Draft ENERGY EFFICIENCY BUILDING CODE (EEBC)

May 2025

1.1 PREAMBLE

The Energy Efficient Building Code 2025focuses on achieving sustainable building design and construction practices nationwide, with the primary goal of promoting and enhancing energy efficiency in buildings. For Tanzania to meet Global Sustainable Development Goals and address the challenges posed by climate change, building design and construction must play a key role in the solution. The Energy Efficient Building Code 2025provides a comprehensive guide, emphasizing the techniques that promote efficiency in building practices.

The purpose of this document is to serve as a guideline for improving energy performance, which is essential for the country's growth. Following extensive stakeholder engagements, their concerns and input have been considered in the development of this document. This document covers buildings of at least 1000m^2 built up floor area and an electric power demand of at least 200Kw, having at least 150kW or 100kW cooling and heating load demand, respectively.

Widespread implementation of the Code would reduce energy waste, minimize hazardous emissions, and lower overall energy consumption and electricity demand, contributing to a cleaner and more sustainable environment.

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2 SECTION 2 – DEFINITIONS, ABBREVIATIONS AND ACRONYMS

2.1 General

The terms, phrases, words, and their derivatives used in this Code shall be interpreted as defined in this Section. These definitions apply to all sections of this code.

2.2 Definitions

24-hour business building: Commercial building or facility that operates for more than 12 hours on each weekday. Intensity of occupancy may vary. Examples may include hospitals, data centers, hotels, manufacturing facilities, and certain retail stores like convenience shops or petrol stations.

A

Accredited independent laboratory: Testing laboratory not affiliated with producer or consumer of goods or products tested at the laboratory. The laboratory is formally accredited by recognized national or international organizations (e.g., ISO/IEC 17025) that validate its technical competence and adherence to standardized testing procedures.

Addition: An expansion of a building that increases its in floor area or height beyond the boundaries of the existing building envelope.

Alteration: Means any change to a building, including a shift from one occupancy type of occupancy to another, structural modifications such as expanding the area or height, removing parts of a building, or altering structural elements such as walls, partitions, columns, beams, joists, floors, or other supports. It also includes changes to or closure of required means of ingress or egress as well as modification to the fixtures or equipment.

Anaerobic Digestion: means a series of biological processes in which microorganisms decompose biodegradable material without oxygen. This process produces biogas, liquid dig estate, and solid dig estate.

Astronomical time switch: an automatic time switch that adjusts to the varying length of the day throughout the year.
Authority having jurisdiction: the agency or agent responsible for enforcing this code.

Automatic control device: a device that can turn loads on and off automatically without manual intervention.

Automatic: self-acting, operating by its own mechanism that operates independently when triggered by a non-manual influence, such as a change in current, pressure, temperature, or mechanical configuration.

B

Balancing, air system: adjusting airflow rates in an air distribution system. This can be done manually by adjusting the position of devices such as dampers, splitters vanes, and extractors, or automatically using control devices such as constant air volume or variable air volume boxes.

Balancing, hydraulic system: adjusting water flow rates in a hydraulic distribution system. This can be done manually adjusting valve positions or automatically using control devices such as automatic flow control valves.

Ballast: a device used in with an electric-discharge lamp to initiate and regulate the lamp's operation, ensuring proper circuit conditions for voltage, current, waveform, and electrode heating.

Boiler: a self-contained low-pressure appliance for supplying steam or hot water.

Borehole: a deep, narrow hole made into the ground, primarily to locate water.

Building envelope: A term used to describe the exterior and semi-exterior components of a building that influence energy transfer. It is classified as follows:

i) Building envelope, exterior: elements that separate conditioned spaces from the exterior environment.
ii) Building envelope, semi-exterior: elements that separate conditioned space from unconditioned space or enclose semi-heated spaces, allowing thermal

energy transfer between the exterior, unconditioned spaces, or conditioned spaces.

Building grounds lighting: illumination provided through a building's electrical service for applications such as parking lot, site, roadway, pedestrian pathway, loading dock, and security.

Building material: any component of the building envelope through which heat flows and is included in the component U-factor calculations, excluding air films and insulation.

Building: any structure, regardless of the material used in its construction and includes billboards and telecommunication towers.

Building, base: a base building includes the structure, building envelope, common areas, circulation areas, parking, basements, services areas, plant rooms with their supporting areas and the open project site area.

Building, core, and shell: buildings where the developer or owner provides only the base building and its services.

Building, existing: a structure or portion of a structure that has been previously occupied or approved for occupancy by the authority having jurisdiction.

C

Cardinal direction: cardinal directions or cardinal points are the four main directional points of a compass, namely north, south, east, and west.

Centralized control: single hardware or software system used to monitor, control, and manage the operations of multiple equipment and devices, either with similar or different functions.

Circuit breaker: an electromechanical switch device designed to make, carry, and break currents under normal circuit conditions. It can also of interrupt currents under a specified abnormal condition, such as those of short circuits.

Class of construction: classification that determines the construction materials for the building envelope, roof, wall, floor, slab-on-grade floor, opaque door, vertical fenestration, or skylight.

Coefficient of Performance (COP) – cooling: the ratio of the rate of heat removal to the rate of energy input, expressed in consistent units, for a complete refrigerating system or some specific portion of that system under designated operating conditions.

Coefficient of Performance (COP) – heating: the ratio of the rate of heat delivered to the rate of energy input, expressed in consistent units, for a complete heat pump system, including the compressor and any auxiliary heat, under designated operating conditions.

Commercial building: a structure, or part of a structure, used or intended for commercial purposes. It is classified based on the operational hours and further sub-classified according to the functional requirements of its design, construction, and use.

Common area: spaces within a building that are accessible to all tenants, such as lobbies, corridors, restrooms,

Compliance documents: forms specified in EEBC Rules and Regulations to document and verify compliance with these rules. These include but are not limited to EPI Ratio Compliance Report, Building Envelope Compliance Form, Mechanical Systems Compliance Form and Permit Checklist, Lighting System Compliance Form, and associated Permit Checklists, as well as certificates from Certified Energy Auditors for existing or proposed buildings.

Connected load: the total rated wattage of all equipment, appliances, and devices to be installed in a building or part of building or building complex. It is expressed in kilowatts (kW) and represents the electric power allocation for applicants in relation to the proposed or completed building or building complex.

Construction documents: means written, graphic and pictorial documents prepared or assembled for describing the design, location, and physical characteristics of the elements of a project necessary for obtaining a building permit.

Contract demand: the maximum electrical demand, measured in kilo Volt Ampere (kVA), that an electricity provider or utility agrees to supply within a consumer's sanctioned load, as specified in the agreement between the user and the provider.

Control device: a specialized device that regulates the operation of equipment.

Control: to regulate the operation of equipment.

Control or control device: manually operated or automatic device or software to regulate the operation of building equipment.

Cool roof: roof with a top layer made of material that process high solar reflectance and high thermal emittance properties. These surfaces are typically light-colored to reflect heat back into the environment.

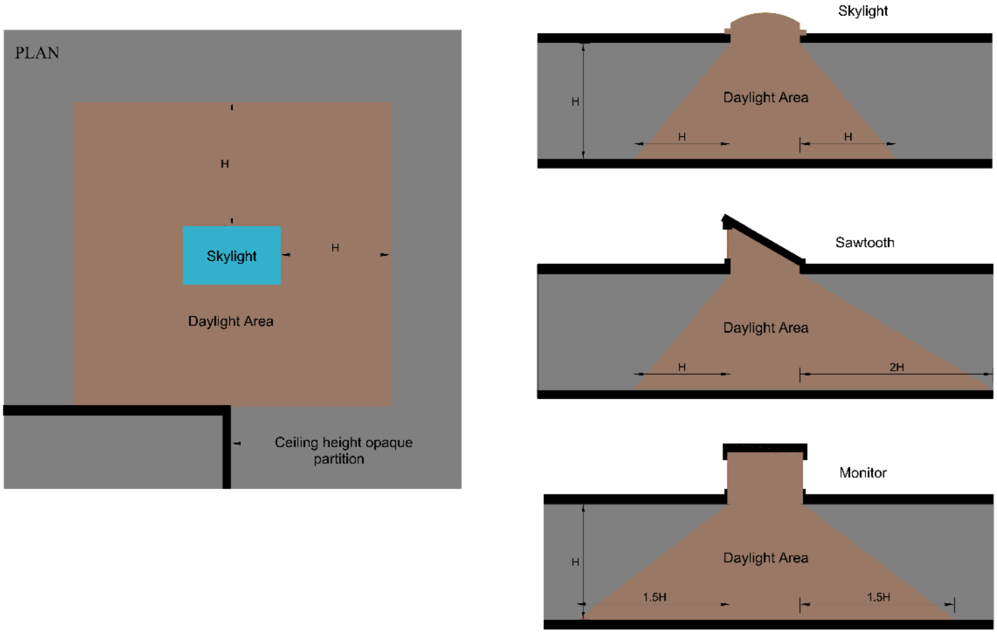
Cumulative design EPI: the energy performance index for a building with two or more different functional uses, calculated based on the AWA method.

D

Daylight area: a portion of illuminated floor area illuminated by natural light, either through horizontal fenestration (e.g., skylights) or adjacent to vertical fenestration (e.g., windows), described as follows:

a. For **horizontal fenestration** (e.g., skylights, monitors, or saw tooth configuration with an effective aperture greater than 0.001 (0.1%), the **daylight area** is the horizontal dimension extending in each direction equal to the top aperture dimension in that direction plus either the floor-to-ceiling height (H) for skylights, or 1.5 times the floor-to-ceiling height (1.5 H for monitors, or either the floor-to-ceiling height (H) or two times the floor-to-ceiling height(2H) for the saw tooth configuration. Alternatively, it is determined by the distance to the nearest opaque partition at least 1 meter high or one-half the distance to an adjacent skylight or vertical glazing, whichever is least.

b. For **vertical fenestration** (e.g., windows in walls) with an effective aperture greater than 0.06 (6%), the **daylight area** is the floor area adjacent to side apertures. Perpendicular to the side aperture, the daylight area extends into the space a distance equal to daylight extension factor (DEF) multiplied by the head height of the side aperture or up to the nearest higher opaque partition, whichever is less. Parallel to the window, the daylight area extends horizontally by the width of the window plus either 1 meter on each side of the aperture, the distance to an opaque partition, or one-half the distance to an adjacent skylight or window, whichever is least.



Daylight window: a fenestration position 2.2 meter above floor, with an interior light shelf at its base.

Daytime business building: a business building operates primarily during daytime hours on weekdays, typically for up to 12 hours per day.

Dead band: the range of values within which a sensed variable can vary without initiating a change in the controlled process, even if the variable fluctuates within this range.

Demand: the maximum rate of electricity (in kW) recorded for a building or facility during a specific time frame.

Demand Control Ventilation (DCV): a ventilation system that automatically reduces of outdoor air intake below design rates when the actual occupancy of served space slower than design occupancy.

Demand factor: the ratio of a system's maximum demand to its total connected load. The demand factor is always less than one.

Demand Side Management Strategy: A strategy employed by electric utilities to regulate electricity demand by encouraging customers to alter their energy consumption patterns, particularly during peak hours, or to reduce their overall energy usage. This is often achieved through incentives, pricing structures, or energy efficiency programs.

Design capacity: the output capacity of a mechanical or electrical system or equipment under its designated operating conditions.

Design conditions: the specified environmental condition—such as temperature and light intensity—that a system is designed to produce and maintain during operation.

Design System Efficiency (DSE): the energy efficiency of the building's cooling or heating system as it operates to meet thermal comfort under designed operating conditions.

Distribution board: a device or assembly of devices that allows the disconnection of circuit conductors their power source.

Distribution system: a network of controlling devices, equipment, and distribution channels (e.g., cables, coils, ducts, or pipes) for delivering of electrical power, cooled or heated water, or air within a building.

Door area: the total area of the door, measured using the rough opening dimensions, including the door slab and the frame.

Door: any operable opening area in the building envelope that is not more than one half glass, including swinging doors, roll-up doors, fire doors, and access hatches.

E

Economizer, air: a duct and damper arrangement with automatic controls that enables a cooling system to reduce or eliminate the mechanical cooling during mild or cold weather.

Economizer, water: a system that cools the supply air of a cooling system indirectly using water which is cooled through heat or mass transfer to the environment without the use of mechanical cooling.

EEBC building: a building that complies with the mandatory requirements of Section 5to 10 and satisfies the prescriptive requirements.

Effective aperture (EA): The product of VLT and Window-to-Wall Ratio (WWR), calculated as EA = VLT x WWR.

Efficacy: the lumens produced by a lamp plus ballast system divided by the total input power (including the ballast), expressed in lumens per watt

Efficiency, combustion: the effectiveness of fuel burning during the combustion process.

Efficiency, thermal: the ratio of work output to heat input.

Efficiency: the performance at a system or device under specified rating condition.

Effluent: gaseous waste, water or liquid or other fluid of domestic, agricultural, trade or industrial origin treated or untreated and discharged directly or indirectly into the environment.

Emittance: the ratio of the radiant heat flux emitted by a material to that emitted by a black body at the same temperature and under identical conditions.

Enclosed building: a building surrounded by walls, floors, roofs, and openable devices such as doors and operable windows.

Energy efficiency: refers to the optimal use of energy, achieved through a combination of regulatory requirements and voluntary measures. This ensures that buildings consume less energy than they otherwise would, without compromising functionality or comfort. Merely cutting energy use can lower comfort, productivity, and health. The goal is to minimize energy for heating, cooling, ventilation, and lighting while maintaining standards, using advanced designs, technologies, and management for sustainable savings.

Energy Efficiency Building Code (EEBC): the Energy Efficiency Building Code as updated from time to time by Tanzania Bureau of Standards (TBS).

Energy Efficiency Ratio (EER): the ratio of net cooling capacity (in watts) to total rate of electric input (in watts)under design operating conditions, as described in the standards referenced in this Code.

Energy Factor (EF): a measure of overall efficiency of water heating equipment.

Energy Performance Index (EPI): The annual energy consumption in a building, expressed in kilowatt-hours per square meter of its area. It is calculated for the existing or proposed building using the formula below.

$$EPI = \frac{Annual\ energy\ consumption\ in\ kWh}{Total\ build-up\ area\ (excluding\ storage\ area\ an\ dthe\ parking\ in\ the\ basement)in\ m^2}$$

Energy Performance Index Ratio: the ratio of the EPI of the Proposed Building to the EPI of the Standard Building.

$$EPI\ Ratio = \frac{EPI\ for\ proposed\ building}{EPI\ for\ standard\ building}$$

Proposed building is consistent with the actual design of the building and complies with all the mandatory requirements of this Code. Standard building is a standardized building that has the same building floor area, gross wall area and gross roof area as the proposed building, complies with the mandatory requirements of **Section 6 to 10** of this code, and minimally complies with prescriptive requirements of **Section 6 to 10**.

Energy recovery system: equipment designed to recover energy from building or space exhaust air and use it to pre-heat or pre-cool air brought into the building or space by ventilation systems.

Energy: power derived from renewable or non-renewable resources to provide heating, cooling, lighting a building, or operating building equipment and appliances. Energy exists in various forms such as thermal (heat), mechanical (work), electrical, and chemical, which can be converted from one form to another. Its customary unit of measurement is watts (W).

Equipment, existing: equipment that has already been installed in an existing building.

Equipment: mechanical, electrical, or static devices used to operate a building, including but not limited to system for cooling, heating, ventilation, lighting, service hot water, vertical circulation, lamps, luminaries, ballasts, elevators, escalators, or other devices or installations.

Equivalent Solar Heat Gain Coefficient (SHGC): The SHGC for a fenestration that incorporates a permanent external shading projection. It is calculated using the Projection Factor (PF) of the permanent external shading projection and the Shading Equivalent Factor (SEF).

Exemption: an exception allowed to compliance with EEBC requirements.

F

Fan system input power: the total nominal power demand (nameplate watts or horsepower) of all fan motors required to operate at design conditions to supply air from the heating or cooling source to the conditioned spaces and return it to the point where is can be exhausted to outside the building.

Fenestration area: the total area of the fenestration, measured using the rough opening and including the glazing, sash, and frame. For doors with a glazed vision area comprising less than 50% of the door area, the fenestration area equals the glazed vision area. For all other doors, the fenestration area is the total door area.

Fenestration: all areas in the building envelope, including frames, that allow light to enter. This includes windows, plastic panels, clerestories, skylights, glass doors with more than half of their surface area as glass, and glass block walls.

a. Skylight: a fenestration surface with a slope of less than 60 degrees from the horizontal plane. Any fenestration mounted on the building's roof is classified as vertical fenestration.
b. Vertical fenestration: all fenestration other than skylights. Trobe wall assemblies, where glazing is installed within 300 mm of a mass wall, are considered walls, not fenestration.

Finished floor level: the level of a floor after the addition of finishing materials to the subfloor, rough floor, or concrete floor slab.

Fossil fuel: a fuel sourced from a hydrocarbon deposit such as petroleum, coal, or natural gas, formed from the remains of living organism from previous geologic time.

Fuel utilization efficiency (FUE): a measure of thermal efficiency of combustion equipment, such as furnaces, boilers, and water heaters.

Fuel: a material used to produce heat or generate power by combustion.

G

Grade: the finished ground level adjoining a building at all exterior walls.

Guest room: room or set of rooms used or intended to be used by a guest for sleeping purposes.

H

Habitable spaces: space within a building or structure intended or used for working, meeting, living, sleeping, eating, or cooking. Spaces such as bathrooms, water closet compartments, closets, halls, storage or utility space, and similar areas are not classified as habitable.

Hazardous waste: any solid, liquid, and gaseous or sludge waste which due to its chemical reactivity, environmental or human hazardousness, its infectiousness, toxicity, explosiveness, and corrosiveness is harmful to human health, life, or environment.

HVAC system: equipment, distribution systems, and terminal devices that provide, either collectively or individually, the processes of heating, ventilating, or air conditioning to a building or its parts.

Industrial waste: waste originating from processing or non-processing industries, including sources such as energy plants, water treatment plants, or communication infrastructure. It also encompasses other solid waste types as defined under Part. IX of Environmental Management Act (EMA) of 2004.

Infiltration: the uncontrolled inward air leakage through cracks, crevices, or gaps in the external surfaces of buildings, such as around windows and doors. This occurs due to pressure differences across these caused by factors such as wind or indoor and outside temperature differences (stack effect), and imbalance between supply and exhaust air systems.

Installed interior lighting power: the power, measured in watts, of all permanently installed general, task, and furniture lighting systems and luminaries.

Integrated part-load value (IPLV): a weighted average efficiency of chillers, calculated based on their performance under part-load conditions (less than design or full-load capacity). It provides a more realistic measure of chiller's efficiency over its operational life.

K

Kilovolt-ampere (kVA): A unit of apparent power. For three-phase systems, kVA is calculated as the product of the line current (amperes), the nominal system voltage (kilovolts), and 1.732. For single-phase system, kVA is the product of the line current (amperes) and the nominal system voltage (kilovolts).

Kilowatt (kW): the basic unit of electric power, equal to 1,000 watts (W).

L

Labeled: equipment or materials marked by the manufacturer with a symbol or other identifier that indicator compliance with a specified standard or performance criteria.

Lamp: a device designed to provide light, typically consisting of electric bulb along with its holder and optionally, a shade or cover.

Lighted floor area, gross: the total gross area of illuminated floor spaces.

Lighting power allowance:

a. Interior lighting power allowance: the maximum permitted lighting power, measured in watts, for the interior of a building.
b. Exterior lighting power allowance: the maximum permitted lighting power, measured in watts allowed, for the exterior of a building.

Lighting Power Density (LPD): the maximum lighting power per unit area of a space, determined by its function or building's classification.

Lighting system: a collection of luminaires connected or controlled together to fulfill a specific function.

Lighting, emergency: battery backed lighting that activate to provide illumination only during power outages when general lighting luminaries are nonfunctional.

Lighting, general: lighting that provides a substantially uniform level of illumination throughout an area. It excludes decorative lighting or lighting intended to provide a different illumination levels for specialized application or feature within the area.

Litter: any refuse, rubbish, animal remains, glass, metal, plastics, garbage, debris, dirt, filth, urine, rubble, ballasts, stones, earth, sewage, or waste matter, or any other similar materials.

Luminaries: a complete lighting unit consisting of a lamp or lamps together with a housing designed to distribute the light, position, and protect the lamps, and connect them to the power supply.

M

Man-made daylight obstruction: any permanent man-made object, such as equipment or an adjacent building that blocks sunlight or solar radiation from reaching part of, or all of a building's external surface at any time during a year.

Manual (non-automatic): a system or control that require personal intervention for operation. It does not necessarily imply the use of manual controller, only that human intervention is necessary.

Manufacturer: a company engaged in the original production and assembly of products or equipment or one that procures such items made to its specifications.

Manufacturing processes: procedure by which raw materials are converted into finished goods for commercial sale using machinery, labor, chemical or biological processes.

Mean temperature: the average of the daily minimum and maximum daily temperatures.

Mechanical cooling: the process of lowering the temperature of a gas or liquid by using energy-driven thermodynamic methods such as vapor compression, absorption, or desiccant dehumidification combined with evaporative cooling. Indirect or direct evaporative cooling along is not classified as mechanical cooling.

Metering: the practice of installing meters in buildings to collect data on energy consumption and the operational characteristics of individual equipment or group of equipment (e.g., lighting, appliances, and chillers). Metering is used to monitor and evaluate a building's performance.

Mixed mode air-conditioned building: a building primarily ventilated using natural ventilation, with air conditioning used only as needed.

Mixed-use development: a single building or a group of buildings used designed for combined uses such as residential, commercial, business, educational, hospitality, or assembly purposes.

N

National Building Code (NBC): a model building code providing guidelines for design and construction of buildings.

Natural daylight obstruction: any natural object, such as a tree or hill that obstructs sunlight from reaching part or all of a building's external surface at any time during a year, casting a shadow on the building surface.

Naturally ventilated building: a building that relies on natural means of air movement, without these mechanical equipment by drawing and expelling air through operable openings in the building envelope.

Non-cardinal directions: any direction which is not perfectly north, south, east, or west, such as northeast, northwest, southeast, or southwest.

O

Occupant sensor: a device that detects the presence or absence of people within an area and adjusts lighting, equipment, or appliances by dimming, switching on, or switching off accordingly.

Oil/water separator: a system or component designed to separate oil and suspended solids from industrial wastewater, commonly used in facilities such as oil refineries, petroleum handling facilities, petrochemical and chemical plants, and natural gas processing plants.

Opaque assembly or opaque construction: the non-transparent or non-translucent portions of a building's roof or walls, excluding fenestration and building service openings such as vents and grills.

Opaque external wall: an external wall made of on-transparent or translucent materials, usually forming the structural part of the building, and supporting the glazed façade. It may consist of one or more materials.

Open Gallery Mall (Type of Shopping Complex): a large retail complex containing a variety of stores and often restaurants and business establishments housed in a series of connected or adjacent buildings or in a single large building. The circulation area and atrium are unconditioned space open to sky.

Orientation: the direction a building façade faces, defined by the vector perpendicular to and pointing away from the façade's surface. For vertical fenestration, the two categories are north-oriented and all other.

Outdoor (outside) air: air taken from the outside the building that has not been previously circulated within the building.

Out-patient healthcare (Type of healthcare): a building or a group of buildings under single management, used exclusive for treating or diagnosing diseases in individuals who do not require overnight or extended stay during their treatment or diagnosis.

Overcurrent: a current exceeding the rated value. For conductors the rated value is a current surpassing the conductor's current -carrying capacity.

Owner: person or entity holding a legal interest in land and/or the building on it. This includes freeholders, leaseholders, sub-lease holder with legal rights of occupation and related liabilities for safety or building condition, or an organization registered in the revenue records for constructing a building or building complex.

P

Party wall: a firewall located on an interior lot line, designed, or adapted for joint service between two buildings.

Permanently installed: equipment that is fixed in place and is not portable or movable.

Plenum: a compartment or chamber that connects one or more ducts, forming part of an air distribution system and is intended for occupancy or storage.

Plug loads: energy consumed by devices powered by means of an AC plug, excluding energy used for major systems such Asha, lighting, and water heating.

Pool: any structure, basin, or tank containing an artificial body of water used for swimming, diving, or recreational bathing. This includes, but no limited to, swimming pool, whirlpool, spa, hot tub.

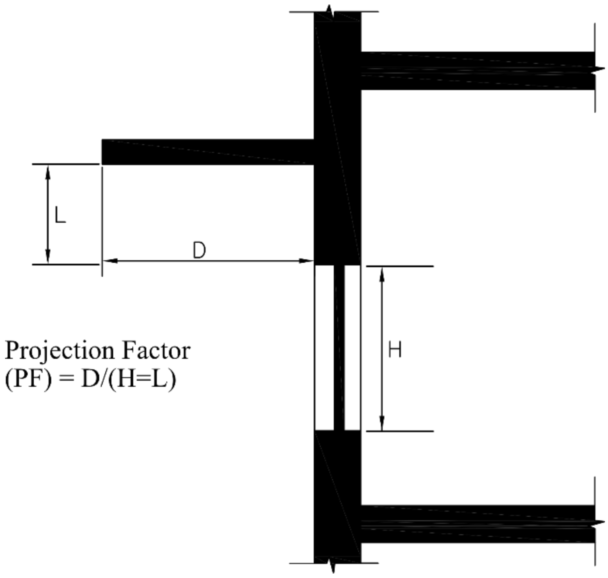
Power: the capacity for doing work. which exists in various forms, such as thermal (heat), mechanical (work),electrical, and chemical, and can be transformed from one form to another. Its unit of measurement is Joule (J).

Primary inter-cardinal direction: any of the four compass points located midway between the cardinal points: northeast, southeast, southwest, or northwest are called primary inter- cardinal direction.

Process load: building loads resulting from the consumption or release of energy of industrial processes or activities other than space conditioning, lighting, ventilation, or service hot water heating.

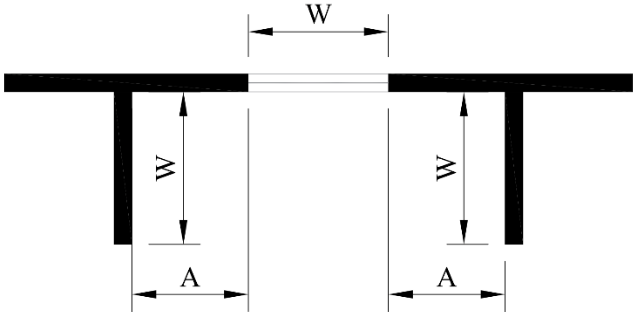
Projection factor, overhang, and side fin: the average of the projection factor ratio for an overhang alone and the projection factor for aside fin alone.

Projection factor, overhang: the ratio of the horizontal depth of the external shading projection to the sum of the height of the fenestration and the distance from the top of the fenestration to the bottom of the farthest point of the external shading projection, measure in consistent units.



Projection factor, side fin: the ratio of the horizontal depth of the external shading projection to the distance from the window jamb to the farthest point of the external shading projection, measured in consistent units.

Projection factor left Fin
(PFL) = C/(A+W)



Proposed building: the actual design of the building, ensuring compliance with all the mandatory requirements of EEBC.

Proposed design: a computer model of the proposed building that aligns with its actual design and complies with all mandatory requirements of EEBC.

R

Readily accessible: able to be quickly reached for operation, renewal, or inspections without the need to climb over obstacles, remove barriers, or use portable ladders, chairs, or similar items. In public facilities, access may be restricted to certified personnel by using locking covers or locating equipment in locked rooms.

Recirculating system: a domestic or service hot water distribution system with a close circulation circuit designed to maintain hot water at usage temperatures near terminal devices (e.g., lavatory faucets, shower heads). This reduces the time needed to access hot water when the terminal device valve is opened. The circulation is driven either by natural forces (temperature-induced water density variations) or mechanical (a recirculation pump).

Renewable energy generating zone: a contiguous or semi-contiguous area, either on rooftop or elsewhere within site boundary, designated for installation of renewable energy systems.

Reset: the automatic adjustment of a controller's set point to a higher or lower value.

Roof area, gross: the total area of the roof, measured from the exterior faces of walls or the centerline of party walls.

Roof: the upper portion of the building envelope, including both opaque areas and fenestration, that is horizontal or tilted at an angle of less than 60° from horizontal. This definition also includes podium roof as well which are exposed to direct sunlight.

R-value (thermal resistance): the reciprocal of the heat flowrate through a unit area caused by a unit temperature difference between two defined surfaces of a material or construction under steady-state conditions. The R-value is expressed m^2.K/W.

S

Service water heating equipment: equipment for heating water for domestic or commercial purposes, excluding space heating and process requirements.

Service water heating: the process of heating water for domestic or commercial purposes, excluding space heating and process requirements.

Service: equipment for delivering energy from the supply or distribution system to the premises it serves.

Set point: the target temperature (°C) of a heated or cooled space, maintained by mechanical heating or cooling equipment.

Sewage: a combination of excreta, urine, and silage and liquid waste from households, institutions, commercial establishments, and industrial processes and operations.

Shading Coefficient (SC): the ratio of solar heat gain through glazing at normal incidence to the solar heat gain through 3 mm thick clear, double-strength glass. This value excludes contributions from interior, exterior, or integral shading devices.

Simulation program: software used to create virtual building models for simulating the energy performance of building systems and conducting daylighting analyses.

Single-zone system: an HVAC system designed to serve a single HVAC zone.

Site-recovered energy: waste energy recovered at the building site and utilized to reduce the need for purchased fuel or electrical energy.

Skylight: a fenestration surface having a slope of less than 60 degrees from the horizontal plane. Other fenestration, even if mounted a building's roof, are classified as vertical fenestration.

Slab-on-grade floor: a building floor slab in direct contact with ground, locate either above grade or no more than 300 mm below the final elevation of the nearest exterior grade.

Solar energy source: a source of thermal, chemical, or electrical energy obtained through the direct conversion of incident solar radiation at the building site.

Solar Heat Gain Coefficient (SHGC): the ratio of solar heat entering a space through fenestration to the incident solar radiation. It includes both directly transmitted solar heat and absorbed solar radiation that is reradiated, conducted, or converted inside the space.

Solar reflectance: the ratio of solar radiation reflected by a surface to the solar radiation incident upon it.

Solid waste management: an essential service focused on protecting public health and the environment promoting hygiene, recovering materials, reducing waste quantities, and preventing disease spread.

Space: an enclosed area within a building, classified as:

a. Conditioned space: a cooled, heated or directly conditioned space.
b. Semi-heated space: an enclosed space within a building with output capacity greater or equal to 10.7 W/m^2 but not a conditioned space.

c. Non-conditioned space: not conditioned or a semi-heated space; includes crawlspaces, attics, and ventilated garages.

Standard building: a building that minimally meets all mandatory and prescriptive EEBC requirements, with the same floor, wall, and roof areas o as the proposed building.

Standard design: a computer model of a hypothetical building that that complies with all of EEBC requirements, used for the Whole Building Performance method.

Storey: the portion of a building that between one finished floor level and the next higher floor level. Basement and cellar are excluded.

Sustainable Urban Drainage System (SUDS): a water management approach designed to efficiently manage surface water runoff in urban areas while minimizing environmental impact. SUDS aim to replicate natural drainage processes, improving water quality, reducing flood risks, and enhancing local ecosystems.

System efficiency: the ratio of the annual electrical energy consumption of a water-cooled chilled water plant (including chillers, chilled water pumps, condenser water pumps, and cooling towers) to the plant's annual thermal energy output, measured in kWh. It measures how effectively the chiller plant converts electrical energy into cooling energy.

System, existing: a previously installed system in an existing building.

System: a combination of equipment and auxiliary devices (including controls, accessories, interconnecting means, and terminal elements) that transform energy to perform specific functions such as HVAC, water heating, or lighting.

T

Terminal device: a device through which heated, cooled, or conditioned air is supplied to a space to maintain its temperature. It typically includes components such as dampers and heating or cooling coils to regulate and supply air. Device by which energy form a system is finally delivered such as registers, diffusers and lighting fixtures.

Thermal comfort conditions: Environmental conditions affecting occupant comfort, including air temperature, and radiant temperature, humidity, and airspeed.

Thermostat: a device with a temperature sensor to automatically maintain temperature at a desirable fixed or adjustable set point.

Tinted (fenestration): bronze, green, or gray coloring that is integrated into the glazing material, excluding surface-applied films or reflective coatings.

Transformer losses: electrical losses in a transformer that reduce its efficiency.

Transformer a static device winding that transforms voltage and current an alternating system frequency while maintaining frequency for power transmission.

Transport buildings (Assembly): structures used for transportation or transit such as airports, train stations, bus stations, and underground and elevated mass rapid transit.

U

U-factor (Thermal transmittance): the rate of heat transfer through unit area of a building component (e.g., wall, roof, window) per unit temperature difference between the interior and exterior environment, measured in/$m^{2o}C$ (SI units) or Btu/h.ft^2.°F (Imperial units).

Unconditioned building: a building where over90% of spaces are unconditioned. A building or structure that is not equipped with systems for mechanical heating, cooling, or humidity control.

Unconditioned space: a space that is ventilated but not mechanically cooled or heated. Such spaces are typically outside the thermal envelope and are not maintained at a target temperature or comfort level. Typical examples include attics, crawl spaces, and garages.

Uninterruptible power supply (UPS): a device that provides a continuous supply of electrical power to connected equipment during power interruptions or fluctuations. It acts as a backup system that ensures the reliable operation of critical systems by delivering power instantaneously from its battery or other energy storage components when the main power source fails or becomes unstable.

V

Variable Frequency Drive (VFD): an electronic device that controls the speed and torque of an electric motor by varying the frequency and voltage of the power supplied to it. It is commonly used in HVAC systems and other industrial applications to optimize energy use and improve operational efficiency.

Ventilation: the process of supplying or removing air by natural or mechanical means without necessarily conditioning it.

Vision windows: windows or large window areas for both daylight and exterior views, typically placed1 meter to 2.2 meter above the floor.

W

Wall area, gross: the total wall area including openings, measured horizontally and vertically. For ceiling-level insulation, measurements are taken to the ceiling top. It accounts for the entire wall area without subtracting the areas occupied by fenestrations, penetrations, or other features.

Wall: a vertical portion (equal or greater than 60° from horizontal) of the building envelope, including opaque and fenestrated areas. This includes above and below grade walls, between floor spandrels, peripheral edges of floors, and foundation walls.

a. Above-grade wall: a wall that is in contact with the ground.
b. Below-grade wall: entirely below the finished grade and in contact with the ground.

Wastewater treatment plant: a facility that removes contaminants from wastewater converting it into effluent suitable for environmental release or reuse.

Water heater: a vessel that heats water for domestic, commercial, or industrial use. It typically uses energy sources such as electricity, gas, oil, or solar energy to raise the temperature of water and provide it on demand for various applications like bathing, cooking, or cleaning.

Z

Zone, critical: a specific area or space within a building that requires the most stringent environmental control to meet is operational or safety needs. Examples include data centers, telecom, and hospital operating rooms, and laboratories. The critical zone often has the most demanding load or environmental requirements compared to other zones.

Zone, HVAC: a specific area or space within a building that is served by a distinct portion of heating, ventilation and air conditioning system, typically heating and cooling needs are controlled by a single thermostat.

Zone, non-critical: a specific area or space within the building where environmental control requirements such as heating, cooling, and ventilation, are less stringent and not critical to systems overall design or performance.

2.3 Abbreviations and Acronyms

Table 2-1 List of Abbreviations and Acronyms

Abbreviation	Definition
AFUE	Annual fuel utilization efficiency
AHJ	Authority having jurisdiction
AHU	Air handling unit
AHRI	Air-Conditioning, Heating and Refrigeration Institute
ANSI	American National Standards Institute
ARI	Air-Conditioning and Refrigeration Institute
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers
ASTM	American Society for Testing and Materials
BMS	Building Management System
Btu	British thermal unit
Btu/h	British thermal units per hour
Btu/hft²°F	British thermal units per hour per square foot per degree Fahrenheit
°C	Celsius

Abbreviation	Definition
cmh	Cubic meter per hour
cm	Centimeter
COP	Coefficient of performance
EER	Energy efficiency ratio
EPI	Energy performance index
°F	Fahrenheit
FCU	Fan coil unit
ft	Feet
h	hour
$hft^2°F/Btu$	Hour per square foot per degree Fahrenheit per British thermal unit
$hm^2°C/W$	Hour per square meter per degree Celsius per Watt
HVAC	Heating, ventilation, and air conditioning
I-P	Inch-pound
in	Inch
IPLV	Integrated part-load value
ISO	International Organization for Standardization
kVA	Kilovolt-ampere
kW	Kilowatt of electricity
kWr	Kilowatt of refrigeration
kWh	Kilowatt-hour
l/s	Liter per second
LE	Luminous efficacy
lin ft	Linear foot
lin m	Linear meter
Lm	Lumens
Lm/W	Lumens per watt
LPD	Lighting power density
Lux	Luminous flux
m	Meter
MEPS	Minimum Energy Performance Standards
mm	Millimeter
m^2	Meter square
m^2K/W	Square meter Kelvin per watt
NBC	National Building Code
NEMC	National Environmental Management Council
Pa	Pascal
PF	Projection factor
R	R-value (thermal resistance)
SC	Shading coefficient
SCOPH	Seasonal Coefficient of Performance – Heating
SHGC	Solar Heat Gain Coefficient

Abbreviation	Definition
SUDS	Sustainable Urban Drainage System
TBS	Tanzania Bureau of Standards
TR	Tons of refrigeration
UASB	Up-flow Anaerobic Sludge Blanket
UPS	Uninterruptible power supply
VFD	Variable frequency drive
VLT	Visible light transmittance
W	Watt
W/l/s	Watt per liter per second
W/m²	Watts per square meter
W/m²·K	Watts per square meter per Kelvin

Table 2-2SI to IP (Imperial) Conversion Factors

SI Unit	IP Unit
1 cmh	1.7 cfm
1 Pa	0.0040 inch of water gauge
1m	3.28 ft
1m	39.37 in
1mm	0.039 in
1 l/s	2.12 cfm
1 m2	10.76 ft2
1 W/m2	0.0929 W/ ft^2
1 W/ lin m	3.28 W/ ft
1 W/m^2·K	0.1761 Btu/ hft2°F
1 W/l/s	0.063 W/ gpm
1 m2.K/W	5.678 ft2-h-ºF/ Btu
1ºC	((ºC X 9/5) + 32) ºF
1 kWr	0.284 TR
1 kW	1.34 hp
1 kW	3412.142 Btu

3 SECTION 3 – SCOPE

3.1 General

This Code establishes technical provisions to address energy efficiency in the design and construction of new buildings and additions to existing buildings according to user groups and their equipment and systems as covered here. The requirements outlined in this Code apply to specific user groups, their equipment, and systems, as detailed herein. This Code covers the following building elements:

a) Building envelope, excluding unconditioned storage space or warehouses,
b) Mechanical systems and equipment including heating, ventilation, and air conditioning (HVAC).
c) Electric powers and motors, and renewable energy systems
d) Interior and exterior lighting.
e) Service water heating.
f) Waste and water management.

The provisions of this Code apply to buildings meeting any of the following criteria:

a) Floor area of 1,000 m^2 or greater.
b) Electrical power demand of 200 kVA or greater.
c) Air-conditioning cooling capacity exceeding 150 kW (thermal) or heating capacity exceeding 100 kW (thermal)

3.2 Exemptions

The provision of this code does not apply to the following:

a) Building that do not use either electricity or fossil fuels.
b) Equipment and portions of building systems that use energy primarily for manufacturing processes.
c) Plug loads, and equipment and parts of buildings that use energy for manufacturing processes, unless otherwise specified in the Code.

3.3 Precedence

This Code covers only the energy performance aspects of the building. It does not supersede other regulations, including but not limited to:

- Environment Impact Assessment and Audit Regulations (GN. No.474)
- Occupational Safety and Health rules (GN. No.244)

- Tanzania Bureau of Standards (TBS) Minimum Energy Performance Standards (MEPS) and Labeling for Appliance Regulations, provided that are stricter than the requirements of the Code and all other applicable Codes, regulations and bylaws pertaining to buildings.

Where stricter requirements exist in this or other codes, regulations, laws, those stricter requirements shall prevail. In the event of conflicts between this Code and the above referenced regulations the United Republic of Tanzania National Building Code, the regulatory authority will determine which requirements take precedence.

3.4 Building Classification

Buildings, or portions thereof, are classified based on their functional design, construction, and use. Classification details are provided in Appendix 1, which outline use groups and their respective requirements.

4 SECTION 4: ADMINISTRATION AND ENFORCEMENT

4.1 General

4.1.1 Administrative Requirement

The regulatory authority, referred to as the authority having jurisdiction (AHJ), is responsible for defining administrative requirements which include permit prerequisites, enforcement protocols, interpretation guidelines, procedures for exemption claims, approved calculation methodologies, and process for appeal.

4.2 Compliance Document

Construction drawings and specifications shall display all relevant information and characteristics of the building, equipment, and systems with sufficient technical detail to enable the AHJ to confirm compliance with the Code. This documentation shall cover, but is not limited to:

a) Building Envelope

   i) Specifications for opaque construction materials, including thermal properties such as thermal conductivity, specific heat, density, and thickness.

   ii) Fenestration details, including U-factors, solar heat gain coefficients (SHGC), visible light transmittance (VLT), and documentation of sealing practices for the building envelope.

   iii) Descriptions of architectural features affecting energy performance, such as overhangs, side fins, and additional sealing elements.

b) Heating, Ventilation, and Air Conditioning

   i) Comprehensive descriptions of system and equipment types, capacities, deficiencies, and controls.

   ii) Inclusion of energy-saving features such as economizers and variable speed drives.

   iii) Specifications for piping and ductwork insulation, sealing, and placement.

   iv) Documentation of solar water heating systems, if applicable.

   v) A balance report confirming HVAC system performance.

c) Lighting

   i) A schedule listing lamp and ballast types, quantities, and wattages.

   ii) Details of energy-efficient controls, including automatic lighting shutoff, occupancy sensors, and additional lighting controls.

   iii) Exterior lighting specifications, including lamp efficacy.

d) Electrical Power

   i) A detailed schedule addressing transformer losses, motor performance issues, and the presence of power factor correction devices.

   ii) Information on electric check metering and monitoring systems.

e) Renewable energy systems

   i) Specifications of system peak installed capacity and technical details.

   ii) Designation of solar zones and their technical requirements.

4.3 Supplemental Information

The AHJ reserves the right to request additional information to ensure adherence to this Code, which may include calculations, worksheets, compliance forms, manufacturer's literature, or other relevant data necessary to verify adherence to the Code.

4.4 Other Laws and Regulations

The provisions of this Code do not replace or supersede any local or national laws and regulations. In the event of a conflict between a provision of this Code and any other law governing construction, the AHJ will determine precedence.

4.5 Mandatory Requirements

All buildings must meet the mandatory requirements outlined in **Sections 6 to 10**of this Code, regardless of the chosen compliance process.

5 SECTION 5 – CLIMATE ZONES AND PASSIVE DESIGN REQUIREMENTS

5.1 General Climatic Zones

Tanzania's climate zones shall be categorized following ASHRAE Standard 169-2013 and the Koppen climatic classification, relying on data from the East African Meteorological Department. These classifications will be applied as needed in this Code.

- Warm Dry Climates: regions classified under Köppen categories Am, Aw, and As,
- Warm Humid Climates: areas exhibiting Af climates, and
- Highland Climates: predominantly areas exhibiting Cfb climates.

Details of these criteria for these classifications can be found in **Appendix 4**. **Table A.4.1**

According to ASHRAE and the East Africa Meteorological Department, Tanzania is classified as having a tropical climate comprising six zones: Coastal Tropical, Intermediate Tropical, Lakes, Plateau, Uplands, and High Uplands Climate Zones, as illustrated in **Figure 5.1**.

Each climate zone exhibits unique outdoor climatic parameters—including temperature, humidity, solar radiation, and wind patterns—which directly influence the thermo-physical properties of building materials and envelope design. These variations necessitate climate-responsive building design strategies, ensuring compliance with ASHRAE standards, regional energy codes, and sustainable building practices.

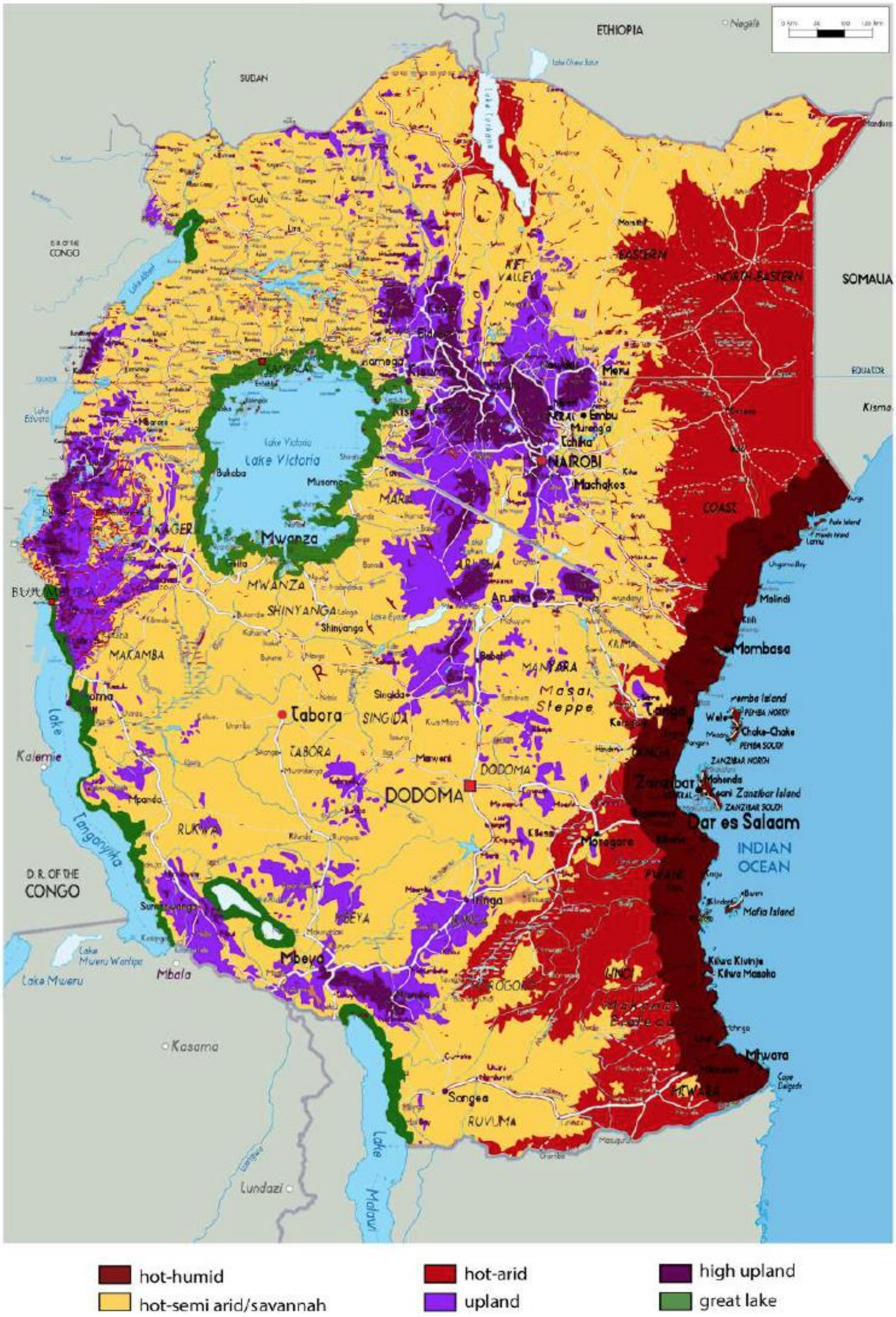


Figure 5-1 Climate Zones of Tanzania

Source: *UN-Habitat (2015) Sustainable Building Design for Tropical Climates: Principles and Applications for Eastern Africa*

5.2 General Consideration during Planning and Design

When planning and designing a built environment for energy efficiency, the following shall be emphasized:

a) Incorporate the major climatic zone characteristics described in Table 4.2 (Appendix 4) into the design process. Understanding local climatic conditions is vital for developing energy-efficient strategies tailored to the specific environmental context.

b) Maintaining human comfort is paramount. For the human body to function properly in the tropical climates, it must sustain a constant internal temperature of about 37°C. To achieve this:

   i) Continuous heat loss to the environment through sweating and exhalation shall be achieved by providing ventilation through either air conditioning or natural air movement.

   ii) During the day, people absorb heat from the sun and the hot ambient air. Energy-efficient designs shall focus on reducing exposure to direct sunlight and facilitating heat dissipation.

   iii) The rate of heat dissipation depends on three key factors: air temperature, humidity, and air movement. Designs shall optimize these through strategies such as incorporating passive cooling techniques, including cross-ventilation and stack ventilation; utilizing shading devices and thermal insulation to minimize solar heat gain; and design building envelopes with materials that regulate heat transfer effectively.

5.3 Building Typology

Functional and formal characteristics of building typologies should be thoroughly analyzed to achieve energy efficiency, as they directly affect heating (gain and loss), natural lighting, and natural ventilation.

5.3.1 Functional Typology

a) Communal areas that require more heating or cooling should be strategically located. Spaces with lower heating requirement, such as the pantries, bathrooms, and toilets shall be used as buffer zones, reducing heat transfer or cooling loss to the exterior, particularly in areas prone to heat loss.

b) Building layout design should incorporate zoning based on factors such as buffer zone, sanitary spaces, noise levels, lighting levels, and heating needs. Thermal zoning and indoors layout shall be designed to promote mutual air movement and optimize energy efficiency.

5.3.2 Formal Typology

a) Design for energy performance of building shall consider form and volume-to-surface ratio, as there is a direct relationship between the geometrical shape of a building and its energy performance.

b) Compactness factors, such as the roof surface-to-wall surface ratio shall be considered when assessing impact on energy consumption of the building.

c) To facilitate natural ventilation through cross ventilation, buildings depths should not exceed 12-15m. For deeper spaces, natural ventilation can be achieved by incorporating central atria and leveraging the “stack effect” to draw air from the outer perimeter upward through the center of the building.

d) Buildings should minimize heat gain during warm seasons and maximize it during cold season. Simple plan shapes such as square or rectangle with reduced surface areas, are advantageous as they reduce both heat loss and heat gain.

e) Smaller buildings, designed with efficient use of internal space, consume less energy. They are more efficient to heat, cool, and illuminate compared to larger buildings.

f) Deep plans and excessive use of dividing elements can impede air circulation. Design strategies shall minimize these features to enhance air motion and overall energy efficiency.

5.4 Climatic Zones Planning and Passive Design Requirements.

5.4.1 Coastal Tropical Zones (Hot Humid zone)

5.4.1.1 Nature of the Climate

i) Coastal Tropical Zones is characterized by hot temperature, high humidity, heavy rainfall with annual mean of 750-1500mm, North – East Monsoon winds, South – East Monsoon winds and global solar radiation of 5.0 – 5.4 kWh/m2

The following passive design strategies may be used to address the cooling requirements that result from the above climatic characteristics:

5.4.1.2 Maximum Protection against Direct and Indirect Solar Radiation

a) Buildings should be oriented with their long axis running east – west to provide effective shading.
b) Openings should be located on the north and south facing façades and avoided on the east and west facing façades to reduce heat gain from the low early morning and late afternoon sun.
c) Appropriate shading devices should be located on all openings. These can be in form of extended roof eaves, covered verandas, porches etc.
d) Additional solar radiation protection may be provided by shade-providing vegetation within the space surrounding the building.
e) Reflective roof surfaces and light-colored external finishes are appropriate to reflect solar radiation and reduce heat gains.
f) Lightweight building materials with low thermal capacity are recommended for walls, floors, and roofs to allow rapid cooling at night.

5.4.1.3 Maximum Ventilation

a) The building layout should be widely spaced to minimize obstruction of the wind and allow for maximum ventilation around and within buildings.
b) Long and narrow buildings with shallow floor plans are more suited for this climate as they facilitate optimal ventilation.
c) Openings should be strategically located on opposite walls to allow for effective cross-ventilations. Internal walls should also include openings to promote airflow through the interior spaces.
d) North- and south-facing walls should incorporate large, fully openable openings. These should be oriented to align with prevailing breezes, maximizing the potential for natural airflow.
e) Permanent vents openings near the ceiling or roof are recommended to prevent the built up of hot air and encourage thermal air movement.
f) Ventilated roofs can enhance air flow the roof structure, reducing the risk of overheating and improving overall thermal comfort.

5.4.2 Intermediate Tropical Zones (Hot Arid zone)

5.4.2.1 Nature of the Climate

Intermediate Tropical Zones is characterized by a hot temperature, less rainfall than coastal tropical zone with annual mean of 600-1200mm, lower humidity than coastal tropical, monsoon wind patterns and global solar radiation of around 7.0kWh/m2.

The following passive design strategies may be used to address the cooling requirements.

5.4.2.2 Maximum Protection against Direct and Indirect Solar Radiation

a) Buildings should be oriented with their long axis aligned east–west to minimize solar exposure and provide effective shading.

b) Openings should be primarily located on the north- and south-facing façades, while east- and west- facing façades should have minimal or no openings to reduce heat gain from the low-angle sun during early mornings and late afternoons.

c) All openings should be equipped with appropriate shading devices such as extended roof eaves, covered verandas, porches, or other architectural elements designed to block direct sunlight.

d) Additional solar protection can be achieved through shade-providing vegetation strategically placed around the building to reduce solar heat gain and enhance thermal comfort.

e) Reflective roof surfaces and light-colored external finishes are effective in reflecting solar radiation and minimizing heat absorption, thereby reducing overall heat gains.

f) Lightweight building materials with low thermal capacity should be used for walls, floors, and roofs. These materials enable rapid cooling at night, improving indoor thermal comfort.

5.4.2.3 Maximum Ventilation

a) The building layout should maintain sufficient spacing between structures to minimize wind obstruction and enable maximum ventilation around and within buildings.

b) Long and narrow buildings with shallow floor plans are more suited to this climate as they facilitate maximum ventilation.

c) Openings should be strategically located on opposite walls to allow for proper cross-ventilations. Internal walls should also include openings to promote airflow through the internal spaces.
d) North- and south-facing walls should incorporate large, fully openable openings. These should be oriented to align with prevailing, maximizing the potential for natural airflow.
e) Permanent vents openings near the ceiling or roof are recommended to prevent the built up of hot air and encourage thermal air movement.
f) Ventilated double roofs enhance ventilation of the roof minimizing overheating.

5.4.3 Plateau Zones (Hot Semi-Arid/Savannah Zone)

5.4.3.1 Nature of the Climate

i) The Plateau Zone is characterized by dry air, low humidity and minimal rainfall which discourage plant life, the dry and dusty ground reflects the strong sunlight, creating an uncomfortable ground glare. Effort should prioritize the development of green areas to mitigate glare, enhance visual comfort, and improve thermal comfort.
ii) Local winds often carry dust and sand which exacerbate air quality challenges and impact comfort.

The following design strategies are recommended:

5.4.3.2 Reduction of Effects of Intense Solar Radiation

a) A compact building layout is recommended to promote mutual shading and minimize overall exposure to solar radiation.
b) Courtyard design of buildings minimizes the impact of solar radiation on the outer walls and provide cooler spaces within the buildings or building layout.
c) Buildings should be oriented along the east–west axis, with the longer sides facing north and south to prevent solar heat gains. The building’s surface area exposed to the east and west should be minimized whenever possible.
d) Openings should be located on the north- and south-facing façades. Small, high-paced openings are recommended to facilitate natural ventilation while reducing glare from ground-reflected light or surrounding buildings.

e) Shading devices are necessary for all openings to reduce heat gain from solar radiation. Vegetation, verandas, covered walkways, pergolas, and other shading structures are recommended to provide shade to walls, openings, and outdoor spaces.

f) Reflective roof surfaces and light-colored external walls are highly effective in reducing heat gains by reflecting a significant portion of incident solar radiation. This helps to minimize heat absorption, thereby reducing indoor daytime temperatures and lowering cooling energy demands.

g) Building envelop design shall consider periodic heat flow characteristics to select construction materials for walls and roofs which can maintain inner surface temperatures below the skin temperature during the day. This approach facilitates heat dissipation from the body to the surrounding surfaces through radiation and enhances indoor air cooling by convection.

h) Hot and dusty outdoor breezes shall be effectively managed to ensure comfort indoors. Mechanical cooling systems, dust filtration, and natural cooling strategies like evaporative cooling may be integrated to cool and clean incoming air.

5.4.3.3 Balance of Diurnal Temperature Range

a) Medium weight building materials with high thermal capacity are recommended to mitigate temperature variations between day and night. These materials absorb heat during the day keeping indoor temperatures cooler than outdoor conditions. At night, they release the stored heat, providing indoor thermal comfort as outdoor temperatures drop below the comfort zone.

5.4.3.4 Air Circulation

a) During the day, ventilation through windows should be minimized to prevent the ingress of hot and dusty air. At night, windows can be opened to provide adequate ventilation for dissipation of heat stored in the walls and the roof, prevent overheating of the indoor environment.

b) Additional ventilation strategies include the use of wind catchers, wind towers, solar chimneys, and roof-mounted exhaust fans to enhance air circulation.

c) Openings should be located to align with prevailing winds, enabling effective cross-ventilation and improving indoor air quality.

5.4.4 Lake Zones

5.4.4.1 Nature of the Climate

i) Lake Zone is characterized by mean air temperature range between 16-29°C, heavy rainfall of annual mean range between 800-2900mm, annual mean relative humidity of 60-70%, lake-land breeze (noon to dusk), land lake breeze (during night) and global solar radiation of 5.5kWh/m2.

The following passive design strategies address the cooling and heating requirements that result from the climatic characteristics of Lake Zones.

5.4.4.2 Maximum Protection against Direct and Indirect Solar Radiation

a) Buildings should be oriented with their long axis aligned east – west to provide effective shading.

b) Openings should be located on the north- and south-facing façades, while east- and west-facing façades should have minimum or no opening to reduce heat gain from the low-angle morning and late afternoon sunlight.

c) Shading devices should be incorporated on all openings, including extended roof eaves, vertical fins, covered verandas, porches, and similar architectural elements.

d) Additional solar radiation protection may be provided by shade-providing vegetation within the space surrounding the building to improve thermal comfort.

e) Reflective roof surfaces and light-colored external finishes are recommended to reflect solar radiation and minimize heat gains.

5.4.4.3 Maximum Ventilation

a) The building layout should be widely spaced to avoid obstruction of the wind and allow maximum ventilation around and within buildings.

b) Long and narrow buildings with shallow floor plans are more suited to this climate as they provide maximum airflow through them.

c) North- and south-facing walls should have large and fully openable openings oriented to leverage prevailing breezes facilitating natural airflow. Openings positioned at body level are more effective in enhancing ventilation.

d) Openings should be located on opposite sides of walls to allow for proper cross-ventilations. Internal walls should also have openings for airflow through the interior spaces.

e) Permanent vents or openings locate near the ceiling or roof are advisable to prevent the built-up hot air and encourage thermal air movement.

5.4.4.4 Enabling Passive Heating

a) Medium-weight walls, floors and ceilings are recommended for storing heat during the day, preventing overheating while balancing nighttime low temperatures to maintain indoor comfort levels.

b) Excessive glazing should be avoided as it can lead to overheating during warmer periods and lead to extensive heat loss at night or during the colder periods.

c) All windows should be airtight to prevent heat losses when the outdoor temperatures drop below the comfort zone.

5.4.5 Uplands Zones

5.4.5.1 Nature of the Climate

i) Upland Zone is characterized by pleasant temperature, not very hot or very cold, Rainfall with annual mean range of 750-1500mm and annual mean relative humidity at 52 - 60%.

The following passive design strategies address the cooling and heating requirements resulting from the climatic characteristics of upland zones.

5.4.5.2 Enabling Passive Heating

a) Buildings should be carefully oriented with main rooms facing northeast to allow passive heating by enabling solar radiation to penetration during the cold periods.

b) The floor plan should be organized to facilitate solar penetration into daytime spaces during the cold periods, enhancing indoor thermal comfort.

c) Compact double-banked house forms are recommended to reduce heat gains during hot periods and minimize heat losses during the cold periods.
d) Excessive glazing should be avoided to prevent overheating during the hot periods and substantial heat loss at night or during the cold periods.
e) All windows should be airtight to prevent heat losses when the outdoor temperatures are below the comfort zone. Additionally, windows should be located on opposite walls to allow for cross-ventilation.
f) Supplemental heating systems such as fireplaces can be integrated in the design for added comfort during colder conditions.

5.4.5.3 Protection against Heat Gain in the Hot Period

a) Buildings should be oriented with the main glazed windows facing north and south for easier sun control and minimizing overheating during hot periods.
b) Large windows on the east- and west-facing façades should be avoided. To mitigate solar radiation and glare during certain hours of the day, appropriate sun-shading devices such as overhangs, louvers, or vertical fins should be incorporated.

5.4.6 High Uplands Zones

5.4.6.1 Nature of the Climate

i) High Upland zone is characterized by cold temperature where sometimes frost occurs, heavy rainfall of annual mean 800-1400mm up to 2000mm, annual relative humidity at 45-65%, brisk winds with heavy gusts during thunderstorms and global solar radiation of 5.3 kWh/m2.

The following passive design strategies address the cooling and heating requirements resulting from the climatic characteristics of high upland zones.

5.4.6.2 Enabling Passive Heating

a) Buildings should be carefully oriented with main rooms facing northeast to allow solar radiation to penetrate and provide passive heating during the cold periods.
b) The floor plan should be designed to ensure sunlight reaches daytime spaces during cold periods for improved indoor comfort.

c) Compact building forms are recommended to reduce heat gains during hot periods and minimize heat losses during cold periods.

d) Medium-weight walls, floors and ceilings are advised for storing heat accumulated during the day to prevent overheating and balance the nighttime low temperatures, maintaining comfort levels.

e) Excessive glazing should be avoided to prevent overheating during the hot periods and significant heat loss at night or during the cold period.

f) All windows should be airtight to prevent heat losses when the outdoor temperatures are below the comfort zone, and they should be located on opposite walls to allow for cross-ventilation.

g) Supplemental heating systems such as fireplaces can be integrated into the design for added warmth during colder conditions.

h) Internal heat gains from occupants, equipment and lights can significantly reduce heating needs, contributing to overall energy efficiency.

5.4.6.3 Protection against Heat Gain in the Hot Period

a) Buildings should be oriented with the main glazed windows facing north and south to allow easier sun control and reduce overheating during the hot periods.

b) Large windows should be avoided on the east- and west- facing façades, as these areas are more susceptible to solar heat gain.

c) Sun-shading devices such as overhangs, louvers, or vertical fins, should be incorporated to block solar radiation and reduce glare during certain hours of the day in hot periods.

6 SECTION 6 – BUILDING ENVELOPE

6.1 General

Building envelope creates a thermal boundary between the exterior environment and the interior spaces of an occupied building. It comprises elements such as walls, roofs, and floors, which collectively influence the energy required to maintain a thermally and visually comfortable indoor environment.

The design of the building envelope is critical in determining the building's operational energy use throughout its lifecycle. A well-designed envelope minimizes energy demand by optimizing thermal performance—reducing reliance on mechanical heating or cooling systems—and enhancing the use of natural daylight, thereby decreasing the need for artificial lighting.

6.2 Scope

6.2.1 New Buildings, Additions, and Existing Building Retrofits

New buildings**,** additions and existing building retrofits shall have an Energy Performance Index Ratio (EPI Ratio) as defined in **Section 2** that is less than or equal to 1. These buildings shall comply withal mandatory requirements and the other provisions outlines in Section 6through10of this Code.

6.2.2 Space Conditioning Types

Specific envelope requirements are provided for different type of conditioned space:

1. Conditioned buildings with enclosed actively cooled spaces.
2. Conditioned buildings with enclosed actively heated spaces.
3. Buildings containing unconditioned spaces.

For spaces described in bullets (1) and (2) are assumed to be conditioned and shall comply with all relevant regulations at the time of construction, regardless of whether the conditioning equipment is installed.

6.3 Energy Efficiency Performance Levels

The Code establishes three levels of energy efficiency performance: : Minimum Compliance, which meets the baseline requirements for energy conservation; Enhanced Performance, which surpasses the minimum by incorporating advanced efficiency measures; and High-Performance or Net-Zero Ready, which optimizes building design, systems, and renewable energy integration to achieve the highest efficiency standards. These levels provide a structured pathway for improving building energy performance, sustainability, and long-term operational savings.

Compliance shall be demonstrated by adhering to either the mandatory and prescriptive requirements or alternative paths listed under requirements in Section 6to 10 of this Code. These compliance pathways ensure that buildings meet minimum energy performance standards, promoting energy conservation and sustainability.

6.3.1 Mandatory Requirements

6.3.1.1 Building Envelope - Air Tightness and Leakage

The design of the building envelope must prevent uncontrolled air leakage to minimize the infiltration of pollutants and hot, humid outdoor air.

Scope: Applicable to all building envelope elements bounding air-conditioned spaces.

The following areas of the building envelope shall be covered, sealed, caulked, gasket, or weather-stripped to reduce air leakage for buildings whose occupancy areas are treated by means other than natural or mechanical ventilation:

a) Junctions between walls and foundations, between walls and building corners, between walls and structural floors, roofs and between roof or wall panels.
b) Joints around fenestration and doors.
c) Openings at penetrations of utility services through roofs, walls, and floors.
d) Site-built fenestrations and doors.
e) Building assemblies used as ducts or plenums.
f) Joints, seams, and penetrations of vapor retarders.
g) All other openings in the building envelope.

The building shall be designed with air permeability of not higher than 8.0$m^2/(h.m^2)$ at a pressure differential of 50 Pa. The compliance to the above requirement shall be confirmed using ISO 9972

6.3.1.2 Visual Light Transmittance

Visible light transmittance (VLT) shall be determined for the fenestration products in accordance withISO-15099by an accredited independent laboratory and labeled by the manufacturer.

For unrated products, the VLT of the glass alone shall be derate by 10% to demonstrate compliance with VLT requirements for the overall fenestration product.

6.3.1.3 Solar Reflectance

Solar reflectance for the external opaque roof construction shall be determined in accordance with ASTM E903-96 by an accredited independent laboratory and labeled by the manufacturer.

6.3.1.4 Emittance

Emittance for external opaque roof construction shall be determined in accordance with ASTM E408-71 (Reapproved 2008 or the latest version available) by an accredited independent laboratory and labeled by the manufacturer.

6.3.2 Prescriptive Requirements

6.3.2.1 Building Envelope U-Value

Compliance with the Code is attained by satisfying the prescriptive criteria of each building envelope sub-element discussed in this Section. U-Values for façades, fenestrations, ground, basement and roofs shall be determined from material properties provided in **Appendix 5** or specific data from material manufacturers. The maximum allowable value of the window-to-wall ratio (WWR) is 40% and maximum skylight coverage is 3% of roof area.

The exterior building envelope U-Value shall comply with the requirements outlined in **Tables 6-2** to **6-4** for the relevant climate, and conditioned status (Maximum allowable U-Values are given).

Table 6-1Building Envelope Requirements for Climate Zone 'Warm-Humid' [Coastal Tropical, Intermediate Tropical, and Lakes Zones]

	Conditioned Cooled		Unconditioned	
Walls (maximum U-Value) W/m²K	2.38		0.16	
Roofs (assembly maximum U-Value) W/m²K	1.30		0.80	
Ground/basement floor with hardcore (maximum U-Value) W/m²K	0.34		0.34	
	U-Value*	SHGC	U-Value*	SHGC
Fenestration				
WWR Ratio (<40%)	2.84	0.23	2.84	0.23
WWR Ratio (>40%)	2.30	0.23	2.30	0.23
Skylight				
Skylight Coverage <3% roof area	3.98	0.30	3.98	0.30
*Incorporating the frame of the fenestration SHGC – Solar Heat Gain Co-efficient				

Table 6-2 Building Envelope Requirements for Climate Zone 'Warm-Dry' [Plateau Zones]

	Conditioned Cooled		Unconditioned	
Walls (maximum U-Value) W/m²K	2.38		0.16	
Roofs (assembly maximum U-Value) W/m²K	1.30		0.80	
Ground/basement floor with hardcore (maximum U-Value) W/m²K	0.34		0.34	
	U-Value*	SHGC	U-Value*	SHGC
Fenestration				
WWR Ratio (<40%)	2.84	0.22	2.84	0.22
WWR Ratio (>40%)	2.30	0.23	2.30	0.23
Skylight				
Skylight Coverage <3% roof area	3.98	0.30	3.98	0.30
*Incorporating the frame of the fenestration SHGC – Solar Heat Gain Co-efficient				

Table 6-3Building Envelope Requirements for Climate Zone 'Upland' [Uplands and High Uplands Zones]

	Conditioned cooled	Unconditioned
Walls (maximum U-Value) W/m²K	2.38	0.16

Roofs (assembly maximum U-Value) W/m²K	1.30		0.80	
Ground/basement floor with hardcore (maximum U-Value) W/m²K	0.34		0.34	
	U-Value*	SHGC	U-Value*	SHGC
Fenestration				
WWR Ratio (<40%)	2.39	0.25	2.39	0.25
WWR Ratio (>40%)	2.30	0.23	2.30	0.23
Skylight				
Skylight Coverage <3% roof area	3.12	0.30	3.12	0.30
*Incorporating the frame of the fenestration SHGC – Solar Heat Gain Coefficient				

6.3.2.2 SHGC of Vertical Fenestration

SHGC for vertical fenestration, including shading by opaque permanent projections, shall comply with values prescribed in **Table 6-2** to **Table 6-4** for respective climate zones.

For demonstrating compliance for south-, east-, or west-oriented vertical fenestration shaded by opaque permanent projections with a life span equal to that of the building itself, the SHGC of the shaded vertical fenestration in the proposed design may be reduced by using the multipliers in **Table 6-5**.

Table 6-4SHGC Multipliers for Permanent Projections

Projection Factor	Projection Factor SHGC Multiplier (South, East and West Orientations)
0 to 0.1	1.00
0.1 to 0.2	0.91
0.2 to 0.3	0.82
0.3 to 0.4	0.74
0.4 to 0.5	0.67
0.5 to 0.6	0.61
0.6 to 0.7	0.56
0.7 to 0.8	0.51
0.8 to 0.9	0.47
0.9 to 1.0	0.44

(Adapted from ASHRAE 90.1-2019)

Note: The projection factor is calculated as the ratio of the horizontal depth of the projection (overhang or shading device) to the vertical distance from the bottom of the projection to the bottom of the fenestration being shaded.

6.3.3 Alternative Path

The overall property of the building envelope is expressed by indices such as the Envelope Thermal Transfer Value (ETTV) and Roof Thermal Transfer Value (RTTV). These indices provide flexibility and allow for variation in the design of individual building elements while maintaining overall compliance with energy efficiency standards.

6.3.3.1 Envelope Thermal Transfer Value

Building envelope design with an ETTV, is a measure of the thermal performance of a building envelop. It is computed based on the methodology and guidelines outlined in this Code.

ETTV considers the three primary heat exchange components across the external walls and windows of a building:

- Heat conduction across opaque walls– Heat transfers due to the temperature difference between the interior and exterior surfaces.
- Heat conduction across glass windows– Thermal transfer through glazing, influenced by the window's U-Value and the temperature differential.
- Solar radiation through glass windows– Solar heat gain due to incident radiation, influenced by SHGC and window orientation.

The ETTV is determined by averaging the three primary heat exchange components over the total external envelope area of the building. This value represents the overall thermal performance of the building envelope.

The maximum allowable ETTV is 60 W/m^2. The calculation methodology for ETTV is provided in **Appendix 2**of this Code**.**

6.3.3.2 Roof Thermal Transfer Value

The RTTV assesses the thermal performance of the roof assembly based on the methodology and guidelines outlined in this Code.

RTTV considers the three primary heat exchange components across the opaque roof and skylights:

- Heat conduction across opaque roof– Thermal transfer due to temperature differences between indoor and outdoor conditions.
- Heat conduction across skylight– Heat flow through the glazing material of skylights, influenced by its U-Value.
- Solar radiation through skylight– Direct solar heat gain transmitted through skylights, dependent on the SHGC and solar exposure.

These components are averaged over the roof area to calculate the RTTV, representing the roof's thermal performance. The maximum allowable RTTV is 55W/m^2. The calculation methodology for RTTV is provided in **Appendix 3.**

6.4 Submittals

The following documentation shall be submitted to verify compliance with this Code.

a. Floor plans clearly identifying conditioned-cooled, conditioned-heated, and unconditioned spaces.

b. Detailed roof plans and sections indicating roof types and fenestration.

c. Sections and elevations details indicating overall envelope, wall, and fenestration types.

d. Air tightness and leakage data, certified by accredited professionals according to the test methods stipulated in this Code.

e. VLT data for fenestrations, certified by an accredited laboratory, or manufacturer.

f. SRI data for roof elements, certified by an accredited laboratory, or manufacturer.

G. For the prescriptive building envelope, detailed construction of envelop sub-elements and U-Values and SHGC for walls, roofs, fenestration (including skylights).

I. For alternative paths, detailed ETTV/RTTV calculations and construction specifications or material schedules by accredited entities.

K. For performance option, extracts of the construction specifications or material schedules showing the material properties of facades, fenestration, external walls, and roofs. Documentation must be certified by an accredited laboratory, nationally recognized organization, or manufacturer.

7 SECTION 7 – HEATING VENTILATION AND AIR CONDITIONING

7.1 General

This section outlines the technical requirements for achieving energy efficiency in the design and construction of new HVAC services and additions to existing buildings. Within the context of the EEBC, “energy efficiency” means “energy use efficiency.”

HVAC systems shall be sized in accordance with good engineering practice, including those prescribed in building codes, latest edition of the ASHRAE Handbook (or equivalent reference) or using computer simulation software.
Critical parameters influencing energy performance, such as U-Values (thermal transmittance) and SHGC, must be calculated based on local climate data to ensure the system's optimal performance in the intended environment.

Application of this Section - This Section applies to alterations and modifications/additions to buildings constructed in compliance with the EEBC. It is intended to ensure that future changes to building assemblies, systems, equipment, and components regulated by this Code, such as tenant improvements and renovations, continue to meet the requirements set forth in this Code. Designers should pay particular attention to situations where the Performance Compliance Path was used in the original construction. In such scenarios, the assumptions used in the original energy model should be carefully reviewed. If necessary, a new energy model must be prepared to validate continued compliance with this Code’s requirements.

Calculation procedures-Calculations carried out to ensure compliance with this Code and not described in the balance of this Subsection or in other Parts of the Code shall be carried out using procedures recognized for the purposes, such as those described in, but not limited to:

a) ASHRAE Handbooks, Standards and Guidelines,
b) Heating, Refrigeration and Air Conditioning Institute (HRAI)
c) Hydronic Institute Manuals, and ISO 52016-1, “Energy performance of buildings – Calculation of energy use for space heating and cooling.”

7.1.1 Scope

7.1.1.1 New Buildings

Mechanical equipment and systems serving HVAC need of new buildings shall comply with the conditions stipulated in this chapter.

7.1.1.2 Existing Buildings

Mechanical equipment and systems serving HVAC needs of additions or modifications to existing buildings shall comply with requirements specified in this chapter. If the HVAC for a building extension (new addition) is provided by existing HVAC systems, those existing systems are exempted from complying with this Code. However, any new systems or equipment installed as part of the addition must fully comply with the specific requirements applicable to those systems and equipment.

7.1.1.3 Exemptions to this Section

The following modifications are exempt:

a. Modifications or repairs to existing equipment that do not increase annual energy consumption, provided the equipment continues to use the same energy type.
b. Replacement or alteration of equipment that requires extensive revisions to other systems, equipment, or building elements, provided the replacement is in-kind with no significant energy performance downgrade.
c. Refrigerant changes for existing equipment compliant with environmental standard
d. Relocation of existing equipment provided the increase in energy use is under5%.
e. Ducts and piping where sufficient space or accesses unavailable to meet these requirements.

7.1.2 Space Conditioning Types

This standard applies to the following space conditioning types:

a) Enclosed actively cooled spaces (hot humid and hot arid zones).
b) Enclosed actively heated spaces (high upland zone)

7.2 Mandatory Requirements

7.2.1 Ventilation

All habitable spaces shall be ventilated with outdoor air in accordance with the requirements of this section and guidelines specified in Chapter7 Section C of the National Building Code. Ventilated spaces shall be provided with outdoor air using one of the following:

a) Natural ventilation

b) Mechanical ventilation

7.2.1.1 Demand Control Ventilation System

Mechanical ventilation systems shall have demand control ventilation if they provide outdoor air greater than 1,500L/s, to a space greater than 50m^2, with occupant density exceeding 40 people per 100m^2 of the space. Systems must include:

a) Air side economizer

b) Automatic outdoor air damper

Exceptions:

a. Classrooms in schools, call centers category under Business.

b) Spaces that have processes or operations that generate dust, fumes, mists, vapors, or gasses and are provided with exhaust ventilation, such as indoor operation of internal combustion engines or areas designated for unvented food service preparation, or beauty salons Systems with exhaust air energy recovering system.

7.2.1.2 Ventilation System Controls

Stair and elevator shafts shall be equipped with motorized dampers capable of being shut during normal operation but that shall come into operation in case of fire or smoke detection. This shall be used in compliance with relevant fire regulations in force.

All outdoor air supply and exhaust air related to vents and ventilation shall be equipped with motorized dampers that will automatically shut down when spaces served are not in use. If manual intervention could be ensured, manual switching off and/or modulating may be accommodated.

Exception**:**

a) Non-motorized systems and ventilation systems catering to unconditioned spaces.

7.3 Prescriptive Requirements

7.3.1 Natural Ventilation Design Requirements

Naturally ventilated buildings shall adhere to the following requirements:

a) Comply with guidelines provided for natural ventilation in Section 4.4 of the Tanzania Building Code.

b) If ceiling fans are installed, they must have a minimum of three-speed settings and meet or exceed the minimum efficiency requirements of MEPS when operating in a downward-blowing direction.

c) Install exhaust fans complying with minimum efficiency requirements of fans.

7.3.2 Mechanical Ventilation Air Quantity Design Requirements

Buildings using mechanical ventilation system that are ventilated with a mechanical system, either completely or in conjunction with natural ventilation systems shall:

a) Install mechanical systems that provide outdoor air change rate as described in chapter 6 (TBC) above.

b) Have a ventilation system controlled by Carbon Monoxide (CO) sensors for basement car park spaces greater than or equal to 600 m^2.

7.3.2.1 Constant-Volume Fan Systems

Where fans produce a constant airflow rate whenever the system is operating, the power demand required by the motors for the combined supply and return fan system at design conditions shall not exceed 1.6W/L/s of supply air delivered to conditioned space, calculated using the following equation:

$$W = 0.001 \times F \times SP/\eta$$

Where:

W = power demand, in watts,

F = design flow rate, in L/s,

SP = design static pressure across the fan, in Pa, and

η = combined fan drive motor efficiency, in decimal.

7.3.2.2 Variable-Air-Volume Fan Systems

For variable air volume systems, the power demand for fan motors shall not exceed 2.65 W/L/s at design conditions. For systems with:

- Fans of 7.5 kW to <25 kW: Must incorporate controls to reduce fan power demand to no more than 55% of design wattage at 50% airflow.
- Fans ≥25 kW: Must include controls to limit fan power to no more than 30% of design wattage at 50% airflow.

For fan systems through which airflow varies automatically as a function of load, the power demand required by the motors for the combined supply and return fan system, as calculated using the equation in Sub-Section 7.3.2.1 shall not exceed 2.65 W per L/s of supply air delivered to the conditioned space at design conditions.

In variable-air-volume systems, any individual supply, relief or return fan with a power demand greater than 7.5 kW and less than 25 kW, as calculated using the equation in Sub-Section7.3.2.1, shall incorporate controls and devices such that, if air delivery volume is reduced to 50% of design air volume, the corresponding fan power demand will be no more than 55% of design wattage, based on the manufacturer‘s test data.

In variable air volume systems, any individual supply, relief or return fan with a power demand equal to or greater than 25 kW, as calculated using the equation in Sub-Section7.3.2.1, shall incorporate controls and devices necessary to prevent the fan motor from demanding more than 30% of design wattage at 50% of design air volume, based on the manufacturer's test data.

7.3.2.3 Piping and Duct Insulation for Space Conditioning

Piping for heating, space conditioning, and service hot water systems shall meet the insulation requirements listed in Tables 7-1 and 7-2. Insulation exposed to weather shall be protected by durable coverings such as aluminum sheet metal, painted canvas, or plastic. Cellular foam insulation shall also be protected or painted with water retardant paint. Additionally, duct insulation installed in areas where it may be subject to mechanical damage or weathering shall be protected.

The following are exceptions to the insulation requirements**:**

a. Reduction in insulation R value.

   i. A reduction of0.2 R-value (to a minimum insulation level of R-0.4) is permitted for any pipe located inside partitions within a conditioned space or buried.

ii. For pipes located in partitions outside a building and directly exposed to weather, the Insulation R-value shall be increased by 0.2 above the requirement stated in Tables **7-1**and**7-2**below.

b) Factory-installed plenums, casings or ductwork furnished as a part of HVAC equipment, if they are either insulated at the factory or installed in a conditioned space.

c) Specific duct types

i. Exhaust air ducts.

ii. Outdoor air ducts.

iii. Return air ducts within conditioned space.

Table 7-1Ductwork and piping Insulation (R value in m^2 K/W) Requirements

Climate Zone	Duct location		
	Exterior	Unconditioned space and burled ducts	Indirectly conditioned space [c, d]
Supply and return ducts for heating and cooling			
0 to 3	R-1.41	R-1.06	R-0.34
Supply and return ducts for heating only			
0 to 1	None	None	None
2 to 3	R-1.06	R-1.06	R-0.34
Supply and return ducts for cooling only			
0 to 3	R-1.41	R-1.06	R-0.34

Notes:

a. Insulation R-values, measured in m^2K/W, represent the insulation as installed and do not include film resistance. The required minimum thicknesses do not consider water vapor transmission or possible surface condensation. Insulation resistance measured on a horizontal plane in accordance with ASTM C518 at a mean temperature of 24°C at the installed thickness.

b) Includes attics above insulated ceilings, parking garages and crawl spaces.

c) Includes return air plenums with or without exposed roofs above.

d) Return ducts in this duct location do not require insulation.

For Energy efficiency performance, if the central air handling unit supply plenum is located outside the conditioned spaces it serves it must be insulated.

Likewise, sections of the supply ducts located outside the final conditioned space they serve must also be insulated. The fan coil supply plenum and the supply-run outs in all the conditioned spaces do not require insulation, since they are located within the spaces they serve.

Designers should consider the length of uninsulated supply ducts and the temperature difference between the supply air and the air surrounding the ducts when deciding whether measures beyond the requirements of insulation are necessary. For instance, uninsulated supply ducts used for cooling may be subject to condensation issues.

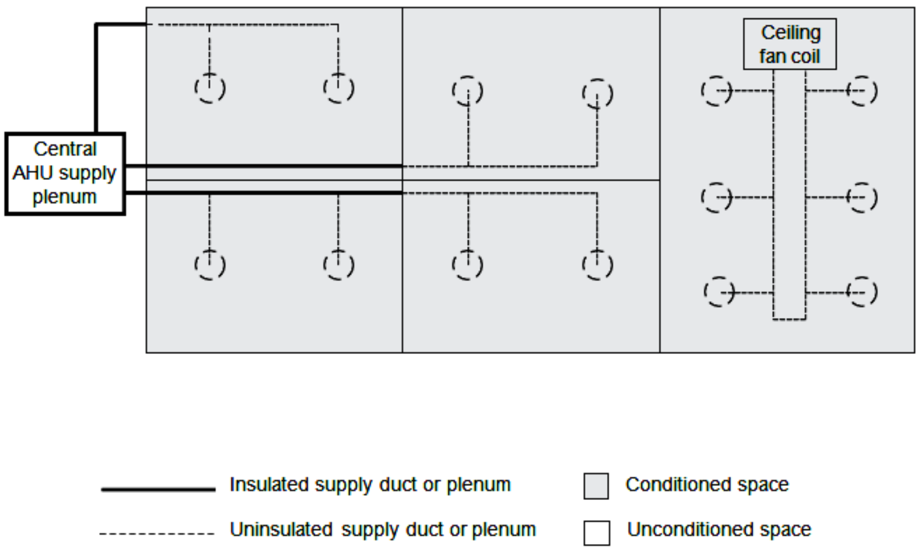


Figure 7-1Duct Insulation Based on Space Condition and Leakage Levels

Ductwork and plenums shall be sealed in accordance with standard industry practice as defined in the Sheet Metal and Air Conditioning Contractors' National Association (SMACNA) 2020 guidelines.

7.3.2.4 Piping insulation

All chilled water piping in an HVAC system shall be thermally insulated in accordance with ASHRAE 90.1-2019as shown in **Tables 7-2**. The insulation shall be suitably protected from damage, and reference should be made to the insulation manufacturer’s catalog for specific protection measures.

Table 7-2Minimum Piping Insulation Thickness

Fluid design	Insulation conductivity		Nominal pipe or tube size (mm)				
Operating temp. range (°C)	Conductivity (W/m·K)	Mean rating temp. °C	<25	25 to <40	40 to <100	100 to <200	>200
Heating systems (steam, steam condensate, and hot water) related to HVAC system							
>177	0.046-0.049	121	162.5	193.0	193.0	259.0	259.0
122-177	0.042-0.046	93	96.5	162.55	193.0	193.0	193.0
94-121	0.039-0.043	66	96.5	96.5	129.5	129.5	129.5
61-93	0.036-0.042	52	63.5	63.5	63.5	96.5	96.5
41-60	0.032-0.040	38	33.0	33.0	63.5	63.5	63.5
Cooling systems (chilled water, brine, and refrigerant)							
16-4	0.032-0.040	38	33.0	33.0	63.5	63.5	63.5
<4	0.032-0.040	38	33.0	63.5	63.5	63.5	96.5

Exceptions

Piping insulation shall not be required for piping that conveys fluids that have a design temperature above 20°C.

Note: If indoor design conditions are exceeded, insulation may require a higher temperature to prevent condensation.

7.3.2.5 System Balancing

Balancing an air distribution system involves fine-tuning to ensure the correct amount of arias designed for the heating, ventilating or air conditioning system is delivered.

Major supply air ducts—such as main, sub main or branch ducts carrying conditioned air—must be equipped with air volume balancing dampers to allow adjustment for specified airflows. This requirement excludes systems with alternative means of air volume control, such as variable air volume systems.

System balancing is mandatory for systems serving zones with a total conditioned area exceeding 500 m^2.

7.3.2.6 Air System Balancing

Air systems shall be balanced to minimize throttling losses. For fans with a system power greater than 0.75 kW, fan speed shall be adjusted to meet design flow conditions.

7.3.2.7 Hydronic System Balancing

Hydronic systems shall be proportionately balanced to minimize throttling losses. Pump impeller shall be trimmed, or pump speed shall be adjusted to meet design flow conditions. Balancing a hydronic system involves fine tuning to ensure the correct amount of fluid for which the system is designed can be delivered to each of the sectors served.

Pumps and major circuit divisions must be installed with adequate access to the fluid to measure differential pressure or flow and must be equipped with a flow adjustment mechanism.

ANSI/ASHRAE 111, "Testing, Adjusting, and Balancing of Building HVAC Systems" and ASHRAE Handbooks should be referenced when balancing hydronic systems.

7.3.3 Air Conditioning System Design

7.3.3.1 Energy Efficiency Indoor Design Condition

The indoor human thermal comfort conditions fora conditioned space are defined as a dry bulb temperature of 24°C ± 2°C and relative humidity of 55 % ± 10 % for actively cooled conditioned spaces and a dry bulb temperature of 20°C ± 2°C and relative humidity of 55% ± 10% for actively heated conditioned spaces. These conditions may vary for special applications such as hotels, medical care facilities, sports-related spaces, and laboratories, based on specific needs.

7.3.3.2 Outdoor Design Condition

Outdoor design values, such as dry and wet bulb temperatures, shall be based on the climate zone. These conditions shall be determined using hourly data analyzed over at least a year from the nearest weather stations, as provided the Tanzania Meteorological Authority (TMA).

7.3.3.3 Hot Water Design Supply Temperatures

Hot water design supply temperature shall be modeled with a supply temperature of82°C and return temperature at 54°C.

7.3.3.4 System/Equipment Type, Capacity and Efficiency requirement Selection

All cooling and heating systems must use refrigerant gases that are non-ozone depleting to comply with environmental standards.

7.3.3.5 Variable Refrigerant Flow

Variable Refrigerant Flow (VRF) systems shall meet or exceed the efficiency requirements, expressed as Coefficient of Performance (COP) values, specified in **Table 7-3** as outlined in the ANSI/AHRI Standard 1230.

Table 7-3Variable Refrigerant Flow Efficiency Requirements

Type	Cooling Capacity (kW)	COP (W/W)
VRF Air Cooled Air Conditioners	<40	3.28
	≥40 or <70	3.26
	≥70	3.02

7.3.3.6 Chiller

Air-cooled chillers are allowed in all buildings with cooling loads less than 530kW. For cooling load equal to or greater than 530kW, air-cooled chiller are restricted toe maximum of33% of the total installed chilled water capacity, unless otherwise required by the AHJ. Air-cooled chillers shall meet or exceed the efficiency requirements specified in **Table7-4.**

Table 7-4Chiller Cooling Capacity

Type	Cooling capacity (kW)	COP (W/W)
Water Cooled Chiller	<260	4.7
	≥260 or <530	4.9
	≥530 or <1050	5.4
	≥1050 or <1580	5.8
	≥1580	6.3
Air Cooled Chiller	<260	2.8
	≥260	3.0

The Integrated Part-Load Value (IPLV) should be considered in system selection to ensure compliance with these requirements across varying operational loads.

7.3.3.7 Unitary, Split, Packaged Air Conditioners

Unitary air-conditioners shall meet or exceed the efficiency requirements listed in **Table 7-5**.

Table 7-5Coefficient of Performance (COP)

Cooling capacity(kW)	COP (W/W)	
	Water Cooled	Air Cooled
Less or equal to 10.5	N/A	2.6
Greater or equal to 10.5	3.3	2.8

Non-ducted single split with a rated cooling output of at or below 16 Kilowatts (kW) shall meet or exceed the efficiency requirements as given in MEPS of Tanzania.

7.3.3.8 Air Conditioning and Condensing Units Serving Server Rooms

Air conditioning and condensing units serving server or computer rooms shall meet or exceed the energy efficiency requirements of 2.5 COP for all types of computer room air conditioners.

7.3.3.9 Condenser

Condensers shall be located such that the heat sink is free of interference from heat discharge by devices located in adjoining spaces, and do not interfere with other such systems installed nearby.

7.3.3.10 Boiler

Gas and oil-fired boilers of all capacity shall meet or exceed the minimum fuel utilization efficiency of 80%. Standard design boilers shall be modeled as natural draft boilers and shall use the same fuel as the proposed design.

7.3.3.11 Heat Pumps

Air-to-air reversible heat pumps of cooling capacity a cooling output rated at or below 16 kW shall meet the efficiency requirements as given in MEPS of Tanzania. For heat pumps with capacities above 16 kW, efficiency requirements shall conform to ANSI/AHRI standards as summarized in **Table 7-6**.

Table 7-6Minimum Efficiency Requirements

Equipment Type	Size Category	Subcategory or Rating Condition	Minimum Efficiency (SCOPH)	Test Procedures
Air cooled (Heating mode)	<19 kW (cooling capacity)	Split system	2.40	AHRI 210/240-2017 or latest
		Single package	2.34	AHRI 210/240-2017 or latest
Space Constrained, air cooled. (Heating mode)	≤9 kW (cooling capacity)	Split system	2.17	AHRI 210/240-2017 or latest
		Single package	2.17	AHRI 210/240-2017 or latest
Air cooled (Heating mode)	≥19 kW and <40 kW	8.3°C dry bulb 6.1°C wet bulb outdoor air	3.30	AHRI 340/360 or latest
VRF (heating mode)	<19 kW (cooling capacity)	20°C entering water	4.3	AHRI 1230 or latest
	≥19 kW and <40 kW		4.3	AHRI 1230 or latest

7.3.3.12 Economizer

Buildings with a built-up area greater than 20,000 m^2 shall include at least one of the following:

- An air economizer capable of modulating outside-air and return-air dampers to supply 50% of the design supply air quantity as outside air.
- A water economizer capable of providing 50% of the expected system cooling load at outside air temperatures of 10°C dry-bulb/7.2°C wet-bulb and below.

Exceptions include:

- Projects in warm-humid climate zones.
- Projects with only daytime occupancy in the hot-dry.
- Individual cooling or heating fan systems less than 3,200 liters per second.

Where required, economizers shall be capable of providing partial cooling even when additional mechanical cooling is required to meet the cooling load**.**

Air economizer shall be equipped with controls that allows dampers to be sequenced with the mechanical cooling equipment and not be controlled by only mixed air temperature.

- Capable of automatically reducing outdoor air intake to the design minimum outdoor air quantity when outdoor air intake will no longer reduce cooling energy usage.
- Capable of high-limit shutoff at 24 °C dry bulb temperature.

Field testing of air economizers is required to verify proper operation, except for factory-calibrated units certified by the manufacturer. For acceptance procedures, refer to **Appendix 6**.

7.3.4 Control

7.3.4.1 Timeclock

Mechanical cooling and heating systems in the public buildings shall include time clocks capable of:

- Starting and stop the system on at least three different schedules per week.
- Retaining programming and time setting for a period of at least 10 hours during power outages.
- Allowing manual override for up to 2 hours.

7.3.4.2 Temperature

Mechanical cooling and heating equipment in all buildings shall be installed with controls to manage the temperature inside the conditioned zones. Each floor of building shall be installed with at least one control to manage the temperature. These controls should meet the following requirements:

- Where a unit provides both heating and cooling, it must feature dead band of 3.0°C where neither heating nor cooling is supplied**.**
- Separate heating and cooling equipment serving the same zone must be interlocked to prevent simultaneous heating and cooling.
- Individual thermostat control shall be installed in guest rooms, small business rooms (<30 m²), classrooms, lecture rooms, computer rooms, and inpatient/outpatient healthcare rooms.

7.3.5 Occupancy

Occupancy controls shall be installed to de-energize or to throttle ventilation and air conditioning systems when there are no occupants when spaces are unoccupied. This applies to guest rooms, public toilets in large buildings (>20,000 m²), meeting rooms, and educational rooms larger than 30 m².

7.3.6 Damper

All Variable Frequency Drive (VFD)air supply and exhaust equipment shall be equipped with dampers that automatically close when the fan is shutdown, or when space being served is not in use. Exceptions include naturally ventilated spaces and kitchen exhaust hoods.

7.3.6.1 Energy Recovery

All spaces in the public buildings, with systems exceeding 2,100L/s and providing at least 70% outdoor air shall have air-to-air heat recovery equipment with a minimum recovery effectiveness of 50%.

7.3.7 Maintenance and Operation of HVAC Systems for Energy Efficiency

Proper maintenance is critical for efficient HVAC systems operation. And a proper maintenance specification for a building must be site specific. Maintenance specifications must be site-specific to ensure optimal energy efficiency and system performance. Key recommendations include:

- Keeping equipment clean. Dirty equipment contributes significantly to failures and inefficiencies.
- Good housekeeping practices. These are integral to maintaining operational efficiency.
- Control usage. Use of controls, including Building Management Systems (BMS), should be effectively utilized to monitor and manage equipment.
- Inspection priorities. Focus on critical components such as coils and filters for maintaining efficiency.

7.4 Alternative Path Design System Efficiency Option

An alternative compliance path is provided in the standard based on Design System Efficiency (DSE) estimated based on the computed design load profile and each of the sub system performance. For compliance, design must meet DSE minimum thresholds and air handling system efficiency minimum thresholds.

7.4.1 Water Cooled System DSE

Chilled water plant DSEs shall be established based on the computed operational design load profile together with the power inputs of various subsystem components at their respective operating load condition as described in the design, including the energy-related to chilled water circulation. The minimum DSEs that must be met are presented in **Table 7.7**.

Table 7-7Water Cooled System — Minimum Design System Efficiency

Max Building Cooling Load (kW)	DSE (kW/TR)
≤500	0.8
>500	0.7

7.4.2 Air Cooled System DSE

The air-cooled plant DSEs shall be established based on the computed operational design load profile and power inputs of the relevant fan subsystem at their respective operating load condition as described in the design. The following minimum design system efficiencies are specified in **Table 7.8**.

Table 7-8Air Cooled System — Minimum Design System Efficiency

Max Building Cooling Load ≤ 500 TR	DSE (kW/TR)
≤500	1.0
>500	0.9

7.4.3 Air Handling System Efficiency

Fan system input power must be less than the prescribed values in **Table 7-9**.

Table 7-9Allowable Fan System Input Power (Adapted from ASHRAE 90.1 - 2019)

Air Distribution System Type	Allowable Fan System Input Power	
	kW/m³/s	W/m³/h
AHUs ≥ 4kW (constant volume)	1.2	0.34
AHUs ≥ 4kW (variable volume)	1.7	0.47
FCUs < 4kW	0.4	0.11

Note. Pressure drop adjustments may follow ASHRAE 90.1 guidelines.

7.5 Submittals

A submittal of compliance with this standard incorporating information as required by each of the subsections above shall be required by the Authority. The information submitted shall include, at a minimum, the following:

I. Compliance checklist for mandatory and prescriptive requirements.
II. Summary describing the low-energy comfort system type, capacity, and efficiency.
III. Comparison of installed capacity of approved low-energy comfort system with alternative HVAC systems to meet the comfort requirement of the building.
IV. Operation and maintenance manual prepared according to industry standards, including maintenance details, service agency contacts, control calibration information.
V. Record drawings with piping and instrumentation diagrams, location, sub-system sizes and performance data.
VI. Description of load calculation methodology.
VII. Detailed commissioning instructions for HVAC systems, provided byte designer in plans and specifications.

8 SECTION 8: WASTE AND WATER MANAGEMENT

8.1 General

This section gives technical directives on energy efficiency in the areas of water supply and drainage systems. Water supply significantly impacts a building's overall energy intensity and contributes to achieving near-net-zero energy structures. Makes a big difference in the pursuit of near-net-zero energy structures. This section provides the mandatory and prescriptive directives to meet energy efficiency requirements in buildings by focusing the engineering design of water supply and waste management. All citizens have a responsibility to manage water and waste management systems.

Effective waste management, covering both solid and liquid waste, follows a mitigation hierarchy emphasizing offsets, minimization, restoration, and avoidance, with priority given to avoidance. By adhering to the Environmental Impact Assessment and Audit Regulations, 2005 and their 2018 revisions, projects can be scrutinized and reviewed before implementation, ensuring environmental compliance.

8.2 Mandatory Requirements

8.2.1 Water Supply

8.2.1.1 Water Distribution System

In high-rise buildings and municipal pressure cannot supply buildings, the drinking water system design shall be vertically zoned according to the pressure requirement to minimize pumping demand.

8.2.1.2 Water Serving Devices.

Reduce the use of water by incorporating water-saving devices such as aerated taps, sensor-controlled taps, low-flush toilets, or hoses with triggers (that supply water only when needed rather than constantly running). Cleaning equipment should use buckets of water instead of running water. Regular maintenance of pipes and taps is essential to prevent water loss through leakages.

8.2.1.3 Water Reuse

Process water should be reused onsite wherever possible, e.g., using water from sinks to clean outdoor equipment or to irrigate plants. Reuse must be safe, requiring filtration systems or UV sterilization to treated and recycle water back into the system. Water quality for reuse and disposal shall meet the wastewater quality as set by TBS or National Environmental Management Council (NEMC).

8.2.1.4 Plumbing System

Plumbing systems must be watertight to avoid water leakages, and the pipes shall be proper sized to reduce friction during pumping.

8.2.2 Drainage

8.2.2.1 Gravity Drainage System

For energy control, the drainage pipes shall be laid at a slope to allow the gravity flow of the wastewater from the building to the treatment plant and gravity flow from the treatment plant to the disposal point. The recommended slopes are specified in BS EN 14654-1:2021. Sizing of pumping systems shall be determined as specified in BS 752-6

8.2.2.2 Wastewater Segregation and Reuse

Gray water (from sinks) shall be separated from soil water (from toilets and urinals) to minimize wastewater volume for recycling, treatment, and disposal. Recycling method should match wastewater strength and reuse purposes while adhering to NEMC wastewater disposal standard. Effluent discharge must comply with Environmental Management (Water Quality Standards) Regulation 2007, published by NEMC.

8.2.2.3 Swales/ Green Drainage Infrastructure

Swales and green drainage infrastructure are a component of a sustainable urban drainage system (SUDS) solution aimed at managing surface water runoff in an environmentally friendly way. Swales shall be constructed to the site in to reduce surface runoff, minimizing the need for treatment and pumping of high surface runoff volumes.

8.2.2.4 Rainwater Disposal

Rainfall that falls on paved surfaces, roofs, and other open places shall be disposed of in a separate and autonomous storm-water disposal system or an organic waterway. The system shall not connect to sewerage systems, as provided in the NBC Section 16 and BS EN 752.

8.2.3 Water for Firefighting

8.2.3.1 Renewable water

Buildings with a total floor area exceeding 2000 m^2 shall consider renewable water sources for fire protection. Fire water pool sizes shall comply with Fire and Rescue Force (Fire Precautions in Buildings) Regulation, 2015.

8.2.3.2 Public Hydrants System

Where the municipal water supply network meets the firefighting water demand, indoor fire pool shall be omitted, therefore the water may be collected directly from the municipal water network, per the Fire and Rescue Force Regulation, 2015.

8.2.4 Hot water systems

8.2.4.1 Solar Hot Water Production

Buildings in cold climate zones and hospitality/healthcare facilities in all climatic zones shall install solar water heating equipment should be designed to supply at least 40% of the total hot water demand when unobstructed solar radiation is available, as recommended by industry standards and technical guidelines.

8.2.4.2 Water Heating Equipment Efficiency

Water heating equipment shall meet or exceed the following performance and minimum efficiency standards:

a) Solar water heaters: BS 12976-1.
b) Gas instantaneous water heaters: BS 6400 with above 80% fuel utilization efficiency.
c) Electric water heaters conforming to BS1566-1 for single-fed cylinders with acceptable minimum efficiency of 92%. It is recommended that water heaters should be installed near point of use.
d) Evacuated tube collectors: Storage tanks shall meet the BS1566 or BS3198, cylinder shall meet IS 16543:2016 and IS 16544:2016 for a complete system.
e) Water heater tanks shall be sized based on usage requirements.

8.2.4.3 Pipe Materials

The pipe materials for hot water supply shall be of minimum thermal emission with high to moderate heat resistance to ensure durability, efficiency, and reduced thermal losses.

8.2.4.4 Distribution Systems and Pipe Sizes

Hot water distribution systems shall be designed to minimize pipe lengths, thereby reducing energy losses. Pipe sizes must comply with the section 16 of this National Building Code and BS 6700.

8.2.4.5 Pipe Insulation

Hot water distribution pipes shall be fully insulated, with insulation specified **Table 7-2 minimum** piping insulation thickness in **Section 7.3.2.4** of this Code.

8.2.5 Water for Landscape and Irrigation System

8.2.5.1 Water Reuse or Rainwater Harvesting

Irrigation water shall be sourced from renewable sources, such as water reuse or rainwater harvesting. Rainwater harvesting systems shall comply with the standard and technologies specified in the Guideline for Rainwater Harvesting 2020 issued by the Ministry of Water.

When the municipal water is used for irrigation, ground sensor shall be installed to prevent over-irrigation. These sensors will ensure that irrigation is conducted only, when necessary, thereby optimizing water use efficiency. Additionally, the area of irrigation shall be not exceeded 800m^2 as per the National Building Code section 2.4.1

8.2.6 Waste Management

The energy efficiency method is enhanced by the waste avoidance and minimization strategies, which reduce the energy required to manage the generated waste. While complete waste elimination may not be feasible in this context, the most practical strategy is to reduce the volume of waste created at the source and provisions for trash management, the waste management shall be conducted in compliance with the building code. The scope of waste management includes solid waste, litter, liquid waste, gaseous waste, hazardous materials, and electronic waste. Waste management should be assessed and implemented across all phases, including mobilization, construction, and operation.

8.2.6.1 Solid Waste

The Code promotes environmentally sound management practices and technologies for the design, sorting, handling, and utilization of waste. It includes provisions for on-site and off-site recovery, recycling, treatment, dismantling, temporarily and permanent storage, and disposal means as provided in the TZS 2265:2018 Solid Waste Management and Environmental Management (Solid Waste Management) Regulations, 2009.

Buildings must implement solid waste management across all phases, including pre-contract, construction, and operation, to ensure sustainability and regulatory compliance. These strategies should include:

- Waste Management hierarchy: prioritizing waste management practices in the following order of preference: prevention, minimization, recycling and reuse, biological treatment, incineration, and landfill disposal.
- Waste estimation. Identify the types and quantities of waste expected to be generated (kg/day)
- Temporary waste collection and storage. Establish designated waste collection point and storage areas on-site.
- Waste sorting and pre-treatment. Implement a waste segregation system with a minimum of four bins for metal, plastics, hazardous waste, papers, electronic and biodegradable waste. The bin capacity should be determined based on the volume of waste generated.
- Waste transportation. Ensure proper means for waste transportation are available to facilitate efficient disposal or recycling.
- Waste re-use technologies. Encourage the adoption of biogas system and other technologies to process biodegradable waste where feasible and voluntary.
- Waste segregation: waste shall be segregated at the site in order to control the amount of solid waste reaching the landfill
- Recycling initiatives. Coordinate with local authorities to identify existing active recycling industries within and outside the project zone for materials such as plastics, metal, and glass.
- Disposal mechanisms. Comply with the Environmental Management (Hazardous Waste Control and Management) Regulations, 2021 to ensure safe and environmentally responsible disposal of all waste types. In case of incineration fuel shall be sourced from renewable energy, such as heat

recovery or methane gas from anaerobic digestion, or landfill gas recovery processes.

8.2.6.2 Wastewater

Water consumption results in wastewater, with approximately 80% of consumed water being converted into wastewater. Improper wastewater management can increase CO2 emissions. To enhance energy efficiency, the Code emphasizes the implementation of eco-friendly features such as plumbing to reduce indoor water usage, and mandates the recycling of a percentage of waste. Wastewater management must comply with the requirements of the Environmental Management (Water Quality Standards) Regulations, 2007 and TZS 3037:2021 Municipal and Industrial Wastewaters.

The Code encourages the adoption of water-efficient sanitary facilities and wastewater management systems, including but not limited to the following:

- The selection of sanitary facilities (Toilets shall have lower volume, with a maximum flush volume of 3 liters).
- The taps shall be controlled through either push pedal or integrated sensor systems for bath taps, shower taps, basin taps, and kitchen sink taps.
- Shower basin shall be selected with reduced water volume requirements.
- All urinal water taps, and flushing taps shall be enhanced with control mechanism such as push pedals or sensors.
- Enhancement of pretreatment in-situ facilities by installing oil/water separators in areas where hydrocarbon contamination is possible.
- Enhancing system for water recycling and reuse.
- Isolation of surface water runoff from wastewater
- Buildings with hydrocarbon components must include at least 1 monitoring borehole.
- Authorities must assess terrain, hydrological properties, aquifers level (water table depth), and the presence of surface water sources.
- Treatment facilities must be appropriately designed with adequate capacity and a plan for the final use of treated effluent. Encourage the use of low-energy systems, such as anaerobic digesters, to minimize pumping requirements.

- The Discharge of effluent shall adhere to the standards set in the Environmental Management (Water Quality Standards) Regulations, 2007.

Appropriate technology for treatment unit processes in wastewater shall include but are not limited to the following:

I. Lagoons treatment (anaerobic),
II. Anaerobic treatment processes of various types such as up-flow anaerobic sludge blanket (UASB) reactors, and anaerobic lagoons.
III. Primary treatment / constructed wetlands.
IV. Stabilization reservoirs for wastewater reuse and other purposes.

8.2.7 Disposal

If there is no alternative to disposing of the water, ensure it is done safely and meets the disposal requirements as prescribed in TZS 2265:2018 Solid waste Management; Environmental Management (Solid Waste Management) Regulations, 2009 and TZS 3154:2021 Solid Waste Environmental Management of Compost Processing Facilities. The disposal process shall follow biological treatment methods. Mechanical treatment may only be considered as the last resort when there is no viable alternatives exist.

8.3 Prescriptive Requirements

The waste and water management strategy shall adhere to the mitigation hierarchy by prioritizing alternatives that enables tasks to be completed without the use of water wherever feasible. This approach reduces the need for water transport, pumping, and treating water, resulting in substantial resource and energy savings.

Store rainfall in tanks, dams, or even swimming pools to reduce dependence on potable water. Prioritize on-site water collection by implementing SUDS to improve water management and collection efficiency. Where possible, utilize collected greywater for non-potable applications such as sanitizing equipment, and providing water for showers and toilets.

8.3.1 Water Management

The fixtures' flow rate must be or less than the values listed in **Table 8-1**.

Table 8-1 Recommended Water Fixture's Flow Rate

Fixture type	Maximum flow rate

Showerheads	8 l/m
Hand washbasins	6 l/m
Kitchen sinks	7 l/m
Dual flush toilets	6 l/full flush
	3l/ part flush
Urinal	2.4 l/flush in non - public facilities
	1l/ flush in public facilities

8.3.2 Indoor Water Efficiency of Water Supply System

Water system installations must be or less than the prescribed in **Table 8-2**.

Table 8-2 Variable Criteria for Indoor Water Efficiency Criteria

Item	Criteria	
Toilet	60 psi	
Bathroom and Kitchen Faucets	Showerhead	80 psi
	Faucets	60 psi
Hot Water Delivery System	Insulation	200 mm wool
	Demand	0.49 liters
	Whole house manifold system	1.44 liters
	Core plumbing system	1.44 liters
Machines	Dish washer	13 liters / cycle
	Evaporative air conditioners	22 liters / load
	Water softeners	K rather than Na
	Washing machine	18.93 liters / hour
	Drinking water treatment systems	efficiency 85%

8.4 Rainwater Harvesting and Waste Management

8.4.1 Rainwater Harvesting

Installation of rainwater harvesting systems and storage for gardening is highly encouraged for purposes such as gardening, external cleaning, and firefighting where mains water may not be necessary. The rainwater harvesting system shall follow guidance contained in the Rainwater Harvesting Guideline 2020 prepared by the Ministry of Water.

The design and sizing water harvesting system shall be by demand approach.

Calculate supply (amount of rainwater collected off all or part of the roof) as follows:

$$\textit{Supply in gallons} = \textit{Rainfall in inches} \times 0.623 \times \textit{Catchment square feet} \times \textit{Runoff Coefficient}$$

Calculate demand (water required for irrigation) as follows:

$$\textit{Demand in gallons} = \textit{Evapotranspiration coefficient} \times \textit{Plant} \times 0.623 \times \textit{Irrigated Area square feet}$$

The demand for firefighting must be sized in accordance with National Fire Protection Association (NFPA) 1 and guidelines outlined in the 2015 Fire Precautions in Buildings by the Fire and Rescue Force.

8.5 Alternative Path

The overall environmental performance of the building shall be assessed to explore alternative approaches that enhance sustainability and efficiency. Alternative paths shall be justified through performance data, calculations, and documentation demonstrating compliance with the objectives of water conservation, waste reduction, and energy efficiency.

8.6 Submittals

The following documentation shall be submitted for verification of Code compliance.

I. List demonstrating compliance with the mandatory and prescriptive requirements.

II. Environmental management plan derived from the Environmental Impact Assessment.

III. Rainwater harvesting systems design and calculations to verify the amount of rainwater harvested is sufficient for intended use.

IV. Solid and liquid waste systems design management plan.

V. Summary describing the low-energy water supply capacity of the pumps and other electrical and sanitary appliances, and efficiency. Including manufacturers certifications showing the sanitary devices are approved as high efficiency devices with trusted Authorities such as TBS.

VI. Operation and maintenance manual prepared according to industry standard practices, including equipment requiring maintenance details of service agency, controls information (set points and calibration).

VII. Record drawings with information on general configuration, piping and instrumentation, location, sub-system sizes, and performance data.

VIII. Description of water demand calculation, including wastewater recycled and volume disposed.

9 SECTION 9: ELECTRICAL POWER SYSTEMS AND EQUIPMENT

9.1 General

In Tanzania's diverse climate, effective management of electrical power systems and equipment is critical to reducing energy usage and avoiding unnecessary losses. Electrical loads, which range from lighting to mechanical ventilation and air conditioning systems, significantly influence the energy footprint of buildings. Careful shall be considered during design and implementation phases, these loads can lead to inefficiencies, resulting in higher energy consumption and increased costs.

To address energy performance issues in buildings, demand-side management shall play a pivotal role. Through collaboration between building occupants and power utilities, energy and cost savings shall be realized by reducing energy demand and associated losses.

This section presents the codes and standards that aim at addressing building energy performance, offering guidance to mitigate inefficiencies and promote sustainable energy use.

9.1.1 Scope

This section applies to electrical power systems and equipment for buildings that are within the scope described in Section 1. All criteria under this section are applicable to all new, existing buildings at the stage of expansion, rerouting, and rewiring.

9.2 Compliance Path

Power distribution systems and equipment installations in all projects shall comply with the requirements of this Section.

9.3 Mandatory Requirements

9.3.1 Power Distribution Losses

9.3.1.1 Distribution Transformers and Cables

1. All transformers shall comply with the requirements of TZS 284-1/IEC 60076-1.

2. During design, designers shall ensure that the most efficient transformers are selected and are correctly sized to ensure they operate close to their rated capacities.

3. Transformers shall be strategically located near load centers, considering factors such as centralized control, operational flexibility, and efficiency. The centralization of transformers to load centers shall ensure that copper losses in the circuit feeder does not exceed 5% of the total active power transmitted along the feeder circuit.

4. The power shall be distributed from the transformers to loads through cables compliant to TZS 1519/IEC 60227.

9.3.1.2 Power Factor

1. Provisions for power factor shall be provided near substations or load centers to improve systems' operating power factor. This shall help minimize increased current, energy losses, and voltage instability in the electrical network.

2. The minimum power factor for all installations shall comply with the Tanzania Electric Grid Code, 2017, asregulatedby the Energy and Water Utilities Regulatory Authority (EWURA).Adherence to this requirement ensures efficient energy utilization, reduces the burden on electrical infrastructure, and enhances overall grid stability.

9.3.2 Electric Motors

1. Except for elevator motors and motors that are components of rated equipment (e.g., pump, fan, compressors), all electric motors serving buildings shall comply with the MEPS requirements.

2. Motors shall be appropriately sized during design to reduce low loading-related inefficiencies. Nameplate ratings shall not exceed 20% of the loads they are designed to serve.

3. Measures shall be provided to ensure that the supply voltage at motor installation points stay within ±6% of the nominal voltage. The frequency of supply shall be within ±3% of the nominal system frequency.

4. High-efficiency motors shall be prioritized during selection. These motors typically incur minimal or no additional capital cost while providing significant efficiency and economic benefits in in most applications.

9.3.3 Uninterruptible Power Supplies

The following requirements apply to uninterruptible power supplies (UPS) installed in buildings to supply clean and standby power to information technology (IT) equipment such as computers, printers, monitors, etc.:

1. All UPSs shall be in accordance with TZS 2743-1/IEC 62040-11’2017for safety and performance.

2. The most efficient UPS shall be selected, ensuring it is appropriately sized to prevent operational inefficiencies at partial loads. Oversizing shall be avoided to optimize energy performance.

3. Voltage-dependent UPS systems shall be preferred over double-line conversion types, except where the latter is explicitly required to meet operational demands or perform specific task effectively.

9.3.4 Office Equipment

Office equipment typically consumes less energy than predicted by design calculations. This is due to the use of nameplate ratings or installed capacity figures during design, which generally exceed the average power consumption, as outlined in **Table9.1.**

Table 9-1Examples of Levels of Energy Used by Office Equipment

Equipment	Nameplate Power	Average Power Consumption	Sleep Mode Consumption
Desktop computer	500–1200 W	65 W (average) (actual power consumption is about 10–15% of the nameplate rating)	<10% of maximum continuous output rating 6.6 W
Laptop computer	50–130 W	15–40 W (actual power consumption is about 25% of nameplate values)	4 W 1.4 W

Flat screen monitor (19” and 22” screens are the most common sizes in workplaces)	280 W (19” screen) 360 W (22” screen)	30 W (average for 19” and 22” screens) 30.42 W (19” screen)	0.52–1.54 W
Laser printer	430–630 W	110 W (average)	10–20 W
Multifunction device (copier/printer/scanner)	40 W (small, desktop type) 700 W (medium, desktop type)	135 W (average)	20–80 W
Photocopier	1440–1850 W	550–1100 W (‘copy’ mode)	130–300 W (‘idle’ mode) 15 W
Fax machine	939 W (medium size) 40 W (small size)	90 W 20 W	10–15 W
Plotter	400 W	250 W	-

Note: Values were derived from various references, including:

- International Electrotechnical Commission (IEC) Standards - IEC 62301 for standby power measurements and IEC 60950-1 for IT equipment power ratings.
- ASHRAE Handbook – HVAC Applications
- Manufacturer Datasheets - Many equipment manufacturers provide technical specifications, including HP, Dell, Lenovo, Epson, and Canon.

The most energy-efficient office equipment shall be selected, ensuring that their average power consumption is thoroughly researched and accurately used for estimation of power demand. This approach prevents power supply systems from operating outside their optimal efficiency range.

9.3.5 Building Transportation Systems

9.3.5.1 Lifts

1. The installation of all transportation systems shall include proper sizing of the systems such that minimize energy losses.

2. The use of variable speed drives shall be prioritized for efficient system regulation and variable flow control, improving energy performance and system responsiveness.

3. The following are design considerations for energy-efficient vertical transportation systems:

- Group lifts together to reduce the number of journeys by facilitating group travel and minimizing individual trips.
- Select lift speeds that are appropriate to suit their specific purpose, with low speeds designated for cargo or service lifts.
- Select an energy-efficient lift drive and evaluate regenerative drive systems to reuse the energy on-site.
- Place lifts in the most appropriate locations and, preferably, ahead of staircases to encourage their use for accessibility.
- In multiple-lift installations, consider omitting parking feature that direct idle elevators to designated floors.
- Consider shutting down some elevators during their idle hours, such as at the end of the workday, to conserve energy.
- Reduce ventilation and car lighting during unoccupied periods to lower energy consumption.

9.3.5.2 Escalators

1. Power consumption of escalators shall be divided into fixed and variable losses. The gradient of a down escalator's variable losses must be negative.

2. The following are design considerations for energy-efficient escalators and moving walks:
    - Delay starting as long as practicable at the beginning of the working day.
    - Stop certain units when convenient, during non-peak periods and after normal working hours when traffic is low.
    - Use automatic start-up switches or programmed multiple escalators to ensure operation only when there is user demand.
    - Use variable speed escalators and moving walks to optimize energy consumption based on real-time usage.

9.3.6 Pumping Systems

1. The selection of efficient pumps is essential, ensuring they operate close to their rated flow and head. On large sites, decentralized generation of heating and hot water can significantly reduce pumping power requirements and thermal losses.

2. The design of re-circulating heating or cooling water systems shall incorporate variable speed pumps to optimize performance and energy savings.

3. Efficient pumps shall always be selected and operated near their point of maximum efficiency.

4. Variable flow pumping systems shall be preferred owing to their energy saving potential.

5. Pumps shall be properly maintained to avoid losses that result from poor maintenance practices.

6. Pressure drop shall be minimized to around 2 m/s maximum flow in water.

7. Low-friction piping material shall be used during installations, and pumps shall be coated with friction reducers to enhance efficiency during operations.

8. A condition monitoring program for large pumps shall be established to determine the optimal time for maintenance or refurbishment, ensuring reliable and efficient operation.

9.3.7 Equipment for Household and Similar Use

1. All household-related equipment, including refrigerators, dishwashers, electric kettles, and washing machines shall comply with the requirements of IEC 60034-1 and other applicable standards specific to the equipment.

2. Equipment shall conform to internationally recognized efficiency standards and best practices. If such standards are not already in place, the equipment shall meet the requirements of the relevant national MEPS.

9.3.8 Renewable Energy

All buildings within the scope of this Code shall have provisions for the installation of renewable energy systems. The selection and implementation of renewable energy systems shall be based on the sites' locations and applications.

9.3.9 Building Management Systems

1. ABMS shall be installed in buildings to manage and monitor equipment such as ventilation, lighting, power systems, fire systems, and security systems. The primary objective of a BMS are to improve occupant comfort, reducing energy consumption, and optimize the efficient operation of building systems, making it an essential tool for energy conservation.

2. A BMS shall be deployed to monitor and control various building operations, including heating, cooling, and lighting. By analyzing real-time data, the system can automatically adjust the operations to run in the most energy-efficient manner. For example, it can dim or switch off lights in unoccupied areas or adjust the temperature based on occupancy levels in a room.

3. Buildings with a built-up area greater than 20,000 m^2 and demonstrating at least 40% energy savings compared to conventional building shall be required to install a BMS. All mechanical cooling and heating systems in these buildings equipped with programmable logic controller (PLC) to the zone level shall have the following control capabilities for centralized demand shedding in non-critical zones:

   Automatic demand shed controls that can implement a centralized demand shed in non-critical zones during the demand response periods based on a demand response signal.
   Controls that can remotely adjust the operating temperature set points by at least ±4°Cin all noncritical zones, based on signals from a centralized control point.
   Controls that can provide an adjustable rate of change for the temperature setup and reset.

4. A comprehensive BMS shall integrate functionalities such as HVAC system control, energy management, operation and maintenance management, medical gas system monitoring, fire alarm system, security system, lighting control, and other reporting and trending software. The BMS may also be integrated into the building owner’s computer network and made accessible via the Internet for remote monitoring and control.

5. The centralized demand shed controls shall include the following additional functionalities.

6. Facility operators shall have ability to disable demand shed control when necessary (operator override).

7. Facility operators shall be able to manually manage heating and cooling set points from a central control point (manual control).

9.4 Submittals

The following documentation shall be submitted to the authority for verification of Code compliance:

1. A single-line diagram of the building's electrical distribution system.

2. Floor plans indicating location and area served for all distribution systems.

3. Schematic and single-line diagram of electrical control systems used for power saving, if applicable.

4. Manufacturers' data sheets confirming the maximum allowable losses for transformers (applicable only for consumer-owned transformers).

5. A detailed commissioning report of the electrical system.

10 SECTION 10: LIGHTING

10.1 General

This Code sets the maximum allowable loads for building lighting systems and minimum acceptable efficiency limits for commonly used lighting sources and components systems that are connected to the building's electrical systems.

Occupancy sensors shall be installed to minimize electricity usage in unoccupied areas of buildings. These sensors must be integrated with lighting controls in applicable building spaces to ensure efficient operation.

Lighting systems and equipment shall comply with the mandatory requirements and the prescriptive requirements outlined in this code.

The lighting requirements in this section shall apply to:

- Interior spaces of buildings.
- Exterior spaces of buildings.
- Exterior building grounds lighting powered through the building's electrical service.

Exemption

This Section does not apply to the following lighting systems:

- Emergency lighting that is automatically switched off during normal hours of building operation.
- Lighting within individual dwelling units.
- Lighting in buildings, parts of buildings, or certain exterior spaces where the nature of the occupancy makes compliance impractical, as justified through documented evidence.

10.2 Mandatory Requirements

10.2.1 Lighting Control

10.2.1.1 Automatic Lighting Shutoff

Interior lighting systems in buildings or space of building larger than 300m^2 shall be equipped with an automatic control device.

Within these buildings, the following areas shall be equipped with occupancy sensors:

- All office areas less than 30 m^2 (300 ft^2) enclosed by walls or ceiling-height partitions.

- All meeting and conference rooms.
- All school classrooms.
- All storage spaces shall be equipped with occupancy sensors.

For other spaces, the automatic control device shall function through one of the following methods:

- A scheduled basis at specific programmed times. An independent program schedule shall be provided for areas of no larger than 2,500 m^2 (25,000 ft^2) and not spanning more than one floor; or,
- Occupancy sensors that shall turn the lighting off within 10 minutes of the occupant leaving the space. Light fixtures controlled by occupancy sensors shall include a wall-mounted manual switch capable of turning off lights while the space is occupied.

10.2.1.2 Space Control

Each space having ceiling-height partitions and an area less than 30 m^2 shall have at least one control device to independently control space lighting. Spaces larger than 1,000 m^2 shall the capability to control lighting to operate in between 30%-60% of full lighting power.

Spaces excluded automatic controls shall have manual lighting controls that are readily accessible to occupants. Occupancy sensors or a timer control shall be installed to shut off lights within 15 minutes after all occupants leave the space in classrooms, lecture rooms, conference rooms, meeting rooms, training rooms, lunchrooms, restrooms and storage areas less than 100 m^2.

Spaces not covered by occupancy control requirements given above shall be installed with either manual or automatic controls. Each control device shall:

- Control a maximum of 250 m^2 for spaces 1,000 m^2 or smaller and a maximum of 1000 m^2 for spaces greater than 1,000 m^2.
- Be capable of overriding any time-of-day scheduled shutoff control for no more than two hours.
- Be readily accessible and located so the occupant can identify the control.

10.2.1.3 Automatic Daylighting Control

1. Lighting spaces within 6m from the wall surface with at least 20% opening ratio (fenestration area) shall be controlled with a daylight controller.
2. Daylighting areas with top-lighted spaces larger than 500 m^2 shall consist of at least three stage lighting control of 100%, 50%-70% and less than 40% of total lighting power, excluding total shutoff.
3. Daylighting areas with top-lighted spaces smaller than 500 m^2 shall consist of at least two stage lighting control of 100%, 40%-60% of total lighting power, excluding total shutoff.
4. For building Spaces smaller than 1,000 m^2, lighting systems shall include the capability to switch off lighting after reaching 200% of required luminance level.

10.2.1.4 Interior Lighting Control

1. Except as provided in Sentence 2 below, interior lighting controls shall be installed in accordance with this Article for each space type in the building.
2. Where the Lighting Power Density (LPD) requirements are determined in accordance with the space-by-space method described in Code 10.4 of this Section, the same space types shall be used to determine the applicable lighting control requirements from **Table 10.4-1**.
3. At least one manual lighting control device shall be installed in conformance with Sentence 4 in each space type listed in **Table 10.4-1**. To control all the lighting
    A. In each area less than or equal to 250 m^2, where the area of the space is less than or equal to 1 000 m^2, and
    B. In each area less than or equal to 1 000 m^2, where the area of the space is greater than 1 000 m^2.
4. Except as provided in Sentence 5, manual lighting control devices referred to in Sentence 3 shall be installed in a readily accessible location from which occupants can see the controlled lighting.
5. Manual lighting control devices are permitted to be located remotely for reasons of safety or security, provided each control device:
    A. Has an integral or adjacent indicator pilot light, and
    B. Bears a label identifying which lighting it controls.

6. Except as provided in Sentence 7, none of the lighting in spaces requires controls that are restricted to “Manual ON” in accordance with **Table 10.4-1**shall turn on automatically.
7. Sentence 6need not apply where “Manual ON” operation of the general lighting would endanger the safety or security of the building occupants.
8. Up to 50% of the lighting power for the general lighting, and for no other lighting, in spaces requiring controls that are restricted to “Partial Automatic ON” in accordance with **Table 10.4-1**. Is permitted to turn on automatically.
9. The general lighting in spaces requires “Bi-level” lighting control in accordance with **Table 10.4-1**. Shall have controls that allow at least one intermediate level of lighting, in addition to “full ON” and “full OFF,” that is between 30% and 70% full lighting power, and continuous dimming.
10. Except as provided in Sentence 12, the general lighting in primary and secondary side lighted areas, as applicable, in spaces requiring “Automatic Daylight Responsive Controls for Side lighting” in accordance with **Table 10.4-1**. Shall be separately controlled by photo controls that comply with Sentence 11, where.
    A. The combined input power of all the general lighting that is completely or partially within the primary side lighted areas is 150 W or greater, or
    B. The combined input power of all the general lighting that is completely or partially within the primary and secondary side-lighted areas is 300 W or greater.
11. The photo controls required in Sentence 10 shall:
    A. Reduce electric lighting power in response to available daylight through:
        1) At least one intermediate level of lighting that is equivalent to 50% to 70% of design lighting power, at least one other intermediate level of lighting that is equivalent to 20% to 40% of design lighting power, or the lowest dimming level the technology allows, as well as a control point that turns off all the controlled lighting, or
        2) Continuous dimming.

B. Control the general lighting in the secondary side-lighted area independently of the general lighting in the primary side-lighted area, and

C. Be readily accessible for calibration adjustments.

12. General lighting in the following areas need not comply with Sentence 10:

A. Primary side-lighted areas where the vertical projected distance from the top of the windows to the top of any adjacent structure divided by the horizontal distance from the window to the adjacent structure is greater than or equal to 2,

B. Side-lighted areas where the total glazing area is less than 2 m2, and

C. Retail spaces.

13. Except as provided in Sentence 15, the general lighting in delighted areas under skylights and roof monitors in spaces requiring “Automatic Daylight Responsive Controls for Top lighting” in accordance with **Table 10.4-1** shall be controlled by photo controls that comply with Sentence 14, where the combined input power of all the general lighting that is completely or partially within the day lighted areas under skylights and under roof monitors is 150 W or greater.

14. The photo controls required in Sentence 13 shall:

A. Reduce electric lighting power in response to available daylight through:

1) At least one intermediate level of lighting that is equivalent to 50%-70% of design lighting power, at least one other intermediate level of lighting that is equivalent to 20% -40% of design lighting power, or the lowest dimming level the technology allows, as well as a control point that turns off all the controlled lighting, or

2) Continuous dimming.

B. Control the general lighting in overlapping top lighted and side lighted areas together with the general lighting in the day lighted areas under skylights or roof monitors, and

C. Be readily accessible for calibration adjustments.

15. General lighting in the following areas need not comply with Sentence (13):

A. Day lighted areas under skylights and roof monitors where it can be demonstrated that existing adjacent structures or natural objects block direct sunlight for more than 1 500 hours per year between 8 a.m. and 4 p.m.,
B. Day lighted areas where the visual transmittance(VT) of the skylights and roof monitors is less than 0.4, and
C. Spaces in buildings located above the 55°N latitude where the input power of the general lighting within day lighted areas is less than 200 W.

16. Except as provided in Sentence 17, the power for general lighting in spaces requiring controls that are “Automatic Partial OFF” in accordance with **Table 10.4-1**. Shall automatically reduce by 50% or more within 20 min of the space being unoccupied.
17. General lighting need not be controlled in accordance with Sentence 16 where:
    A. The lighting power density for the space is not greater than 8.6 W/m^2,
    B. The space is lit by high intensity discharge (HID) lamps, and c) the power for the general lighting in the space reduces automatically by 30% or more within 20 min of the space being unoccupied.
18. Except as provided in Sentence 19, the lighting in spaces requires controls that are “Automatic Full OFF” in accordance with **Table 10.4-1**. Shall be controlled by automatic control devices that shut off the lighting within 20 min of the space being unoccupied, where each automatic control device controls an area not greater than 50 m^2.
19. The following lighting applications need not comply with Sentence 18:
    A. General lighting and task lighting in shop and laboratory classrooms,
    B. General lighting and task lighting in spaces where automatic shut-off would endanger the safety or security of the building occupants, and
    C. Lighting required to operate continuously due to operational requirements.
20. Except as provided in Sentence 23, the lighting in spaces requiring controls that are “Scheduled Shutoff” in accordance with **Table 10.4-1**. Shall shut off automatically during periods when the spaces are scheduled to be

unoccupied by means of control devices complying with Sentence 21 that are.

A. Time-of-day operated control devices that automatically turn the lighting off at programmed times, or
B. Signals from other automatic control devices or alarm/security systems.

21. A control device installed to meet the requirements of Sentence 20 shall control the lighting for an area of not more than 2500 m^2 on not more than one floor.
22. Any manual control device installed to override the “Scheduled Shut-off” control device required in Sentence 20 shall:
    A. Turn the lighting on for 2h or less per activation during scheduled “off” periods, and
    B. Control an area of 500 m^2 or less.
23. Lighting need not be controlled in accordance with Sentence 20 where it is:
    A. Required to operate continuously due to operational requirements,
    B. Located in spaces where patient care is rendered, or
    C. Located in spaces where automatic shut-off would endanger the safety or security of the building occupants.

10.2.1.5 Lighting Controls in Storage Garages

1. Lighting in a storage garage shall be divided into zones no larger than 360 m^2.
2. Except as provided in Sentence 5, the lighting power in a lighting zone referred to in Sentence 1 shall be controlled by a device that automatically reduces the lighting power by at least 30% when no activity is detected for 20 min.
3. Lighting for covered vehicle entrances and exits from storage garages shall be separately controlled by a device that automatically reduces the lighting by at least 50% from sunset to sunrise.
4. Except as provided in Sentence 5, where the combined input of all luminaires within 6.1 m of any perimeter wall having a net opening- to -wall ratio of at least 40% and no exterior obstructions within 6.1 m exceeds 150 W, the power to those luminaires shall be automatically reduced in response to daylight.

5. Daylight transition zones and ramps without parking need not comply with the provisions of Sentences 1, 2 and 4.

10.2.1.6 Special Applications

1. The following lighting applications shall be controlled separately from the general lighting in all spaces:
    - A. Display or accent lighting,
    - B. Lighting in display and merchandising cases,
    - C. Lighting for non-visual applications, such as plant growth and food warming, and
    - D. Lighting equipment that is for sale or for demonstrations in lighting education.
2. Except for night lighting in bathrooms that does not exceed 2W, all lighting and all switched receptacles used for lighting in guest rooms and suites in commercial temporary lodgings shall be controlled so that their power supply turns off within 20 minutes of the space being unoccupied.

3. Where captive key systems are used to meet the requirements of Sentence 2, they shall be located at the entrance to each guest room and suite.

4. All supplemental task lighting, including permanently installed under shelf or under cabinet lighting, shall be controlled by a device that is:
    - A. Integral to the luminaires, or
    - B. Wall-mounted in a readily accessible location from which the occupant can see the controlled lighting.

10.2.1.7 Exterior Lighting Control Requirements

1. Except as provided in Sentences 2 and 3, exterior lighting shall be controlled by either of following:
    - A. Astronomical time controls,
    - B. Photo sensors,
    - C. A combination of photo sensors and timer shut-off switch, or
    - D. Other types of controls that perform the same function as those referred to in Clauses (A) to (C).
2. Except as provided in Sentence3, exterior lighting designated for dusk- to -dawn operation shall be controlled by:

   A. Astronomical time controls, or
   B. Photo sensors.
3. Exterior lighting for covered vehicle exterior entrances or exterior exits from buildings or storage garages need not comply with Sentences 1 and 2 where it is required for safety, security, or eye adaptation.
4. Except as provided in Sentence 5, all exterior lighting, including advertising signage and parking lot lighting, shall be equipped with a device that has the capability to automatically reduce the total connected lighting power by at least 30%.
5. Facade lighting and landscape lighting shall have the capability to shut off automatically.
6. All lighting schedule controllers shall be equipped with backup provisions to retain programming and the time setting for at least 10 hours during a power outage.
7. All lamps used in exterior lighting greater than 70W of power shall have a minimum luminous efficacy of 80 lm/W.

10.2.2 Exit Signs

Internally illuminated exit signs shall not exceed 5W per face.

10.2.3 Exterior Building Grounds Lighting.

Lighting for exterior building ground luminaires which operate at greater than 100 W shall contain lamps having a minimum luminous efficacy of 60 lm/W unless the luminaire is controlled by a motion sensor.

10.3 Prescriptive Requirements

10.3.1 Interior Lighting Power

10.3.1.1 Installed Interior Lighting Power

The installed interior lighting power calculated for compliance with 9.3 shall include all power used by the luminaires, including lamps, ballasts, current regulators, and control devices.

Exception to 10.3.3: If two or more independently operating lighting systems in a space are controlled to prevent simultaneous user operation, the installed interior lighting power shall be based solely on the lighting system with the highest power.

10.3.1.2 Luminaire Wattage

Light output ratio shall be 0.7 or above. Luminaire wattage incorporated into the installed interior lighting power shall be determined in accordance with the following:

1. The wattage of incandescent luminaires with medium base sockets and not containing permanently installed ballasts shall be the maximum labeled wattage of the luminaires.
2. The wattage of luminaires containing permanently installed ballasts shall be the operating input wattage of the specified lamp/ballast combination. Operating input wattage can be either values from manufacturers' catalogs or values from independent testing laboratory reports.
3. The wattage of all other miscellaneous luminaire types not described in (1) or (2`) shall be the specified wattage of the luminaires.
4. The wattage of lighting track, plug-in busway, and flexible-lighting systems that allow the addition and/or relocation of luminaires without altering the wiring of the system shall be the larger of the specified wattage of the luminaires included in the system or 135W/m. Systems with integral overload protection, such as fuses or circuit breakers, shall be rated at 100% of the maximum rated load of the limiting device.

10.3.1.3 Limits to Installed Interior Lighting Power

1. The installed interior lighting power described in Sub-Section 10.3.1 of this section. Shall not exceed the value of the interior lighting power allowance determined using:
   A. The building area method described in Sub-Section 10.3.2 of this Section, or
   B. The space-by-space method described in Sub-Section 10.4 of this Section.
2. The individual power allowances in each space of the building do not have to be met, provided the total installed interior lighting power is not exceeded.
3. Only one of the methods described in Sentence 1 shall be selected for use within the same building.

10.3.1.4 Determination of the Installed Interior Lighting Power

1. Except as provided in Sentences 4 and 5, the installed interior lighting power shall include all power used by the luminaires, including lamps, ballasts, transformers, and control devices.
2. The determination of the installed interior lighting power shall include:
   A. connected lighting power for both permanently installed interior lighting and supplemental interior lighting provided by movable or plug-in luminaires, and
   B. In cases where two or more independently operating lighting systems in a space are controlled to prevent simultaneous operation, the lighting system with the highest wattage.
3. Luminaire wattage to be included in installed interior lighting power shall be determined in accordance with the following criteria:
   A. Except as provided in Clause (B), the wattage of luminaires shall be the design operating input wattage of the lamp/auxiliary combination based on values provided by a recognized testing laboratory or, in the absence of such information, the maximum labeled wattage of the luminaire shall be used.
   B. The wattage of luminaires with ballasts designed for multiple wattages shall be the maximum labeled wattage of the luminaire,
   C. For line voltage lighting track and plug-in busway designed to allow the addition and/or relocation of luminaires without altering the wiring of the system, the wattage shall be:
      1) The specified wattage of the luminaires included in the system with a minimum of 98 W/m,
      2) The wattage limit of the system's circuit breaker, or
      3) The wattage limit of other permanent current limiting device(s) on the system,
   D. The wattage of low voltage lighting track, cable conductor, rail conductor, and other flexible lighting systems that allow the addition and/or relocation of luminaires without altering the wiring of the system shall be the specified wattage of the transformer supplying the system, and
   E. The wattage of all other miscellaneous lighting equipment shall be the specified wattage of the lighting equipment.

4. Lighting for the following functions, spaces or equipment need not be included in the calculation of installed interior lighting power:
    A. Display or accent lighting that is an essential element for the function it performs in galleries, museums, and monuments,
    B. Lighting that is integral to equipment or instrumentation and is installed by its manufacturer.
    C. Lighting specifically designed for use only during medical or dental procedures,
    D. Lighting integral to both open and glass enclosed refrigerator and freezer cases,
    E. Lighting integral to food warming and food preparation equipment,
    F. Lighting for plant growth or maintenance,
    G. Lighting in retail display windows, provided the display area is enclosed by ceiling height partitions,
    H. Lighting in interior spaces that have been specifically designated as a registered interior historic landmark,
    I. Lighting that is an integral part of advertising or directional signage,
    J. Exit signs,
    K. Lighting that is for sale or for lighting educational demonstration systems,
    L. Lighting for theatrical purposes, including performance, stage, and film and video production,
    M. lighting for television broadcasting in sporting activity areas,
    N. Casino gaming areas,
    O. Mirror lighting in dressing rooms, and
    P. Accent lighting in religious pulpit and choir areas.
5. Lighting for functions, spaces or equipment need not be included in the calculation of installed interior lighting power where it can be shown that its inclusion will adversely affect the intended functions or the use of the space or equipment.

10.3.2 Building Area Method

1. The Building Area method of calculating interior lighting power allowance shall follow these steps:
    A. Determine the appropriate building area type from **Table 10-1** and the corresponding Lighting Power Density (LPD) allowance. For

building area types not listed, selection of a reasonably equivalent type shall be permitted.

B. Determine the gross lighted floor area in m^2 of the building area type.

C. Multiply the gross lighted floor areas of the building area types by the LPD.

D. The interior lighting power allowance for the building is the sum of the lighting power allowance of all building area types. Trade-offs among building area types are permitted, provided that the total installed interior lighting power does not exceed the interior lighting power allowance.

2. Except as provided in Sentence 3, interior lighting power allowance calculations shall be based on the primary use for which the building is intended.
3. Where 10% or more of the gross lighted area of the building can be classified as being of a building type other than the principal type for the building, the interior lighting power allowance shall be calculated using the space -by- space method described in Subsection 10.4. Of this Section.
4. Where the building is of a type other than those listed in **Table 10-1** and no equivalent building type can be selected, the interior lighting power allowance shall be calculated using the space -by- space method described in Subsection 10.4. Of this Section.
5. The interior lighting power allowance using the building area method shall be calculated by multiplying the lighting power density, in W/m^2, for the building type provided in **Table 10-1**. By the gross lighted area, in m^2.

Table 10-1Lighting Power Density by Building Type for Use with the Building Area Method

Forming Part of Sentences 10.3.2. (1), (4) and (5)

Building Area Type	**LPD(W/m^2)**	**Building Area Type**	**LPD(W/m^2)**
Office Building	6.9	Police Station	7.1
Healthcare-Clinic	8.7	Sports Arena	8.2
Hospital/HealthCare	10.3	Parking Garage	3.2
Hotels/Motel	6.0	Warehouse	4.8
Courthouse	8.5	Convention Center	6.9
Shopping mall	7.0	Post Office/Town Hall	7.0

Building Area Type	LPD(W/m^2)	Building Area Type	LPD(W/m^2)
University and Schools	7.8	Museum	5.9
Religious Building	7.2	Workshop	9.8
Multifamily Residential	4.8	Library	8.9
Dining: family	7.6	Dining: Bar Lounge/ Leisure	8.6
Dormitory/Hostel	7.6	Dining: Cafeteria/Fast Food	8.2

10.3.3 Exterior Lighting Power

1. Exterior lighting allowances shall be based on the lighting zone in which the building is located, as determined from **Table 10-2**.

Table 10-2Lighting Zones Used to Determine Exterior Lighting Allowances
Forming Part of Sentence 10.3.3. (1)

Lighting Zone	Description
0	Undeveloped areas within national, provincial, or territorial parks, forest land, and rural areas, and other undeveloped areas
1	Developed areas within national, provincial, or territorial parks, and rural areas
2	Areas predominantly consisting of residential zoning, neighborhood business districts, light industrial areas with limited nighttime use, and residential mixed-use areas
3	All other areas
4	High-activity commercial districts

2. The basic site allowance to be applied in the calculation of maximum connected exterior lighting power in Sentences 3 to 5 shall not exceed the limits specified in **Table 10-3**for the applicable lighting zone.
3. Except as provided in Sentence 6, the connected exterior lighting power for each specific building exterior application listed in **Table 10-4** that is to be illuminated shall not be greater than the individual allowance for that application taken from **Table 10-4** for the applicable lighting zone plus any unused power applied from the basic site allowance listed in **Table 10-3.**

4.

Table 10-3 Basic Site Allowances for Exterior Lighting

Forming Part of Sentences 10.3.3. (2) and (3)

Basic Site Allowance According to Lighting Zone				
Zone 0	Zone 1	Zone 2	Zone 3	Zone 4
No allowance	350 W	400 W	500 W	900 W

5. Except as provided in Sentence (6), the connected exterior lighting power for all general building exterior applications not listed in **Table 10-4** that are to be illuminated shall not be greater than the sum of the individual allowances for these applications provided in **Table 10-5**for the applicable lighting zone plus any remaining basic site allowance not used in compliance with Sentence (3).

Table 10-4Lighting Power Allowances for Specific Building Exterior Applications

Forming Part of Sentences 10.3.3. (3) and (4)

Exterior Application	**Lighting Power Allowances According to Lighting Zone**				
	Zone 0	**Zone 1**	**Zone 2**	**Zone 3**	**Zone 4**
Building facades (facade lighting)	A single luminaire of 25 W or less may be installed for each roadway or parking entry, trail head, and toilet facility, or other locations approved by the authority having jurisdiction	No allowance	1.1 W/m^2 for each illuminated wall or surface, or 8.2 W/m for each illuminated wall or surface length	1.6 W/m^2 for each illuminated wall or surface, or 12.3 W/m for each illuminated wall or surface length	2.2 W/m^2 for each illuminated wall or surface, or 16.4 W/m for each illuminated wall or surface length
Automated teller machines (ATM) and night depositories		135 W per location plus 45 W per additional ATM per location			
Entrances and gatehouse inspection stations at guarded facilities		5.4 W/m^2 of covered and uncovered area			

Exterior Application	Lighting Power Allowances According to Lighting Zone				
	Zone 0	**Zone 1**	**Zone 2**	**Zone 3**	**Zone 4**
Loading areas for law enforcement, fire, ambulance, and other emergency service vehicles		3.8 W/m^2 of covered and uncovered area			
Drive-up windows and doors		200 W per drive-through			
Parking near 24-hour retail entrances		400 W per main entry			

6. Except as provided in Sentence (6), the connected exterior lighting power for all building exterior applications not listed in **Table 10-5**that are to be illuminated shall not be greater than the sum of the individual allowances for these applications provided in **Table 10-6**for the applicable lighting zone plus any remaining basic site allowance not used in compliance with Sentences 3 and 4.
7. The following exterior lighting applications need not comply with Sentences 1 to 5 where the lighting is equipped with an independent control device:
   A. specialized signal, directional, and marker lighting associated with transportation,
   B. lighting for advertising and directional signage,
   C. lighting integral to equipment or instrumentation and installed by its manufacturer,
   D. lighting for theatrical purposes, including performance, stage, film, and video production,
   E. lighting for athletic activity areas,
   F. temporary lighting,
   G. lighting for industrial production, material handling, transportation sites, and associated storage areas for industrial sites,

H. lighting for theme elements in theme/amusement parks, and

I. Lighting used to highlight features of art objects, public monuments and designated national or provincial historic sites.

Table 10-5Lighting Power Allowances for General Building Exterior Applications

Forming Part of Sentences 10.3.3. (4) and (5)

Exterior Application	Lighting Power Allowances According to Lighting Zone				
	Zone 0	Zone 1	Zone 2	Zone 3	Zone 4
Uncovered Parking Areas ○ Parking areas and drives	No allowances	0.32 W/m^2	0.43 W/m^2	0.65 W/m^2	0.86 W/m^2
Building Grounds ○ Walkways less than 3 m wide		0.6 W/m	1.6 W/m	2.0 W/m	2.3 W/m
○ Walkways 3 m wide or greater, plaza areas, special feature areas		1.1 W/m^2	1.1 W/m^2	1.2 W/m^2	1.5 W/m^2
○ Dining areas		7.0 W/m^2	7.0 W/m^2	8.1 W/m^2	10.2 W/m^2
○ Stairways		6.5 W/m^2	7.5 W/m^2	7.5 W/m^2	7.5 W/m^2
○ Pedestrian tunnels		1.3 W/m^2	1.3 W/m^2	1.5 W/m^2	2.3 W/m^2
○ Landscape lighting		2.1 W/m^2	0.43 W/m^2	0.43 W/m^2	0.43 W/m^2
Exterior Entrances and Exterior Exits ○ Pedestrian and vehicular entrances and exits	No allowances	46 W/m of opening	46 W/m of opening	69 W/m of opening	69 W/m of opening
○ Entry canopies		2.1 W/m	2.7 W/m	4.3 W/m	4.3 W/m
Loading docks	No allowances	3.8 W/m^2			

Exterior Application	Lighting Power Allowances According to Lighting Zone				
	Zone 0	Zone 1	Zone 2	Zone 3	Zone 4
Sales Canopies ○ Free-standing and attached	No allowances	4.3 W/m^2	4.3 W/m^2	6.5 W/m^2	7.5 W/m^2
Outdoor Sales ○ Open areas (including vehicle sales lots) ○ Street frontage for vehicle sales lots in addition to "open area" allowance	No allowances	2.1 W/m^2	2.1 W/m^2	3.8 W/m^2	5.4 W/m^2
		No allowances	23W/m	23W/m	69 W/m

Table 10-6Lighting Power Allowances for Building Exterior Applications

Not Covered in Sub-Section 10.3.3. (5) Of this Section.

Exterior Application	Lighting Power Allowances According to Lighting Zone, % of interior lighting power allowance in W/m2				
	Zone 0	Zone 1	Zone 2	Zone 3	Zone 4
Areas not covered in Article 9.3.3 (5)	0%	65%	65%	80%	100%

10.4 Alternative Path- Space by Space Method

Calculation of Interior Lighting Power Allowance Using the Space-by-Space Method

The interior lighting power allowance using the space-by-space method shall be determined as follows:

A. Determine the appropriate space type and the corresponding LPD allowance from Table **10-7**. If a space has multiple functions, where more than one space type is applicable, that space shall be broken up into smaller subspaces, each using its own space type from **Table 10-7**.
B. Based on the space type selected for each space or subspace, determine the lighting power allowance of each space or subspace by multiplying the calculated area of the space or subspace by the appropriate LPD allowance

given in **Table 10-7**. For space types not listed, selection of a reasonably equivalent type shall be permitted.

C. The interior lighting power allowance is the sum of the lighting power allowances of all spaces and subspaces. Trade-offs among spaces and subspaces are permitted, provided that the total installed interior lighting power does not exceed the interior lighting power allowance.

Table 10-7Lighting Power Density Using the Space-by-Space Method and Minimum Lighting Control Requirements

Category	LPD (W/m^2)	Category	LPD (W/m^2)
Common space types			
Office-enclosed	7.1	Stairway	5.3
Office-open plan	6.6	Corridor/transition	4.4
Conference/meeting/ multipurpose	10.5	Vehicle maintenance area	6.5
Restrooms	4.4	Lobby	9.0
Workshop	13.5	Storage	4.1
Laboratory	14.3	Dressing/locker/fitting room	5.6
Computer/Server room	10.1	Copy/print room	3.3
Hospital			
Nurse station	12.6	Medical supply room	6.7
Nursery	9.9	Recovery	13.5
Pharmacy	17.9	Physiotherapy	9.8
Patent room	7.3	Operating room	24.3
Exam/treatment room	15.1	Laundry—washing	5.7
Classroom/lecture/training		Courthouse/Police station/penitentiary	
Penitentiary	9.5	Courtroom	12.9
All other classroom/lecture/ training	7.6	Confinement cells	7.5
Dormitory		Washroom	13.5
Living quarters	5.4	Dining area	
Seating area general	2.5	Hotel	4.3
Warehouse		Bar lounge/leisure dining	9.3
Fine material storage	3.6	Family dining	6.5
Small hand-carried	7.4	All other dining area	4.7
Religious buildings		Storage room	
Worship pulpit, choir	9.2	$<5m^2$	5.5

Category	LPD (W/m^2)	Category	LPD (W/m^2)
Fellowship hall	5.8	>5m^2	4.1
		Inactive storage	
Library		Museum	11.9
Stacks	12.7	Workshop	13.5
Reading area	10.3	All other inactive storage	13
Audience seating area-permanent			
Auditorium	6.5	Sports arena	3.5
Religious building	7.8	Others	2.5

10.5 Submittals

A complete set of plans, depicting lighting devices, shall be submitted to the Authority. These plans shall be accompanied by the following information:

A. The standard and design-maintained illuminances for all the interior spaces.
B. The specifications and numbers of each type of lighting device.
C. The total power of each type of lighting device, including nominal rating and control gear losses.
D. The installed lighting power for interior and exterior spaces.
E. Control systems installed for the lighting system components including locations of sensors and controls.

In addition, any other submittal of compliance with this standard, incorporating information as required by each of the subsections above, shall be required by the Authority.

11 APPENDICES

11.1 Appendix 1: Building Classification

1. **Use Groups A, B and C**: Residential buildings (other than dwelling houses) and special residential buildings used for commercial purpose such as:

i. Boarding Houses. Block of flats, apartment houses, and housing estate meant for different housing density but principally of marionettes and/or detached and/or terraced dwelling house, residential accommodation over or attached to shops and offices, so far as it applies to that portion designed for dwelling purposes only, residential clubs and convalescent and nursing homes.

ii. Hospitality buildings: Any building in which sleeping accommodation is provided for commercial purposes, except any building classified under health care. Buildings and structures under hospitality shall include the following:

a. No-star Hotels – like lodging-houses, dormitories, no-star hotels/motels and resort, guest house, lodge, public or private licensed for boarding and the sale of intoxicating liquor, rest house.
b. Star Hotels – hotels classified under a recognized star rating system based on facilities, amenities, and services provided
c. Hostels and residential educational facilities – hostels, institutional accommodation such as residential portion of schools, institutes, colleges, universities, convents, and monasteries.

iii. Healthcare buildings: Any building or part thereof, which is used for purposes such as medical or other treatment or care of persons suffering from physical or mental illness, disease, or infirmity; care of infants, convalescents, or aged persons, and for penal or correctional detention in which the liberty of the inmates is restricted. Health care buildings ordinarily provide sleeping accommodation for the occupants. Buildings and structures like hospitals, sanatoria, out-patient healthcare, laboratories, research establishments, and test houses are included under this type.

2. **Use Group G**: Offices including central or local government offices, offices of any organization or political party, embassies, and other diplomatic missions, including offices of international organizations enjoying diplomatic privileges, offices of parastatal organizations, offices of business or professions not including public offices listed in refer to United Republic of Tanzania National Building Code.

3. **User Group D and E**: Buildings used for business purpose both day time and 24-hour business buildings; buildings which are used primarily for the storage of goods, wares or merchandise and buildings for retail trade or retail services but excluding cafés or restaurants, bars (licensed for the sale of intoxicating liquor), hairdressers, cleaners and dyers, shops for the sale of uncooked meats, fish or fried fish, retail markets and petrol service stations.

4. **Use Group Hand P**: Public buildings and places of assembly, such as art galleries, museums, exhibition halls, meeting halls and houses and public halls.
    i. Assembly: Any building or part of a building, where number of persons congregate or gather for amusement, recreation, social, religious, patriotic, civil, travel including public bathing and swimming establishments, clinics, health centers, dispensaries, clinic logy lab center not including animal clinics or dispensaries and excluding retail pharmacy shops.

    ii. Clubs - non-residential, community centers, function halls, concert halls, cinemas, theatres, lecture halls, gymnasia, courts of law, buildings for social service, voluntary or charitable associations, public libraries, post offices, police posts and police stations, places of worship, mandals and places for religious institutions.

    iii. Similar purposes -Buildings like theatres or motion picture halls, gathering halls, and transport buildings like airports, railway stations, bus stations, and underground and elevated mass rapid transit system are included in this group.

5. **Use Group L**: Wholesale and storage warehouses designed both for storage of goods and transaction of business (other than retail business) relating to such goods; storage and transit warehouses and go-downs (not including storage of offensive goods or materials); and furniture repositories.

6. **Use Group M, N, O and R**: Industrial - Service trades, special industrial, general industrial plant, and animal husbandry, including manufacture or processing of confectionery, motor vehicle light repairs and servicing and workshops, yards, storehouses, plant, and animal husbandry.

7. **User Group K**: Educational Buildings.

   i. Buildings used for nursery, day care and kindergarten, primary schools, secondary schools, schools/faculties, institutes, colleges, university colleges, and universities.

   ii. Buildings used for schools, colleges, universities, and other training institutions for day-care purposes involving assembly for instruction, education, or recreation for students. If residential accommodation is provided in the schools, colleges, or universities or coaching/ training institution, that portion of occupancy shall be classified as a no-star hotel. Buildings and structures under educational shall include following types.

8. **Mixed-use Building**: In a mixed-use building, each commercial part of a building must be classified separately, and

   i. If a part of the mixed-use building has different classification and is less than 10% of the total above grade floor area, the mixed-use building shall show compliance based on the building sub-classification having higher percentage of above grade floor area.

ii. If a part of the mixed-use building has different classification and one or more sub-classification is more than 10% of the total above grade floor area, the compliance requirements for each sub-classification, having area more than 10% of above grade floor area of a mixed-use building shall be determined by the requirements for the respective building classification in 4A to 4F.

iii. Any building which does not fall under any of the categories defined above shall be classified in a category mentioned above that best describes the function of the building.

11.2 Appendix 2: Envelope Thermal Transfer Value - ETTV Formula

The ETTV formula is given as follows:

$$ETTV = 12\,(1 - WWR)\,U_w + 3.4\,(WWR)\,U_f + 211\,(WWR)\,(CF)\,(SC)$$

Where:

ETTV	Envelope thermal transfer value (W/m^2)
WWR	Window-to-wall ratio (fenestration area/gross area of exterior wall)
U_w	Thermal transmittance of opaque wall (W/m^2K)
U_f	Thermal transmittance of fenestration (W/m^2K)
CF	Correction factor for solar heat gain through fenestration
SC	Shading coefficients of fenestration

Where more than one type of material and/or fenestration is used, the respective term or terms shall be expanded into sub-elements as shown:

$$ETTV = \frac{12\ (A_{w1} \times U_{w1} + A_{w2} \times U_{w2} + \ldots + A_{wn} \times U_{wn})}{A_O} + \frac{3.4\ (A_{11} \times U_{11} + A_{12} \times U_{12} + \ldots + A_{fn} \times U_{fn})}{A_O} + \frac{211\ (A_{11} \times SC_{11} + A_{12} \times SC_{12} + \ldots A_{fn} \times SC_{fn})\ (CF)}{A_O}$$

Where:

A_{w1}, A_{w2}, A_{wn}	Areas of different opaque wall (m^2)
A_{f1}, A_{f2}, A_{fn}	Areas of different fenestration (m^2)
A_o	Gross area of the exterior wall (m^2)
U_{w1}, U_{w2}, U_{wn}	Thermal transmittances of opaque walls (W/m^2K)
U_{f1}, U_{f2}, U_{fn}	Thermal transmittances of fenestrations (W/m^2K)
SC_{f1}, SC_{f2}, SC_{fn}	Shading coefficients of fenestrations
CF	Correction factor for solar heat gain through fenestration

As walls at different orientations receive different amounts of solar radiation, it is necessary in general to first compute the ETTVs of individual walls, then the ETTV of the whole building envelope is obtained by taking the weighted average of these values. To calculate the ETTV for the envelope of the whole building, the following formula shall be used:

$$ETTV = \frac{A_{01} \times ETTV_1 + A_{02} \times ETTV_2 + \ldots + A_{on} \times ETTV_n}{A_{01} + A_{02} + \ldots + A_{on}}$$

Where:

$ETTV_1$, $ETTV_2$, $ETTV_n$ are ETTVsof the wall of each orientation i(W/m^2).

A01, A02, A0n are gross areas of the exterior wall for each orientation (m2).

N is the total number of orientations considered.

The solar correction factors for eight primary orientations of the walls have been determined for the climate conditions of Tanzania. They are given in **Table A.2-1**

Table A.2-1Solar Correction Factors (CF) for Walls

Pitch Angle	Orientation							
	N	**NE**	**E**	**SE**	**S**	**SW**	**W**	**NW**
70^0	1.17	1.33	1.47	1.35	1.21	1.41	1.56	1.38
75^0	1.07	1.23	1.37	1.25	1.11	1.32	1.47	1.28
80^0	0.98	1.14	1.30	1.16	1.01	1.23	1.39	1.20
85^0	0.89	1.05	1.21	1.07	0.92	1.14	1.31	1.11
90^0	0.80	0.97	1.13	0.98	0.83	1.06	1.23	1.03
95^0	0.73	0.90	1.05	0.91	0.76	0.99	1.15	0.96
100^0	0.67	0.83	0.97	0.84	0.70	0.92	1.08	0.89
105^0	0.62	0.77	0.90	0.78	0.65	0.86	1.01	0.83
110^0	0.59	0.72	0.83	0.72	0.61	0.80	0.94	0.78
115^0	0.57	0.67	0.77	0.67	0.58	0.75	0.87	0.73
120^0	0.55	0.63	0.72	0.63	0.56	0.71	0.81	0.69

Note: 1. The correction factors for other orientations and other pitch angles may be obtained by interpolation.

If the wall is curved, the eight primary orientations are segmented as follows:

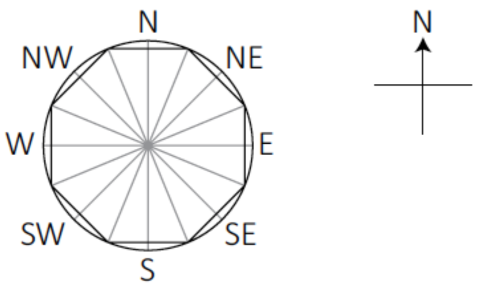


Figure 11-1Eight Primary Orientation for a Curved Wall

Shading Coefficient

Shading coefficient of the fenestration system is defined as the ratio of solar heat gain through the fenestration system having combination of glazing and shading device to the solar heat gain through an unshaded 3mm clear glass. This ratio is a unique characteristic of each type of fenestration system and is represented by the equation:

$$SC = \frac{\text{Solar heat gain of any glass and shading combination Solar}}{\text{heat gain through a 3mm unshaded clear glass}}$$

In general, the shading coefficient of any fenestration system can be obtained by multiplying the shading coefficient of the glass (or effective shading coefficient of glass with solar control film where a solar control film is used on the glass), and the shading coefficient of the sun-shading devices as follows:

$SC = SC_1 \times SC_2$

Where:

SC: shading coefficient of the fenestration system

SC_1: shading coefficient of glass or effective shading coefficient of glass with solar control film where a solar control film is used on the glass.

SC_2: effective shading coefficient of external shading devices.

The shading coefficient of the glass or effective shading coefficient of glass with solar control film should be based on the manufacturer's recommended value.

The effective shading coefficient of external shading devices as given in Tables A.2-2 to A.2-13 shall be used unless the type of shading device is not included in the tables. In that case, the effective shading coefficient shall be calculated from the basic solar data with the method specified below.

Method of calculating effective shading coefficient of external sun- shading device

When a window is partially shaded by an external shading device, it is assumed that the exposed portion receives the total radiation, IT, and the shaded portion receives only the diffuse radiation, Id.

The instantaneous heat gain due to solar radiation can then be expressed as follows:

$$\begin{aligned} Q &= (A_e \times I_T) + (A_S \times I_d) \\ &= (A_e \times I_D) + (A_e + A_S) \times I_d \end{aligned}$$

Where:

Q: solar heat gain

A_e: exposed area of window

A_s: shaded area of window

I_T: total radiation

I_D: direct radiation

I_d: diffused Radiation

Since

$A = A_e + A_s$

Therefore

$Q = (A_e \times I_D) + (A \times I_d)$

For an unshaded 3mm clear glass, the solar heat gain is given by $A \times I_T$. The hourly Shading Coefficient, SC, of a shading device can be expressed as:

$$SC = \frac{(A_e \times I_D) + (A \times I_d)}{A \times I_T}$$

$$= \frac{G \times I_D + I_d}{I_T}$$

Where:

$$G = \frac{A_e}{A}$$

, the fraction of area exposed to direct solar radiation.

To calculate SC of a shading device for the whole day, the hourly solar heat gain shall be computed and summed up for the 12 daylight hours. The total solar heat gain is then divided by the sum of the total radiation, I_T, through an unshaded 3mm clear glass for the same hours of the day, to obtain the SC for the day. Mathematically, the computation can be expressed as follows:

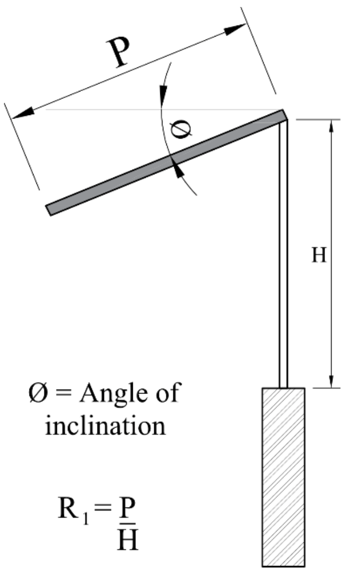
$$SC_{day} = \frac{\sum_{h=1}^{h=12} (A_e \times I_D + I_d)_h}{\sum_{h=1}^{h=12} (A \times I_T)_h}$$

Where subscripts ‘day’ and ‘h’ refers to daily and hourly respectively. To determine the effective SC of a shading device, theoretically, the computation must be carried out for each day of the year.

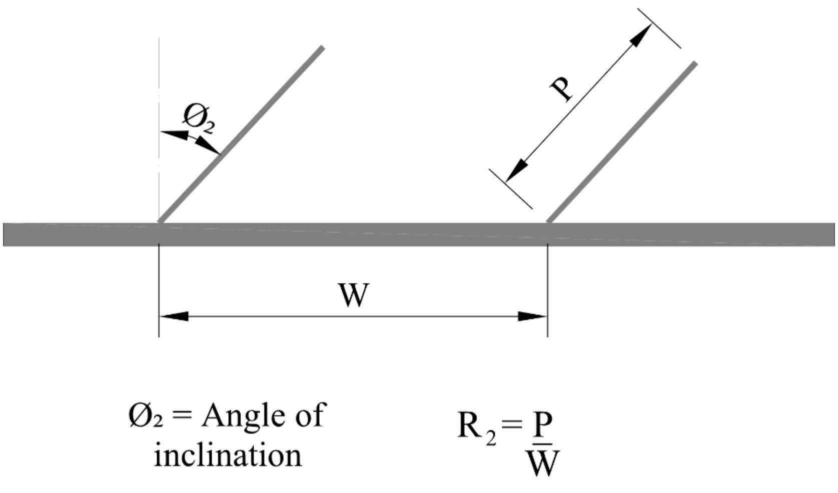
This methodology ensures consistent assessment of shading device effectiveness and aligns with international energy efficiency standards, such as ASHRAE 90.1, ISO 52016-1, and ECBC guidelines for solar heat gain calculations.

Keys for Tables of Effective Shading Coefficient of External Shading Devices

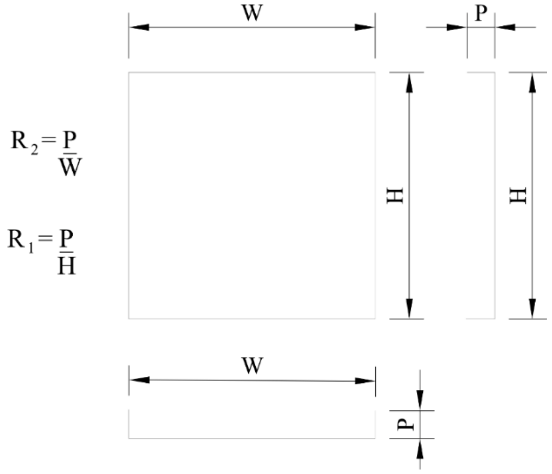
Key 1 Horizontal Projections [Tables A.2-1to A.2-5]



Key 2 Vertical Projections [Tables A.2-6 to A.2-9]



Key 3Egg-crate Louvers [Tables A.2-10 to A.2-13]



Key 4 Projection Factors in Fenestration Energy

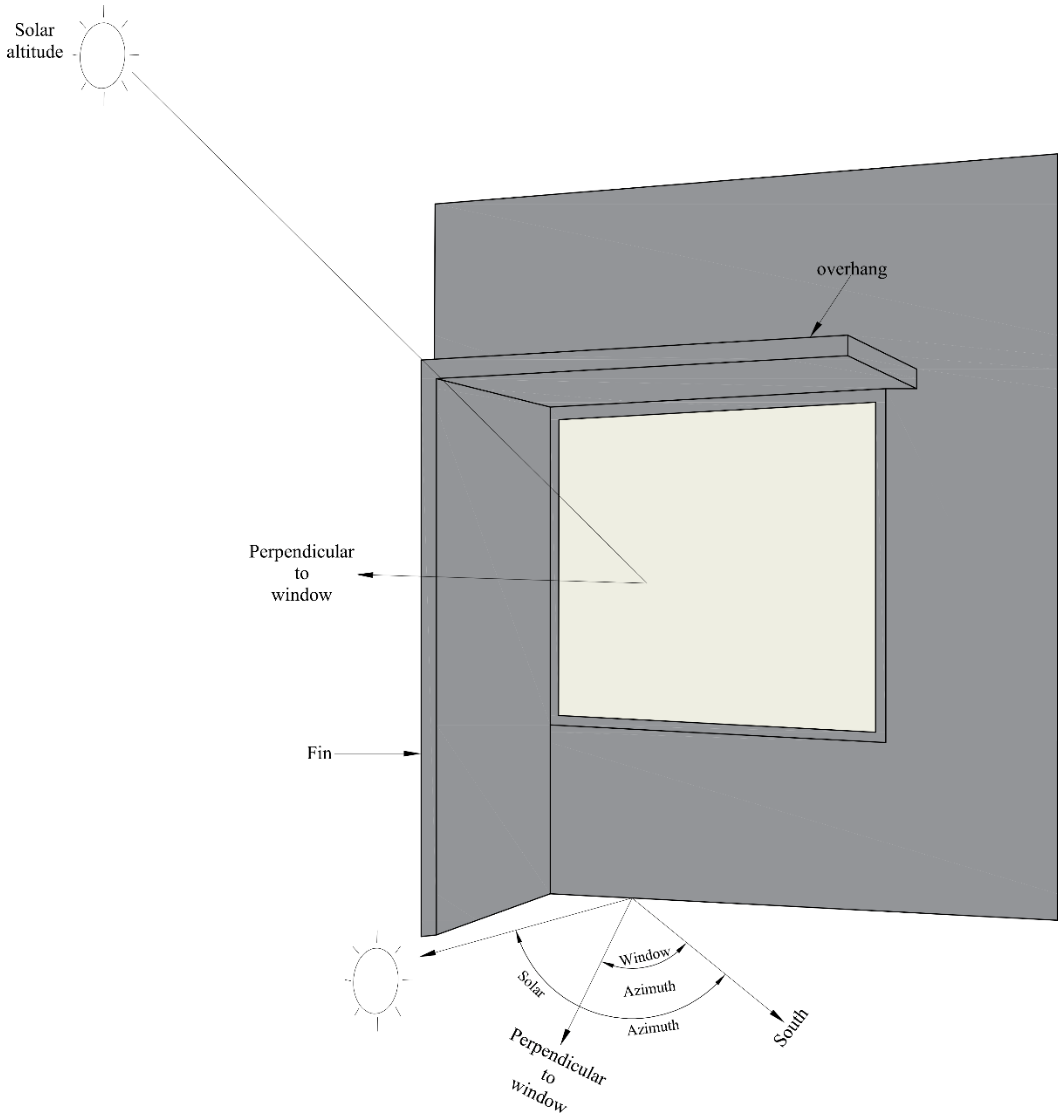


Table A.2-2Effective Shading Coefficients of Horizontal Projection at various Angles of Inclination. Orientation: North and South

R1	0°	10°	20°	30°	40°	50°
0.1	0.9380	0.9330	0.9300	0.9291	0.9303	0.9336
0.2	0.8773	0.8674	0.8613	0.8595	0.8619	0.8685
0.3	0.8167	0.8017	0.7927	0.7897	0.7935	0.8033
0.4	0.7560	0.7392	0.7288	0.7245	0.7263	0.7382
0.5	0.7210	0.7080	0.6940	0.6904	0.6927	0.6938
0.6	0.7041	0.6921	0.6848	0.6804	0.6774	0.6760
0.7	0.6923	0.6842	0.6775	0.6723	0.6689	0.6672
0.8	0.6871	0.6779	0.6702	0.6661	0.6641	0.6626
0.9	0.6819	0.6718	0.6702	0.6643	0.6600	0.6583
1.0	0.6767	0.6690	0.6655	0.6605	0.6584	0.6577
1.1	0.6713	0.6678	0.6640	0.6586	0.6577	0.6577
1.2	0.6713	0.6667	0.6628	0.6577	0.6577	0.6577
1.3	0.6705	0.6660	0.6615	0.6577	0.6577	0.6577
1.4	0.6698	0.6644	0.6596	0.6577	0.6577	0.6577
1.5	0.6690	0.6643	0.6588	0.6577	0.6577	0.6577
1.6	0.6683	0.6633	0.6579	0.6577	0.6577	0.6577
1.7	0.6675	0.6625	0.6577	0.6577	0.6577	0.6577
1.8	0.6667	0.6617	0.6577	0.6577	0.6577	0.6577
1.9	0.6660	0.6599	0.6577	0.6577	0.6577	0.6577
2.0	0.6645	0.6589	0.6577	0.6577	0.6577	0.6577
2.1	0.6637	0.6581	0.6577	0.6577	0.6577	0.6577
2.2	0.6637	0.6581	0.6577	0.6577	0.6577	0.6577
2.3	0.6633	0.6581	0.6577	0.6577	0.6577	0.6577
2.4	0.6622	0.6577	0.6577	0.6577	0.6577	0.6577
2.5	0.6614	0.6577	0.6577	0.6577	0.6577	0.6577
2.6	0.6605	0.6577	0.6577	0.6577	0.6577	0.6577
2.7	0.6597	0.6577	0.6577	0.6577	0.6577	0.6577
2.8	0.6590	0.6577	0.6577	0.6577	0.6577	0.6577
2.9	0.6590	0.6577	0.6577	0.6577	0.6577	0.6577
3.0	0.6596	0.6577	0.6577	0.6577	0.6577	0.6577

Table A.2- 3Effective Shading Coefficients of Horizontal Projection at Various Angles of Inclination. Orientation: East and West

R1	0°	10°	20°	30°	40°	50°
0.1	0.9363	0.9268	0.9195	0.9147	0.9124	0.9129
0.2	0.8752	0.8565	0.8416	0.8359	0.8257	0.8685
0.3	0.8228	0.7947	0.7733	0.7723	0.7935	0.7448
0.4	0.7603	0.7330	0.7288	0.6820	0.6826	0.6664
0.5	0.6911	0.6842	0.6934	0.5691	0.5467	0.5349
0.6	0.6574	0.6424	0.6011	0.5249	0.5012	0.4851
0.7	0.6237	0.6060	0.5559	0.5012	0.4651	0.4467
0.8	0.5998	0.5693	0.5273	0.4923	0.4427	0.4237
0.9	0.5827	0.5463	0.4991	0.4424	0.4222	0.4043
1.0	0.5637	0.5232	0.4577	0.4089	0.3963	0.3963
1.1	0.5485	0.4828	0.4468	0.4089	0.3963	0.3963
1.2	0.5314	0.4729	0.4319	0.4089	0.3963	0.3963
1.3	0.5156	0.4561	0.4230	0.4089	0.3963	0.3963
1.4	0.5051	0.4561	0.4230	0.4089	0.3963	0.3963
1.5	0.4995	0.4517	0.4213	0.4089	0.3963	0.3963
1.6	0.4939	0.4472	0.4123	0.4089	0.3963	0.3963
1.7	0.4862	0.4438	0.4130	0.4089	0.3963	0.3963
1.8	0.4826	0.4423	0.4079	0.4089	0.3963	0.3963
1.9	0.4770	0.4237	0.4057	0.3968	0.3963	0.3963
2.0	0.4713	0.4190	0.4013	0.3963	0.3963	0.3963
2.1	0.4657	0.4176	0.3991	0.3963	0.3963	0.3963
2.2	0.4601	0.4169	0.3984	0.3963	0.3963	0.3963
2.3	0.4544	0.4149	0.3978	0.3963	0.3963	0.3963
2.4	0.4486	0.4149	0.3968	0.3963	0.3963	0.3963
2.5	0.4430	0.4108	0.3963	0.3963	0.3963	0.3963
2.6	0.4369	0.4081	0.3963	0.3963	0.3963	0.3963
2.7	0.4333	0.4077	0.3963	0.3963	0.3963	0.3963
2.8	0.4300	0.4067	0.3963	0.3963	0.3963	0.3963
2.9	0.4265	0.4063	0.3963	0.3963	0.3963	0.3963
3.0	0.4237	0.4035	0.3963	0.3963	0.3963	0.3963

Table A.2- 4Effective Shading Coefficients of Horizontal Projection at Various Angles of Inclination. Orientation: North-East and North-West

R1	0°	10°	20°	30°	40°	50°
0.1	0.9273	0.9193	0.9137	0.9106	0.9101	0.9122
0.2	0.8630	0.8471	0.8355	0.8283	0.8263	0.8291
0.3	0.8054	0.7820	0.7645	0.7563	0.7489	0.7448
0.4	0.7563	0.7278	0.7055	0.6895	0.6803	0.6799
0.5	0.7171	0.6824	0.6546	0.6226	0.6208	0.6198
0.6	0.6915	0.6566	0.6264	0.5940	0.5790	0.5710
0.7	0.6549	0.6166	0.5842	0.5587	0.5432	0.5320
0.8	0.6327	0.5889	0.5563	0.5360	0.5200	0.5088
0.9	0.6105	0.5681	0.5412	0.5184	0.5026	0.4919
1.0	0.5922	0.5560	0.5261	0.5051	0.4900	0.4826
1.1	0.5809	0.5440	0.5148	0.4939	0.4840	0.4790
1.2	0.5722	0.5321	0.5046	0.4877	0.4804	0.4759
1.3	0.5634	0.5243	0.4971	0.4857	0.4782	0.4759
1.4	0.5547	0.5165	0.4921	0.4825	0.4775	0.4759
1.5	0.5466	0.5086	0.4894	0.4802	0.4759	0.4759
1.6	0.5413	0.5030	0.4874	0.4784	0.4759	0.4759
1.7	0.5359	0.5001	0.4854	0.4765	0.4759	0.4759
1.8	0.5306	0.4965	0.4837	0.4759	0.4759	0.4759
1.9	0.5250	0.4936	0.4823	0.4759	0.4759	0.4759
2.0	0.5203	0.4936	0.4804	0.4759	0.4759	0.4759
2.1	0.5162	0.4923	0.4787	0.4759	0.4759	0.4759
2.2	0.5141	0.4909	0.4774	0.4759	0.4759	0.4759
2.3	0.5119	0.4897	0.4760	0.4759	0.4759	0.4759
2.4	0.5097	0.4886	0.4753	0.4759	0.4759	0.4759
2.5	0.5075	0.4876	0.4753	0.4759	0.4759	0.4759
2.6	0.5053	0.4865	0.4753	0.4759	0.4759	0.4759
2.7	0.5037	0.4855	0.4753	0.4759	0.4759	0.4759
2.8	0.5031	0.4843	0.4753	0.4759	0.4759	0.4759
2.9	0.5031	0.4823	0.4753	0.4759	0.4759	0.4759
3.0	0.5031	0.4823	0.4753	0.4759	0.4759	0.4759

Table A.2- 5Effective Shading Coefficients of Horizontal Projection at Various Angles of Inclination. Orientation: South-East & South-West

R1	0°	10°	20°	30°	40°	50°
0.1	0.9253	0.9167	0.9107	0.9072	0.9065	0.9086
0.2	0.8574	0.8405	0.8203	0.8283	0.8263	0.8204
0.3	0.7964	0.7715	0.7527	0.7563	0.7537	0.7377
0.4	0.7413	0.7271	0.6862	0.6692	0.6601	0.6597
0.5	0.6981	0.6615	0.6231	0.5663	0.5503	0.5349
0.6	0.6578	0.6179	0.5890	0.5503	0.5417	0.5320
0.7	0.6289	0.5891	0.5555	0.5289	0.5004	0.5004
0.8	0.6059	0.5604	0.5251	0.5004	0.4765	0.4765
0.9	0.5828	0.5372	0.5096	0.4863	0.4592	0.4592
1.0	0.5619	0.5248	0.4824	0.4429	0.4429	0.4429
1.1	0.5502	0.5124	0.4826	0.4429	0.4429	0.4429
1.2	0.5413	0.5003	0.4722	0.4551	0.4477	0.4449
1.3	0.5234	0.4843	0.4596	0.4492	0.4449	0.4429
1.4	0.5150	0.4763	0.4558	0.4449	0.4449	0.4429
1.5	0.5100	0.4714	0.4538	0.4449	0.4449	0.4429
1.6	0.5096	0.4678	0.4521	0.4449	0.4449	0.4429
1.7	0.5042	0.4678	0.4521	0.4449	0.4449	0.4429
1.8	0.4988	0.4662	0.4521	0.4449	0.4449	0.4429
1.9	0.4934	0.4642	0.4489	0.4449	0.4449	0.4429
2.0	0.4879	0.4598	0.4472	0.4449	0.4449	0.4429
2.1	0.4820	0.4585	0.4460	0.4449	0.4449	0.4429
2.2	0.4778	0.4572	0.4449	0.4449	0.4449	0.4429
2.3	0.4777	0.4572	0.4449	0.4449	0.4449	0.4429
2.4	0.4755	0.4562	0.4449	0.4449	0.4449	0.4429
2.5	0.4712	0.4521	0.4449	0.4449	0.4449	0.4429
2.6	0.4694	0.4501	0.4449	0.4449	0.4449	0.4429
2.7	0.4688	0.4491	0.4449	0.4449	0.4449	0.4429
2.8	0.4688	0.4491	0.4449	0.4449	0.4449	0.4429
2.9	0.4688	0.4491	0.4449	0.4449	0.4449	0.4429
3.0	0.4688	0.4491	0.4449	0.4449	0.4449	0.4429

Table A.2-6Effective Shading Coefficients of Vertical Projection at Various Angles of Inclination. Orientation: North & South

R1	0°	10°	20°	30°	40°	50°
0.1	0.9526	0.9534	0.9549	0.9571	0.9606	0.9638
0.2	0.9066	0.9082	0.9110	0.9155	0.9225	0.9289
0.3	0.8665	0.8630	0.8670	0.8739	0.8844	0.8940
0.4	0.8144	0.8177	0.8236	0.8293	0.8638	0.8591
0.5	0.7752	0.7800	0.7892	0.8005	0.8159	0.8277
0.6	0.7563	0.7623	0.7733	0.7768	0.806	0.8078
0.7	0.7379	0.7434	0.7464	0.758	0.7771	0.7920
0.8	0.7290	0.7306	0.7348	0.7423	0.7637	0.7807
0.9	0.7202	0.723	0.7269	0.7319	0.7507	0.7699
1	0.7114	0.7183	0.719	0.7246	0.7388	0.7595
1.1	0.7060	0.7137	0.7144	0.7173	0.7308	0.7523
1.2	0.7022	0.7091	0.7098	0.7099	0.7251	0.7451
1.3	0.6977	0.6999	0.707	0.7055	0.7173	0.7377
1.4	0.6954	0.6999	0.707	0.7022	0.7173	0.7351
1.5	0.6936	0.6961	0.6981	0.7003	0.7141	0.7236
1.6	0.6909	0.6939	0.696	0.6983	0.7109	0.7173
1.7	0.6886	0.6916	0.694	0.696	0.7077	0.7131
1.8	0.6868	0.6894	0.6919	0.6945	0.7044	0.7105
1.9	0.6844	0.6886	0.6887	0.6926	0.7022	0.7052
2	0.6818	0.6884	0.6858	0.6888	0.6994	0.7005
2.1	0.6773	0.6881	0.6849	0.6879	0.6984	0.6979
2.2	0.6750	0.6876	0.6845	0.6878	0.698	0.6974
2.3	0.6728	0.6864	0.6843	0.6876	0.6979	0.6972
2.4	0.6695	0.6862	0.6845	0.6874	0.6976	0.6970
2.5	0.6678	0.686	0.6846	0.6872	0.6973	0.6968
2.6	0.6665	0.6868	0.6845	0.6871	0.6971	0.6966
2.7	0.6655	0.6868	0.6833	0.6870	0.6969	0.6964
2.8	0.6638	0.6860	0.6830	0.6869	0.6967	0.6963
2.9	0.6627	0.6863	0.6826	0.6868	0.6965	0.6962
3	0.6668	0.6860	0.6822	0.6867	0.6964	0.6961

Table A.2-7Effective Shading Coefficients of Vertical Projection at Various Angles of Inclination. Orientation: East & West

R1	0°	10°	20°	30°	40°	50°
0.1	0.9805	0.9751	0.9704	0.9653	0.9584	0.9520
0.2	0.9607	0.9499	0.9406	0.9302	0.9166	0.9038
0.3	0.9409	0.9247	0.9108	0.8844	0.8737	0.8555
0.4	0.9223	0.9007	0.8821	0.8614	0.8483	0.8281
0.5	0.9047	0.8774	0.8537	0.8275	0.7931	0.7606
0.6	0.8870	0.8543	0.8264	0.7980	0.7710	0.7133
0.7	0.8694	0.8313	0.7980	0.7616	0.7529	0.6671
0.8	0.8518	0.8090	0.7728	0.7312	0.6753	0.6227
0.9	0.8348	0.7884	0.7476	0.7014	0.6406	0.5823
1.0	0.8193	0.7678	0.7233	0.6747	0.5850	0.5493
1.1	0.8057	0.7471	0.7015	0.6511	0.5605	0.5458
1.2	0.7921	0.7287	0.6810	0.6320	0.5361	0.5088
1.3	0.7654	0.6960	0.6482	0.5949	0.5120	0.4633
1.4	0.7541	0.6826	0.6334	0.5764	0.4899	0.4526
1.5	0.7441	0.6696	0.6187	0.5579	0.4820	0.4474
1.6	0.7349	0.6589	0.6042	0.5397	0.4709	0.4422
1.7	0.7257	0.6485	0.5906	0.5220	0.4760	0.4371
1.8	0.7125	0.6276	0.5634	0.5065	0.4700	0.4319
1.9	0.7070	0.6172	0.5497	0.4966	0.4670	0.4221
2.0	0.7036	0.6076	0.5362	0.4950	0.4611	0.4185
2.1	0.7036	0.6000	0.5326	0.4950	0.4611	0.4185
2.2	0.7036	0.6000	0.5326	0.4950	0.4611	0.4185
2.3	0.7070	0.5987	0.5326	0.4950	0.4611	0.4185
2.4	0.6966	0.5897	0.5101	0.4918	0.4581	0.4145
2.5	0.6956	0.5808	0.4971	0.4902	0.4551	0.4132
2.6	0.6956	0.5629	0.4747	0.4886	0.4491	0.4105
2.7	0.6956	0.5539	0.4668	0.4868	0.4468	0.4079
2.8	0.6956	0.5450	0.4591	0.4841	0.4431	0.4082
2.9	0.6956	0.5360	0.4511	0.4824	0.4401	0.4080
3.0	0.6957	0.5360	0.4511	0.4841	0.4401	0.4082

Table A.2-8Effective Shading Coefficients of Vertical Projection at Various Angles of Inclination Orientation: North-East & North-West

R1	0°	10°	20°	30°	40°	50°
0.1	0.9517	0.9445	0.9389	0.9346	0.9317	0.9314
0.2	0.9074	0.8931	0.8819	0.8729	0.8670	0.8650
0.3	0.8646	0.8464	0.8286	0.8281	0.8036	0.7381
0.4	0.8262	0.7991	0.7770	0.7854	0.7484	0.6809
0.5	0.7912	0.7573	0.7297	0.7066	0.6895	0.6239
0.6	0.7600	0.7155	0.6646	0.6546	0.6342	0.5701
0.7	0.7230	0.6740	0.6356	0.5584	0.5832	0.5701
0.8	0.6899	0.6352	0.6038	0.5836	0.5643	0.5493
0.9	0.6575	0.6069	0.5806	0.5530	0.5468	0.5296
1.0	0.6359	0.5981	0.5691	0.5380	0.5125	0.5104
1.1	0.6300	0.5803	0.5461	0.5241	0.4984	0.5005
1.2	0.6240	0.5892	0.5576	0.5141	0.4948	0.4915
1.3	0.6181	0.5715	0.5348	0.5091	0.4891	0.4898
1.4	0.6121	0.5626	0.5257	0.5050	0.4880	0.4884
1.5	0.6061	0.5562	0.5250	0.5050	0.4884	0.4888
1.6	0.6002	0.5537	0.5202	0.5028	0.4881	0.4888
1.7	0.5924	0.5449	0.5161	0.5024	0.4884	0.4869
1.8	0.5883	0.5291	0.5120	0.4936	0.4860	0.4813
1.9	0.5763	0.5235	0.5079	0.4934	0.4860	0.4811
2.0	0.5704	0.5198	0.5064	0.4933	0.4860	0.4798
2.1	0.5604	0.5166	0.5018	0.4933	0.4860	0.4798
2.2	0.5590	0.5135	0.5005	0.4933	0.4860	0.4798
2.3	0.5541	0.5104	0.5020	0.4934	0.4860	0.4798
2.4	0.5510	0.5084	0.5020	0.4933	0.4860	0.4798
2.5	0.5452	0.5042	0.4991	0.4934	0.4860	0.4798
2.6	0.5410	0.5027	0.4976	0.4933	0.4860	0.4798
2.7	0.5349	0.5002	0.4944	0.4934	0.4860	0.4798
2.8	0.5323	0.4989	0.4941	0.4934	0.4860	0.4798
2.9	0.5323	0.4989	0.4941	0.4934	0.4860	0.4798
3.0	0.5323	0.4989	0.4941	0.4934	0.4860	0.4798

Table A.2-9Effective Shading Coefficients of Vertical Projection at Various Angles of Inclination Orientation: South-East & South-West

R1	0°	10°	20°	30°	40°	50°
0.1	0.9528	0.9457	0.9396	0.9351	0.9317	0.9304
0.2	0.9081	0.8938	0.8815	0.8724	0.8654	0.8624
0.3	0.8650	0.8437	0.8315	0.8195	0.8005	0.7955
0.4	0.8257	0.7988	0.7746	0.7555	0.7385	0.7381
0.5	0.7907	0.7570	0.7269	0.7029	0.6829	0.6715
0.6	0.7597	0.7150	0.6987	0.6540	0.6264	0.6127
0.7	0.7229	0.6743	0.6313	0.6504	0.5832	0.5539
0.8	0.6897	0.6342	0.5861	0.5629	0.5412	0.5242
0.9	0.6565	0.5987	0.5700	0.5530	0.5288	0.5015
1.0	0.6233	0.5863	0.5584	0.5185	0.4850	0.4850
1.1	0.6056	0.5771	0.5470	0.5185	0.4737	0.4737
1.2	0.5915	0.5599	0.5235	0.5046	0.4712	0.4672
1.3	0.5791	0.5513	0.5130	0.4882	0.4677	0.4586
1.4	0.5853	0.5513	0.5130	0.4882	0.4677	0.4586
1.5	0.5791	0.5427	0.5037	0.4831	0.4642	0.4572
1.6	0.5705	0.5311	0.4974	0.4776	0.4604	0.4548
1.7	0.5668	0.5255	0.4915	0.4719	0.4583	0.4534
1.8	0.5568	0.5169	0.4876	0.4680	0.4527	0.4528
1.9	0.5506	0.5096	0.5096	0.4696	0.4565	0.4495
2.0	0.5499	0.5096	0.5096	0.4696	0.4565	0.4495
2.1	0.5451	0.4990	0.5096	0.4696	0.4565	0.4495
2.2	0.5355	0.4933	0.4974	0.4666	0.4552	0.4485
2.3	0.5307	0.4879	0.4876	0.4654	0.4554	0.4466
2.4	0.5256	0.4820	0.4827	0.4634	0.4542	0.4449
2.5	0.5203	0.4776	0.4796	0.4634	0.4542	0.4449
2.6	0.5168	0.4701	0.4787	0.4634	0.4542	0.4449
2.7	0.5110	0.4715	0.4677	0.4656	0.4542	0.4449
2.8	0.5084	0.4715	0.4634	0.4655	0.4542	0.4449
2.9	0.5084	0.4715	0.4634	0.4655	0.4542	0.4449
3.0	0.5084	0.4715	0.4634	0.4655	0.4542	0.4449

Table A.2-10Effective Shading Coefficients of Egg-Crate Louvers with Inclined Horizontal Fins Orientation: North & South

R1	R2	0°	10°	20°	30°	40°
0.2	0.2	0.8482	0.8306	0.8165	0.8064	0.8013
0.2	0.4	0.8212	0.8047	0.7914	0.7818	0.7769
0.2	0.6	0.7942	0.7788	0.7663	0.7572	0.7525
0.2	0.8	0.7672	0.7529	0.7412	0.7327	0.7302
0.2	1.0	0.7417	0.7284	0.7175	0.7095	0.7052
0.2	1.2	0.7190	0.7066	0.6965	0.6890	0.6850
0.2	1.4	0.6968	0.6852	0.6758	0.6688	0.6652
0.2	1.6	0.6786	0.6677	0.6589	0.6524	0.6490
0.4	0.2	0.7513	0.7162	0.6883	0.6678	0.6556
0.4	0.4	0.7323	0.6993	0.6730	0.6530	0.6418
0.4	0.6	0.7133	0.6825	0.6577	0.6393	0.6280
0.4	0.8	0.6943	0.6656	0.6424	0.6251	0.6143
0.4	1.0	0.6754	0.6488	0.6271	0.6108	0.6006
0.4	1.2	0.6570	0.6322	0.6118	0.5967	0.5871
0.4	1.4	0.6389	0.6158	0.5968	0.5827	0.5738
0.4	1.6	0.6235	0.6017	0.5840	0.5708	0.5523
0.4	1.8	0.6096	0.5890	0.5723	0.5599	0.5398
0.6	0.2	0.6768	0.6307	0.5917	0.5611	0.5399
0.6	0.4	0.6626	0.6190	0.5822	0.5532	0.5329
0.6	0.6	0.6483	0.6073	0.5726	0.5452	0.5251
0.6	0.8	0.6341	0.5956	0.5630	0.5372	0.5191
0.6	1.0	0.6198	0.5840	0.5535	0.5290	0.5114
0.6	1.2	0.6056	0.5723	0.5434	0.5208	0.5032
0.6	1.4	0.5915	0.5607	0.5344	0.5134	0.4917
0.6	1.8	0.5788	0.5500	0.5254	0.5058	0.4852
0.8	0.2	0.6740	0.6688	0.6645	0.6622	0.6612
0.8	0.4	0.6609	0.6598	0.6589	0.6584	0.6583
0.8	0.6	0.6577	0.6577	0.6577	0.6577	0.6577
0.8	0.8	0.6577	0.6577	0.6577	0.6577	0.6577
0.8	1.0	0.6577	0.6577	0.6577	0.6577	0.6577
0.8	1.2	0.6577	0.6577	0.6577	0.6577	0.6577
0.8	1.4	0.6577	0.6577	0.6577	0.6577	0.6577
0.8	1.6	0.6577	0.6577	0.6577	0.6577	0.6577
0.8	1.8	0.6577	0.6577	0.6577	0.6577	0.6577
0.8	0.2	0.6681	0.6638	0.6619	0.6603	0.6590
0.8	0.4	0.6595	0.6586	0.6584	0.6581	0.6579
0.8	0.6	0.6577	0.6577	0.6577	0.6577	0.6577
0.8	0.8	0.6577	0.6577	0.6577	0.6577	0.6577
1.0	0.2	0.6681	0.6638	0.6619	0.6603	0.6590
1.0	0.4	0.6595	0.6586	0.6584	0.6581	0.6579
1.0	0.6	0.6577	0.6577	0.6577	0.6577	0.6577

R1	R2	0°	10°	20°	30°	40°
1.0	0.8	0.6577	0.6577	0.6577	0.6577	0.6577
1.0	1.0	0.6577	0.6577	0.6577	0.6577	0.6577
1.0	1.2	0.6577	0.6577	0.6577	0.6577	0.6577
1.0	1.4	0.6577	0.6577	0.6577	0.6577	0.6577
1.0	1.6	0.6577	0.6577	0.6577	0.6577	0.6577
1.0	1.8	0.6577	0.6577	0.6577	0.6577	0.6577
1.0	0.2	0.6651	0.6618	0.6603	0.6589	0.6580
1.0	0.4	0.6588	0.6585	0.6583	0.6578	0.6577
1.0	0.6	0.6577	0.6577	0.6577	0.6577	0.6577
1.0	0.8	0.6577	0.6577	0.6577	0.6577	0.6577
1.2	1.0	0.6577	0.6577	0.6577	0.6577	0.6577
1.2	0.2	0.6651	0.6618	0.6603	0.6589	0.6580
1.2	0.4	0.6588	0.6585	0.6583	0.6578	0.6577
1.2	0.6	0.6577	0.6577	0.6577	0.6577	0.6577
1.2	0.8	0.6577	0.6577	0.6577	0.6577	0.6577
1.2	1.0	0.6577	0.6577	0.6577	0.6577	0.6577
1.2	1.2	0.6577	0.6577	0.6577	0.6577	0.6577
1.2	1.4	0.6577	0.6577	0.6577	0.6577	0.6577
1.2	1.6	0.6577	0.6577	0.6577	0.6577	0.6577
1.2	1.8	0.6577	0.6577	0.6577	0.6577	0.6577
1.4	0.2	0.6642	0.6613	0.6587	0.6577	0.6577
1.4	0.4	0.6587	0.6583	0.6579	0.6577	0.6577
1.4	0.6	0.6577	0.6577	0.6577	0.6577	0.6577
1.4	0.8	0.6577	0.6577	0.6577	0.6577	0.6577
1.4	1.0	0.6577	0.6577	0.6577	0.6577	0.6577
1.4	1.2	0.6577	0.6577	0.6577	0.6577	0.6577
1.4	1.4	0.6577	0.6577	0.6577	0.6577	0.6577
1.4	1.6	0.6577	0.6577	0.6577	0.6577	0.6577
1.4	1.8	0.6577	0.6577	0.6577	0.6577	0.6577
1.4	0.2	0.6634	0.6601	0.6578	0.6577	0.6577
1.4	0.4	0.6586	0.6581	0.6577	0.6577	0.6577
1.4	0.6	0.6577	0.6577	0.6577	0.6577	0.6577
1.6	0.2	0.6634	0.6601	0.6578	0.6577	0.6577
1.6	0.4	0.6586	0.6581	0.6577	0.6577	0.6577
1.6	0.6	0.6577	0.6577	0.6577	0.6577	0.6577
1.6	0.8	0.6577	0.6577	0.6577	0.6577	0.6577
1.6	1.0	0.6577	0.6577	0.6577	0.6577	0.6577
1.6	1.2	0.6577	0.6577	0.6577	0.6577	0.6577
1.6	1.4	0.6577	0.6577	0.6577	0.6577	0.6577
1.6	1.6	0.6577	0.6577	0.6577	0.6577	0.6577
1.6	1.8	0.6577	0.6577	0.6577	0.6577	0.6577
1.6	0.2	0.6626	0.6602	0.6578	0.6577	0.6577
1.8	0.4	0.6584	0.6579	0.6577	0.6577	0.6577
1.8	0.6	0.6577	0.6577	0.6577	0.6577	0.6577
1.8	0.8	0.6577	0.6577	0.6577	0.6577	0.6577

R1	R2	0°	10°	20°	30°	40°
1.8	1.0	0.6577	0.6577	0.6577	0.6577	0.6577
1.8	1.2	0.6577	0.6577	0.6577	0.6577	0.6577
1.8	1.4	0.6577	0.6577	0.6577	0.6577	0.6577
1.8	1.6	0.6577	0.6577	0.6577	0.6577	0.6577
1.8	1.8	0.6577	0.6577	0.6577	0.6577	0.6577
1.8	0.2	0.6626	0.6602	0.6578	0.6577	0.6577
1.8	0.4	0.6584	0.6579	0.6577	0.6577	0.6577

Table A.2- 11Effective Shading Coefficients of Egg-Crate Louvers with Inclined Horizontal Fins. Orientation: East & West

R1	R2	0°	10°	20°	30°	40°
0.2	0.2	0.8482	0.8306	0.8165	0.8064	0.8013
0.2	0.4	0.8212	0.8047	0.7914	0.7818	0.7769
0.2	0.6	0.7942	0.7788	0.7663	0.7572	0.7525
0.2	0.8	0.7672	0.7529	0.7412	0.7327	0.7302
0.2	1.0	0.7417	0.7284	0.7175	0.7095	0.7052
0.2	1.2	0.7190	0.7066	0.6965	0.6890	0.6850
0.2	1.4	0.6968	0.6852	0.6758	0.6688	0.6652
0.2	1.6	0.6786	0.6677	0.6589	0.6524	0.6490
0.4	0.2	0.7513	0.7162	0.6883	0.6678	0.6556
0.4	0.4	0.7323	0.6993	0.6730	0.6530	0.6418
0.4	0.6	0.7133	0.6825	0.6577	0.6393	0.6280
0.4	0.8	0.6943	0.6656	0.6424	0.6251	0.6143
0.4	1.0	0.6754	0.6488	0.6271	0.6108	0.6006
0.4	1.2	0.6570	0.6322	0.6118	0.5967	0.5871
0.4	1.4	0.6389	0.6158	0.5968	0.5827	0.5738
0.4	1.6	0.6235	0.6017	0.5840	0.5708	0.5523
0.4	1.8	0.6096	0.5890	0.5723	0.5599	0.5398
0.6	0.2	0.6768	0.6307	0.5917	0.5611	0.5399
0.6	0.4	0.6626	0.6190	0.5822	0.5532	0.5329
0.6	0.6	0.6483	0.6073	0.5726	0.5452	0.5251
0.6	0.8	0.6341	0.5956	0.5630	0.5372	0.5191
0.6	1.0	0.6198	0.5840	0.5535	0.5290	0.5114
0.6	1.2	0.6056	0.5723	0.5434	0.5208	0.5032
0.6	1.4	0.5915	0.5607	0.5344	0.5134	0.4917
0.6	1.8	0.5788	0.5500	0.5254	0.5058	0.4852
0.8	0.2	0.6135	0.5615	0.5215	0.4881	0.4622
0.8	0.4	0.6033	0.5537	0.5157	0.4839	0.4593
0.8	0.6	0.5931	0.5459	0.5099	0.4798	0.4564
0.8	0.8	0.5829	0.5381	0.5041	0.4756	0.4534
0.8	1.0	0.5727	0.5304	0.4983	0.4714	0.4505

R1	R2	0°	10°	20°	30°	40°
0.8	1.2	0.5625	0.5226	0.4925	0.4673	0.4476
0.8	1.4	0.5523	0.5148	0.4867	0.4631	0.4447
0.8	1.6	0.5421	0.5070	0.4809	0.4589	0.4418
1.0	0.2	0.5744	0.5178	0.4695	0.4422	0.4212
1.0	0.4	0.5661	0.5123	0.4663	0.4401	0.4201
1.0	0.6	0.5578	0.5068	0.4631	0.4381	0.4191
1.0	0.8	0.5495	0.5014	0.4599	0.4361	0.4181
1.0	1.0	0.5412	0.4959	0.4567	0.4341	0.4170
1.0	1.2	0.5329	0.4904	0.4535	0.4321	0.4159
1.0	1.4	0.5246	0.4849	0.4503	0.4301	0.4149
1.0	1.6	0.5163	0.4794	0.4471	0.4280	0.4138
1.0	1.8	0.5080	0.4740	0.4439	0.4260	0.4128
1.2	0.2	0.5420	0.4791	0.4447	0.4144	0.4033
1.2	0.4	0.5354	0.4754	0.4426	0.4130	0.4027
1.2	0.6	0.5289	0.4704	0.4405	0.4116	0.4024
1.2	0.8	0.5223	0.4680	0.4384	0.4102	0.4021
1.2	1.0	0.5158	0.4643	0.4363	0.4088	0.4017
1.2	1.2	0.5092	0.4606	0.4340	0.4074	0.4014
1.2	1.4	0.5027	0.4569	0.4321	0.4060	0.4011
1.2	1.8	0.4961	0.4532	0.4300	0.4046	0.4009
1.4	0.2	0.5107	0.4621	0.4220	0.4055	0.3969
1.4	0.4	0.5058	0.4592	0.4210	0.4051	0.3969
1.4	0.6	0.5008	0.4563	0.4200	0.4047	0.3969
1.4	0.8	0.4959	0.4535	0.4190	0.4043	0.3969
1.4	1.0	0.4910	0.4506	0.4180	0.4039	0.3969
1.4	1.2	0.4860	0.4477	0.4170	0.4035	0.3969
1.4	1.4	0.4811	0.4449	0.4160	0.4031	0.3969
1.4	1.6	0.4762	0.4420	0.4150	0.4028	0.3969
1.6	0.2	0.4951	0.4451	0.4117	0.3998	0.3963
1.6	0.4	0.4907	0.4431	0.4110	0.3997	0.3963
1.6	0.6	0.4863	0.4410	0.4103	0.3996	0.3963
1.6	0.8	0.4820	0.4390	0.4096	0.3995	0.3963
1.6	1.0	0.4776	0.4369	0.4089	0.3994	0.3963
1.6	1.2	0.4732	0.4349	0.4083	0.3993	0.3963
1.6	1.4	0.4688	0.4329	0.4076	0.3992	0.3963
1.6	1.6	0.4644	0.4309	0.4070	0.3992	0.3963
1.8	0.2	0.4600	0.4288	0.4062	0.3991	0.3963
1.8	0.4	0.4844	0.4281	0.4075	0.3992	0.3963
1.8	0.6	0.4805	0.4269	0.4070	0.3991	0.3963
1.8	0.8	0.4767	0.4254	0.4061	0.3990	0.3963
1.8	1.0	0.4728	0.4235	0.4056	0.3989	0.3963
1.8	1.2	0.4690	0.4221	0.4044	0.3987	0.3963
1.8	1.4	0.4651	0.4196	0.4037	0.3986	0.3963
1.8	1.6	0.4574	0.4184	0.4030	0.3985	0.3963

Table A.2-12 Effective Shading Coefficients of Egg-Crate Louvers with Inclined. Orientation: North-East & North-West

R1	R2	0°	10°	20°	30°	40°
0.2	0.2	0.8019	0.7886	0.7788	0.7727	0.7705
0.2	0.4	0.7439	0.7331	0.7250	0.7198	0.7178
0.2	0.6	0.6944	0.6857	0.6790	0.6746	0.6727
0.2	0.8	0.6452	0.6381	0.6332	0.6298	0.6281
0.2	1.0	0.6024	0.5973	0.5935	0.5909	0.5897
0.2	1.2	0.5926	0.5880	0.5844	0.5820	0.5809
0.2	1.4	0.5829	0.5786	0.5754	0.5732	0.5722
0.2	1.6	0.5732	0.5693	0.5663	0.5644	0.5635
0.2	1.8	0.5634	0.5599	0.5573	0.5555	0.5548
0.4	0.2	0.7138	0.6898	0.6709	0.6573	0.6494
0.4	0.4	0.6724	0.6527	0.6371	0.6258	0.6203
0.4	0.6	0.6369	0.6207	0.6079	0.5986	0.5973
0.4	0.8	0.6013	0.5887	0.5787	0.5715	0.5673
0.4	1.0	0.5688	0.5593	0.5519	0.5466	0.5436
0.4	1.2	0.5613	0.5524	0.5455	0.5407	0.5380
0.4	1.4	0.5537	0.5456	0.5392	0.5348	0.5324
0.4	1.6	0.5386	0.5318	0.5266	0.5231	0.5214
0.4	1.8	0.5281	0.5186	0.5113	0.5096	0.5084
0.6	0.2	0.6479	0.6186	0.5951	0.5766	0.5634
0.6	0.4	0.6178	0.5934	0.5741	0.5588	0.5481
0.6	0.6	0.5920	0.5704	0.5560	0.5435	0.5348
0.6	0.8	0.5663	0.5502	0.5379	0.5282	0.5214
0.6	1.0	0.5416	0.5294	0.5204	0.5134	0.5072
0.6	1.2	0.5353	0.5240	0.5159	0.5074	0.5006
0.6	1.4	0.5289	0.5196	0.5110	0.5050	0.4950
0.6	1.6	0.5225	0.5132	0.5067	0.5017	0.4905
0.6	1.8	0.5161	0.5078	0.5022	0.4978	0.4854
0.8	0.2	0.6089	0.5719	0.5445	0.5270	0.5133
0.8	0.4	0.5855	0.5551	0.5328	0.5182	0.5067
0.8	0.6	0.5665	0.5403	0.5190	0.5027	0.5010
0.8	0.8	0.5449	0.5225	0.5022	0.4924	0.4952
0.8	1.0	0.5252	0.5109	0.5019	0.4917	0.4895
0.8	1.2	0.5219	0.5070	0.4989	0.4908	0.4863
0.8	1.4	0.5147	0.5030	0.4909	0.4905	0.4863
0.8	1.6	0.5095	0.4991	0.4930	0.4883	0.4847
0.8	1.8	0.5042	0.4950	0.4900	0.4900	0.4841
1.0	0.2	0.5750	0.5440	0.5183	0.5005	0.4878
1.0	0.4	0.5579	0.5321	0.5105	0.4965	0.4856
1.0	0.6	0.5429	0.5218	0.5030	0.4902	0.4839
1.0	0.8	0.5279	0.5114	0.4972	0.4884	0.4822

R1	R2	0°	10°	20°	30°	40°
1.0	1.0	0.5129	0.5010	0.4905	0.4870	0.4805
1.0	1.2	0.5087	0.4981	0.4888	0.4836	0.4799
1.0	1.4	0.5056	0.4942	0.4870	0.4834	0.4793
1.0	1.6	0.5002	0.4922	0.4852	0.4814	0.4787
1.0	1.8	0.4960	0.4893	0.4834	0.4834	0.4781
1.2	0.2	0.5577	0.5232	0.5002	0.5002	0.4787
1.2	0.4	0.5434	0.5144	0.4922	0.4950	0.4795
1.2	0.6	0.5309	0.5069	0.4822	0.4882	0.4787
1.2	0.8	0.5153	0.4994	0.4886	0.4886	0.4787
1.2	1.0	0.5060	0.4900	0.4830	0.4860	0.4771
1.2	1.2	0.5040	0.4880	0.4827	0.4855	0.4769
1.2	1.4	0.4995	0.4860	0.4821	0.4846	0.4767
1.2	1.6	0.4960	0.4840	0.4804	0.4804	0.4765
1.2	1.8	0.4919	0.4840	0.4804	0.4773	0.4765
1.4	0.2	0.5424	0.5101	0.4894	0.4815	0.4759
1.4	0.4	0.5303	0.5039	0.4868	0.4805	0.4759
1.4	0.6	0.5199	0.4987	0.4846	0.4796	0.4759
1.4	0.8	0.5095	0.4936	0.4825	0.4786	0.4759
1.4	1.0	0.4991	0.4884	0.4803	0.4777	0.4759
1.4	1.2	0.4963	0.4868	0.4797	0.4774	0.4759
1.4	1.4	0.4935	0.4853	0.4791	0.4772	0.4759
1.4	1.6	0.4907	0.4837	0.4785	0.4770	0.4759
1.4	1.8	0.4879	0.4821	0.4781	0.4770	0.4759
1.6	0.2	0.5310	0.4994	0.4856	0.4777	0.4759
1.6	0.4	0.5208	0.4952	0.4838	0.4771	0.4759
1.6	0.6	0.5122	0.4917	0.4822	0.4767	0.4759
1.6	0.8	0.5036	0.4883	0.4806	0.4764	0.4759
1.6	1.0	0.4949	0.4848	0.4790	0.4761	0.4759
1.6	1.2	0.4926	0.4837	0.4783	0.4759	0.4759
1.6	1.4	0.4902	0.4825	0.4775	0.4759	0.4759
1.6	1.6	0.4855	0.4813	0.4770	0.4759	0.4759
1.6	1.8	0.4821	0.4800	0.4769	0.4759	0.4759
1.8	0.2	0.5221	0.4930	0.4826	0.4769	0.4759
1.8	0.4	0.5137	0.4897	0.4815	0.4765	0.4759
1.8	0.6	0.5067	0.4861	0.4803	0.4764	0.4759
1.8	0.8	0.4997	0.4841	0.4794	0.4762	0.4759
1.8	1.0	0.4926	0.4813	0.4781	0.4759	0.4759
1.8	1.2	0.4906	0.4798	0.4777	0.4759	0.4759
1.8	1.4	0.4864	0.4781	0.4772	0.4759	0.4759
1.8	1.6	0.4843	0.4784	0.4769	0.4759	0.4759

Table A.2-13Effective Shading Coefficients of Egg-Crate Louvers with Inclined. Orientation: South-East & South-West

R1	R2	0°	10°	20°	30°	40°
0.2	0.2	0.7951	0.7808	0.7702	0.7634	0.7608
0.2	0.4	0.7351	0.7233	0.7144	0.7087	0.7064
0.2	0.6	0.6842	0.6745	0.6672	0.6623	0.6602
0.2	0.8	0.6340	0.6250	0.6205	0.6167	0.6149
0.2	1.0	0.5838	0.5782	0.5739	0.5709	0.5696
0.2	1.2	0.5669	0.5620	0.5581	0.5555	0.5542
0.2	1.4	0.5570	0.5525	0.5489	0.5465	0.5453
0.2	1.6	0.5471	0.5430	0.5397	0.5375	0.5364
0.2	1.8	0.5372	0.5334	0.5305	0.5285	0.5275
0.4	0.2	0.6979	0.6713	0.6510	0.6365	0.6285
0.4	0.4	0.6555	0.6334	0.6165	0.6044	0.5977
0.4	0.6	0.6193	0.6019	0.5868	0.5868	0.5797
0.4	0.8	0.5831	0.5683	0.5572	0.5768	0.5712
0.4	1.0	0.5469	0.5358	0.5275	0.5510	0.5519
0.4	1.2	0.5361	0.5263	0.5188	0.5315	0.5185
0.4	1.4	0.5286	0.5196	0.5127	0.5216	0.5107
0.4	1.6	0.5212	0.5129	0.5066	0.5135	0.4999
0.4	1.8	0.5137	0.5063	0.5005	0.5056	0.4944
0.6	0.2	0.6266	0.5923	0.5677	0.5483	0.5347
0.6	0.4	0.5995	0.5700	0.5466	0.5306	0.5157
0.6	0.6	0.5694	0.5452	0.5233	0.5110	0.4948
0.6	0.8	0.5430	0.5231	0.5011	0.5000	0.4862
0.6	1.0	0.5166	0.5018	0.4800	0.4800	0.4709
0.6	1.2	0.5091	0.4957	0.4751	0.4733	0.4652
0.6	1.4	0.5030	0.4905	0.4696	0.4671	0.4593
0.6	1.6	0.4969	0.4853	0.4656	0.4616	0.4537
0.6	1.8	0.4907	0.4801	0.4637	0.4566	0.4482
0.8	0.2	0.5821	0.5434	0.5133	0.4954	0.4814
0.8	0.4	0.5586	0.5264	0.5016	0.4865	0.4741
0.8	0.6	0.5381	0.5114	0.4912	0.4709	0.4689
0.8	0.8	0.5176	0.4966	0.4809	0.4697	0.4671
0.8	1.0	0.4971	0.4815	0.4709	0.4630	0.4573
0.8	1.2	0.4914	0.4773	0.4695	0.4609	0.4557
0.8	1.4	0.4863	0.4695	0.4587	0.4607	0.4551
0.8	1.6	0.4812	0.4656	0.4573	0.4593	0.4543
0.8	1.8	0.4761	0.4667	0.4581	0.4562	0.4521
1.0	0.2	0.5448	0.5129	0.4864	0.4682	0.4552
1.0	0.4	0.5277	0.4970	0.4786	0.4597	0.4514
1.0	0.6	0.5125	0.4827	0.4719	0.4552	0.4491
1.0	0.8	0.4973	0.4680	0.4652	0.4527	0.4480
1.0	1.0	0.4822	0.4550	0.4593	0.4511	0.4457
1.0	1.2	0.4779	0.4527	0.4566	0.4489	0.4443

R1	R2	0°	10°	20°	30°	40°
1.0	1.4	0.4738	0.4493	0.4548	0.4477	0.4436
1.0	1.6	0.4696	0.4480	0.4532	0.4470	0.4429
1.0	1.8	0.4654	0.4481	0.4521	0.4453	0.4429
1.2	0.2	0.5125	0.4915	0.4636	0.4441	0.4445
1.2	0.4	0.5000	0.4827	0.4566	0.4434	0.4439
1.2	0.6	0.4874	0.4751	0.4514	0.4429	0.4432
1.2	0.8	0.4748	0.4666	0.4468	0.4429	0.4430
1.2	1.0	0.4821	0.4566	0.4457	0.4429	0.4429
1.2	1.2	0.4678	0.4576	0.4445	0.4429	0.4429
1.2	1.4	0.4643	0.4559	0.4434	0.4429	0.4429
1.2	1.6	0.4608	0.4539	0.4425	0.4429	0.4429
1.2	1.8	0.4576	0.4513	0.4429	0.4429	0.4429
1.4	0.2	0.5112	0.4781	0.4571	0.4483	0.4429
1.4	0.4	0.4991	0.4719	0.4541	0.4467	0.4429
1.4	0.6	0.4886	0.4666	0.4517	0.4454	0.4429
1.4	0.8	0.4781	0.4616	0.4503	0.4446	0.4429
1.4	1.0	0.4676	0.4563	0.4493	0.4440	0.4429
1.4	1.2	0.4647	0.4548	0.4486	0.4436	0.4429
1.4	1.4	0.4590	0.4532	0.4476	0.4434	0.4429
1.4	1.6	0.4562	0.4500	0.4472	0.4432	0.4429
1.4	1.8	0.4512	0.4478	0.4462	0.4429	0.4429
1.6	0.2	0.4995	0.4672	0.4522	0.4470	0.4429
1.6	0.4	0.4806	0.4631	0.4506	0.4455	0.4429
1.6	0.6	0.4719	0.4597	0.4491	0.4448	0.4429
1.6	0.8	0.4631	0.4573	0.4476	0.4440	0.4429
1.6	1.0	0.4563	0.4548	0.4460	0.4436	0.4429
1.6	1.2	0.4543	0.4526	0.4446	0.4434	0.4429
1.6	1.4	0.4510	0.4512	0.4434	0.4432	0.4429
1.6	1.6	0.4504	0.4481	0.4432	0.4432	0.4429
1.6	1.8	0.4490	0.4466	0.4429	0.4429	0.4429
1.8	0.2	0.4821	0.4576	0.4483	0.4465	0.4429
1.8	0.4	0.4750	0.4521	0.4471	0.4460	0.4429
1.8	0.6	0.4709	0.4508	0.4460	0.4456	0.4429
1.8	0.8	0.4683	0.4491	0.4451	0.4450	0.4429
1.8	1.0	0.4660	0.4485	0.4445	0.4443	0.4429
1.8	1.2	0.4643	0.4481	0.4442	0.4436	0.4429
1.8	1.4	0.4610	0.4481	0.4440	0.4432	0.4429
1.8	1.6	0.4567	0.4477	0.4436	0.4429	0.4429
1.8	1.8	0.4524	0.4462	0.4429	0.4429	0.4429

11.3 Appendix 3: Roof Thermal Transfer Value Formula

Conversion to Uniform Energy Units

The Roof Thermal Transfer Value (RTTV) formula is given as follows:

$$RTTV = 12.5\,(1 - SKR)\,U_r + 4.8\,(SKR)\,U_s + 485\,(SKR)\,(CF)\,(SC)$$

Where:

RTTV =	Roof thermal transfer value (W/m^2)
SKR =	Skylight ratio of roof (skylight area/gross area of roof)
U_r=	Thermal transmittance of opaque roof (W/m^2K)
U_s=	Thermal transmittance of skylight area (W/m^2K)
CF =	Solar correction factor for roof (climate-dependent)
SC =	Shading coefficient of skylight portion of the roof

Similarly, when more than one type of material and or skylight is used, the respective term(s) shall be expanded into sub-elements, as follows:

RTTV = $12.5 \times (A_1 \times U_{r1} + A_2 \times U_{r2} + ... + A_n \times U_{rn}) / A_0 + 4.8 \times (A_1 \times U_{s1} + A_2 \times U_{s2} + ... + A_n \times U_{sn}) / A_0 + 485 \times (A_1 \times SC_1 + A_2 \times SC_2 + ... + A_n \times SC_n) / A_0$

Where:

A_{r1}, A_{r2}, A_{rn}=	Areas of different opaque roof(m^2)
A_{s1}, A_{s2}, A_{sn}=	Areas of different Skylight (m^2)
A_o=	Gross area of roof (m^2)
U_{r1}, U_{r2}, U_{rn}=	Thermal transmittances of opaque roofs (W/m^2K)
U_{s1}, U_{s2}, U_{sn}=	Thermal transmittances of skylights (W/m^2K)
SC_{s1}, SC_{s2}, SC_{sn}=	Shading coefficients of skylights

If a roof consists of different sections facing different orientations or pitched at different angles, the RTTV for the whole roof shall be calculated as follows:

$$\mathrm{RTTV} = (A_{01} \times \mathrm{RTTV}_1 + A_{02} \times \mathrm{RTTV}_2 + \ldots + A_{0n} \times \mathrm{RTTV}_n) / (A_{01} + A_{02} + \ldots + A_{0n})$$

Where

A_{o1}, A_{o2}, A_{on}= Gross areas of the roof for each section (m^2)

The solar correction factors for roof are given in **Table A.3-1**.

Table A.3-1Solar Correction Factors (CF) for Roofs ETTV

Pitch Angle	Orientation							
	N	NE	E	SE	S	SW	W	NW
0^0	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
5^0	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
10^0	0.99	0.99	1.00	1.00	1.00	0.99	0.99	0.99
15^0	0.98	0.98	0.99	0.99	0.99	0.98	0.98	0.98
20^0	0.96	0.97	0.98	0.98	0.97	0.97	0.97	0.96
25^0	0.93	0.95	0.96	0.96	0.95	0.95	0.95	0.94
30^0	0.91	0.92	0.94	0.94	0.93	0.93	0.93	0.91
35^0	0.88	0.90	0.92	0.91	0.90	0.90	0.90	0.89
40^0	0.84	0.87	0.89	0.88	0.87	0.87	0.87	0.85
45^0	0.80	0.83	0.86	0.85	0.83	0.84	0.84	0.82
50^0	0.76	0.80	0.83	0.82	0.79	0.80	0.81	0.78
55^0	0.72	0.76	0.80	0.78	0.75	0.76	0.78	0.75
60^0	0.67	0.72	0.76	0.74	0.70	0.73	0.74	0.71
65^0	0.63	0.68	0.73	0.70	0.66	0.69	0.71	0.67

***Appendix 3** information is based on Code on Envelope Thermal Performance for Buildings published by Building and Construction Authority (BCA) of Singapore.

11.4 Appendix 4: Climate Zone Classification

ASHRAE Standard Method

Determine the thermal climate zone, 0–3, from **Table A.4-1**, using heating degree-days (HDD) and cooling degree-days (CDD) along with the dry (B) or wet (A) classification to categorize the thermal climate zone for a given location.

Table A.4-1Thermal Climate Zones

Thermal Zone	Name	Range
0	Extremely hot	CDD 10ºC > 6,000
1	Very hot	5,000 > CDD 10ºC ≥ 6,000
2	Hot	3,500 > CDD 10ºC ≥ 5,000
3	Warm	CDD 10ºC < 3,500 and HDD18ºC ≤ 2,000

Dry (B) /Wet (A) Classification

To classify whether a location is dry (B) or humid (A):

1. Determine the percentage of annual precipitation during the high sun period (summer):
   - Northern Hemisphere (April–September) or Southern Hemisphere (October–March).
2. Use the precipitation percentage to apply one of the thresholds for annual precipitation, P (mm), and mean annual temperature, T (°C):

Dry/Humid Thresholds:

a. If 70% or more of the precipitation, P, occurs during the high sun period, then the dry/humid threshold is:
   $P < 20.0 \times (T + 14)$ (SI units)
b. If between 30% and 70% of the precipitation, P, occurs during the high sun period, then the dry/humid threshold is:
   $P < 20.0 \times (T + 7)$ (SI units)
c. If 30% or less of the precipitation, P, occurs during the high sun period, then the dry/humid threshold is:
   $P < 20 \times T$ (SI units)

Combine Results to Determine Climate Zone

After determining:

1. Thermal Zone (0–3) based on CDD and HDD.
2. Dry/Wet Classification (B/A) based on annual precipitation and temperature.

You can label the climate using a combination like "3A" (Warm Humid) or "2B" (Hot Dry).

Climatic Zone Classification (Köppen)

The **Köppen climate classification system** organizes climates based on temperature and precipitation patterns. Below is a detailed breakdown of the relevant classifications provided:

1. Tropical climates (Af, Am, Aw/As)

These climates are characterized by consistently warm temperatures, with every month of the year averaging 18°C or higher, with varying levels of precipitation.

Af – Tropical Rainforest Climate

Temperature: Average temperature remains above 18°C year-round

Precipitation:

- Significant rainfall every month of the year.
- Minimum 60 mm in in the driest month.

Characteristics: No distinct dry season; Found in equatorial regions.

Example Locations: Parts of the coastal tropical regions and near Lake Victoria.

Am –Tropical Monsoon Climate

Temperature: Average temperature stays above 18°C throughout the year.

Precipitation:

- Driest month has precipitation less than 60 mm (2.4 in), but meets this formula: Precipitation ≥100 mm-(annual precipitation (mm)/25).

- Significant rainfall during the wet season.

Characteristics: Short dry season, followed by heavy monsoonal rains. Typical in areas affected by monsoon winds.

Example Locations: Coastal areas influenced by monsoon patterns, such as near Dar es Salaam.

Aw or As – Tropical Wet and Dry or Savannah Climate;

Temperature: Monthly averages exceed 18°C year-round.

Rainfall:

- Driest month has precipitation less than 60 mm and does not meet the monsoon formula.
- Wet season alternates with a marked dry season.

Characteristics: Savannah vegetation dominates. The dry season coincides with the lower sun period (winter).

Example Locations: Plateau regions, such as Dodoma and the Masai Stepp.

2. Subtropical Highland Climate (Cfb)

Temperature:

- Warmest month below 22°C but the average temperature is typically above −3°C year-round.
- At least one month's average temperature is below 18°C.

Precipitation:

- Rainfall occurs year-round, with no distinct dry season.

Characteristics: Moderate temperatures, with cooler nights due to higher altitudes. Typical in highland or mountainous regions.

Example Locations: Uplands and High Uplands, such as areas around Iringa, Mbeya, and Mount Kilimanjaro.

Table A.4-2Characteristics of the Major Climatic Zones in Tanzania

Zone	Characteristics		Representative Areas/Towns
1	Coastal Tropical (Hot Humid)	**Location**: The island and a strip of land from 20 to 100 km wide along the Indian ocean. **Altitude**: From sea level to about 300m above sea level **Temperature**: Never excessively hot Annual mean max range 25 – 32°C: Annual mean min range: 21.5 – 25°C Diurnal range of 6.5 - 9.5°C **Rainfall**: may fall at any time of the year. Annual mean 750 -1,500mm Rainy days 80-140 days **Humidity**: Permanent high Annual mean at 1500 hrs. 65-75% **Winds**: North – East Monsoon winds (December – March), South – East Monsoon winds (April – October) **Global solar radiation**: 5.0 – 5.4kWh/m^2. Lowers inlands to 4.5kWh/m^2.	Tanga, Bagamoyo, Dar es Salaam, Pemba, Zanzibar, Mafia, Kilwa, Lindi and Mtwara
2	Intermediate Tropical (Hot arid)	**Location**: A strip of land from 10 to 200 km wide behind coastal tropical zone **Altitude**: From 100 m – 600 m above sea level **Temperature**: Hotter than coastal tropical zone; annual mean max: 23 – 36°C; annual mean Min: 18 - 21°C; diurnal range; 10 -12°C **Rainfall**: less rainfall than coastal tropical zone, average annual mean: 600 – 1200mm Rainy days: 90-130 days. **Humidity**: lower humidity than coastal tropical climate but still permanent high. Annual mean relative humidity at 1500 hrs: 50-60%	Handeni, Mkata, Ifakara, Liwale, Ruangwa, Nachingwea, Liwale

		Winds: Same monsoon pattern as coastal tropical zone but less pronounced **Global solar radiation**: Around 7.0kWh/m^2	
3	Lakes (Great lakes)	**Location**: The area bordering Lakes Victoria, Tanganyika, Nyasa and Rukwa **Altitude**: From lake to about 150m above **Temperature**: Mean air temperature range: 16 – 29°C Annual Mean Max: 26 – 28°C Annual Mean Min: 16 - 18°C Diurnal range: 10 -12°C Rainfall. Annual mean: 800 – 2900mm Rainy days: 70-165 days. Humidity: Annual mean relative humidity at 1500hrs.: 60 - 70% **Winds**: Lake-land breeze (noon to dusk) and land lake breeze (during night) near the lake. The lakes of rift system have catabolic winds (cold wind sliding down from mountains during night) Global solar radiation: 5.5kWh/m^2	Mwanza, Musoma,Bukoba, Geita, Ukiriguru, Kigoma, Mputi, Ngomba, Itungi, Manda
4	Plateau (Hot Semi-Arid/Savannah)	**Location**: comprises of 3 sub-zones ·Central and Western plateau area stretching from lake Nyasa to Mount Kilimanjaro) ·Southeastern plateau; Ruvuma region and Ulanga district, ·Northeastern Plateau; Masai steppe which comprises of Arusha District **Altitude**: between 450 – 1,200 m above sea level **Temperature**: day may be hot, but night give relief Annual Mean Max: 27 – 31°C Annual Mean Min; 15 - 19°C Diurnal range; 12 -16°C **Rainfall**: Follows the same pattern as on	*Northeastern* - Moshi, Korogwe *Western* - Uvinza, Mpanda, Shinyanga, Urambo, Tabora, Mpanda, *Central* -Dodoma, Kongwa, *Southeastern* - Songea, Tunduru, Mahenge

		the coastal at same latitude, but with less rain. Annual mean; 250 – 1650mm Rainy days: 40-150 days. ·Central and Western plateau has one rainy season (November – April) ·Southeastern plateau has one rainy season (November – April) ·Northeastern Plateau has two rainy seasons major from March-May and minor October to December **Humidity**: Annual mean relativehumidityat 1500hrs.: 40 - 50% **Winds**: generally light breezes following monsoon pattern. Global solar radiation: 6.3kWh/m^2	
5	Uplands	**Location:** Mainly the lower parts of the ridge of land stretching from Lake Nyasa to Kenyan Boarder, along western perimeter of the country some high learning parts of the internal plateau and other mountain area. **Altitude**: 1,200 – 1,800 m above sea level **Temperature**:Pleasant climate, never very hot, never very cold. Annual Mean Max: 23 – 25°C Annual Mean Min: 10,5 - 14°C Diurnal range: 11 -12.5°C **Rainfall**: Annual mean; 750 – 1500mm Rainy days: 80-150 days. Northern uplands are drier than the southern except for Mount Kilimanjaro. The northern has two rainy seasons March-April and November – December. The southern has one rainy season from November to April **Humidity**: Annual mean relativehumidityat 1500hrs.: 52 - 60%	Iringa,Mbeya, Tunduma, Mbinga, Kondoa, Singida, Babati, Luguru, Olduvai, Kasulu, Kibondo, Biharamulo, Bugene

		Winds: Moderate breeze with no predominant direction. Strong gust during thunderstorm. **Global solar radiation**: Around 5.0 – 6.0 kWh/m2	
6	High Uplands	**Location**: Mainly the area around Mbeya, Njombe, Iringa, also include highest altitudes of Mount Mbalizi, Morogoro, Kilimanjaro, Meru, Loliondo, Ngorongoro, and Mbulu between Hanang and Endabah. **Altitude:**Above 1800 m **Temperature:** Generally cool area, frost sometimes occurs. Annual mean max: 18 – 23°C Annual mean max: 8 – 12°C **Rainfall**: Annual mean 800 – 1400mm up to 2000mm Rainy days: 60-230 days. North has two rainy seasons, from March-May and November to December **Humidity**: Annual relative humidity at 1500 hrs. 45-65% **Winds**; Brisk winds with heavy gusts during thunderstorms, Global solar radiation: 5.3 kWh/m^2	Tukuyu, Njombe, Sao Hill.

Source: Tanzania Meteorological Authority (TMA); United Nations Framework Convention on Climate Change (UNFCCC), Intergovernmental Panel on Climate Change (IPCC), and regional studies on the Great Lakes, uplands, and plateaus.

11.5 Appendix 5: U – Value

To calculate a U-Value you first need to determine the R-Value or resistivity of the material that make up the building element. The R-Value, or thermal resistance, is a measure of a material's ability to resist heat transfer. It depends on the material's thickness and thermal conductivity and is expressed in $W/m^2 \cdot K$.

The R-Value is calculated as:

$$R = t/\lambda$$

Where:

t= the thickness of the material in meters and

λ (lambda) is the thermal conductivity of the material in W/m·K.

U-Value formula

U-Value is the reciprocal of all resistances of the materials found in the building element. It represents the rate of heat transfer through the element and is calculated as:

U-Value = 1/ (Sum of all R-Values)

his calculation accounts for the thermal resistance of each layer of material in the element, including the interior and exterior surface resistances. The formula can be expressed as:

$$U\text{-}Value\ (of\ building\ element) = 1 / (R_{so} + R_{si} + R_1 + R_2 + \ldots)$$

Where:

I. R_{so} is the fixed external resistance (external of air film),
II. R_{si} is the fixed internal resistance (internal air film) and
III. R_1, R_2, etc., are resistances of all elements within the application, including that of cavities within the construction.

Table A.5-1Example for Calculation of Thermal Resistance (Timber Frame)

Layer	Material	Thickness, t (mm)	Thermal conductivity, K (W/m·K)	Thermal resistance, R (m^2K/W)
	External surface	-	-	0.040
1	Outer leaf brick	102	0.77	0.132
2	Air cavity	50	-	0.180
3	Sheathing	9	0.13	0.069
4(a)	Mineral wool quilt between timber studs	140	0.040	3.500
4(b)	Timber framing occupies 15%of the wall area	140	0.12	1.167
5	Plasterboard	12.5	0.21	0.060
	Internal surface	-	-	0.130
	Total Thermal Resistance, R			**5.278**

U-Value = 1/ (Sum of all R-Value)

U-Value = 1/ (5.278)

U-Value = 0.19

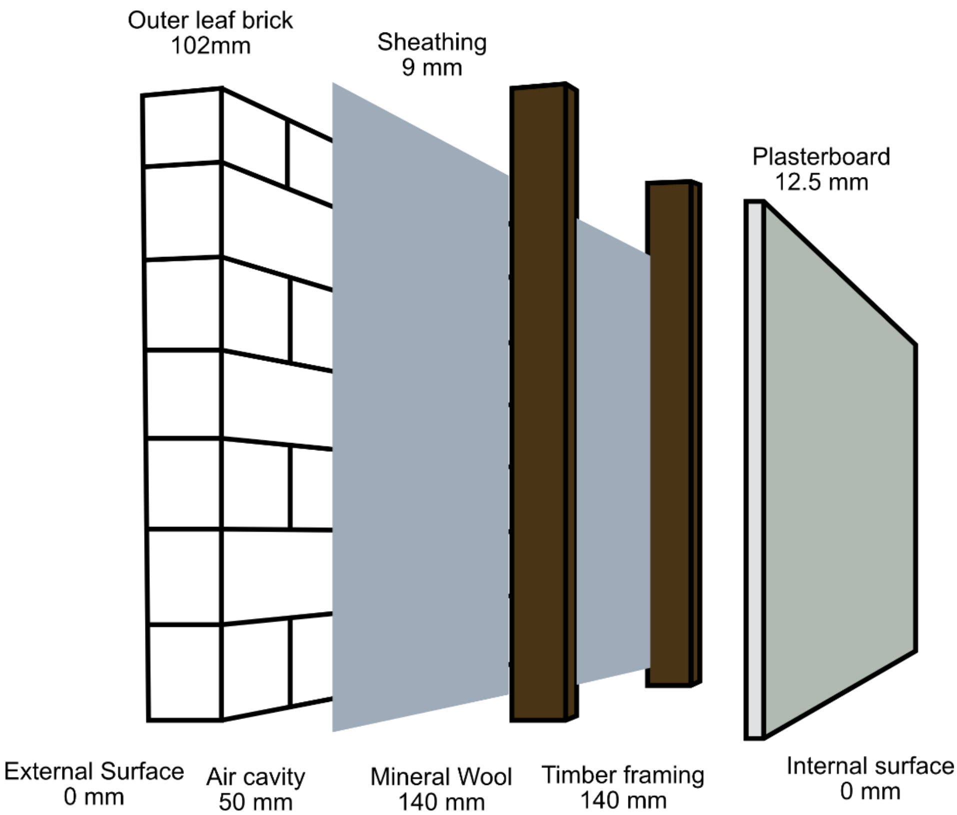


Figure A.5-1Wall Arrangement and U-Value Calculation

Table A.5-2Indicative U-Values of Typical Building Materials

Envelope component	Construction type	U-Value (W/m²K)
Wall	Single brick wall with textured plaster	3.39
	Single brick walls with 5 mm air gap and textured plaster	1.95
	Single brick walls with 10 mm air gap and textured plaster	1.84
	Single brick walls with 70 mm polystyrene insulation and textured plaster	0.40
	Double brick wall with textured plaster	2.47
	English bond brick wall with textured plaster	2.47
	Flemish bond brick wall with textured plaster	2.47
	Cement block wall (large solid blocks) with textured plaster	2.68
	Cement block walls (large solid blocks) with 10 mm airgap and textured plaster	1.43
	Cement block wall (small solid blocks) with textured plaster	3.22
	Cement block walls (small solid blocks) with 10 mm airgap and textured plaster	1.74
	Rubble wall	4.38
	RCC wall (wide)	3.84
	RCC wall (narrow)	4.75
	Cement block wall with 150 mm thick solid block, plaster 25 mm for each inside and outside face	2.90
	Cement block wall with 230 mm thick solid block, plaster 25 mm for each inside and outside face	2.38
	Cement hollow block with 200 mm thick and 150 mm air gap and plaster of 25 mm thick for each inside and outside face	0.16
Windows	Single glazing 6 mm clear glass (timber frame)	5.80
	Double glazing with 6mm clear glass and 12 mm air gap(timber frame)	2.70
	Double glazing with one Low e glass and 12 mm air gap(Timber frame)	1.70
	Single glazing 6 mm clear glass (Aluminum frame)	6.09
	Double glazing with 6mm clear glass and 12 mm air gap (Aluminum frame)	3.46
	Double glazing with one Low e glass and 12 mm air gap(Aluminum frame)	2.17
Roof	Pitched tiled roof with horizontal ceiling and no insulation	1.30
	Pitched metal roof with horizontal ceiling and no insulation	1.33
	Pitched tiled roof with horizontal ceiling and 50 mm insulation on ceiling	0.57
	Pitched tiled roof with horizontal ceiling and 100 mm insulation on ceiling	0.30
	Pitched tiled roof with sloping flat ceiling and no insulation	2.03
	Pitched tiled roof with sloping ceiling and 100 mm insulation at rafter level	0.30
	Pitched metal roof with sloping ceiling and 50 mm insulation	0.51
	Concrete roof	0.88
	With 150mm concrete slab, 30mm Screed, 8mm Ceramic tiles and hardcore (clay or silt)	0.27
	With 150mm concrete slab, 30mm Screed, 8mm Ceramic tiles and hardcore (sand or gravel)	0.34
	With 150mm concrete slab, 30mm Screed, 8mm Ceramic tiles and hardcore (homogeneous rock)	0.54
	With 150mm concrete slab, 30mm Screed, 40mm terrazzo and hardcore (clay or silt)	0.27

Ground	With 150mm concrete slab, 30mm Screed, 40mm terrazzo and hardcore (sand or gravel)	0.34
	With 150mm concrete slab, 30mm Screed, 40mm terrazzo and hardcore (homogeneous rock)	0.54
	With 150mm concrete slab and hardwood timber floor with 50mm thick applied direct on slab and hardcore (clay or silt)	0.24
	With 150mm concrete slab and hardwood timber floor with 50mm thick applied direct on slab and hardcore (sand or gravel)	0.30
	With 150mm concrete slab and hardwood timber floor with 50mm thick applied direct on slab and hardcore (homogeneous rock)	0.45
	With 150mm concrete slab and softwood timber floor with 50mm thick applied direct on slab and hardcore (clay or silt)	0.23
	With 150mm concrete slab and softwood timber floor with 50mm thick applied direct on slab and hardcore (sand or gravel)	0.28
	With 150mm concrete slab and softwood timber floor with 50mm thick applied direct on slab and hardcore (homogeneous rock)	0.43
	With 150mm concrete slab and hardwood floor joists of 25mm with timber beam of 50x100 mm spaced at 300mm and hardcore (clay or silt)	0.11
	With 150mm concrete slab and hardwood floor joists of 25mm with timber beam of 50x100 mm spaced at 300mm and hardcore (sand or gravel)	0.13
	With 150mm concrete slab and hardwood floor joists of 25mm with timber beam of 50x100 mm spaced at 300mm and hardcore (homogeneous rock)	0.16
Basement	With 400 mm basement concrete slab, 30mm Screed, 8mm Ceramic tiles and hardcore (clay or silt)	0.19
	With 400 mm basement concrete slab, 30mm Screed, 8mm Ceramic tiles and hardcore (sand or gravel)	0.25
	With 400 mm basement concrete slab, 30mm Screed, 8mm Ceramic tiles and hardcore (homogeneous rock)	0.41
	With 400 mm basement concrete slab with fair-faced and hardcore (clay or silt)	0.20
	With 400 mm basement concrete slab with fair-faced and hardcore (sand or gravel)	0.25
	With 400 mm basement concrete slab with fair-faced and hardcore (homogeneous rock)	0.41
	Basement concrete wall with 150 mm thick below the ground level, backfilled with sand or gravel	1.12

Note:

1. For design thermal conductivity values for materials in general building applications, refer to ISO 10456:2007.

2. The hardcore was treated as clay, sand and homogeneous rock as per description in ISO 13370

3. The steel reinforcement used in the basement concrete slab was assumed to be 1.0% as described in ISO 10456:2007

11.6 Appendix 6: Air-Side Economizer Acceptance Procedures

1. Construction Inspection

Prior to Performance Testing, verify and document the following:

a) System controls are wired correctly to ensure economizer is fully integrated (i.e., economizer will operate when mechanical cooling is enabled).

b) Economizer lockout control sensor location is adequate (open to air but not exposed to direct sunlight nor in an enclosure; away from sources of building exhaust; at least 8 meters away from cooling towers).

c) System is provided with barometric relief, relief fan or return fan to control building pressure.

2. Equipment Testing

Step 1: Simulate a cooling load and enable the economizer by adjusting the lockout control set point. Verify and document the following:

a) Economizer damper modulates opens to 100% outside air.

b) Return air damper modulates closed and is completely closed when economizer damper is 100% open.

c) Economizer damper is 100% open before mechanical cooling is enabled.

d) Relief fan or return fan (if applicable) is operating or barometric relief dampers freely swing open.

Step 2: Continue from Step 1 and disable the economizer by adjusting the lockout control set point. Verify and document the following:

e) Economizer damper closes to minimum ventilation position.

f) Return air damper opens to at or near 100%.

g) Relief fan (if applicable) shuts off or barometric relief dampers close. Return fan (if applicable) may still operate even when economizer is disabled.

11.7 Defaults for Unrated Fenestration (Overall Assembly Including the Sash and Frame)

		Clear Glass			Tinted Glass		
Frame Type	Glazing Type	U-Factor	SHGC	VLT	U-Factor	SHGC	VLT
All frame types	Single glazing	7.1	0.82	0.76	7.1	0.70	0.58
Wood, vinyl, or fiberglass frame or metal frame	Double Glazing	3.3	0.59	0.64	3.4	0.42	0.39
Metal and other frame types	Double Glazing	5.1	0.68	0.66	5.1	0.50	0.40

11.8 Appendix 7: Building Envelope Trade-off Method

1. Computation Equation

The envelope performance factor shall be calculated using the following equations.

$$EPF_{Total} = EPF_{Roof} + EPF_{Wall} + EPF_{Fenest}$$

Where:

$$EPF_{Roof} = c_{Roof} \sum_{s=1}^{n} U_s A_s$$

$$EPF_{Wall} = c_{Wall,Mass} \sum_{s=1}^{n} U_s A_s + c_{Wall,Other} \sum_{s=1}^{n} U_s A_s$$

$$\begin{aligned} \mathrm{EPF_{Fenes}} = {} & \mathrm{c_{1Fenest,North}} \sum_{w=1}^{n} \mathrm{SHGC_w M_w A_w} + \mathrm{c_{2Fenest,North}} \sum_{w=1}^{n} \mathrm{U_w A_w} \\ & + \mathrm{c_{1Fenest,NonNorth}} \sum_{w=1}^{n} \mathrm{SHGC_w M_w A_w} + \mathrm{c_{2Fenest,NonNorth}} \sum_{w=1}^{n} \mathrm{U_w A_w} \\ & + \mathrm{c_{1Fenest,Skylight}} \sum_{r=1}^{n} \mathrm{SHGC_s A_s} + \mathrm{c_{2Fenest,Skylight}} \sum_{r=1}^{n} \mathrm{U_s A_s} \end{aligned}$$

Where:

EPF_{Roof}	Envelope performance factor for roofs. Other subscripts include walls and fenestration.
A_s, A_w	The area of a specific envelope component referenced by the subscript "s" or for windows the subscript "w".
$SHGC_w$	The solar heat gain coefficient for windows (w). SHGCs refers to skylights.
M_w	A multiplier for the window SHGC that depends on the projection factor of an overhang or side fin.
U_s	The U-factor for the envelope component referenced by the subscript "s".

C_{Roof} A coefficient for the "Roof" class of construction. Values of "c" are taken from **Table A.7-1** through **Table A.7-5** for each class of construction.

Table A.7-1Envelope Performance Factor Coefficients – Composite Climate

Category	Daytime Occupancy		24-Hour Occupancy	
	U-factor	SHGC	U-factor	SHGC
Mass Walls	6.01	-	13.85	-
Curtain Walls, Other	15.72	-	20.48	-
Roofs	11.93	-	24.67	-
North Windows	-1.75	40.65	-4.56	58.15
Non-North Windows	-1.25	54.51	0.68	86.57
Skylights	-96.35	311.71	-294.66	918.77

Table A.7-2Envelope Performance Factor Coefficients – Hot Dry Climate

Category	Daytime Occupancy		24-Hour Occupancy	
	U-factor	SHGC	U-factor	SHGC
Mass Walls	5.48	-	15.01	-
Curtain Walls, Other	6.38	-	22.06	-
Roofs	11.14	-	25.98	-
North Windows	-2.40	36.57	-1.49	56.09
Non-North Windows	-1.86	46.79	1.187	81.79
Skylights	-96.27	309.33	-295.81	923.01

Table A.7-3Envelope Performance Factor Coefficients – Hot Humid Climate

Category	Daytime Occupancy		24-Hour Occupancy	
	U-factor	SHGC	U-factor	SHGC
Mass Walls	6.42	-	9.6	-
Curtain Walls, Other	14.77	-	19.71	-
Roofs	9.86	-	14.11	-
North Windows	-1.58	34.95	-7.29	64.19
Non-North Windows	-1.00	43.09	-6.48	76.83
Skylights	-96.11	305.45	-295.45	893.55

Table A.7-4Envelope Performance Factor Coefficients – Moderate Climate

Category	Daytime Occupancy		24-Hour Occupancy	
	U-factor	SHGC	U-factor	SHGC
Mass Walls	2.017	-	3.11	-
Curtain Walls, Other	2.72	-	4.11	-
Roofs	5.46	-	5.86	-
North Windows	-3.10	29.66	-11.95	62.14

Non-North Windows	-2.98	34.86	-11.62	68.45
Skylights	-96.21	298.82	-294.12	876.7

Table A.7-5Envelope Performance Factor Coefficients – Cold Climate

Category	Daytime Occupancy		24-Hour Occupancy	
	U-factor	SHGC	U-factor	SHGC
Mass Walls	5.19	-	5.19	-
Curtain Walls, Other	6.76	-	6.76	-
Roofs	5.69	-	5.67	-
North Windows	1.55	9.13	1.55	9.13
Non-North Windows	-1.13	16.32	-1.13	16.32
Skylights	-93.44	283.18	-93.44	283.18

2. Overhang and Side Fin Coefficients

The “M” multiplication factor can also be calculated using equation below.

$$M = a \cdot PF^2 + b \cdot PF + 1$$

Where:

PF: Projection factor

a and *b*: Coefficients that vary based on orientation and shading condition.

If the equation is used, a separate calculation shall be made for each orientation and unique shading condition.

Table A.7- 6Overhang and Side Fin Coefficients

Device	Coefficient	North	South	East/West
Overhangs	a	0.16	0.21	0.10
	b	-0.61	-0.83	-0.58
Side Fins	a	0.23	0.12	0.14
	b	-0.74	-0.59	-0.52

3. Standard Building Definition

The following rules shall be used to define the budget building.

a) The standard building shall have the same building floor area, gross wall area and gross roof area as the proposed design. If the building has both 24-hour and daytime occupancies, the distribution between these shall be the same as the proposed design.

b) The U-factor of each envelope component shall be equal to the criteria from Section 6for each class of construction.
c) The vertical fenestration area shall be equal to the proposed design or 40% of the gross exterior wall area, whichever is less. The skylight area shall be equal to the proposed design or 5% of the gross exterior roof area, whichever is less.
d) The SHGC of each window or skylight component shall be equal to the criteria from Section 6.

11.9 Appendix 8: Standards

Table A.8-1 Referenced Standards

Issuing Agency	Document Number	Document Title
AHRI	ANSI/AHRI 210/240-2008	Performance Rating of Unitary Air-Conditioning and Air-Source Heat Pump Equipment
AHRI	AHRI 310/380-2014/CSA C744-14	Packaged Terminal Air-Conditioners and Heat Pumps
AHRI	ANSI/AHRI 340/360-2007	Performance Rating of Commercial and Industrial Unitary Air-Conditioning
AHRI	ANSI/AHRI 366 (SI/2009)	Performance Rating of Commercial and Industrial Unitary Air-Conditioning Condensing Units
AHRI	1361 (SI/2017)	Performance Rating of Water-chilling and DX-Dedicated Outdoor Air System Units
AHRI	Draft Air-Cooled Refrigerant Condensers	Performance Rating of Variable Refrigerant Flow (VRF) Multi-Split Air-Conditioning and Heat Pump Equipment (with Addendum 1)
AMCA	ANSI/AMCA 500-D-12	Methods of Testing Dampers for Rating
AMCA	ANSI/AMCA 500-L-12	Methods of Testing Louvers for Rating
ASHRAE	2011	ASHRAE Handbook – HVAC Applications
ASHRAE	2013	ASHRAE Handbook – Fundamentals
ASHRAE	ANSI/ASHRAE 55-2013	Thermal Environmental Conditions for Human Occupancy
ASHRAE	ANSI/ASHRAE 62.1-2016	Ventilation for Acceptable Indoor Air Quality
ASHRAE	ANSI/ASHRAE 84-2013	Method of Testing Air-to-Air Heat/Energy Exchangers
ASHRAE	ANSI/ASHRAE/IES 90.1-2013	Energy Standard for Buildings Except Low-Rise Residential Buildings
ASHRAE	RP-1365-2011	Thermal Performance of Building Envelope Details for Mid- and High-Rise Buildings
ASHRAE	ASHRAE Handbook – HVAC Applications	Testing, Adjusting, and Balancing of Building HVAC Systems
ASHRAE	ASHRAE Handbook – Fundamentals	Thermal Performance of Building Envelope Details for Mid- and High-Rise Buildings
ASTM	C177-19	Standard Test Method for Steady-State Heat Transfer Properties of Pipe Insulation
ASTM	C335/C335M-17	Standard Test Method for Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus

Issuing Agency	Document Number	Document Title
ASTM	C518-17	Standard Test Method for Thermal Performance of Building Materials and Envelope Assemblies by Means of a Hot Box Apparatus
ASTM	C1363-11	Standard Test Method for Determining Rate of Air Leakage Through Exterior Windows, Curtain Walls, and Doors Under Specified Pressure Differences Across the Specimen
ASTM	E283-04	Standard Test Method for Determining Air Leakage Rate by Fan Pressurization
ASTM	E779-10 E3158-18	Standard Test Method for Measuring the Air Leakage Rate of a Large or Multitoned Building
HRAI	2017 Edition	HRAI Digest
ISO	13790:2008	Energy performance of buildings – Calculation of energy use for space heating and cooling
ISO	15099:2003	Thermal performance of windows, doors, and shading devices — Detailed calculations
ISO	52016-1:2017	Energy performance of buildings – Calculation of energy use for space heating and cooling
SMACNA	ANSI/SMACNA 006-2006	HVAC Duct Construction Standards – Metal and Flexible
SMACNA	ANSI/SMACNA 016-2012	HVAC Air Duct Leakage Test Manual
SMACNA	2003	Fibrous Glass Duct Construction Standards
SMACNA	2006	HVAC Systems Duct Design

Notes to Table A8-1:

(1) While every effort was made to ensure the accuracy of the information in this Table, the technical committee is not responsible for the accuracy, timeliness or reliability of the content presented therein. For all purposes of interpreting and applying the referenced standards, Code users should refer to the most recent official versions of the referenced editions.

(2) Some documents may have been reaffirmed or reapproved. Check with the applicable issuing agency for up-to-date information.