definition 1 M, scope 1 M)

g) Full forms of GRIHA and LEED.

2 M

GRIHA: Green Rating for Integrated Habitat Assessment.

LEED: Leadership in Energy and Environmental Design.

(1 M each)

Q.2

a) Contribution of green buildings to sustainable development.

4 M

Sustainable development is development that meets the needs of the present generation without compromising the ability of future generations to meet their own needs (Brundtland Commission report, 1987).

1. **Environmental protection:** less energy and water use, use of renewable energy and recycled materials reduce resource depletion, CO₂ emission and pollution.
2. **Economic sustainability:** lower operating cost (electricity and water bills), longer life and higher asset value of the building.
3. **Social sustainability:** better daylight, fresh air and thermal comfort improve health and productivity of occupants; local materials and labour support the community.
4. **Resource conservation for future:** rainwater harvesting, waste recycling and efficient design leave resources for future generations — which is the core idea of sustainable development.

(Any four points, 1 M each)

b) EC Act, 2001 features with 2022 amendment.

4 M

Main features of the original Act (2001):

1. **Bureau of Energy Efficiency (BEE):** The Act set up BEE (operational from 1 March 2002) under the Ministry of Power as the statutory body to frame policies and programmes for energy efficiency.
2. **Designated consumers:** Energy-intensive users notified under the Act (e.g. thermal power stations, cement, iron & steel, aluminium, fertiliser, textile, pulp & paper, chlor-alkali, railways) must appoint a certified energy manager, get mandatory energy audits done by accredited energy auditors, report energy use and meet the energy-consumption norms given to them.
3. **Standards and labelling:** The Central Government can specify energy-consumption standards for equipment and appliances and make the energy label (star label) compulsory, and can stop the sale of appliances that do not meet the standards.
4. **Energy Conservation Building Code (ECBC):** Energy-efficiency norms for new commercial buildings above a threshold load; State Governments may modify the code for local climate and enforce it.
5. **State Designated Agencies (SDA):** Each State Government designates an agency (in Maharashtra: MEDA) to co-ordinate, regulate and enforce the provisions of the Act in the state.
6. **Energy Conservation Funds:** A Central Energy Conservation Fund and State Energy Conservation Funds for promoting energy-efficiency activities.

Energy Conservation (Amendment) Act, 2022 — main changes:

1. Central Government may specify a **carbon credit trading scheme**.
2. Designated consumers may be required to meet a minimum share of energy from **non-fossil sources** (renewable, green hydrogen etc.).
3. ECBC widened to **Energy Conservation and Sustainable Building Code**, which can also apply to large residential buildings.
4. Energy-consumption standards extended to **vehicles and vessels**; penalties revised.

Note: The Energy Conservation and Sustainable Building Code (ECSBC) was notified in 2024; its adoption by states is in progress — check the BEE website for the current status.

(Features 3 M, amendment 1 M)

c) Principles of green building with diagram.

4 M

1. **Sustainable site design:** select a suitable site, protect top soil and trees, reduce heat-island effect, provide access to public transport.
2. **Energy efficiency and conservation:** orient the building correctly, use passive design, insulation, efficient lighting and HVAC, and renewable energy (solar).
3. **Water efficiency and conservation:** low-flow fixtures, rainwater harvesting, waste-water recycling, drip irrigation and native landscaping.
4. **Materials selection and life cycle:** use local, recycled, rapidly renewable and low-embodied-energy materials; consider the whole life cycle of each material.

5. **Indoor environmental quality (IEQ):** good daylight, fresh air, thermal comfort, low-VOC paints and low noise for health of occupants.
6. **Waste reduction:** reduce, reuse and recycle construction and operational waste; segregation of waste at source.

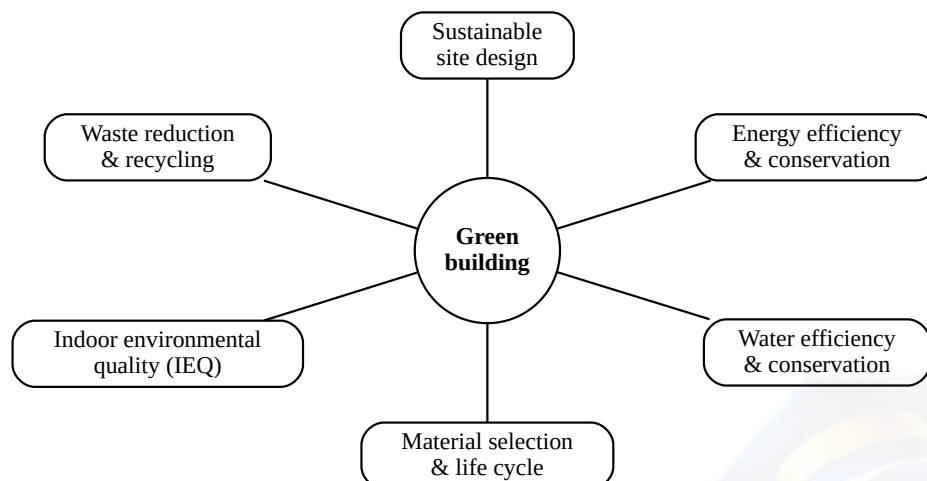


Fig.: Principles of green building

(Any four principles 3 M, diagram 1 M)

d) Economic considerations of green buildings.

4 M

Initial cost:

- Green features (insulation, high-performance glass, solar PV, rainwater harvesting, efficient HVAC) and certification/consultant fees may raise the initial cost slightly (often quoted as only a few percent of project cost, depending on the rating level).
- Integrated design at the beginning keeps this extra cost low; some items (smaller HVAC plant due to a better envelope) even reduce cost.

Long-term financial benefits:

- Lower energy and water bills every year; the extra cost is usually recovered in a few years (simple payback = extra cost ÷ annual saving).
- Lower maintenance and replacement cost; longer building life.
- Higher rent / resale value and better occupancy.

Impact on stakeholders:

- **Owner / developer:** better marketability and asset value; incentives such as extra FAR or faster approvals in some states/cities.
- **Occupants / tenants:** lower bills, healthier space, higher productivity.
- **Government / society:** lower peak demand, less pollution, less burden on water supply and drainage.
- **Contractors and suppliers:** new market for green materials and skills (also needs training).
- **Banks / investors:** green loans and green bonds with lower risk.

Simple payback period = Extra initial cost ÷ Annual saving in running cost.

(Initial cost 1 M, long-term benefits 1 M, stakeholders 2 M)

Q.3

a) Characteristics and uses of four green building materials.

4 M

Cross-laminated timber (CLT):

- Engineered wood panels made by gluing layers of timber at right angles.
- High strength and dimensional stability; prefabricated, so fast and clean construction.
- Stores carbon; much lighter than concrete.
- *Uses:* Floors, walls and roofs of mid-rise buildings, prefabricated houses.

Recycled plastic lumber:

- Made from waste plastic (HDPE, PET, mixed plastics), sometimes with wood fibre.
- Does not rot, absorb water or get attacked by termites; needs no painting.
- Diverts plastic waste from landfills.
- *Uses:* Benches, decking, fencing, park furniture, door frames.

Fly-ash bricks:

- Made from fly ash (thermal power plant waste), lime/cement, gypsum and sand.
- Uniform size, smooth finish, less mortar and plaster needed.
- Saves top soil (unlike burnt clay bricks) and uses industrial waste.
- *Uses:* Load-bearing and partition walls.

AAC blocks:

- Autoclaved aerated concrete — light-weight, porous blocks.
- Good thermal insulation and fire resistance.
- Reduce dead load and steel in the structure.
- *Uses:* Partition and external walls of framed buildings.

Selection criteria: Low embodied energy and carbon, Recycled / recyclable content, Locally available (within short distance), Rapidly renewable source, Durability and low maintenance, Non-toxic, low-VOC, Cost and availability, Reusable at end of life.

(Each material 1 M)

b) Energy-efficient measures in HVAC system.

4 M

1. **Reduce the load first:** shading, insulation, cool roof and efficient glazing reduce cooling load so that a smaller plant is needed.
2. **High-efficiency equipment:** chillers with high COP, 5-star / inverter split ACs, efficient pumps and motors.
3. **Variable frequency drives (VFD)** on AHU fans, chilled-water and condenser pumps — speed follows the actual load.
4. **Heat-recovery wheel** to pre-cool fresh air with exhaust air.
5. **Demand-controlled ventilation** using CO₂ sensors; economiser mode using cool outside air when available.
6. **Controls:** thermostats set at 24–25 °C, time schedules and zoning through BMS.
7. **Thermal energy storage** (ice / chilled water) to shift load to off-peak hours.

8. Maintenance and commissioning: clean filters/coils, insulate ducts and pipes, check refrigerant leaks; use low-GWP refrigerants.

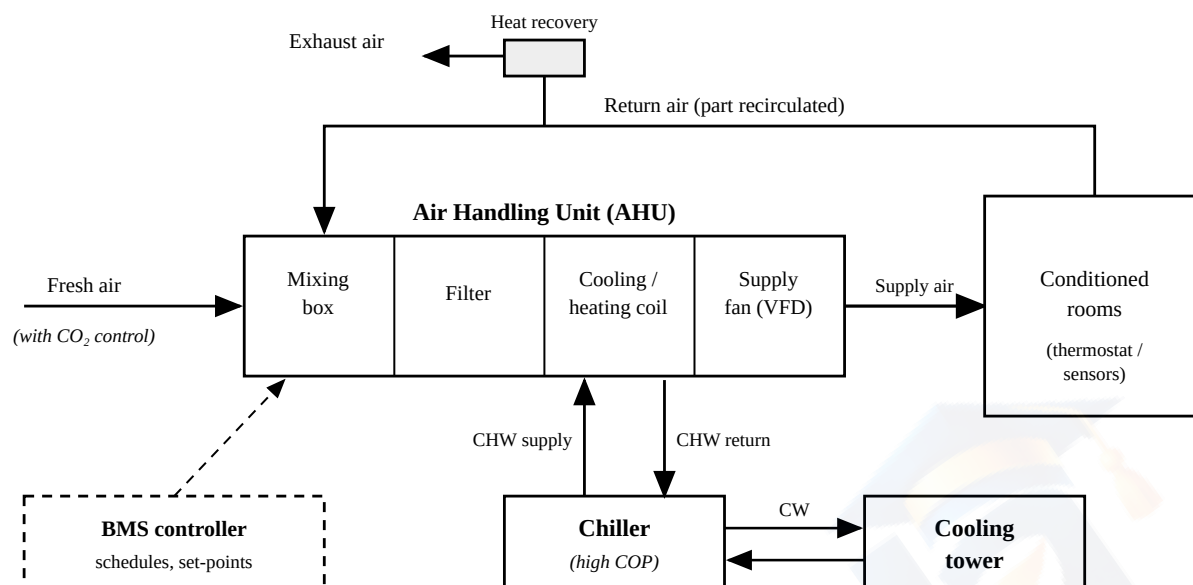


Fig.: Central HVAC system with energy-saving features (schematic)

(Any four measures 3 M, sketch 1 M)

c) Need and benefits of green building audit.

4 M

- 1. Reduces operating cost** — finds energy and water wastage; savings measures with payback.
- 2. Improves occupant health and comfort** — checks IEQ (light, air, thermal comfort).
- 3. Environmental protection** — lowers carbon footprint, water use and waste.
- 4. Compliance** — checks legal and code requirements (EC Act, ECBC, pollution norms) and prepares for green rating.
- 5. Better maintenance** — detects faulty equipment and leakages early.
- 6. Benchmarking and planning** — gives baseline data (e.g. EPI kWh/m²/year) for targets and future monitoring.
- 7. Awareness** — creates awareness among staff and students; supports institutional accreditation (green campus indicators).

(Any four, 1 M each)

d) LED lighting and daylighting strategies.

4 M

- 1. LED lighting:** LEDs give the same light with roughly half (or less) the power of fluorescent tubes and much less than incandescent lamps; long life (about 25,000–50,000 h) and less heat.
- 2. Daylighting:** using natural light through windows, skylights, light shelves and clerestory windows to reduce artificial lighting in daytime.
- 3. Controls:** occupancy sensors, daylight (photo) sensors with dimming, timers.
- 4. Good design:** light-coloured interiors, task lighting, avoiding over-lighting and glare.
- 5. Light shelf:** a horizontal reflecting shelf at window head level shades the lower window and reflects daylight to the ceiling, so light reaches deeper into the room.

6. **Skylights / roof monitors** and light pipes for single-storey and top-floor spaces; North-facing glazing gives uniform glare-free light.

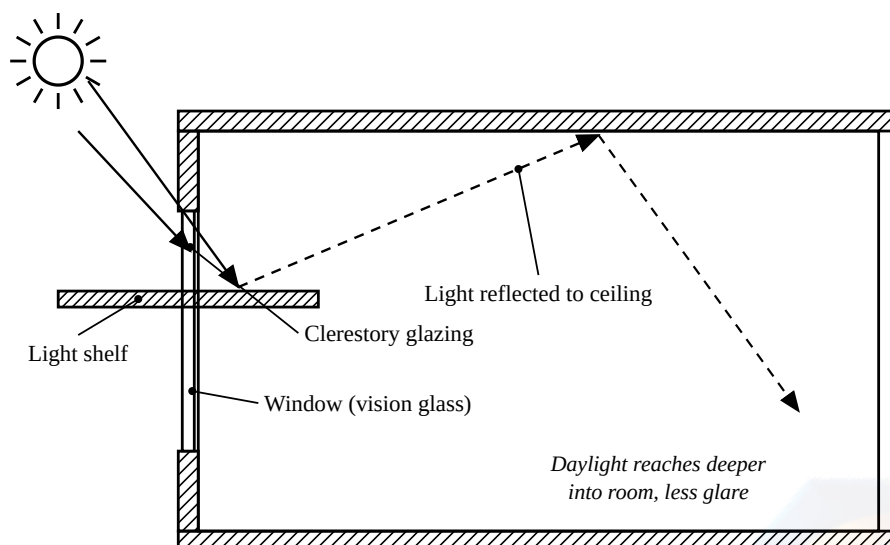


Fig.: Daylighting with light shelf and clerestory (section)

(LED 1 M, daylighting 2 M, sketch 1 M)

Q.4

a) Compare GRIHA and IGBC.

4 M

Sr.	Point	GRIHA	IGBC
1	Full form	Green Rating for Integrated Habitat Assessment	Indian Green Building Council
2	Original development	Developed by TERI (The Energy and Resources Institute) with MNRE; adopted as the national rating system in 2007; now run by GRIHA Council.	Set up in 2001 by CII (Confederation of Indian Industry); industry-led council.
3	Nature	Government-supported national rating; strong focus on Indian climate and actual performance.	Voluntary, consensus-based, market-driven rating.
4	Certification levels	1 to 5 stars (★ to ★★★★★) according to points scored.	Certified, Silver, Gold, Platinum (points per level depend on the rating type/version).
5	Scoring	100 points + innovation points; mandatory criteria must be met.	100 points; mandatory requirements + credits.
6	Main users	Widely used for government and public buildings; also private buildings.	Mostly private commercial, residential, campuses, factories.

Note: Point ranges per level depend on the rating version — check the current manual.

(Any four points, 1 M each)

b) Role of MNRE.

4 M

1. **Nodal ministry** of Government of India for all matters of new and renewable energy — solar, wind, small hydro, bio-energy, green hydrogen. (Set up as Ministry of Non-Conventional Energy Sources in 1992; renamed MNRE in 2006.)
2. **Policy and planning:** frames national policies, targets and missions for renewable energy (India's target: 500 GW non-fossil capacity by 2030).
3. **Schemes and financial support:** subsidies/central financial assistance, e.g. roof-top solar programme (PM Surya Ghar: Muft Bijli Yojana, 2024), PM-KUSUM for solar pumps (scheme names as on 2026 — check MNRE website).
4. **Implementing and financing agencies:** SECI (Solar Energy Corporation of India) and IREDA (finance) work under MNRE.
5. **Standards and quality control** of renewable energy products and approved lists of models/manufacturers.
6. **Awareness, training and international co-operation** (e.g. International Solar Alliance).

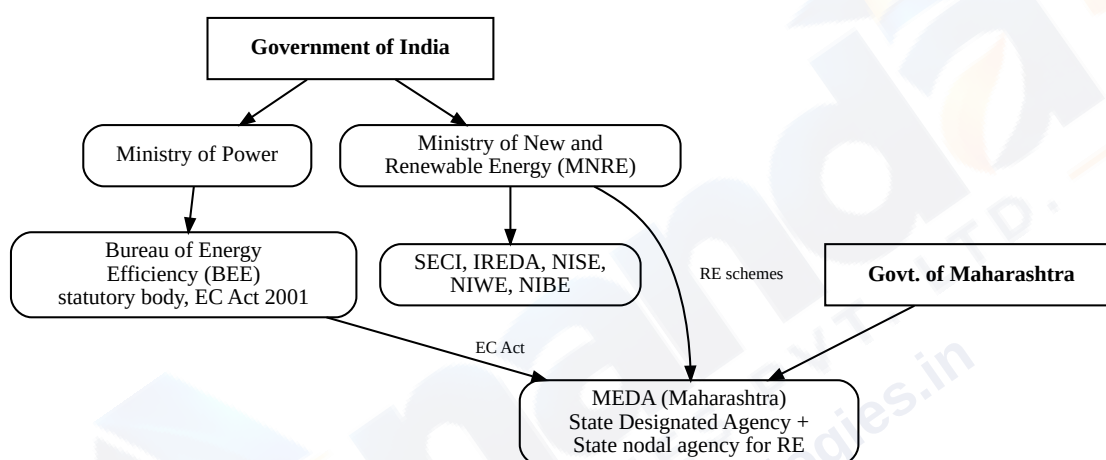


Fig.: Government bodies for energy conservation (India / Maharashtra)

(Any four roles, 1 M each)

c) LEED criteria for certification.

4 M

LEED (Leadership in Energy and Environmental Design) by USGBC awards points under the following criteria (credit categories); some prerequisites are compulsory:

1. **Location and Transportation:** site near public transport and amenities; bicycle facilities; reduced parking; EV charging.
2. **Sustainable Sites:** erosion control, protect habitat, open space, rainwater management, reduce heat-island and light pollution.
3. **Water Efficiency:** reduce indoor and outdoor water use, water metering, cooling-tower water management.
4. **Energy and Atmosphere:** minimum energy performance, commissioning, metering, renewable energy, refrigerant management.
5. **Materials and Resources:** storage and collection of recyclables, construction waste management, life-cycle impact, responsibly sourced materials.

6. **Indoor Environmental Quality:** minimum indoor air quality, no smoking, low-emitting materials, thermal comfort, daylight, quality views, acoustics.

7. **Innovation:** exceptional or new green strategies; LEED Accredited Professional on team.

Levels (out of 110 points, v4/v4.1): Certified 40–49, Silver 50–59, Gold 60–79, Platinum 80 and above.

Note: USGBC released LEED v5 in 2025; check which version is current when quoting points.

(Any four criteria 3 M, levels 1 M)

d) Role of MEDA in energy conservation in a city.

4 M

1. **About:** Maharashtra Energy Development Agency, set up in 1985 by the Government of Maharashtra (head office Pune), works as the **State Designated Agency (SDA)** under the Energy Conservation Act, 2001 and as the **state nodal agency for renewable energy**.
2. **Municipal energy efficiency (in the city):** energy-efficient street lights, efficient water-pumping systems, solar systems on municipal buildings.
3. **Energy audits:** promotes and supports energy audits of government buildings, municipal bodies, industries and institutions.
4. **Renewable energy promotion:** roof-top solar, solar water heaters, solar pumps, wind, small hydro, biomass and bagasse co-generation projects; implements state and MNRE schemes.
5. **Awareness and training:** Energy Conservation Week, seminars, training programmes for engineers and students.

(Any four roles, 1 M each)

e) Building Management System with block diagram.

4 M

Building Management System (BMS) is a computer-based control system that monitors and controls the mechanical and electrical services of a building — HVAC, lighting, pumps, lifts, fire and security systems — from one place, to save energy and improve comfort.

1. Scheduling: switches equipment ON/OFF as per time table and occupancy.
2. Set-point control of temperature, humidity and CO₂.
3. Energy metering and monitoring — shows where and when energy is used.
4. Alarms and fault detection for quick maintenance.
5. Reports and trends for energy management and audits.

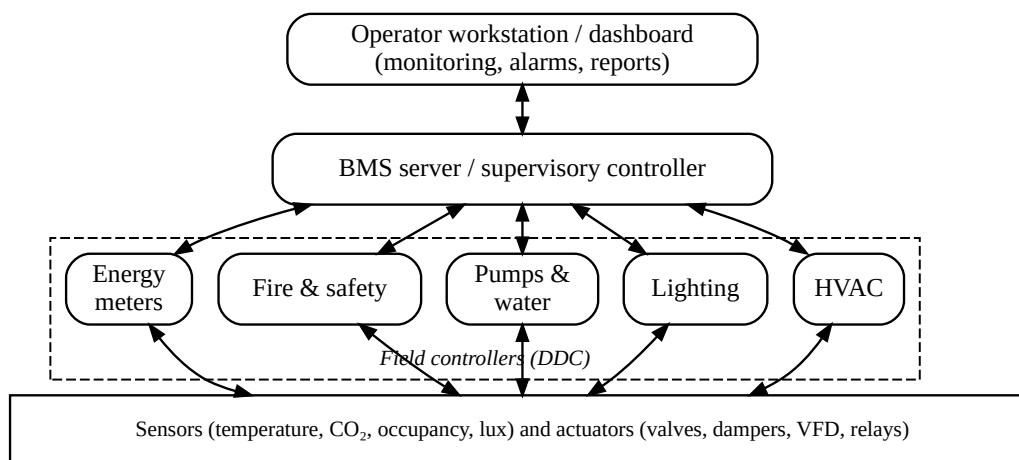


Fig.: Building Management System (BMS) — architecture

(Explanation 2 M, block diagram 2 M)

Q.5

a) Improving energy efficiency at home — with calculation.

6 M

Simple ways:

1. Replace tube lights/CFLs with LED lamps; use task lights.
2. Use BLDC fans and 5-star rated appliances (AC, refrigerator, geyser).
3. Set AC at 24–25 °C, clean filters, close doors/windows while AC is on.
4. Switch off lights, fans and TV when not needed; avoid stand-by mode at plug points.
5. Use daylight and cross-ventilation; light-coloured walls; shade West windows (curtains, chajjas, plants).
6. Install solar water heater / roof-top solar PV; use pressure cooker and lids while cooking.

Calculation (saving = quantity × reduction in watts × hours/day × days/year ÷ 1000):

Item	Energy saved (kWh/year)	Cost saved @ ₹8 (₹/year)	Investment (₹)	Payback (years)
Ceiling fan → BLDC fan	$4 \times (75 - 28) \text{ W} \times 10 \text{ h} \times 300 \text{ d} \div 1000 = 564.00$	4,512.00	12,800	2.84
Tube light → LED tube	$6 \times (40 - 18) \text{ W} \times 6 \text{ h} \times 365 \text{ d} \div 1000 = 289.08$	2,312.64	2,100	0.91

Total annual saving = 853.08 kWh = ₹6,824.64 per year

Total investment = $4 \times 3,200 + 6 \times 350 = ₹14,900$

Simple payback = $14,900 \div 6,824.64 = 2.18$ years (LED tubes alone pay back in about 11 months).

(Ways 2 M, calculation 4 M)

b) Thermosiphon solar water heater.

6 M

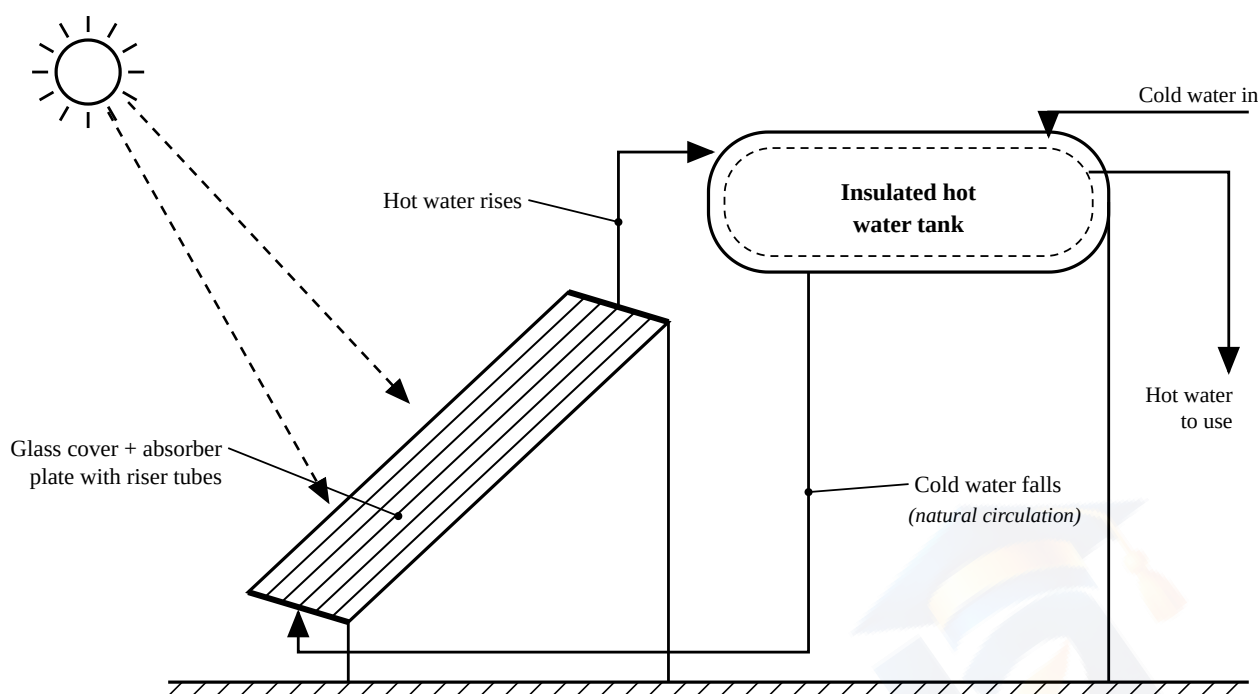


Fig.: Thermosiphon type solar water heater (flat plate collector)

Construction: flat-plate collector (black-coated copper/aluminium absorber plate with riser tubes, covered by toughened glass and insulated at the back), insulated hot-water storage tank placed **above** the collector, cold-water supply tank, and connecting pipes.

Working:

1. Sun rays pass through the glass and are absorbed by the black absorber plate; the glass reduces heat loss (greenhouse effect).
2. Water in the riser tubes gets heated; hot water becomes lighter and rises to the top of the storage tank.
3. Colder, heavier water from the bottom of the tank flows down to the bottom header of the collector.
4. This natural circulation (thermosiphon) continues as long as the sun shines — no pump is needed. Hot water is drawn from the top of the tank.

Role in green building: replaces electric geysers (large saving in hostels, hospitals, hotels, homes), uses free renewable energy, reduces CO₂ emission, earns points in GRIHA/IGBC, and some municipal bodies have made solar water heaters compulsory for certain new buildings.

(Sketch 2 M, working 2 M, role 2 M)

c) Continuous improvement after a green building audit.

6 M

1. **Action plan:** prioritise recommendations (no-cost, low-cost, high-cost) with responsibility, budget and time-line.
2. **Set targets and KPIs:** e.g. reduce EPI by 15 %, water use per person by 20 %; baseline from audit.
3. **Implement:** carry out measures in phases; train staff.

4. **Monitor and verify:** sub-meters / BMS, monthly reports; compare with baseline.
5. **Review and act:** management review meetings; correct deviations; standardise good practices (SOPs).
6. **Re-audit periodically** (e.g. every year or two) and update targets — Plan–Do–Check–Act cycle.
7. **Awareness and participation:** green committee, posters, rewards for saving.
8. **Aim for rating / higher rating** (GRIHA/IGBC/LEED) and adopt ISO 50001 energy-management system where suitable.

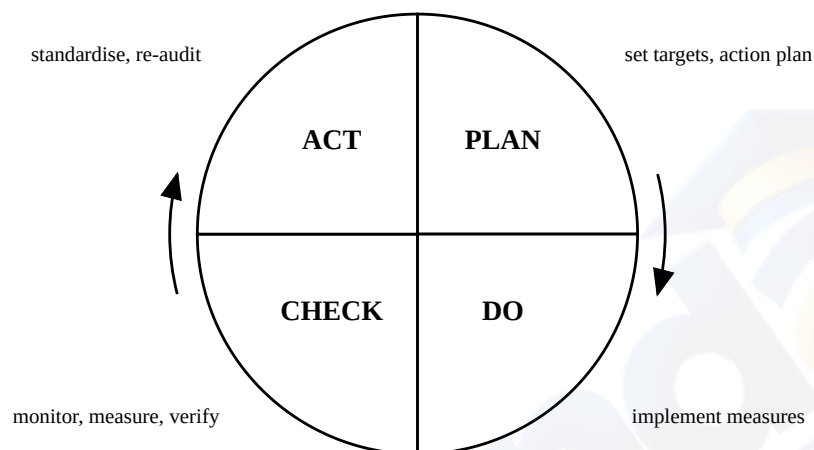


Fig.: Continuous improvement (PDCA) cycle after green building audit

(Any five points 5 M, PDCA 1 M)

Q.6

a) Functions and benefits of BEE.

6 M

Functions:

1. **Statutory body** under the Ministry of Power, set up on 1 March 2002 under the Energy Conservation Act, 2001, to reduce the energy intensity of the Indian economy.
2. **Standards and Labelling (S&L) programme:** star labels (1 to 5 stars) for appliances such as ACs, refrigerators, fans, LED lamps, motors; mandatory for several appliances.
3. **Building codes:** Energy Conservation Building Code (ECBC 2007, updated 2017) for commercial buildings; Eco-Niwas Samhita (2018) for residential buildings; the Energy Conservation and Sustainable Building Code (ECSBC) after the 2022 amendment (check latest notification); star rating of existing buildings.
4. **Industry:** PAT (Perform, Achieve and Trade) scheme for designated consumers; energy audits and energy managers.
5. **Certification:** national examination for energy managers and energy auditors; accreditation of energy auditors.
6. **Demand-side management** programmes for municipalities, agriculture and SMEs.

7. **Awareness:** National Energy Conservation Day (14 December), National Energy Conservation Awards, school programmes.
8. **Co-ordination** with State Designated Agencies (e.g. MEDA) and role in the carbon credit trading scheme.

Benefits:

1. Consumers can choose efficient appliances easily using star labels — lower bills.
2. Lower energy demand reduces need for new power plants and fuel imports (energy security).
3. Reduction in CO₂ emissions.
4. Energy-efficient buildings through ECBC — lower operating cost.

(Functions 4 M, benefits 2 M)

b) Benefits of IGBC rating to a commercial office building.

6 M

1. **Lower operating cost:** less electricity (efficient envelope, lighting, HVAC) and water bills; savings are often quoted as roughly 20–30 % energy and 30–50 % water by IGBC (actual saving varies).
2. **Higher rent and occupancy:** companies (especially multinationals) prefer certified offices; better resale value.
3. **Employee health and productivity:** fresh air, daylight, thermal comfort, low-VOC materials — fewer sick days.
4. **Brand image and CSR/ESG reporting:** certified green office supports sustainability reports of tenant companies.
5. **Incentives:** some states/cities give extra FAR or fee concessions for IGBC/GRIHA-rated projects; green loans at better terms.
6. **Third-party verified performance** and documented operation practices; easier compliance with ECBC/ECSBC.
7. **Environmental benefits:** lower carbon footprint and waste, less load on city water and power supply.

(Any six benefits, 1 M each)

c) School — audit steps and roof-top solar PV sizing.

6 M

A) Audit steps applied to the school:

1. **Plan:** objective — reduce electricity use; scope — classrooms, labs, office, pumps; team of teacher-in-charge, electrician, students; checklist and instruments (lux meter, power meter).
2. **Collect data:** 12 months of electricity bills (3,000 kWh/month average), connected load list, timings, built-up area for EPI.
3. **Walk-through and measure:** count lamps and fans with wattage, check lights ON in empty rooms, measure lux in classrooms, check pump running hours.
4. **Analyse:** find EPI (kWh/m²/year) and share of each load; compare with benchmark and previous years.
5. **Recommend:** LED lamps, BLDC fans, timers on pumps, daylight use, awareness and roof-top solar PV.

6. **Report and follow-up:** present report with cost and payback; monitor monthly bills after implementation.

B) Solar PV sizing (assumed: peak sun hours = 5 h/day, performance ratio PR = 0.75, 30 days/month):

Daily energy need = $3,000 \div 30 = 100 \text{ kWh/day}$

PV capacity = $\text{Daily energy} \div (\text{Peak sun hours} \times \text{PR}) = 100 \div (5 \times 0.75) = 26.67 \text{ kWp} \approx 27 \text{ kWp}$

Roof area needed $\approx 26.67 \times 10 = 267 \text{ m}^2$ (shadow-free)

Expected annual generation $\approx 26.67 \times 5 \times 0.75 \times 365 = 36,500 \text{ kWh/year} = 12 \times 3,000 \text{ kWh}$.

After the efficiency measures reduce consumption, a smaller PV plant will be sufficient — so efficiency first, then renewable energy.

(Audit steps 3 M, PV calculation 3 M)

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