

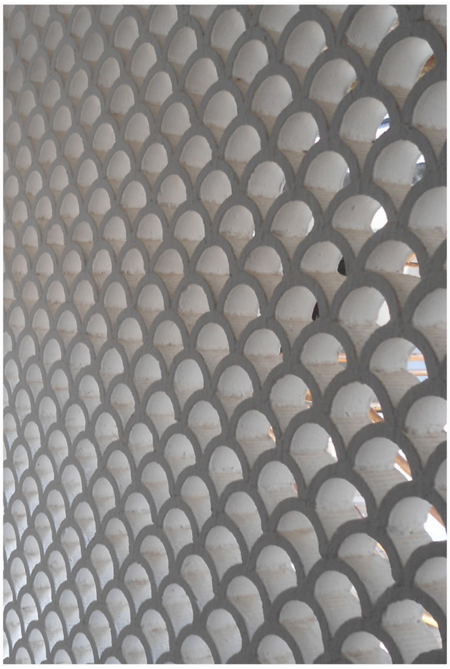

Build Green

100 ways to save money and the environment

UN HABITAT
FOR A BETTER URBAN FUTURE

Build Green: 100 ways to save money and the environment

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UN-HABITAT

British High Commission, UGANDA © Adrian Hobbs

INTRODUCTION

Are you thinking about building a new home or maybe renovating the one you have now? Why not make it "green"?

Green buildings are healthy buildings, both for the occupants and the environment. They are energy efficient, conserve resources, create healthier indoor environments and offer durable and beautiful spaces that use environmentally suitable materials. Ultimately, adoption of green building practices could lead to a paradigm shift in the building industry, with sustainability meticulously embedded in its practice, products, standards, codes, and regulations.

Constructing your home in an environmentally responsible manner requires a great deal of planning, as well as educating architects and builders and urging them to seek out greener materials and construction techniques. Local governments and private industry often do not have the resources to do the research that is needed to assemble information on sustainable practices, assuming such information is readily available.

The 'Build Green: 100 ways to save money and the environment' guidebook is written to fill that void. In its pages, we have consolidated and prioritized information from the scattered and growing body of knowledge of green building. The guidebook's primary intent is to provide a resource for building professionals in which they will find suggestions for green practices through the full cycle of a building project - from site planning to building design, construction and operation. Its most crucial consideration is balancing economic and time input with personal and environmental benefit.

This booklet is intended as a general guide to the basics of green building for your home. Exciting opportunities exist beyond its scope if you are planning a major commercial sized building project. We highly recommend that you tap into the references listed in this booklet for more detailed information, to make your project even greener. The building professionals who will find this guide a useful resource include; homeowners and developers, planners, architects, interior designers, engineers, contractors, property managers, landscape architects, product manufacturers, utility companies, building tenants, maintenance staff, and local government officials.

We hope that you will find this guidebook a valuable resource for advancing your adoption and daily practice of green building principles – a necessary and vital step towards recognizing the need to conserve our Earth's natural resources.

A. SITE ANALYSIS

1. Select a suitable site

The location of a building within a piece of land can have a significant impact on energy bills. Make sure that the selected site allows for proper orientation of the building to minimize heat gains and take advantage of the prevailing wind.

Development of previously used sites such as brownfield sites is likely to improve the immediate environment and the community. However, wetlands, floodplains, steep slopes vulnerable to erosion and vegetated areas should be avoided to preserve the natural ecosystem.

2. Do not ignore the topography

Topography and adjacent landforms affect solar access, daylighting, airflow within the site, building proportions, floor elevations, drainage strategies etc. The slope of the land determines the possibility of using gravity drainage systems.

To benefit from passive solar gain for heating, a south facing slope is best in the northern hemisphere while a north facing slope is preferred in the southern hemisphere.

3. Check the groundwater and surface runoff characteristics

When deciding on the location of a building, you should take into account natural storm runoff channels according to the slope of the land. This helps to divert stormwater from the building as well as to determine the most suitable location for runoff detention ponds.

4. Consider the solar access

The position of the building should take maximum advantage of solar access for passive solar heating (in cold climates), daylighting and generation of electricity by using photovoltaics.

5. Make use of diurnal and annual patterns of air movement

The prevailing wind patterns and their average speed and direction on a particular site should be investigated as they influence the siting of multiple buildings. The wind should be exploited to improve natural ventilation, therefore, providing fresh air for building's occupants as well as maintaining acceptable levels of air quality. It is also useful for passive cooling in warm weather.

6. Check the characteristics of the soil and its load-bearing capacity

When selecting a site, it is very imperative to check the soil as it determines the most appropriate type of foundation to be used. It also influences the choice of the most suitable stormwater drainage. The soil should be tested to check its suitability for backfills, slope structures, infiltration rates and compactibility as well as to identify the presence of contamination from industrial activities. These tests are crucial for determining the feasibility of the site and for identifying the most suitable construction methods.

7. Consider the surrounding buildings in your design

Neighbouring buildings should be considered in the design of a proposed development as they have the potential to affect it in terms of daylighting, shading, ventilation etc.

8. Consider sources of pollution

Select a site away from major sources of pollution. Activities that are likely to cause air or noise pollution should be sited away from areas where they are likely to cause disturbance to occupants. However, if the site is located near noisy areas such as roads, the building should be set as far back as possible. In addition, non-occupied spaces such as parking lots and landscaping features such earth berms may be used as sound buffers.

9. Design for your climate

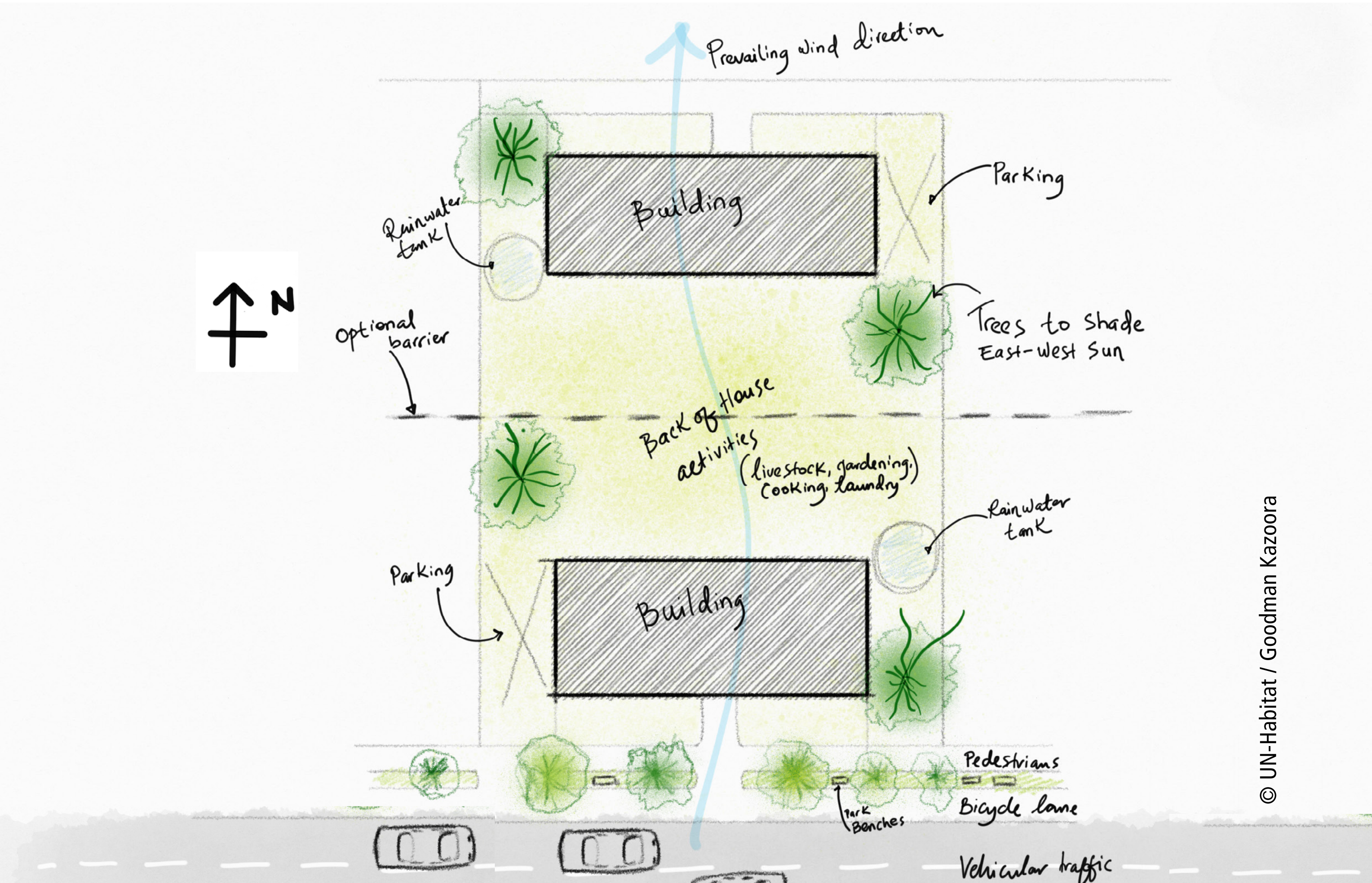
It is critical to consider the local climate at the start of the design process. Climatic factors including air temperature, wind, solar radiation, humidity and rainfall have a major influence and should be considered in the energy-conscious design. These factors affect the layout and orientation of the building and they enable selection of the most appropriate building materials for a particular climate.

10. Create walkable neighbourhoods

Ideal sites are either where occupants can walk or cycle to the shops or their workplaces etc. or are located close to public transport nodes. Therefore, sites for new buildings should be selected where the energy consumed for transport can be minimized. Short streets encourage pedestrian movement. They also provide air movement corridors for natural ventilation and passive cooling.

11. Use appropriate construction methods

Sustainable construction methods that eliminate unnecessary site disruption, as well as degradation of the natural resources at each step of the building process, should be used. In addition, the building process should be planned in such a way that there is an orderly sequence from site clearing to end of construction. This ensures that there is minimal damage to the site and reduces costs.



B. BUILDING LAYOUT

12. Base the orientation of rooms on the movement of the sun

Orient the building according to the movement of the sun in order to avoid unwanted heat gains or losses.

Generally, the ideal orientation of buildings in a tropical climate should be along the east-west axis with the long façades facing north or south and the shorter sides facing east or west. This gives good access to daylight and reduces unwanted heat gains from early morning and late afternoon solar radiation on the east and west façades respectively.

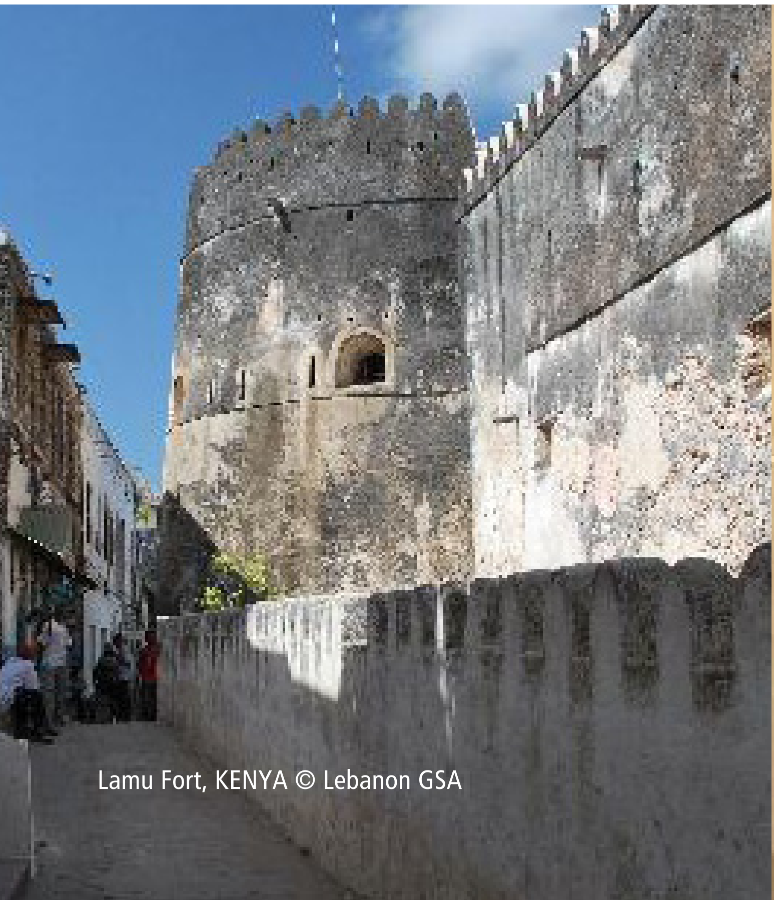
Spaces that are used the most should be oriented to face north in the southern hemisphere and south in the northern hemisphere in order to minimize heat gain and maximize daylighting. Building services such as elevators, lobbies, toilets, ducts, stores and staircases should ideally be placed on the east and west sides of the building to act as buffer zones against the intense solar radiation that strikes the building in the morning and afternoon.

13. Build better, not bigger

Through careful design and optimization of interior space, you can achieve a well-designed building with a smaller carbon footprint. Smaller, more efficient units use significantly fewer resources for construction and less energy to operate.

14. Design for efficiency

An efficient building layout can be achieved by locating spaces with similar technology requirements such as plumbing, HVAC systems etc. close to each other, in order to minimize materials and energy losses. As already mentioned in 12., secondary spaces such as toilets, staircases, elevator shafts, stores and ducts should be located on the east and west sides of a building to act as buffer zones against the intense morning and afternoon sun.



Lamu Fort, KENYA © Lebanon GSA

Lamu street, KENYA © Daisy Carrington & Aja Harris

15. Build more floors instead of a sprawling one storey building

Densification through the use of multi-storey buildings should be carefully planned and designed to allow for better land use and increase the number of dwellings on a site.

It also presents an opportunity to develop environmentally friendly, low energy buildings as it eliminates the wasted space between single storey houses, freeing it up for vegetation and landscaping thus making it possible to create external shading. It also creates opportunities for correct building orientation, i.e. according to the movement of the sun, so minimizing unwanted heat gains.

16. Go for narrow floor plans

Buildings that are narrow in plan help to achieve good cross-ventilation and maximum daylight penetration. Buildings that are poorly shaped and therefore not suitable for optimum orientation make it more expensive to achieve energy efficiency using active systems.

17. Design spacing for daylighting

Buildings should be arranged on site to ensure that they have good access to daylight and do not shade adjacent buildings.

18. Organise spacing and orientation as to use sunlight as an amenity

In cold climates where heating is required, the sun can be used for passive heating. Buildings should, therefore, be organised so that they have good access to sunshine. To make use of this, the spaces to be heated by the sun should be oriented facing south in the northern hemisphere and north in the southern hemisphere.

Equipment such as photovoltaic panels and solar water heaters that require sunshine should also be provided with good solar access and should not be shaded by adjacent buildings or vegetation so as not to compromise their performance.

Outdoor spaces in cool climates should be exposed to sunshine during the cold periods and shaded during the hot periods. In hot climates, exposure to sunshine should be limited through shading.

19. Make the maximum use of breezes

The building layout should ensure that there is good access to the breezes required for natural ventilation and cooling inside and outside the buildings. Choose more open building layout patterns in hot-humid climates to maximize natural ventilation. In hot-arid climates, dense layout patterns are preferable in order to maximize shading and protection from hot sandy winds.

Vegetation can also be used as a windbreak to protect external spaces against cold winds and to reduce heat losses from buildings during cold periods.

20. Intersperse buildings with green spaces

Replacing hardscape surfaces such as paving and parking with vegetation, or shading these spaces can significantly reduce the urban heat island (UHI) effect, which results in higher air temperatures and makes it difficult to cool buildings.

UHI can also be minimized by using light coloured external surfaces and paving materials as well as green (vegetation covered) roofs that reduce heat absorption. Creating green spaces around buildings contributes to energy efficiency because warm air is cooled before it enters the building so reducing the cooling needs.

21. Make use of outdoor ‘rooms’.

Living areas can be maximized by including outdoor areas. These outdoor spaces should be designed with respect to buildings and vegetation so that they are well shaded and ventilated to provide comfort to users.

C. BUILDING FORM

United Nations Office, Nairobi, KENYA © UN-Habitat / Julius Mwelu

22. Choose the best building shape for the climate

The optimum shape of a building depends on the type of climate. It should complement the daylighting, solar heating, ventilation, cooling and function of the building. In hot-arid climates a compact shape is better as it will minimize the area exposed to the sun, consequently reducing heat gains. In hot-humid climates, on the other hand, the shape should be as open as possible to allow for natural ventilation. The building depth also has an influence on natural ventilation. For instance, in hot and humid climates this depth should be limited in order to promote air circulation for natural ventilation and cooling.

23. Exploit courtyards

Low, wide, permeable courtyards are useful in promoting airflow through buildings. In hot climates, well-designed courtyards provide cool outdoor spaces thus contributing to cool indoor temperatures, especially if they are shaded or contain water features.

24. Use earth to save energy

During hot periods, the ground has a lower temperature than the ambient temperature whereas, in cold periods, it is warmer than the ambient temperature. Earth can, therefore, be used to reduce temperature variations inside buildings thus providing thermal comfort. Earth-sheltered or underground buildings provide indoor passive cooling in hot climates as heat is lost to the ground. In cold climates or in cold periods, there is a decrease in heat losses as the warm ground contributes to heat gains. Other strategies such as the use of earth berms or green roofs minimize solar heat gains and wind-driven air filtration and so provide thermal comfort.

25. Avoid solar dazzle

Solar dazzle occurs when sunlight is reflected from a large glazed façade made of tinted reflective glass, shiny metal or mirror-clad surfaces or sloped surfaces made of glass. This adversely affects road users and occupants of adjacent buildings. This problem can be avoided at the design stage by reducing glazed areas, specifying clear glass as opposed to reflective glass and replacing the tilted glass with either vertical or near-horizontal glazed surfaces.

D. SUN SHADING

26. Provide shading against solar radiation

In hot climates, minimizing the heat entering buildings improves thermal comfort and reduces cooling loads resulting in lower energy consumption.

Solar heat gains may be minimized by appropriate shading of all glazed areas by the use of vertical and horizontal sun-shading elements, roof overhangs, balconies, vegetation etc. Shading allows good indoor climatic conditions to be achieved with minimal energy consumption.

Orienting the building with the long sides facing north and south, as well as placing minimal to no openings in the east and west facing façades, reduces excessive solar gains and facilitates ventilation.

27. Insulate your roof

Roofs receive a great deal of solar radiation in hot climates and are a major source of heat gain. They should, therefore, be insulated to minimize heat gain in hot periods and heat loss from the interior during cold periods.

28. Design for mutual shading

The mutual shading of buildings which results from the compact layout suitable for hot-arid climates reduces heat gains by keeping the façades of the building cool. This strategy also keeps the spaces between buildings cool and creates desirable outdoor spaces.

29. Consider the reflectivity of the building envelope

Hot regions have significant cooling loads. These loads can be minimized through the use of light coloured external finishes with high reflectivity to reflect unwanted solar radiation.

House of Culture, TANZANIA © Tengbom Architects / Inger Thede

E. NATURAL VENTILATION

30. Ventilate buildings naturally

A building can be naturally ventilated by using operable windows, thermal chimneys and openings set into walls or roofs to provide fresh air and cooling. Natural ventilation reduces or eliminates the need for mechanical ventilation and in this way, minimizes energy consumption and the costs associated with cooling.

31. Take advantage of the breezes

Natural ventilation demands good exposure of the building and its openings to the dominant breezes. Buildings should, therefore, be oriented to maximize surface exposure to the prevailing winds.

In hot-humid climates, a well-spaced building layout is recommended to allow maximum ventilation for cooling indoor and outdoor spaces. Multi-storey buildings benefit more from breezes than single-storey buildings.

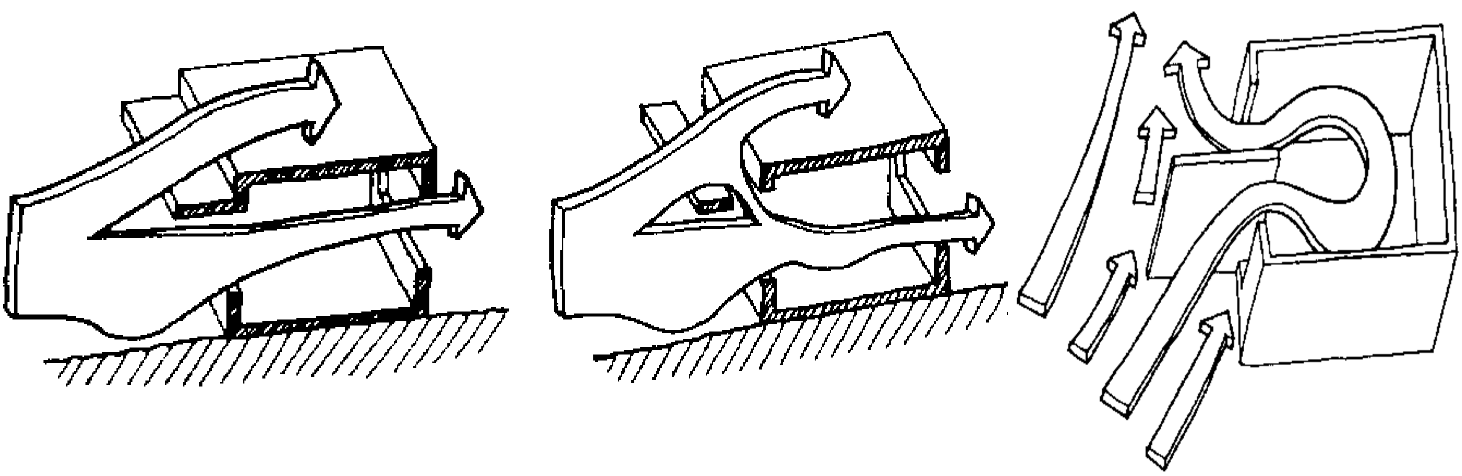
However, in hot-arid climates, ventilation should be limited during the daytime when the air is hot; it should be increased at night to cool the building down.

32. Design your buildings to be as permeable as possible

You should design buildings that are permeable both in plan and section so as to encourage air flow through the building.

In hot-humid climates, you can create maximum ventilation by placing large openings in opposite walls and ventilation openings at the top of exterior walls, by providing ventilated roofs and by placing rooms on only one side of an access corridor.

In hot arid climates, small openings provided in external walls, facilitate cross-ventilation. High and low -level openings should be provided in walls bordering courtyards in order to encourage air movement.



F. NATURAL COOLING

© UN-Habitat / Jerusha Ngungui

33. Control direct solar heat gains

Controlling direct solar gains – through orienting a building along the east-west axis and the use of sun shading - minimizes solar heat gains in hot climates thereby providing cool and comfortable interior spaces. Vegetation planted strategically on the east and west sides of the building block undesirable radiation when the sun is low in the east or west thus contributing to cool interiors during the daytime.

34. Go for a green roof

Because roofs receive the most solar radiation, their thermal performance is critical. Green roofs, which are rooftops covered partially or entirely by vegetation, have a significant cooling effect on buildings by blocking the underlying roof structure from sunlight thereby reducing temperatures. This also helps to reduce the urban heat island effect.

35. Have minimal window openings

Glazed openings in the east and west facing façades should be limited or entirely avoided as they are harder to shade from the low angle rays of the eastern morning sun or the intense western afternoon sun.

36. Consider innovative cooling strategies

Natural ventilation through operable windows brings fresh cooling air into a building without the need for a mechanical system hence saving energy. Other strategies include the use of fresh air inlets located near the floor, the use of ceiling fans and the use of atria and stairwells to enhance the upward escape of hot air which is then replaced by cool fresh air from outside. Evaporative cooling devices - suitable for hot-dry climates - cool the outdoor air before it is introduced into the building thereby serving to cool indoor spaces.

Wind cowls on the roof improve the rate of indoor cooling by enhancing air flow. Wind towers can also be used to capture hot air from outside via an upper opening where it is cooled and flows down the tower into interior spaces through a lower opening.

37. Explore the use of thermal mass

Building materials should be chosen according to the climate. In climates that have large diurnal temperature ranges, such as hot-arid climates, the outer walls should have a large thermal capacity. This acts as a 'heat sponge' and absorbs heat, resulting in cool indoor conditions by slowing internal temperature rise on hot days.

G. DAY LIGHTING

Strathmore Business School, Nairobi, KENYA © UN-Habitat / Jerusha Ngungui

38. Allow enough daylight into an occupied space

Daylighting is a very effective way of saving energy because it minimizes the use of artificial lighting during the day. This is particularly useful in locations where natural lighting alone is adequate throughout the day, which is the case in tropical climates. In addition to reducing energy use, daylighting also has a positive effect on visual comfort.

The use of openings in the walls, roof lights, atria, light-pipes, light ducts, clerestory windows and sawtooths are all strategies that can be used to provide natural lighting in interior spaces.

39. Establish basic daylighting parameters as part of the building design

For effective use of daylighting base the building's location and orientation on the required performance and on the need for passive solar heating or cooling.

Daylighting should be factored in at the beginning of the design stage as it is dependent on availability, and location and on the size and orientation of openings. A well-designed daylighting system, with the correct placement of openings in the building envelope, allows light penetration and at the same time avoids unwanted thermal gains and glare, which can both cause discomfort.

40. Specify the details for lighting systems and products

When selecting glazing materials, consider the climate, the position of the openings, the orientation of the building and the shading devices that are going to be used.

The type of glass chosen affects the quality of daylight. Clear glass allows a high transmission of daylight as well as a high transmission of solar radiation if it is not properly shaded. Tinted or reflective glass reduces solar heat gains but limits the amount of visible light, therefore, affecting the quality of the daylight.

Appropriate sun shading systems such as light shelves and window blinds should be incorporated if need be in order to minimize unwanted direct sun in interior spaces and also moderate the amount of glare.

41. Maintain daylighting features for optimum performance

Ensure that all daylighting openings and systems are operating as specified through regular maintenance. All glazing should be cleaned regularly to ensure optimal lighting levels in all spaces. This minimizes the use of artificial lighting during the day.

42. Specify the appropriate room reflectivity

The reflectance of surfaces such as walls, ceilings and floors determines the amount of light that can be reflected to the back of the room from an opening located on the exterior walls.

Light-coloured surfaces reflect light and therefore the highest practical room reflectance should be specified so as to achieve the best overall efficiency of the daylighting. Dark coloured surfaces absorb light and so reduce the quality of the daylight received.

Rough textures create diffuse light while smooth or glossy surfaces create reflected light. They also have the potential to create glare.

43. Think outside the box!

In cases where rooms are not located along the perimeter of the building or where deep spaces exist (more than 7 m), daylighting may be compromised. However, innovative strategies may be incorporated into the design to introduce daylighting into such spaces thus minimizing the use of artificial lighting during daytime. These strategies include the use of solar tubes, light pipes, light shelves, anidolic ceilings, Venetian blinds, solar bulbs and the use of translucent materials for walls or roofs.

H. PASSIVE HEATING

44. Let a little sunlight in

In cold climates where heating is needed most of the time, allowing direct solar gain inside buildings is the simplest and most cost-effective way of passively heating a space using the sun. This strategy is needed more in the morning hours, less in the afternoon.

45. Design the building's floor plan to optimize passive solar heating

The orientation of the building should be carefully considered during the design phase. Orienting the building along the east-west axis takes advantage of the consistent sun exposure of the north and south facing façades. Spaces should be carefully planned to allow a certain amount of solar heat to penetrate rooms that are mostly used during the day.

46. Use thermal mass for heating

The use of the building fabric for storing thermal energy is an effective way of heating (or cooling) the internal environment of buildings. This can be achieved using high thermal mass materials such as concrete floor slabs, and masonry walls that absorb and retain heat, slowing down the rate at which the sun's heat enters a space as well as the rate at which it loses heat after the sun sets. This helps occupants stay comfortable for longer periods of time.

47. Locate thermal mass appropriately

The appropriate location of thermal mass inside the building can make a huge difference to comfort as well as to the energy use associated with space heating. Floor slabs constructed of high thermal mass materials such as brick or concrete should be exposed in order to absorb the solar radiation streaming in through glazed surfaces. Curtains or window blinds should be left open during the day in cold periods to let the sunshine in and to heat the floor.

I. BUILDING MATERIALS

48. Use building materials that are appropriate for the climate

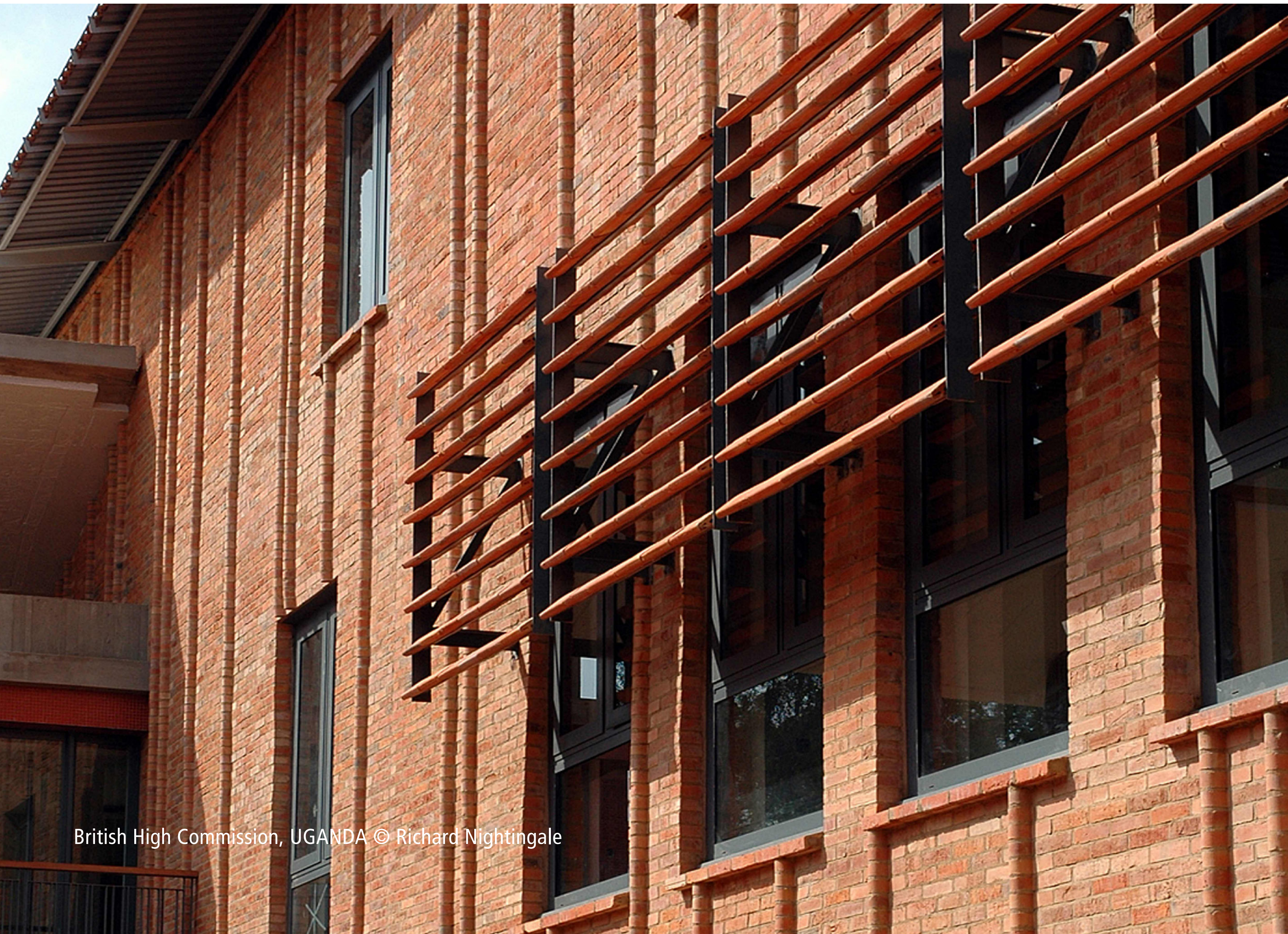
The prevailing climate has a great influence on the choice of building materials and should, therefore, be considered right at the beginning of the design stage.

Hot-dry climates are characterized by significant diurnal temperature swings as a result of high daytime temperatures and low temperatures at night. This means that thick envelopes using high thermal mass materials are the most suitable for this type of climate. Thick envelopes allow heat to penetrate slowly during the day and for it to be released at night, resulting in cool indoor conditions during the day and warmer temperatures at night when exterior temperatures fall. This minimizes the need for mechanical cooling during the day and artificial heating at night.

In hot-humid climates, the temperature difference between daytime and nighttime is not significant, therefore it is better to use light materials with low thermal capacity.

In colder climates, the selection of materials depends on the heating strategy used for the building. Passively solar heated buildings require high thermal mass materials.

Light coloured external finishes on walls and reflective roof surfaces should be incorporated to reflect unwanted solar radiation, minimizing heat gain in hot climates.



British High Commission, UGANDA © Richard Nightingale

49. Use resources efficiency: Reduce, Reuse, Recycle

An important strategy in resource-efficient building is to buy fewer products/materials, use purchased materials efficiently or make use of reclaimed materials. For example, in renovation or restoration projects, many durable building components such as doors, cabinets, windows etc. can be readily reclaimed and reused.

Where possible, materials with great potential for reuse and recycling and materials with high amounts of recycled content should be selected. It is also important that materials left over following a demolition should be reused or recycled to the fullest extent possible.

50. Avoid waste

It is essential to use purchased building materials more efficiently. Care should be taken not to waste materials, particularly when dealing with materials with high embodied energy.

For example, gypsum boards come in standard sizes, which means that the design of the wallboard installation should factor this in with a view to avoiding wastage during construction.

Other standard-sized building materials include acoustic ceiling panels and man-made boards such as MDF boards, chipboard, plywood etc.

51. Choose green materials

When you are selecting building materials, consider the following aspects: renewability, sustainable production and recyclability.

Wood, bamboo, plant fibres etc. are examples of renewable materials that can potentially be replaced within a limited time after harvesting should also be harvested through sustainable management practices.

Non-renewable materials like stone are useful since they can be reused or recycled.

52. Keep it local as far as possible

Use locally available materials and technologies as well as locally made products. This reduces the embodied energy of building materials and their life-cycle cost as well as the carbon emissions associated with their transportation.

Choose materials with low embodied energy, that is, they have low CO_2 emissions throughout their lifecycle, from the extraction of the raw material to transportation and manufacturing, use, reuse and even final disposal.

53. Choose regionally appropriate materials

Because of differences in climate, some types of construction materials are more appropriate in one region than another. For example, thick masonry walls are more appropriate in hot-dry climates to reduce heat gain during the day while lightweight construction is more suitable for hot-humid climates.

54. Select durable products and materials

Using durable components and materials allows long-term use as well as a reduction in maintenance, renovation and refurbishment costs during the lifetime of the building.

Where possible, select building materials that will require little maintenance (painting, waterproofing etc.) or whose maintenance will have a minimal environmental impact.

55. Reuse a building

Instead of demolishing old buildings to make way for new ones, existing, structurally sound buildings can be conserved, restored and reused to minimize the consumption of materials while maximizing resource efficiency.

J. LANDSCAPING

56. Vegetation

Landscaping of any proposed development should be done using native or well-adapted trees, vines and shrubs. Exotic varieties should be avoided. Local or native vegetation is adapted to the climatic conditions of the location as well as other conditions such as native soils, pest problems and seasonal droughts. It also requires minimal watering and can thrive with the use of manure instead of fertilisers.

Using native vegetation in landscaping also helps maintain the biodiversity of a region.

57. Use plants to mitigate climate conditions

Evergreen trees are useful in hot climates to provide shade and reduce heat gain all year round. Their use significantly reduces the energy needed for cooling. In cold climates, deciduous trees, when correctly located, provide shade in hot periods and allow access to the sun for passive heating during the cold periods when they shed their leaves.

Trees can also be used for wind and noise protection. However, for there to be a significant decrease in noise, a wide band of trees (about 200 foot) is required.

58. Use water features to cool outdoor spaces

Water features such as ponds and fountains can be incorporated into the landscaping to keep temperatures lower through evaporation.

59. Think of the hardscapes as well

Non-living parts of the landscape such as patios, decks, pavements, driveways, flat roofs etc. comprise some of the most useful areas on a site. However, the use of dark-coloured hardscapes should be kept to a minimum to reduce the urban heat island effect. Porous materials should be used to reduce impervious surfaces and allow water to soak into the soil thus reducing surface runoff.

K. ACOUSTICS

Learning Resource Centre, Nairobi, KENYA © Musau Kimeu

60. Locate noise-sensitive areas away from noise-producing elements

Building spaces should be planned carefully so as to avoid locating sensitive spaces like facility rooms, hospital wards, office areas etc. adjacent to noise producing areas such as generator rooms, gymnasiums, music practice areas etc. However, less-sensitive spaces (e.g. data centres) may be placed adjacent to noise producing ones.

61. Use buffers to reduce the impact of noise from external sources

In cases where buildings are located close to busy, noisy roads, landscaping features such as earth mounds/ berms can be erected alongside the road to act as buffers against the noise generated by traffic.

62. Consider the acoustic properties when selecting surface finishes

The main aim in designing spaces for speech, such as audio-visual facilities, halls, theatres, religious centres etc., is to ensure that audiences can clearly hear what the speaker is saying. It is therefore important to consider the acoustic properties of surface finishes to avoid echoes.

Surface finishes such as thick foam padding on internal walls and columns and acoustic timber panelling can be installed when quiet spaces are needed. Acoustic ceiling products and carpeted floors can also be used to control the sound generated in spaces such as offices.

63. Think about the noise from mechanical equipment

In most cases, mechanical equipment generates noise during use. The resulting acoustic conditions can be improved in the following ways: relocate the equipment to a less noise sensitive place; fit or increase a lining made of sound absorbent material within the ductwork, if possible; install sound attenuators within the system or; replace the equipment with a better, more efficient model.

L. ENERGY

64. Use renewable resources

Renewable energy is energy derived from natural processes that do not involve the consumption of exhaustible resources such as fossil fuels. Renewable energy resources include solar, hydro, wind, wave, biomass, tidal and geothermal energy. Depending on the resources available, you should choose the most appropriate and effective renewable technology. A renewable energy system can be used to supply some or all of your electricity needs.

65. Evaluate your load

Before you install a renewable energy system, it is important to identify your power requirements by assessing the building's daily energy profile as well as the load profile over time. This ensures that the RE system is neither over-sized (which affects the price of the generated power) nor under-sized (which reduces the reliability of the supply).

The load can be evaluated using past energy bills (monthly /annual), manufacturer's data on the power usage of any equipment, and typical data on energy consumption per hour for a particular appliance.

66. Generate your own electricity

Renewable energy technology can be integrated into the building to generate electricity. This can be in the form of photovoltaic systems to harness solar energy or small-scale building-integrated wind turbines to harness wind energy.

Solar panels © UN-Habitat / Jerusha Ngungui

M. APPLIANCES

67. Install solar water heaters for your water heating needs

Solar thermal systems in the form of flat plate, evacuated tube collectors use solar energy for domestic hot water heating. These solar hot-water systems should be selected according to climate, cost, user needs, operation and maintenance preferences.

68. Select a heat or power storage strategy

Storage systems are important as they balance the mismatch between electrical loads and energy generated. They are also necessary for off-grid systems due to the variable nature of solar radiation (daily and seasonal).

Therefore, a power storage strategy in the form of batteries should be considered within the system. The following factors should be considered: availability, cost, life cycle, the frequency of maintenance requirements and environmental and safety aspects such as toxicity and the risk of explosion etc. Hot water systems involve thermal storage that should be adequately sized for storing hot water for use as needed even in the absence of solar radiation.

69. Go green. Cook clean

Choose improved cookstoves that use less fuel and emit less smoke. Using improved cookstoves results in a reduction in indoor air pollution and Green House Gas (GHG) emissions; fewer respiratory diseases; improved health to users due to reduced exposure to smoke; and reduced fire hazards in the kitchen.

70. Convert waste to energy

Biodegradable wastes from toilets, animal dung or crops can be used to generate energy in the form of biogas, which is a clean renewable energy that can be used for cooking and lighting. Using biogas greatly reduces the indoor air pollution associated with the use of kerosene, charcoal and firewood. It also results in savings on the purchase of kerosene, firewood and charcoal and reduces GHG emissions and deforestation.

71. Invest in energy efficient appliances

Choose energy efficient appliances and fixtures with a high-energy st1ar rating for your home. Appliances and equipment such as fridges, freezers, washing machines, dishwashers, air conditioners and printers are given energy efficiency star rating labels that provide information on the energy efficiency of the product. The higher the star rating the better!

The more energy efficient a model is; the less energy it will use. This will save you money on running costs and reduce the impact on the environment.

72. Use your appliances wisely

Energy efficient washing machines can clean clothes effectively using cold water, so there is no need to waste energy heating the water used for washing. In addition, having a full load ensures that energy is saved.

Drying clothes on a clothesline or drying rack is an effective way of saving the energy otherwise used for machine/tumble drying. Energy can also be conserved by running your dishwasher only when it is fully loaded.

73. Switch to energy saving bulbs

Replace highly inefficient incandescent bulbs with energy star rated compact fluorescent lamps (CFLs) or with energy efficient LED lights. CFLs use 75% less electricity and have a much longer life. These factors make them cost less in the long run.

74. If you switch off, you'll be better off

Switch off lights and unplug electronic appliances when they are not in use. Gadgets and appliances that are on standby still consume electricity and therefore should be completely switched off or unplugged.

N. WATER

75. Pick the right toilet

A great way to save water and money is through the use of dual-flush toilets. These toilets offer the option of using only the water needed.

You could also consider using composting toilets. As they are a near- waterless technology, they provide an ecological alternative for dealing with human waste. Composting toilets mix human waste with organic material and make use of natural decomposition, producing an odourless product that can be used as garden compost.

76. Choose low-flow kitchen and bath fixtures

The overall reduction in water use reduces water wastage. This can be achieved by using more efficient plumbing fixtures such as low-flow or aerated taps and showerheads, waterless toilets and urinals. These fixtures reduce water consumption by including pressurised air bubbles in the water stream resulting in less water being used.

77. Design an efficient layout of the plumbing system

The design of the plumbing layout affects water usage. The most efficient plumbing design is to locate all the wet areas (kitchen, laundry and bathrooms), adjacent or at least close to each other. This strategy means

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short pipe runs and not only saves on plumbing costs but also results in savings on water bills.

The same is true in the case of multi-storey buildings with stacked water services e.g. locating upstairs bathrooms directly above downstairs kitchens.

Additionally, effluent from buildings should be allowed to flow via gravity without the need for mechanical sump pumps.

78. Look into the feasibility of grey water

Grey water, which is generated from indoor uses such as bathrooms, sinks, showers, tubs and laundries can be treated and reused for toilet flushing or irrigation. This saves on freshwater and reduces water consumption thereby reducing water bills and demand on the public water supply.

For this strategy to be effective, a dual plumbing system should be installed to separate the grey water from black water, which is wastewater generated from the flushing of toilets.

79. Harvest your rainwater

Rainwater should be harvested and used for cleaning, flushing toilets and watering plants. This has several benefits. It significantly lowers water bills, minimizes the likelihood of overloading the stormwater drainage system, reduces surface runoff and minimizes the need for water provided from the public supply. In remote areas where populations are dispersed, rainwater harvesting is a low-cost alternative to a piped water supply.

For rainwater harvesting, the roof design, as well as the gutter system, should be well thought out. Six-inch-wide gutters are recommended. Rainwater can also be directed to flow into an underground water tank. The water stored in this tank will come in handy for domestic use in the dry season.

80. Create a rain garden

Not all rainwater can be harvested and most of it flows away as surface runoff. A rain garden, which is a rich plant basin that acts as a sponge, can be created to channel the water from roofs, walkways, driveways, parking lots and compacted lawn areas. As the water flows into it, it is filtered and allowed to soak slowly into the surrounding soil.

81. Consider porous paving materials

One way of restoring natural cycles is to use permeable paving materials that allow for water infiltration thus minimizing surface runoff from surfaces such as walkways, patios, driveways, parking areas etc. Loose aggregate, wooden decks, well-spaced paving stones or permeable vegetated surfaces are examples of permeable paving materials that can be used to good effect.

82. Create water efficient landscaping

Landscaping using local plants that are adapted to the local climate ensures that minimal water is required for irrigation.

O. BEHAVIOUR CHANGE

83. Make education a part of your daily practice

The cheapest and easiest step to reducing energy consumption at home and in commercial buildings consists of changing the occupants' behaviour. For this behavioural change to happen, people need to be made aware of where and how electricity is being wasted and then they can take appropriate action. Examples include switching off lights and unplugging appliances that are not being used. Simple actions like these will result in significant cost savings.

84. Audit your energy usage

Simple home energy audits should be conducted to investigate how energy is being used within the building. This is done by identifying the appliances and equipment that use the most electricity and therefore cost the most money to run. A simple walkthrough energy audit will enable you to identify the energy-saving opportunities that exist and so you will be able to reduce energy consumption.

85. It's the little things

Our everyday activities contribute hugely to energy consumption. Adjusting the manner in which we do things is the first step towards achieving energy and resource efficiency. For example, having short showers is an easy and cheap way to save water and the energy used for heating it.

Allowing hot food to cool before putting it in the fridge means that the fridge does not have to work so hard, which reduces energy consumption.

86. Wear the right clothes

Dressing for the prevailing weather conditions will help save the energy that would be required for heating or cooling. For example, dressing warmly in the cold season helps you to keep warm, reducing the need to keep the heater on.

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P. INDOOR AIR QUALITY

87. Use fresh air

Operable windows allow for natural ventilation by ensuring that fresh air from outside is introduced into the building to replace the stale indoor air. This contributes to the comfort, health, productivity and well-being of occupants.

Using operable windows to naturally ventilate a building also reduces HVAC energy consumption either by reducing the number of hours during which the HVAC system operates or by completely eliminating the need for one.

88. Use daylight

Controlling the quality and amount of daylight within a space results in a comfortable environment for occupants. It also results in an accompanying reduction in the cost of energy by minimizing the need for artificial lighting during the day.

89. Create visual comfort

Ensure the visual comfort of a building's occupants by providing; the level of light required by the usage of the space; external views allowing different focal points, and; appropriate external sun shading elements to mitigate glare.

90. Choose healthy paints and adhesives

Indoor air quality is also affected by the choice of paints and adhesives used for interior finishes. This is attributed to the Volatile Organic Compounds (VOC) content of these products. Low-toxicity adhesives with the lowest VOC components should be selected for the installation of all building materials that require adhesives, such as ceramic tiles, linoleum, vinyl flooring, carpets, wall coverings and countertops.

'Green paints' should be chosen for indoor paintwork. These paints contain low levels of VOCs or none at all. They can be environmentally friendly natural or synthetic.

91. Keep the heat out

In hot climates, keeping the heat out makes it possible to create comfortable indoor thermal conditions. This can be done using passive design strategies such as the proper orientation of the building with the long sides along the east-west axis; appropriate sun shading devices on all the major openings; light coloured and reflective external finishes; high thermal mass materials and; the installation of operable windows to facilitate cross-ventilation.

92. Provide heating, ventilation or air conditioning

In a cold climate, a flexible heating system may be needed within a building. HVAC systems may, therefore, be required to provide thermal comfort and appropriate air quality in an enclosed space.

An HVAC system should be designed to provide thermal comfort based on the use of the building/ room, occupancy patterns, passive solar design opportunities, equipment, lighting levels and user-specific needs. High energy efficient HVAC systems should be installed.

In buildings where it may be necessary to use AC systems, infiltration of hot air into the building/room should be avoided to ensure that the AC unit is used efficiently. This improves energy efficiency, air quality and comfort by eliminating unwanted drafts.

Q. OPERATION AND MAINTENANCE

93. Take advantage of new technology

Meters can be used to monitor the power being used by appliances and equipment thus making it possible to identify potential energy saving opportunities.

Occupancy/motion sensors should be installed in rooms such as bathrooms and offices to ensure that lights are only switched on when the space is occupied.

Daylight sensors, linked to the building's lighting systems, can be used to dim or turn off electric lights according to the natural daylight entering the space, thereby reducing energy consumption.

Exterior lighting should also be automatically switched off when sufficient daylight is available.

Appliances/devices that need to be operated at a certain time of day or for a specific number of hours should be connected to automatic switch controls or time/scheduling controls. This applies to security lighting, air conditioners, pool pumps and electric water heaters.

All the above strategies are cost-effective ways of ensuring lighting needs are minimized and result in reduced energy consumption for lighting and cooling.

94. Create a smoke-free environment

Make the building a smoke-free zone or restrict smoking to a limited outdoor area in order to create comfortable indoor spaces and provide for the health, well-being and productivity of the occupants.

Other benefits of a smoke-free building include a reduction in damage to the property, lower maintenance costs and better fire prevention

95. Educate the users

Occupants play a major role in shaping the performance of a building and maximizing its environmental, health and sustainability benefits. They should, therefore, be educated on how to use the building correctly so as not to compromise its performance. Information on how to optimize the building's performance should also be provided.

If you make the sustainable initiatives that have been incorporated into the building, such as energy, water, material efficiency etc., visible to the occupants, you will provide them with valuable learning opportunities and create awareness of the building's impact on the environment and natural resources. In this way, buildings can be transformed into interactive learning tools.

These measures may also result in significant savings on operational costs for a building's owner and its occupants.

96. Manage waste

Before disposing of waste material, it should be considered for reuse, recycling and or composting – depending on the nature of the waste. A recycling management plan should, therefore, be set up in order to reduce the amount of waste generated and determine its method of disposal.

Waste collection bins that encourage waste separation (for recycling) should be conveniently located in or around the building. Signs should be put up at these collection areas to inform users about what can be recycled.

Organic waste such as food scraps and garden waste can be composted and transformed into valuable manure, which is beneficial for maintaining healthy soils and stimulating plant growth thus minimizing the need for artificial fertilisers.

97. Allow real-time monitoring and evaluation

Where applicable, Building Management Systems should be installed to control and monitor the building's mechanical, electrical and water systems. These systems, which are computer-based, actively control and optimize building services by monitoring energy use, water use and internal building conditions. They provide real-time data on the building's performance thus making it possible to identify poorly performing systems and improve them.

98. Formulate green housekeeping strategies

Regular cleaning can make the difference between a building with a healthy environment and one with significant Indoor Air Quality issues. However, commercial cleaning products often contain harsh chemicals and have the potential to create toxic environments. Non-toxic alternative products such as baking soda, or distilled white vinegar should be used instead. The latter are not only healthier to use, but are also cheaper. Cleaning products that leave a scent in the room should be avoided as some of these fragrances can be irritating to people with asthma, eye allergies, skin allergies or hypersensitive airways.

99. Inspect your building regularly

Regular building inspections help identify problems that have the potential to affect the quality of the indoor environment and the comfort of the occupants as well as energy and water use. Such problems include groundwater penetration, roof leaks, air infiltration, structural damage, insect infestation, plumbing and drainage issues, insufficient ventilation, flaking paintwork, damaged window panes etc.

100. Maintain the HVAC systems

It is a good idea to have periodic inspection and maintenance of the HVAC systems. These practices will vary depending on the type of equipment installed as well as the building type, location, usage patterns and envelope conditions. Regular maintenance of HVAC components ensures that occupants enjoy a comfortable indoor environment.

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