

HEAT



Global Alliance
for Buildings and
Construction

DEVELOPMENT OF GREEN BUILDING STANDARDS FOR GHANA



GHANA BUILDING ENERGY EFFICIENCY GUIDELINES

Prepared for:
The Environmental Protection Authority (EPA)
The Government of Ghana
Accra
Ghana



Prepared by the consortium consisting of HEAT GmbH, DEM, and Wisstech Consulting

With funding from the



HEAT GmbH

Habitat, Energy Application & Technology

Seilerbahnweg 14
61462 Königstein /Ts.
Germany

Contact person

Dietram Oppelt,
Managing Director

kontakt@heat-
international.de

Phone: +49 6174 9 69 47-0

DEM

Danish Energy Management

Søren Frichs Vej 38A
8230 Åbyhøj
Denmark

Contact person

Mr. Jørn Lykou
Global Business Director

lyk@dem.dk

Wisstech Engineering

P.O. Box 660 La
Accra
Ghana

Contact person

Eng. Wisdom K. Gyansah
Director

(Lead Contractor)

Table of Contents

1	Foreword.....	9
2	Scope and application.....	10
2.1	Building types and characteristics of buildings covered by the guidelines	11
2.1.1	Residential buildings	11
2.1.2	Office buildings	11
2.1.3	Commercial building	12
2.2	Climate zones	12
3	Policy context.....	13
3.1	List of existing building standards, codes, and regulations	13
3.2	Interactions with existing building standards, codes, and regulations	16
4	General requirements.....	16
4.1	Overall objectives of the BEEG	16
4.2	Practices and technology overview	18
4.3	Performance goals	18
5	Building orientation.....	19
5.1	Maximise desirable solar gains	19
5.2	Minimise undesirable solar gain	20
5.3	Natural daylighting	20
5.4	Wind patterns	21
6	Building envelope.....	21
6.1	Walls	22
6.1.1	Material selection	22
6.2	Roofs	22
6.2.1	Roof insulation	23
6.2.2	Reflective roof materials or painting	23
6.3	Windows	24
6.3.1	Window-to-wall ratio	24
6.3.2	Shading coefficient	24
6.3.3	Shading and overhang	25
6.4	Doors	26
6.5	Insulation – thermal performance	26
7	Low-carbon materials.....	27
7.1	Embodied carbon	27
7.2	Selection of building materials	27
7.3	Local sourcing of building materials	27

7.4	Recycling and reused materials	27
7.5	Efficient building design	28
8	Heating, Ventilation and Air Conditioning (HVAC)	28
8.1	Air conditioning	28
8.1.1	Energy-efficient air conditioners	29
8.1.2	Minimum efficiency requirements	29
8.1.3	Sizing of air-conditioning systems	29
8.2	Ventilation and indoor air quality	29
8.2.1	Minimum ventilation requirements	30
8.2.2	Ventilation strategies	30
8.2.3	8.2.3 Ventilation for Specific Areas	31
9	Lighting	31
9.1	Strategies for energy-efficient lighting	31
9.2	Minimum energy efficiency requirements – lighting power density	32
9.2.1	Residential spaces:	32
9.2.2	Commercial spaces:	33
9.2.3	Educational institutions:	33
9.2.4	Healthcare facilities:	33
9.2.5	Hospitality:	33
9.2.6	Public and community spaces:	33
9.2.7	Outdoor areas:	33
9.2.8	Special cases:	33
9.3	Lighting power density requirements	34
10	Electrical appliances and equipment.....	35
10.1	Water heating	35
10.2	Electrical water heating	36
10.3	Conservation of hot water usage	36
10.4	Electrical Systems and Allied Installations Requirements	36
11	Renewable energy	37
11.1	Solar water heating	38
11.2	Solar PV	38
11.3	Biomass Cookstoves	39
12	Building control systems	39
12.1	Occupancy sensors	39
12.2	Thermostat settings and control	40
12.3	Lighting controls	40
12.4	Energy Management Systems	40
12.5	Green Public Procurement (GPP) for Sustainable Building Projects	40

13	Energy performance – energy index/specific energy consumption	41
13.1	Energy Index	41
13.2	Specific Energy Consumption	41
14	MVE: Compliance pathways	42
14.1	Building simulation and estimation of building performance	43
14.1.1	Methods for calculating energy performance	43
14.1.2	Energy modelling	43
14.1.3	Key performance information needs for modelling	44
15	MVE: Enforcement	44
15.1	Integration with existing building inspection and testing requirements	45
15.1.1	Phased approach	46
15.2	Compliance inspection and testing	46
15.3	Roles and capacity	47
15.4	Information required for validation/compliance check	50
15.4.1	Initial application and documentation	50
15.4.2	Design review and pre-construction assessment	51
15.4.3	Construction stage monitoring and verification	51
15.4.4	Completion stage review and certification	51
15.4.5	Occupancy and post-occupancy monitoring	52
16	Annexe	53
16.1	Modelling guidelines for building energy performance assessment	53
16.2	Sample information requirement sheets for energy performance modelling	53
16.2.1	Purpose and Functionality	54
16.2.2	Key Input Categories	54
16.3	Operational assumptions of building equipment	57
16.4	List of contributors	60

List of Tables

Table 1: Key existing national standards, codes, and regulations that influence the development of these Guidelines.	14
Table 2: Recommended energy performance thresholds for the three key building types targeted in these Guidelines.....	18
Table 3: Required SHGC for the respective WWR of buildings prescribed by the Ghana Building Code for unshaded windows.....	21
Table 4: SHGC adjustment factors.....	25
Table 5: Ventilation air changes per hour recommended.....	31

Table 6: Light power density requirements for different building uses.....	34
Table 7: Solar PV applications for buildings.....	38
Table 8: Inspection and testing mapping of roles, responsibilities and needed expertise for the successful implementation of a BEEG. (Source: HEAT Analysis)	49
Table 9: Recommended assumptions for the schedule of operation of key energy services in office buildings.....	58
Table 10: Recommended assumptions for the schedule of operation of key energy services in residential buildings.....	58
Table 11: Recommended assumptions for the schedule of operation of key energy services in residential buildings.....	59
Table 12: Recommended assumptions for the schedule of operation of key energy services in multistorey residential buildings.	60

List of Figures

Figure 1: Map depicting the general climatic zones in Ghana. (Source: Research Gate)	13
Figure 2: Building orientation measures to minimise solar exposure.	19
Figure 3: Minimise low sun angle exposure.	19
Figure 4: Using prevailing winds for natural ventilation.	21
Figure 5: Shading options.	25
Figure 6: Illustration of the basic information data entry sheet of the assessment tool.	55
Figure 7: Headline energy performance results indicating the level of compliance.....	55
Figure 8: Insulation and WWR entry sheet.	56
Figure 9: Input sheet for AC information of the building.....	57

Abbreviations

AGI	Association of Ghana Industries
BC	Building Codes
BEEG	Building Energy Efficiency Guidelines
BMS	Building Management System
CTCN	Climate Technology Centre and Network
COP	Coefficient of Performance
EC	Energy Commission
EE	Energy Efficiency
EER	Energy Efficiency Ratio
AEER	Annual Energy Efficiency Ratio
TCSPF	Total Cooling Seasonal Performance Factor
EPA	Environmental Protection Authority
GGBC	Ghana Green Building Council
GhBC	Ghana Building Code
GIA	Ghana Institute of Architects
GhIE	Ghana Institution of Engineering
GhIS	Ghana Institution of Surveyors
GSA	Ghana Standards Authority
HVAC	Heating, Ventilation, and Air Conditioning
ICC	International Code Council
IECC	International Energy Conservation Code
IEQ	Indoor Environmental Quality
LCC	Life Cycle Cost
LPD	Lighting Power Density
MMDAs	Metropolitan, Municipal, and District Assemblies
MRV	Monitoring, Reporting, and Verification
MWHWR	Ministry of Works, Housing and Water Resources
NZEB	Net-Zero Energy Building
NEEAP	National Energy Efficiency Action Plan

NDC	Nationally Determined Contributions
SHGC	Solar Heat Gain Coefficient
SWG	Stakeholder Working Group
WWR	Window to Wall Ratio
ZEB	Zero Energy Building

1 Foreword

This document has been developed with support from the United Nations Environment Programme (UNEP) and the UN Climate Technology Centre and Network (CTCN) to support the government of Ghana and the Ghanaian people in their objectives to transition to a more sustainable built environment. It has been funded by the Federal Ministry for Economic Development and Cooperation of Germany (BMZ) under the framework of the UNEP-led project “Transforming the built environment through sustainable materials” and following the publication of the Climate Action Roadmap for Buildings and Construction of Ghana.

The need to address climate change has become more urgent than ever as the impacts of climate change intensify and the need for proactive measures becomes clearer. In response, the Government of Ghana, in collaboration with the CTCN, has initiated the development of a Building Energy Efficiency Guidelines (BEEG) document. These Guidelines aim to support a transition towards more climate-friendly operations in the building sector, which is a significant contributor to the country’s greenhouse gas emissions.

The primary objective of the Building Energy Efficiency Code is to provide the technical foundation for the construction of energy-efficient buildings. These buildings offer multiple benefits, including reduced emissions during construction, improved structural quality and resilience, enhanced occupant health and comfort, and overall environmental sustainability.

The introduction of a building energy efficiency code represents a forward-thinking strategy to address these challenges. It promotes a built environment that is environmentally sustainable and enhances the well-being of all Ghanaians.

Furthermore, this initiative aligns with Ghana’s commitments under the Paris Agreement and demonstrates the country’s dedication to sustainable development. By implementing high building standards, the goal is to improve the climate performance of new buildings, lower greenhouse gas emissions, and increase energy efficiency.

In the development of these Guidelines, the authors have aimed at an inclusive and collaborative process, involving government ministries, local authorities, the private sector, and civil society. With this approach, the authors and key Ghana stakeholders look to foment broader acceptance and effective implementation of the guidelines, as well as awareness of building energy efficiency.

The team responsible for this document extends its sincere appreciation to all stakeholders and partners who have contributed to this effort and the development of the present document. Their dedication and cooperation are essential for the successful application of these guidelines.

All stakeholders are encouraged to continue their engagement and support as the Building Energy Efficiency Guidelines are finalised and implemented. Together, we can build a sustainable future and create a built environment that improves the quality of life for current and future generations.

2 Scope and application

These guidelines aim to establish a consistent and enforceable framework to promote energy-efficient design and construction practices with a view to increasing sustainability and eventually aiming for net-zero energy buildings in Ghana.

The Guidelines have been prepared with due consideration to existing regulations, codes and standards related to the design and construction of buildings and structures with the purpose of serving as shelter for people and protecting them against climatic impacts. In this context, an existing key document is the “Ghana Building Code” (GhBC) – Building and Construction (GS1207:2018), prepared and issued by the Ghana Standards Authority (GSA). In the current version of the GhBC, there are sections that are of direct relevance to the objectives of these Guidelines. These sections are:

- Part 13: Interior Environment
- Part 14: Energy Efficiency and Sustainability
- Part 28: Electrical Systems and Allied Installations
- Part 29: Mechanical Systems
- Part 37: Green Building Requirements

The requirements stated under these Parts of the GhBC must always be complied with.

The GhBC also makes references to the International Energy Conservation Code (IECC) issued by the International Code Council; these should also be consulted with during the design and construction of any new types of buildings covered by these guidelines.

The Guidelines are tentatively voluntary and should be consulted and followed with that assumption.

The following areas are covered by the present Guidelines:

1. **Minimum energy efficiency requirements and verification procedures:** The BEEG will define the baseline energy performance requirements that buildings must meet. These requirements address areas such as building envelope insulation, lighting systems, Heating, Ventilation, and Air Conditioning (HVAC) performance, renewable energy integration, and overall building energy demand. It will also detail how compliance is verified through inspections, testing protocols, or performance simulations, ensuring that buildings adhere to the minimum energy-saving standards during design, construction, and operation phases.
2. **Energy performance calculation methods and assessment tools:** This Guidelines document will provide support on the use of recognised methodologies and tools used to evaluate a building's energy performance. These may include simulation software, energy modelling procedures, and benchmarking systems that help designers and auditors assess expected versus actual performance. This will ensure that energy calculations are standardised, transparent, and scientifically valid.
3. **Certification systems and incentives for energy-efficient buildings:** This component will explain mechanisms to promote and recognise green buildings through certification schemes (such as energy labels or performance ratings) and financial or policy-based incentives. These measures are designed to encourage stakeholders (developers, owners, and tenants) to invest in and adopt energy-efficient practices. Incentives could include tax credits, grants, priority permitting, or reduced utility rates.
4. **Compliance monitoring and regulatory enforcement:** To support the development of mechanisms that enable strong adherence to the code, this report will detail the processes for market surveillance and legal enforcement. This includes regular audits, compliance checks, penalties for non-compliance, and the roles of regulatory authorities.

5. **Qualification requirements for professionals in the building industry:** The effective deployment of the BEEG depends on skilled professionals. This section will describe the education, training, and certification standards required for various roles, such as energy auditors, certifiers, building inspectors, and designers. It will categorise levels of expertise and ensure a robust talent pipeline capable of delivering on the goals of energy efficiency.
6. **Review, feedback, and code updates:** Recognising that building technologies, industry standards and capability, and climate targets evolve, the code will include a structured process for periodic review and updates. This ensures the code remains relevant, reflects current best practices, and incorporates emerging technologies. Stakeholder feedback, performance data, and international standards will inform each revision cycle.

These components comprise the key elements that are needed to have a well-rounded policy and regulatory approach to effect a positive transformation of the industry in a country.

2.1 Building types and characteristics of buildings covered by the guidelines

The Ghana Building Energy Efficiency Guidelines (BEEG) are developed for and apply to three main categories of buildings:

- **Residential buildings:** Single-family homes and multi-story apartment buildings designed for long-term habitation,
- **Commercial buildings:** Warehouses, supermarkets, and retail spaces
- **Office buildings:** single or multi-floor buildings for administrative and business use.
- **Institutional buildings:** educational facilities (schools, universities) and healthcare facilities (hospitals, clinics).

Reference is also made to the **Ghana Building Code Part 3: Occupancy Classification and Use**, which include a more detailed definition of various classifications primarily depending on the purpose of the building structure.

Exemptions for heritage buildings may be granted with compensatory measures.

2.1.1 Residential buildings

The characteristics of residential buildings in Ghana reflect a combination of cultural norms, climatic conditions, economic factors, urbanisation trends, and traditional building techniques. These characteristics vary significantly between urban and rural areas, and across different income levels, but there are general trends that define the residential built environment across the country. Residential buildings typically include bedrooms, kitchens, bathrooms, and living areas, and they are designed to offer a safe, comfortable, and private environment.

The following typologies are included under residential buildings:

- single-family detached homes
- compound houses
- semi-detached and terraced houses
- apartment blocks and flats

A lower limit for compliance with these guidelines is set at **75 m² for total floor area (air-conditioned)** within this category. Although units of residential buildings that may be smaller than this threshold are exempted, they will always benefit from following the requirements and recommendations presented in these guidelines.

2.1.2 Office buildings

Office buildings are a subset of commercial buildings that are primarily used for business, administrative, and professional activities. They can be both public or privately owned. These structures often have

extended operational hours and require substantial energy for lighting, cooling, and powering office equipment, as well as other plug loads. Energy-efficient measures, such as advanced HVAC systems, improved insulation, and the use of natural lighting, can significantly reduce the energy demand of these buildings. Centrally controlled Energy Management Systems can also offer and lead to comprehensive energy savings.

A lower limit for compliance with these guidelines is set at **500 m² for total floor area (air-conditioned)** within this category.

2.1.3 Commercial building

Commercial buildings are structures primarily used for business and professional activities, encompassing spaces such as retail shops, hotels, restaurants, theatres and other service-oriented establishments. These buildings typically have high energy demands due to extended operational hours and the need for various amenities to support business activities. Implementing energy-efficient practices in commercial buildings can significantly impact overall energy consumption, reduce operational costs, and contribute to national efforts to lower greenhouse gas emissions.

A lower limit for compliance with these guidelines is set at **500 m² for total floor area (air-conditioned)** within this category.

Gross Floor Area thresholds will be reviewed every three years post-implementation and based on observed outcomes, may be adjusted by the regulatory authority to ensure relevance and ongoing policy alignment.

2.2 Climate zones

The development of these guidelines is grounded in consideration of local climate conditions to optimise the results of building operations efficiently and comfortably across different parts of the country. This means that energy performance measures and standards should not be generalised but must reflect regional environmental factors that influence building energy demand.

One of the most widely accepted tools for climate-responsive building design is the concept of degree days, a metric that quantifies how much (and for how long) the outside air temperature deviates from a base indoor comfort level, typically set between 18°C and 20°C. Choosing a higher indoor set point (for example, at 25°C) would result in energy savings.

- **Heating Degree Days (HDD)** provide a measure of the heating requirements in a building by counting the number of degrees the outdoor temperature falls below the set baseline.
- **Cooling Degree Days (CDD)** indicate the need for cooling when outdoor temperatures exceed the comfort range.

Ghana does not experience significant temperature swings like temperate countries, but CDD values are significantly more relevant due to the persistent heat and humidity in many parts of the country. HDDs are relatively negligible across Ghana, reflecting the minimal to no need for active heating. However, energy demand for cooling is growing, particularly in urban and rapidly developing areas.

While Ghana's overall temperature profile is relatively stable, other climatic parameters, such as humidity levels, rainfall intensity, wind exposure, and solar radiation, can vary notably between the coastal, forest, and savannah zones. These differences can affect building energy use, indoor environmental quality, and the performance of passive design strategies.

These guidelines do not cover detailed requirements per climate zone, but they provide the tools needed for the central or regional governments to adapt the requirements to the different climate zones. For this, it is recommended to consider three distinct climate-responsive versions of the guidelines that respond to the climate zone differences in Ghana (Figure 1).

The proposed three variations respond to the main climate variables that may vary across climate zones and affect building design requirements, including:

- **The Coastal Zone**, with high humidity and saline conditions, features such as natural ventilation and corrosion-resistant materials improve building quality and performance.
- **The Forest Zone**, characterised by high rainfall and dense vegetation, in which buildings would benefit greatly from robust moisture control and daylight optimisation measures.
- **The Savannah Zone**, with hot, dry seasons and significant dust exposure, in which shading, thermal mass, and dustproofing are key.

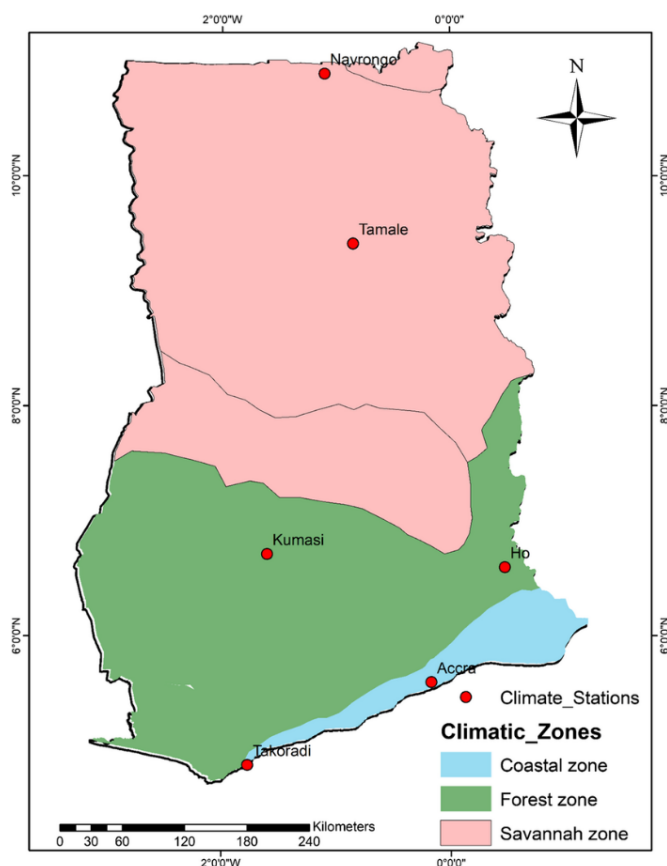


Figure 1: Map depicting the general climatic zones in Ghana. (Source: Research Gate)

Integrating such climate-responsive zoning into the codes would enable more precise energy performance requirements and support the design of buildings that are both resource-efficient and resilient to climate variability. At the same time, this would require greater resources over time to implement, as there would be a need to maintain each one independently.

A recommended middle ground would be to begin with national-level minimum requirements that set thresholds attainable for all climate regions, while setting up the tools and processes needed for further refinement into climate zones in the near future, once experience and capacity in the country start to develop.

3 Policy context

3.1 List of existing building standards, codes, and regulations

Ghana has an established and nuanced framework of governance around the building sector and the related issues. This includes institutions dedicated to the development of standards, as well as agencies

in charge of developing policy and regulations for buildings, energy, infrastructure, and other related areas. This section provides a summary of the setting in which these guidelines will fit in and the main organisations that will need to be actively involved in the development and implementation of the final regulatory requirements. The key organisations include:

- The Ghana Energy Commission (EC) is mandated by law to regulate and manage the development and utilisation of energy resources in Ghana as well as to provide the legal, regulatory, and supervisory framework for all providers of energy in the country, specifically by granting licenses for the transmission, wholesale, supply, distribution and sale of electricity and natural gas and related matters¹.
- The Ghana Ministry of Works and Housing (MWH) is mandated to initiate and formulate policies for the Works and Housing sector, as well as coordinate, monitor and evaluate the implementation of plans, programmes, and performance of the sector for national development.
- The Ghana Environmental Protection Authority (EPA) manages the environmental performance of buildings and is in charge of pursuing a climate-friendly development agenda.
- The Ghana Standards Authority (GSA) is the National Statutory Body responsible for the development and promulgation of standards in Ghana.

These agencies have developed several standards, codes, and regulations for energy efficiency in the country. Table 1 lists the title and scope of some existing standards, codes, and regulations that may influence the implementation of the BEEG or future development of a mandatory code.

Table 1: Key existing national standards, codes, and regulations that influence the development of these Guidelines.

Title and scope	No.
Ghana Building Code. <ul style="list-style-type: none"> • Lays down the essential requirements buildings must comply with. 	GS 1207: 2018
Building Regulations, 2022. <ul style="list-style-type: none"> • Provide safety to life and property and to ensure public health, the general welfare of people and environmental protection in the construction of buildings. 	L.I. 2465
Electrical Wiring Regulations, 2011. <ul style="list-style-type: none"> • Minimum standards of electrical wiring on premises and people safety, livestock, and other properties. 	L.I. 2008
Energy Commission (Electrical Wiring Cables and Electrical Wiring Accessories) Regulations, 2023. <ul style="list-style-type: none"> • Minimum standards of electrical wiring cables and electrical wiring accessories. 	L.I. 2478
Renewable Energy (Standards and Labelling) (Solar Panels) Regulations, 2022. <ul style="list-style-type: none"> • Promote the efficient use of solar panels in the country and mitigate climate change. Enforcement of standards, minimum efficiency standards, labelling of solar panels, supplementary product information, and registration of models. 	L.I. 2449

¹ Energy Commission (2025). Mandate and Functions. <https://www.energycom.gov.gh/index.php/about-us/mandate-and-functions> (accessed Aug. 23, 2025).

Title and scope	No.
Renewable Energy (Standards & Labelling) (Inverters) Regulations, 2022. <ul style="list-style-type: none"> Promote the efficient use and conservation of energy in the country and mitigate climate change. Enforcement of standards, minimum efficiency standards, labelling of inverters, supplementary product information, and registration of models. 	L.I. 2461
Renewable Energy (Standards & Labelling) (Renewable Energy Batteries) Regulations, 2022. <ul style="list-style-type: none"> Promote efficient use of renewable energy batteries in the country and mitigate climate change. Enforcement of standards, minimum efficiency standards, labelling of renewable energy batteries, supplementary product information, and registration of models. 	L.I. 2452
Energy Commission Net Metering Code 2023. <ul style="list-style-type: none"> Guidelines and technical connection conditions for the interconnection of renewable energy generating facilities (e.g., solar panels) to the low voltage distribution network. 	N/A
Renewable Energy Act, 2011. <ul style="list-style-type: none"> Provide for the development, management, utilisation, sustainability, and adequate supply of renewable energy for the generation of heat and power and for related matters. 	Act 832
Energy Commission (Energy Efficiency Standards and Labelling (Air Conditioners) Regulations, 2022. <ul style="list-style-type: none"> Promote the efficient use and conservation of energy in the country and mitigate climate change. Enforcement of standards, minimum energy performance standards and sound power levels of air conditioners, labelling of electric mains-operated air conditioners, supplementary product information, and registration of models. 	L.I. 2458
Energy Commission (Energy Efficiency Standards and Labelling (Water Heaters) Regulations, 2022. <ul style="list-style-type: none"> Promote the efficient use and conservation of energy in the country and mitigate climate change. Enforcement of standards, minimum energy performance standards, labelling of electric mains-operated water heaters, supplementary product information, and registration of models. 	L.I. 2451
Energy Commission (Efficiency Standards and Labelling) (Light Emitting Diode and Self-ballasted fluorescent lamps) Regulations, 2017. <ul style="list-style-type: none"> Enforcement of minimum energy efficiency standards and labelling. 	L.I. 2353
Energy Commission (Energy Efficiency Standards and Labelling) (Public lighting) Regulations, 2022. <ul style="list-style-type: none"> Promote the efficient use and conservation of energy in the country and mitigate climate change. Enforcement of standards, minimum energy performance standards, labelling of electric mains-operated lamps and luminaires, supplementary product information, and registration of models. 	L.I. 2453

Title and scope	No.
Energy Efficiency (Prohibition of Manufacture, Sale or Importation of Incandescent Filament Lamp, Used Refrigerator, Used Refrigerator-Freezer, Used Freezer and Used Air-Conditioner) Regulations, 2008. <ul style="list-style-type: none"> Prohibit certain used electrical appliances and air conditioners, and incandescent filament lamps. 	L.I. 1932
Energy Commission (Energy Efficiency) (Prohibition of Manufacture, Importation and Sale of Incandescent Filament Lamps) Regulations, 2022. <ul style="list-style-type: none"> Promote the efficient use and conservation of energy in the country and mitigate climate change and contamination of water bodies by prohibiting incandescent filament lamps (similar to L.I. 1932 above). 	L.I. 2442
Climate Action Roadmap for Buildings and Construction. <ul style="list-style-type: none"> Guidelines towards reducing greenhouse gas emissions, promoting energy efficiency, enhancing resilience of the built environment, and promoting sustainable building practices across the country. 	N/A
Energy Commission (Energy Efficiency Standards and Labelling) (Improved Biomass Cookstove) Regulations, 2022. <ul style="list-style-type: none"> A regulation that establishes MEPS and mandatory labelling for improved biomass cookstoves, setting thermal efficiency thresholds to phase out inefficient traditional stoves. 	L.I. 2454

3.2 Interactions with existing building standards, codes, and regulations

The implementation of the BEEG is expected to be influenced by existing national building standards, codes, and regulations, such as the Ghana Building Code (GS 1207: 2018) and Building Regulations, 2022 (L.I. 2465). Therefore, throughout the BEEG, relevant references are made to these standards, codes, and regulations, ensuring compliance or recommending improved requirements where necessary. The adoption of some of these recommended improved requirements may require relevant evaluation and revision of existing standards, codes, and regulations. Until the BEEG is enforced within the existing national building standards, codes, and regulations, it is important to review existing or available standards, codes, and regulations and ensure that they are followed when commencing a design phase of a new building project or in connection with building renovations, to avoid problems due to non-compliance. Especially, it is important to check whether requirements align with such available national standards, codes, and regulations.

4 General requirements

4.1 Overall objectives of the BEEG

The BEEG for Ghana is developed to address the growing need for sustainable development within the built environment, with a focus on reducing GHG emissions by enhancing energy efficiency of building operations through its lifetime, as well as promoting the use of low-carbon building materials during the construction phase. These objectives align with both global and national efforts to mitigate climate change, improve energy security, and foster long-term economic growth in a way that is environmentally responsible. Further, the development of a successful implementation of BEEG can result in significant co-benefits for users of buildings, such as improved health, improved comfort, and improved

productivity. Investing in energy-efficient buildings is also a gender-smart strategy. It reduces economic and health burdens on women, creates inclusive job opportunities, and supports broader societal resilience.

This is an important first step towards achieving the long-term country objectives of implementing full Green Building Standards.

In practice, the reduction of GHG emissions is achieved through the optimisation of building designs to minimise the requirements for active energy services (cooling, lighting, etc.) and maximise the utility of naturally available energy services such as natural light and ventilation, which reduces the need for artificial lighting and mechanical cooling. Additionally, the integration of energy-efficient technologies for key building services such as HVAC systems and lighting further minimises energy demand, particularly for temperature control and illumination.

The BEEG promotes the integration of renewable energy solutions, which are an important alternative in reducing GHG emissions and decreasing reliance on non-renewable energy sources. The BEEG recommends the installation of on-site renewable energy systems, with solar power being a prominent solution given Ghana's abundant sunlight. Solar photovoltaic (PV) systems and solar water heaters are specifically promoted to generate clean, renewable energy, reducing the need for grid-based electricity. Furthermore, in long-term perspectives, the BEEG encourages preparing buildings for smart grid integration through advanced sensors and metering.

To support the successful implementation of the BEEG, robust compliance and enforcement mechanisms based on the desired regulatory approach are needed. This can include the following steps:

- Building plans will be assessed during the design phase to ensure alignment with the guidelines' energy efficiency standards. Compliance with energy efficiency minimum requirements should be checked along with compliance with safety standards.
- Regular inspections during construction and post-completion to verify ongoing compliance. Minimum energy efficiency requirements should be checked before issuance of usage.

This approach will not only help Ghana meet its national climate targets but also contribute to the broader global commitment to reducing the environmental impact of urbanisation and infrastructure development. The BEEG's emphasis on energy efficiency and renewable energy integration will be a significant step toward creating a sustainable built environment in Ghana, ensuring that new buildings are both environmentally responsible and economically viable for future generations.

It is important to note that while the concept of "green buildings" encompasses a wide range of environmental and social performance criteria, this BEEG focuses specifically on energy performance and climate-related aspects of buildings, as well as some recommendations on the application of building materials with a lower carbon footprint than those that are traditionally used. By narrowing its scope to energy efficiency and GHG reduction, the BEEG will streamline efforts to address climate change within the building sector while setting clear, measurable targets for energy consumption and sustainability.

An energy-efficient building initiative becomes **gender-responsive** when it not only saves energy but also improves safety, affordability, access to decision-making, health, and economic opportunity for all genders. The BEEG aims to enhance inclusivity in the process, ensuring that the implementation of energy-efficient standards does not exacerbate gender inequalities or exclude marginalised groups from benefiting from sustainable building practices. This is particularly important in a diverse society like Ghana, where access to affordable and energy-efficient housing can contribute significantly to reducing social disparities and energy poverty.

4.2 Practices and technology overview

These Guidelines look at a range of technologies and strategies to improve the climate performance of buildings through the reduction of the energy demand, implementation of renewable energy, and the use of low-carbon building materials. These include a deep look at the following elements:

- **Building orientation** can play an important role in helping to reduce energy demand by optimising solar exposure, daylight access, and natural ventilation. Proper window placement and light shelves are used to increase daylighting and reduce dependence on artificial lighting. Additionally, aligning building openings with Ghana's prevailing southwest-northeast wind patterns enhances natural ventilation, reducing the need for mechanical cooling and improving indoor air quality and comfort.
- The **building envelope** plays a critical role in reducing energy demand by limiting heat gain and improving thermal comfort. Key strategies include using high thermal mass materials for walls (e.g., concrete, masonry), applying insulation (especially in roofs), and adopting reflective or green roofing systems to mitigate solar heat absorption.
- **Reducing embodied carbon** through the careful selection and sourcing of building materials is another option for GHG emissions reductions. Locally available, low-carbon options like compressed earth blocks, bamboo, and stabilised soil are encouraged to minimise transport emissions and align with Ghana's climate. Recycled and reused materials (e.g., reclaimed timber, recycled concrete) are promoted as part of a circular economy approach.
- **Space conditioning systems** (HVAC in particular) are among the highest energy consumers in buildings, especially in warm climates. The use of highly efficient equipment and proper system sizing and design are among the most important options. But passive design strategies such as cross-ventilation, high ceilings, and louvred openings are also good options to reduce dependence on mechanical cooling.
- Energy-efficient **lighting** is a low-cost, high-impact solution for reducing building energy use. The use of LED lighting and controls such as occupancy sensors, dimmers, daylight harvesting, and timers maximises efficiency and reduces energy waste. But it is also important to consider the need to provide sufficient lighting for the intended activities of the buildings.
- The integration of **renewable energy** systems, especially solar technologies, into building designs is often used to reduce energy demand from electricity grids. Solar water heating systems are another recommended option.
- **Smart building technologies**, such as occupancy sensors to control lighting, AC, and ventilation based on real-time use, are central to building performance optimisation. Programmable thermostats are also encouraged as part of centralised energy management systems (EMS) to enable real-time monitoring and optimisation of energy use, while building users and operators are encouraged to undergo training to maximise the benefits of these technologies.

4.3 Performance goals

These Guidelines set specific performance targets and objectives for different building categories to ensure that they achieve high standards of energy efficiency and climate sustainability.

For the three categories of buildings covered by these guidelines, the following recommended maximum energy performance thresholds are based on inputs from public consultation processes, previous work carried out in the country, and levels recommended by alternative certification schemes.

Table 2: Recommended energy performance thresholds for the three key building types targeted in these Guidelines.

No.	Building category	Maximum energy index (kWh/m ² /yr)
1	Residential	50

2	Office	100
3	Commercial	150

- **Renewable Energy Contribution (REC):** Minimum 5% of final energy demand by 2035.
- **Clean Cooking Index (CCI, residential):** Minimum >80% electricity/LPG by 2035.

5 Building orientation

Building orientation and site selection (where possible) are important initial considerations and decisions related to energy efficiency in Ghana, affecting heat gains, shading, and natural light. Orienting buildings with their shorter sides/facades facing east and west can reduce solar heat gain, especially from intense afternoon sun, while maximising north-facing windows provides consistent natural light. Effective shading through overhangs, awnings, and vegetation can further manage heat gain. Proper window placement and the use of light shelves can enhance daylighting, reducing the need for artificial lighting. Additionally, orienting buildings to facilitate natural cross-ventilation improves indoor air quality and reduces reliance on mechanical cooling.

5.1 Maximise desirable solar gains

Optimisation for the capture of desirable solar gains in Ghana focuses on the use of natural lighting and capturing solar energy (PV or thermal) for human use. Considering the prevalent hot climate throughout most of Ghana, solar thermal gains are not desirable in most cases.

For this, building orientation, window placement, appropriate glazing materials, and the roof/platform for solar energy capture all contribute to maximisation of the desired energy services.

- **Orientation:** Where possible, main windows and openings should face north or south, as these facades receive more predictable and moderate solar exposure. This allows for easier control of solar heat gain using fixed shading devices (e.g., overhangs, louvres).
- **Roof design and reflectivity:** Roof slopes should ideally face true north (or slightly northwest, depending on location) with a tilt angle close to the site's latitude (~5–10° for Ghana) to maximise solar photovoltaic (PV) output. Flat or low-slope roofs can accommodate modular PV panels and solar water heaters with adjustable mounting. Skylights or roof monitors should be integrated on north-facing slopes to enhance daylighting without excessive heat gain, using diffusers or shading as needed. Additionally, solar chimneys can be designed into roofs to support passive ventilation.
- **Design Features:** Window structures should be oriented with their longer facades facing true north and south. This alignment allows for consistent, easily shaded natural light throughout the day, reducing glare and minimising unwanted heat gain. Larger windows should be concentrated

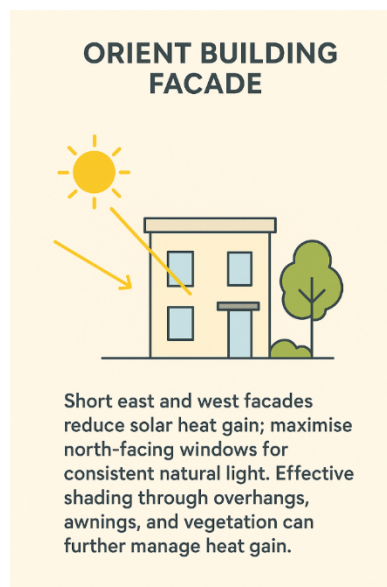


Figure 2: Building orientation measures to minimise solar exposure.



Figure 3: Minimise low sun angle exposure.

on the north and south sides, while east and west openings should be minimised or shaded. Narrow building footprints and north–south oriented courtyards further enhance daylight penetration into interior spaces, reducing the need for artificial lighting and improving energy efficiency.

5.2 Minimise undesirable solar gain

To prevent overheating and reduce cooling loads, it is recommended to minimise undesirable solar gains (mostly thermal) using shading devices like overhangs, louvres, and vegetation, as well as reflective roofing and wall materials. It will also emphasise ventilation strategies and low emissivity glazing to limit unwanted heat gain.

- **Orientation:** Buildings should be oriented with their longer axis running east–west. This reduces the exposure of large surfaces to intense, low-angle morning and afternoon sun, which significantly contributes to heat gain. Smaller east and west-facing walls reduce cooling loads.
- **Shading Devices:** Install shading devices like overhangs, pergolas, or vertical fins to block excessive solar gain during the hot and dry season. These should be designed to block the high-angle seasonal sun, while allowing the lower-angle rainy season sun to penetrate.
- **Vegetation:** Plant deciduous trees on the north and west sides to provide natural shading in summer and permit sunlight in winter when they shed their leaves.
- **Roof design and reflectivity:** Roofs are major sources of heat gain. Use reflective or cool (albedo) roof materials and design with appropriate slopes and overhangs to increase shading and reduce direct heat absorption. Opt for ventilated roof spaces or double roofs, which allow hot air to escape and reduce internal heat buildup. In flat or low-slope roofs, consider green roofs or applying cool roof coatings, both of which significantly lower surface temperatures and improve indoor comfort.

5.3 Natural daylighting

Building designs that enhance indoor natural lighting to reduce the use of artificial lighting through strategic window placement, skylights, and light shelves are recommended. It will encourage the use of high-reflectance interior surfaces to reduce reliance on artificial lighting, improving energy efficiency and occupant well-being.

South and North Facades:

- **South Facade:** Windows on the south side should be maximised to allow ample natural light without excessive heat gain. Use light shelves and reflective surfaces to bounce light deeper into the building.
- **North Facade:** Windows on the north side provide consistent, diffuse light, reducing the need for artificial lighting. This orientation minimises glare and heat gain, enhancing indoor comfort.

East and West Facades:

- **Minimise Window Areas:** Reduce window sizes on the east and west facades to minimise heat gain and glare from the low-angle morning and afternoon sun.
- **Shading:** Use vertical louvres, screens, or other shading devices to reduce or block direct sunlight, preventing overheating and glare.

5.4 Wind patterns

Considering Ghana’s prevailing wind patterns, which typically flow from the **southwest** during the rainy season and from the **northeast** during the Harmattan (dry season), building orientation and ventilation strategies should be adapted to harness these conditions for improved indoor comfort and reduced mechanical cooling needs.

Natural Ventilation:

- **Prevailing Winds:** Buildings should be oriented to capture the dominant southwest winds, especially in the southern and coastal regions, to enhance natural cooling during the hot and humid months. In northern Ghana, where dry Harmattan winds dominate during the cooler months, ventilation openings can be adjusted or shaded to minimise dust and cold air intrusion.
- **Ventilation Design:** Place operable windows or vents on opposite walls, ideally aligned with the southwest–northeast axis, to enable cross-ventilation. This allows air to move efficiently through indoor spaces, flushing out heat and humidity.



Figure 4:Using prevailing winds for natural ventilation.

Wind Protection:

- **Landscaping:** Use trees, hedges, and earthen berms strategically on the northeast side to reduce the impact of cold Harmattan winds and airborne dust. In warmer months, deciduous trees on the southwest side can offer seasonal shading while allowing breezes to filter through.
- **Building Forms:** Incorporate courtyards, breezeways, or staggered layouts that channel airflow through occupied spaces while offering wind buffering zones. In areas with strong seasonal winds, buildings can be partially enclosed or include adjustable louvre systems to manage airflow and maintain thermal comfort.

6 Building envelope

The importance of the building envelope lies in its ability to reduce the building's overall demand for energy services (cooling, heating, lighting, etc) by mitigating unwanted heat gain in warm climates and heat loss in cooler climates. Effective design and the use of optimum materials can lead to significant energy savings. Examples of high-performance materials or design features include double-glazed windows (or triple-glazed) and roof and wall insulations.

For Ghana, the key variables influencing the building envelope's energy efficiency performance relate to the reduction of Solar Heat Gain Coefficient (SHGC), the U-value, and Window-to-Wall Ratio (WWR). SHGC measures the fraction of solar radiation admitted through windows, with lower values reducing cooling loads. The Ghana Building Codes under Part 37.3 prescribe recommended SHGC for unshaded glazing, which should be complied with. The recommendations depend on the Window-to-Wall ratio and whether shading is provided. If exterior shading is mounted, the requirements can be relaxed.

Table 3: Required SHGC for the respective WWR of buildings prescribed by the Ghana Building Code for unshaded windows.

WWR	<30%	31-40%	41-50%	51-60%	61-70%	71-80%	>80%
SHGC	0.80	0.60	0.48	0.40	0.34	0.30	0.26

The U-value measures thermal transmittance, indicating the rate of heat transfer through the building's walls, roof, and fenestration. Lower U-values indicate better insulation and reduced heat losses or gains between the outside environment and the inside of the building. WWR represents the proportion of the building's exterior wall covered by windows, which can greatly impact both thermal performance and natural lighting. The recommended SHGC in the Ghana Building Codes are under the condition of a WWR of 30%. A lower WWR of 20% will reduce heat gain and may be a less costly measure compared with shading or higher-performance glazing. See also Section 5.3.

Another metric used for building envelope insulation is R-value, which is related to the U-value in an inverse relationship. That is to say that while the U-value measures the transmission of thermal energy with lower values being more beneficial, R-values measure the resistance to thermal energy transfer, with higher values being sought.

The primary focus for Ghana is on minimising heat gains due to its predominantly hot and humid weather. Insulating roofs, walls, and floors helps prevent external heat from penetrating indoor spaces, thereby reducing the need for mechanical cooling and improving occupant comfort.

6.1 Walls

Walls are one of the most important components of a building envelope, and for their energy efficiency performance by acting as a barrier between the indoor and outdoor environments. They influence the rate of heat transfer, which directly affects indoor temperatures and the energy needed for indoor heating or cooling. In warm climates like Ghana's, poorly insulated or improperly designed walls can allow excessive heat to penetrate indoor spaces, increasing reliance on fans or air conditioning. Conversely, well-designed walls with appropriate thermal mass and surface treatments can significantly reduce heat gain, maintaining more stable and comfortable interior conditions.

Beyond thermal performance, walls also contribute to air tightness, solar gain control, and moisture management, which all contribute to a durable and energy-efficient building that also improves the quality of indoor environments, which translates to increased user comfort.

6.1.1 Material selection

The use of materials with high thermal mass, such as concrete and masonry, in building design can significantly improve energy efficiency by stabilising indoor temperatures. Thermal mass allows these materials to absorb heat during the day, preventing excess warmth from entering the building, and release it gradually as temperatures cool at night. This process helps maintain a consistent indoor environment and reduces the need for cooling systems, ultimately saving energy and lowering utility costs. For instance, a concrete wall can absorb substantial heat during hot daytime hours, cooling the interior, and later release that stored warmth during cooler nighttime hours, reducing reliance on HVAC systems.

However, there are environmental considerations associated with high thermal mass materials, particularly concrete, which has a high carbon footprint due to the energy-intensive cement production process. To balance these impacts, green building practices can integrate recycled concrete or combine high thermal mass materials with bio-based options like timber, which sequester carbon. By combining sustainable sourcing, improved production processes, and innovative material use, buildings can benefit from the thermal properties of materials like concrete while reducing their overall environmental impact. This balanced approach helps maximise the energy-saving benefits of thermal mass while minimising carbon emissions associated with construction.

6.2 Roofs

In Ghana's hot and humid climate, most buildings are exposed to high levels of solar radiation, leading to excessive heat gain through the roof structure. This results in increased reliance on mechanical cooling systems, such as fans and air conditioners, resulting in increased energy consumption.

6.2.1 Roof insulation

The current Ghana Building Code (GS 1207:2018) does not explicitly mandate the installation of roof insulation in buildings, despite the roof being one of the most significant contributors to heat gain in tropical climates. In response, these Guidelines recommend the introduction of minimum roof insulation requirements as a necessary update.

It is recommended that all new buildings and major renovations incorporate roof insulation with a minimum thermal resistance (R-value) of $1.8 \text{ m}^2\cdot\text{K}/\text{W}$, equivalent to a U-value of $0.56 \text{ W}/(\text{m}^2 \text{ K})$. This can be achieved through the use of different technologies and materials, such as installing 50 mm of polyurethane foam insulation beneath a metal, especially in areas like Accra or Kumasi, where daytime temperatures frequently exceed 30°C . In residential buildings, insulated ceiling panels or multilayer reflective insulation under roofing sheets are cost-effective solutions. In commercial or office buildings with flat or parapet roofs, inverted roof systems with rigid insulation boards are practical and durable.

However, to align with international best practices and improve thermal performance, it is further recommended that exposed roof surfaces achieve an R-value of $\geq 4.2 \text{ m}^2\cdot\text{K}/\text{W}$, using under-deck or over-deck insulation systems.

For ventilated attics and rafter spaces, cross ventilation should be provided at a rate of $\geq 1/150$ of the attic area, with a minimum 25 mm (1 inch) airspace between the insulation and roof sheathing to prevent heat buildup and moisture accumulation.

6.2.2 Reflective roof materials or painting

Reflective roof painting, also known as **cool roofing**, offers a simple, cost-effective, and scalable solution to reduce heat absorption in buildings. Reflective roof painting involves the application of high-albedo (highly reflective) coatings to roof surfaces to reflect a significant portion of the sun's energy, rather than absorbing it. These coatings are typically white or light-coloured and contain additives that enhance solar reflectance and thermal emittance.

These coatings should meet minimum aged performance standards to ensure long-term effectiveness:

Roof slope $\leq 2:12$:

- Solar Reflectance ≥ 0.575
- Thermal Emittance ≥ 0.75
- Solar Reflectance Index (SRI) ≥ 64

Roof slope $> 2:12$:

- Solar Reflectance ≥ 0.30
- Thermal Emittance ≥ 0.75
- Solar Reflectance Index (SRI) ≥ 25

At least 75% of roof surfaces should comply with these reflectance, emittance, and SRI standards to significantly reduce heat gain and improve indoor comfort.

When applied properly, reflective paint can reduce surface roof temperatures by up to **$30\text{--}40^\circ\text{C}$** compared to conventional dark roofing materials. This in turn leads to a measurable drop in interior room temperatures (often by **2°C to 5°C**).

Green roofs, also known as living roofs, are another rooftop system that incorporates vegetation over a waterproofing layer, providing both environmental and building performance benefits. They help insulate buildings and provide other co-benefits such as managing stormwater runoff as they absorb rainfall, lessening the burden on urban drainage systems and reducing the risk of flooding.

In Ghana, with year-round high temperatures, especially in coastal and savannah zones, this approach is beneficial for all, especially in more urbanised areas, such as Accra and Kumasi, where reflective roofs can also help alleviate the urban heat island effect.

6.3 Windows

Windows serve multiple functions in a building envelope, letting natural daylight in, enabling ventilation, and providing a visual connection to the outdoors. However, windows can also be a major source of uncontrolled heat gain, especially in warm climates like Ghana's. Large windows enhance daylight and occupant well-being but, without adequate shading or thermal control, may lead to increased glare, overheating, and higher cooling energy demands. On the other hand, small windows reduce solar heat gain and improve thermal insulation but may compromise access to daylight and natural airflow.

These guidelines seek to strike a balanced approach, ensuring that window areas are optimised for natural light and ventilation, while limiting energy loss and excessive solar heat gain. This involves not just regulating the size of window openings but also requiring performance measures such as appropriate glazing types, shading devices, and orientation strategies.

6.3.1 Window-to-wall ratio

The WWR is a term used in architecture and building design to describe the proportion of a building's exterior wall area that is occupied by windows. It is typically expressed as a percentage and is an important factor in determining a building's energy efficiency, aesthetics, and overall functionality.

A higher window-to-wall ratio means that a larger portion of the exterior walls is composed of windows, while a lower ratio means that there are fewer windows in proportion to the wall area. The choice of WWR can have significant implications for a building's performance and occupants' comfort.

$$WWR (\%) = \frac{\sum \text{Glazing area (m}^2\text{)}}{\sum \text{Gross exterior wall area (m}^2\text{)}}$$

The window-to-wall ratio for any orientation **shall not exceed 20%**. Where the intended design is such that this cannot be achieved, all glazing elements on the relevant facades are to be adequately shaded² or high-performance glazing should be installed.

6.3.2 Shading coefficient

Shading and overhangs are important design elements for enhancing the energy efficiency of buildings as they control solar heat gain and improve thermal performance. **Overhangs on north- and south-facing windows** are particularly effective, as they can block the high-angle midday sun, while still allowing in softer, indirect light. To complement this, features like louvres, pergolas, and shade trees can be strategically used on east- and west-facing facades to protect against low-angle morning and afternoon sun, which contributes significantly to indoor overheating.

In the Ghanaian context, where cooling loads represent a significant share of building energy use, incorporating well-designed shading is effective for achieving the energy efficiency goals set out in the Guidelines. These passive design strategies also support long-term sustainability and resilience in both residential and commercial buildings.

A key metric for this is the shading coefficient (SC) of windows, which is a measure used in building design and energy analysis to quantify the effectiveness of window treatments or shading devices in reducing solar heat gain. It represents the fraction of solar heat that is transmitted through a window with shading compared to the solar heat transmitted through the same window without any shading. In other words, it measures how well a shading system can block or reduce the amount of solar radiation that enters a building through windows.

² World Green Building Council. (n.d.). *Daylighting the way to greener and healthier buildings*. World Green Building Council. Retrieved from <https://worldgbc.org/article/daylighting-the-way-to-greener-and-healthier-buildings/>

The shading coefficient is typically expressed as a dimensionless number between 0 and 1, where:

- An SC of 1 means that no shading is applied, and all the solar heat is transmitted through the window.
- An SC of 0 means that the shading system completely blocks all solar heat, so no heat is transmitted through the window.

Lower shading coefficients indicate better shading performance and can lead to reduced cooling loads in warm climates, as they help prevent excessive solar heat gain in a building's interior.

To standardise shading performance:

- Interior shading devices should cover at least 90% of the fenestration area and have a minimum solar reflectance of 0.50.
- Exterior shading devices should also cover at least 90% of the fenestration area.

For more precise evaluation, the Solar Heat Gain Coefficient (SHGC) can be adjusted using Horizontal Adjustment Factors (HAF) and Vertical Adjustment Factors (VAF) based on the geometry of the shading device:

Table 4: SHGC adjustment factors.

Dh/H	<0.25	0.25–0.32	0.33–0.49	0.50–0.99	>1.0
HAF	0	0.31	0.36	0.43	0.50
Dv/W	<0.25	0.25–0.32	0.33–0.49	0.50–0.99	>1.0
VAF	0	0.14	0.16	0.18	0.21

$$Max\ SHGC = USHGC \times (1 + (HAF + VAF))^3$$

6.3.3 Shading and overhang

One of the most effective passive strategies is the use of shading elements such as roof overhangs, verandas, and deep window recesses. For example, in many traditional Ghanaian homes, particularly in the northern regions and older coastal compounds, wide verandas and extended eaves are used, not only for social space, but also to protect interiors from direct sunlight. These local design features naturally reduce indoor temperatures and are well-suited for modern adaptation.

For windows, horizontal overhangs on south-facing elevations (in Ghana's northern hemisphere context) are particularly effective in blocking midday sun, while vertical fins or side screens work better on east and west-facing facades, where low-angle sun tends to cause excessive heat and glare. In urban areas like Accra or Kumasi, incorporating green facades or using shade trees like neem or flamboyant can also offer cooling benefits while enhancing the urban landscape.

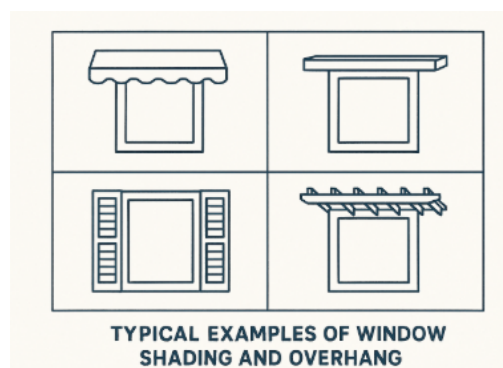


Figure 5: Shading options.

³ U-Factor: Measures how well a window insulates (lower is better). SHGC (Solar Heat Gain Coefficient): Measures how much solar radiation passes through a window (range from 0 to 1; lower means less heat gain).

Integrating such climate-appropriate, culturally rooted shading solutions aligns with the objectives of Ghana's BEEG, offering both performance and practicality in residential, institutional, and commercial buildings.

6.4 Doors

Doors play a significant role in the energy efficiency of buildings. Poorly designed or installed doors can lead to significant heat gain, air leakage, and reduced indoor comfort, thereby increasing reliance on mechanical cooling. In many Ghanaian buildings, doors made of hollow metal, single-layer wood, or uninsulated materials are common, but these allow outdoor heat to penetrate easily, raising indoor temperatures and energy use for cooling. Upgrading to insulated doors such as solid-core timber, insulated steel, or uPVC options can help reduce thermal transfer and maintain more stable indoor conditions.

Air leakage through gaps around door frames is another significant issue, especially in urban areas where cooling appliances are widely used. These leaks not only reduce energy efficiency but also allow dust, humidity, and pests into the building. The use of proper weather stripping, airtight seals, and door sweeps is essential to minimise unwanted air exchange. To meet performance standards, the building envelope, including doors, should be sealed to limit air leakage to 1.25 L/s·m² at 75 Pa, in accordance with ASTM E779. In Ghana's hot climate, doors with glass panels can also contribute to solar heat gain if not treated or shaded. Utilising low solar heat gain coefficient (SHGC) glazing and shading devices like canopies or verandas can mitigate this issue effectively.

In traditional and modern Ghanaian buildings, doors can serve as important components of natural ventilation strategies. When placed opposite windows and aligned with prevailing wind directions, especially in coastal and savannah areas, doors can support effective cross-ventilation, reducing the need for fans or air conditioning. Finally, choosing door materials that are both thermally efficient and suitable for the local climate is key. Timber provides good insulation but may warp in humid conditions, while metal doors require internal insulation to prevent heat transfer. In conclusion, improving door design and selection in Ghanaian buildings can greatly enhance energy efficiency, lower cooling demands, and contribute to more sustainable construction practices.

6.5 Insulation – thermal performance

Insulation plays a vital role in enhancing the thermal performance of buildings in Ghana, where high temperatures and varying humidity levels are characteristic of the tropical climate. Effective insulation helps to regulate indoor temperatures by reducing the transfer of heat through walls, roofs, and floors. In many Ghanaian buildings, especially in urban areas, inadequate insulation leads to excessive indoor heat gain, increasing reliance on mechanical cooling systems such as fans and air conditioners. This not only drives up energy consumption and costs but also contributes to greenhouse gas emissions. Incorporating proper insulation materials, such as mineral wool, polyurethane foam, or locally available alternatives like straw bales or stabilised earth, can significantly improve comfort by maintaining cooler indoor temperatures during the day and reducing heat loss at night.

In hot-humid zones like Accra or Takoradi, roof insulation is especially important, as the roof is the main surface exposed to direct solar radiation. Similarly, in the savannah regions of northern Ghana, insulation also helps buffer the wide temperature swings between day and night. Proper insulation reduces the peak indoor temperatures and delays heat transfer, enabling buildings to remain cooler for longer without mechanical assistance. Beyond comfort and energy savings, insulation also contributes to the durability of buildings by preventing moisture condensation and the associated risks of mould and material degradation. As Ghana moves toward more sustainable and energy-efficient building practices, prioritising insulation as a cost-effective strategy for improving thermal performance is essential for both new constructions and retrofits.

7 Low-carbon materials

One of the largest components of the climate impact of a building is the embodied carbon within the materials used for constructing buildings. The selection and use of appropriate yet low-carbon materials are therefore an important step in the decision process when designing a building to lower its environmental impact across its entire life cycle, from sourcing and manufacturing to usage and disposal. Embodied carbon represents the total greenhouse gas emissions measured in carbon dioxide equivalent (CO₂e) released during material extraction, processing, transportation, and installation.

This section provides some guidance on the significance of embodied carbon in constructions, strategies for reduction, and the role of alternative low-carbon materials. Selecting sustainable materials is an important process that involves incorporating lifecycle assessments and adopting circular economy principles such as material reuse and recycling. Through these considerations, the standard would support the development of buildings with a lower environmental footprint while maintaining durability and performance.

7.1 Embodied carbon

In the context of sustainable construction in Ghana, addressing embodied carbon is essential for reducing the overall environmental footprint of buildings. Embodied carbon refers to the greenhouse gas emissions associated with the extraction, manufacturing, transportation, and installation of building materials. To minimise these emissions, building professionals in Ghana should prioritise the use of low-carbon materials such as compressed earth blocks, bamboo, or sustainably harvested timber. These materials not only have a lower environmental impact but are also well-suited to Ghana's climate and building traditions.

7.2 Selection of building materials

Careful selection of building materials is vital to ensure durability, resource efficiency, and minimal environmental harm. Materials should be chosen based on their life-cycle performance, thermal efficiency, and adaptability to local conditions. In Ghana's hot and humid regions, for instance, materials with good thermal mass and low conductivity, like adobe or stabilised soil blocks, can reduce the need for active cooling, enhancing energy efficiency. The selection process should also consider materials that require minimal processing and generate less waste during construction.

7.3 Local sourcing of building materials

Local sourcing of building materials supports the national economy, reduces transportation-related emissions, and fosters the development of local industries. Ghana has abundant natural resources such as clay, stone, and timber, which can be harnessed responsibly to meet construction needs. Prioritising locally available materials not only lowers costs and carbon emissions but also ensures cultural and environmental appropriateness in building practices.

7.4 Recycling and reused materials

Incorporating recycling and the reuse of materials into construction practices in Ghana can significantly reduce the demand for virgin resources and minimise construction waste. Reclaimed timber, recycled metal, and repurposed bricks or concrete elements can be used effectively in new construction projects. Establishing construction waste management systems and encouraging the circular use of materials should be promoted as standard practice across both public and private sector developments. Together, these guidelines foster a sustainable, climate-resilient built environment tailored to Ghana's ecological and socio-economic context.

7.5 Efficient building design

Efficient building design plays a foundational role in sustainability by minimising energy use, enhancing natural ventilation, and optimising daylight. In Ghana, climate-responsive design strategies such as orientation to minimise solar gain, deep overhangs, natural shading, and cross-ventilation should be prioritised. Compact building forms, passive cooling techniques, and the integration of energy-efficient systems such as solar lighting or rainwater harvesting can also enhance building performance while reducing operational energy demands.

8 Heating, Ventilation and Air Conditioning (HVAC)

Green cooling in the context of the BEEG focuses on significantly reducing energy consumption and minimising the climate impact of refrigeration and air-conditioning (RAC) systems. This is achieved through a combination of mandatory appliance standards, a push for high-efficiency, low-Global Warming Potential (GWP) refrigerants, and the promotion of passive cooling strategies in building design. The effort is guided by the Ghana Cooling policies and National Cooling Plan as outlined under the country's international obligations under the Montreal Protocol.

Green cooling recommendations for buildings in Ghana, as part of green building guidelines, focus on a layered approach that prioritises passive design to reduce heat load, followed by using high-efficiency active systems with climate-friendly refrigerants. This strategy is through the promotion of natural refrigerants essential for reducing energy consumption.

When it comes to mechanical cooling the policy under the Environmental Protection Act, 2025 (Act 1124) and management of ozone depletion substances, Environmental Protection (Management of Ozone Depleting Substances, halocarbons, halocarbons alternatives and their products) Regulations, 2025 (LI 2505), and Environmental Protection (Refrigeration and Air Conditioning Certification) Regulations, 2025 (LI 2503) systems must meet stringent energy and environmental standards in terms of high efficiency cooling systems and greening building must adhere as support the implementation of the policy by

- Promoting climate-friendly refrigerants, ensuring the adoption of cooling equipment that uses natural refrigerants with an Ultra-Low Global Warming Potential (GWP), such as R290 (Propane).
- Ensuring technically robust installation, servicing, and end-of-life recovery procedures are in place to prevent leaks of any remaining high-GWP refrigerants (HFCs) from existing equipment.

8.1 Air conditioning

Rising temperatures and urban development have increased the demand for indoor cooling, particularly in offices, hotels, and commercial buildings, where air conditioning systems account for a significant portion of electricity use, often as high as 60–80% in some cases⁴. While air conditioners are less common in typical residential homes, their use is expanding, especially in urban households and apartment buildings. Fortunately, advancements in technology have made modern air conditioning units much more energy-efficient, providing effective cooling while using less electricity.

Ghana, through agencies such as the Energy Commission, has taken steps to promote the adoption of energy-efficient and climate-friendly air conditioners, including the introduction of Minimum Energy

⁴ Amato, A., & Ayensu, A. (2019). Energy efficiency and cost-saving opportunities in public and commercial buildings in developing countries: The case of air-conditioners in Ghana. https://www.researchgate.net/publication/333000946_Energy_efficiency_and_cost_saving_opportunities_in_public_and_commercial_buildings_in_developing_countries_-_The_case_of_air-conditioners_in_Ghana

Performance Standards (MEPS) and appliance labelling schemes. These efforts aim to reduce national electricity consumption and curb greenhouse gas emissions associated with inefficient cooling. For both homeowners and businesses, selecting the right capacity unit, using features like inverter technology, and ensuring regular maintenance can lead to significant energy and cost savings. By implementing these practices, Ghanaians can enjoy greater indoor comfort while supporting national goals for energy efficiency and environmental sustainability.

8.1.1 Energy-efficient air conditioners

Energy-efficient air conditioners are characterised by the following:

- Inverter technology: Adjusts the compressor speed to maintain the desired temperature, reducing energy consumption and providing more consistent comfort.
- Variable speed motors: Fan and compressor motors that can adjust speeds to meet cooling demands more efficiently than single-speed models.
- Smart thermostats and controls: Devices that allow for precise temperature control, scheduling, and remote access via smartphones. Smart thermostats can learn user preferences and optimise cooling schedules.
- Energy saving mode: Reduces power consumption by operating the unit at a lower capacity or cycling the compressor on and off.
- High-efficiency filters: Improve indoor air quality and maintain system efficiency by ensuring proper airflow and reducing strain on the system.

8.1.2 Minimum efficiency requirements

It is strongly recommended to install high-efficiency unitary air conditioning units that meet or exceed the national MEPS set for AC by the Energy Commission. Specifically, air conditioners should all be inverter-type units with an Annual Energy Efficiency Ratio (AEER) of at least 3.22 to qualify for the MEPS. The recommended Total Cooling Seasonal Performance Factor (TCSPF) is 5.50, which corresponds to 3 stars and should contain refrigerants with Global Warming Potential (GWP) less than 700. These units not only consume significantly less electricity but also reduce greenhouse gas emissions, making them ideal for both residential and commercial applications.

For larger commercial applications, an AEER of 3.10 is widely available internationally from technology providers, and it should be considered as a minimum for Ghana^{5,6}.

8.1.3 Sizing of air-conditioning systems

Sizing of air-conditioning systems correctly is crucial for energy efficiency in buildings. An oversized AC system cools the space too quickly, leading to short cycling and resulting in energy waste, reduced system lifespan and often poor humidity control, which can make specs feel clammy. An undersized system runs continuously trying to meet demand, resulting in high energy consumption, inadequate cooling and increased wear and tear.

The correct and proper sizing requires determining the actual cooling load of the space that is considered. ASHRAE Handbook – Fundamentals provides specific guidance on this process, and it is recommended to refer to this reference as a minimum requirement in Ghana.⁷

8.2 Ventilation and indoor air quality

Ventilation is critical for ensuring good indoor air quality in buildings across Ghana, where high temperatures and humidity levels can create uncomfortable and sometimes unhealthy indoor

⁵ Public Consultation on Introduction of (MEPS) and (MELS) for Variable Refrigerant Flow Air Conditioners (Singapore, 2024)

⁶ Energy Star (Unites States, 2016).

⁷ <https://www.ashrae.org/technical-resources/standards-and-guidelines/>

environments. Proper ventilation allows for the continuous exchange of stale indoor air with fresh outdoor air, helping to remove pollutants, excess heat, moisture, and indoor-generated contaminants such as carbon dioxide, volatile organic compounds (VOCs), and cooking fumes.

Effective ventilation not only enhances indoor comfort but also reduces reliance on mechanical cooling systems, thereby lowering energy consumption and promoting a healthier living environment. Passive design strategies such as the strategic placement of windows and doors, the use of louvred openings, ventilation blocks, and high ceilings can significantly improve cross-ventilation. Additionally, incorporating roof vents, clerestory windows, and shaded openings can help expel warm air and draw in cooler air, making buildings more comfortable and sustainable. In cases where natural ventilation is insufficient, mechanical systems such as ceiling or exhaust fans can be used to enhance air circulation, especially in kitchens and bathrooms.

8.2.1 Minimum ventilation requirements

These guidelines recommend that the minimum requirement for ventilation in buildings in Ghana should include at least two operable windows or openings in each regularly occupied room to facilitate cross-ventilation, with a combined openable area not less than 10% of the floor area. Bathrooms and kitchens should be equipped with exhaust fans or ventilation grilles to expel moisture and odours. These minimum requirements should be adopted in building design practices to ensure that all buildings support healthy indoor air quality and thermal comfort throughout Ghana's varied climate zones.

Residential habitable rooms shall have ventilation openings $\geq 15\%$ of the floor area, with some part ≥ 1.75 m above the floor, unless mechanically ventilated as stipulated in the Ghana Building Codes Part 35.23.2 on Ventilation as a minimum requirement.

8.2.2 Ventilation strategies

The following strategies for passive and mechanical ventilation are recommended.

Passive Ventilation:

- Openable Windows (Section 37.3.1.2, 13.9.5):
 - Occupied spaces shall have openable windows, doors, or louvres with a minimum openable area of 15% of the occupied floor area (including balcony doors) or 4% of the floor area (minimum 0.67 m² per 1000 m²), whichever is greater.
 - Adjoining spaces shall have unobstructed openings $\geq 8\%$ of the interior room floor area (minimum 2.3 m²).
 - Residential habitable rooms shall have ventilation openings $\geq 15\%$ of the floor area, with some part ≥ 1.75 m above the floor, unless mechanically ventilated (Section 35.23.2).
- Openings for Natural Ventilation (Section 4.6.5):
 - Exterior walls shall have uniform openings on ≥ 2 sides, totalling $\geq 20\%$ of the perimeter wall area per tier, with an aggregate length $\geq 40\%$ of the tier perimeter.
 - Interior walls shall be $\geq 20\%$ open with uniform openings.
 - **Exception:** Distribution over 40% is not required if openings are on two opposing sides.
- Design Integration:
 - Buildings shall be designed to leverage natural airflow through strategic placement of openings, ensuring cross-ventilation where possible (Section 37.3.1).
- Performance Requirements:
 - **Indoor Air Quality and Comfort:** Dilute pollutants and maintain comfort without mechanical energy (Section 3.1).

- o Air velocity ≤ 0.5 m/s, ideally 0.13-0.23 m/s in occupied zones (Section 29.2.3.4.6).

Mechanical Ventilation System:

Minimum fresh air supply per occupant density/activity; increase by 50% for heavy smoking or below-ground rooms.

Table 5: Ventilation air changes per hour recommended.

Application	Air Changes/Hour
Offices	6-10
Hospitals (Wards)	6-8
Restaurants	8-12

8.2.3 8.2.3 Ventilation for Specific Areas

The following prescriptive requirements shall be considered for ventilation for specific areas.

Garages (Section 37.8.2):

Enclosed garages with >20 parking slots shall have mechanical ventilation with CO sensors activating fans to maintain CO <50 ppm.

High-Occupancy Spaces (Section 37.8.1):

Auditoriums, conference rooms, and theatres >200 m² shall have CO₂ sensors in return air ducts to keep CO₂ <1,000 ppm.

Toilets and Utility Rooms:

Located on exterior walls with mechanical extract (ventilating fans) or natural exhaust, isolated from conditioned spaces by self-closing doors (Clause 14.2 Note 2).

9 Lighting

Energy-efficient lighting is another key element of sustainable building design, offering one of the most straightforward ways to improve performance due to the widespread availability and price competitiveness of the top-performing technology: LED lighting.

This chapter of the BEEG outlines best practices for lighting design, focusing on the use of LED fixtures, smart lighting controls, and daylight integration. It emphasises strategies such as occupancy sensors, dimming systems, and automated daylight harvesting to maximise the use of natural lighting, further reducing energy demand. The BEEG also recommends lighting requirements based on building function and occupancy patterns.

This section of the Guideline on Lighting should be considered in parallel with the Ghana Building Code (2018), Part 13.11 Lighting and Part 14.5 Lighting and Electrical Appliances

9.1 Strategies for energy-efficient lighting

The options to ensure maximum energy efficiency of lighting in commercial buildings include:

- Install/upgrade to LED lighting options that meet or exceed the minimum energy performance standards (MEPS), energy efficiency star ratings, and labelling requirements as prescribed by L.I. 2353 (Light Emitting Diode and Self-Ballasted Fluorescent Lamps).
- Use Lighting Controls to reduce energy use when daylight is sufficient or spaces are unoccupied (Clause 37.5.1), such as:
 - **Dimmers:** Adjust light levels to suit needs and save energy when full brightness is not necessary.
 - **Photo Sensor Controls** (Clause 37.5.1, 28.5.4.8): Required in perimeter zones >50 m² with exterior windows: Offices: Open offices, lobby, meeting rooms. Retail Buildings: General sales areas. Hotels: Meeting rooms. Schools: Meeting rooms/auditoriums. Automatically dim or switch off lights when daylight exceeds 300 lux (Clause 28.6.2.3).
 - **Occupancy Sensors:** Automatically turn lights on and off based on room occupancy, reducing wasted energy. Required in: Offices, Meeting rooms, staircases, enclosed offices, corridors. Hotels: Meeting rooms, corridors. Residential Buildings: Enclosed car parks, staircases, corridors. Schools: Enclosed car parks, classrooms, corridors. Turn off lights within 20 minutes of vacancy (Clause 28.6.2.1.1).
 - **Integration** (Clause 37.5.1 Note): Occupancy sensors override photo sensors during non-occupancy
 - **Daylight Harvesting:** Adjust artificial lighting based on natural light availability, reducing energy use during daylight hours.
 - **Install Time-Switch controls:** Use timers to ensure lights are turned off during unoccupied hours, such as overnight in commercial buildings. Required where occupancy sensors are not installed: 7-day clock, holiday shutoff, 10-hour backup, 2-hour override (max 465 m² per switch).
- **Optimise Lighting Design:** Ensure that lighting is designed to meet the specific needs of the space without over-illumination. Use task lighting where needed and reduce general ambient lighting levels.
- **Regular Maintenance:** Clean fixtures and replace bulbs as needed to maintain optimal efficiency and light quality.
- **Minimum Window Glass Area** (Clause 35.6.2.2, Table 35.6.2.A):
 - Residential occupancies shall provide unobstructed glass areas:
 - Living rooms, dining rooms, bedrooms: ≥15% of area served.
 - Kitchens: ≥15% of area served.
 - Laundry, basement recreation rooms: ≥4% of area served.
 - Water-closet rooms: ≥0.37 m².
 - **Public spaces (e.g., corridors, stairways):** Include windows where practicable (Clause 35.6.2.3).

9.2 Minimum energy efficiency requirements – lighting power density

The recommended lux levels for various rooms depend on the activities typically performed in those spaces. Lux is a measure of illuminance, indicating how much light is cast on a given area. The following are general guidelines for recommended lux levels in different types of rooms and spaces in different types of buildings.

9.2.1 Residential spaces:

- Living Room: 100-300 lux
- Kitchen: 300-750 lux (higher levels for task areas like countertops)
- Dining Room: 150-300 lux
- Bedroom: 100-300 lux (lower levels for relaxation areas, higher for reading areas)

- Bathroom: 200-750 lux (higher levels for grooming areas)
- Hallways and Stairs: 100-200 lux
- Home Office/Study: 300-500 lux

9.2.2 Commercial spaces:

- Office Areas: 300-500 lux (higher levels for detailed tasks)
- Conference Rooms: 300-500 lux
- Reception Areas: 200-300 lux
- Corridors and Staircases: 100-200 lux
- Retail Stores: 500-1000 lux (higher levels for display areas)
- Workshops and Manufacturing Areas: 300-1000 lux (depending on the precision of tasks)
- Warehouses: 100-300 lux (higher for packing and inspection areas)

9.2.3 Educational institutions:

- Classrooms: 300-500 lux
- Lecture Halls: 300-500 lux
- Libraries and Reading Areas: 500-750 lux
- Laboratories: 500-1000 lux

9.2.4 Healthcare facilities:

- General Wards: 100-300 lux
- Examination Rooms: 500-1000 lux
- Operating Theatres: 1000-2000 lux
- Nurse Stations: 300-500 lux
- Waiting Rooms: 200-300 lux

9.2.5 Hospitality:

- Hotel Lobbies: 200-300 lux
- Restaurants and Dining Areas: 150-300 lux
- Guest Rooms: 100-300 lux
- Bathrooms: 200-750 lux

9.2.6 Public and community spaces:

- Museums and Galleries: 200-500 lux (lower for preservation of sensitive exhibits)
- Sports Facilities: 300-750 lux (higher levels for detailed tasks like scorekeeping)
- Auditoriums: 150-300 lux

9.2.7 Outdoor areas:

- General Outdoor Areas: 20-100 lux
- Pathways and Walkways: 5-30 lux
- Parking Lots: 30-75 lux
- Building Entrances: 100-200 lux

9.2.8 Special cases:

- Task Lighting: In areas where specific tasks are performed, such as reading, cooking, or sewing, additional task lighting may be needed to achieve the required lux levels.
- Ambient Lighting: General lighting to ensure overall illumination and safety.
- Accent Lighting: Used to highlight specific areas or objects, not necessarily related to the overall lux levels, but important for aesthetics.

9.3 Lighting power density requirements

The recommendations presented in this section should be followed in parallel with the requirements specified under this topic by the Ghana Building Codes (2018) Part 37.5.

Lighting Power Density (LPD) is a measure of the amount of electrical power used for lighting per unit area in a building, typically expressed in watts per square meter (W/m^2).

LPD is a **key metric** used in building design and energy codes to:

- **Limit excessive lighting** and reduce energy use.
- **Promote efficient lighting technologies** (e.g., LEDs, smart lighting controls).
- Help meet **building energy standards** and certifications (like **LEED**, **ASHRAE**, or **IECC**).

The Ghana Building Codes specify, under Part 37.5 maximum LPD for the following building types:

Table 6: Light power density requirements for different building uses.

Building Type	Maximum LPD (W/m^2) Ghana BC	Beyond BC requirements (W/m^2) ⁸
Office (Open Plan)	11	8
Offices (Private/Enclosed)		10.5
Hotel (Guest Rooms)	11	8
Hotels (Lobby/Public Area)		10
Hospitals (Patient Rooms)	13	8.5
Hospitals (Operating Rooms)		20.0
Health care centre	11	-
Library	14	-
Convention	15	-
School (Classrooms)	12	9.5
Commercial, services, Retail (Sales Area)	16	12
Indoor parking space	3	-
Residential (Living Area)	8	6.5
Residential (Kitchens)		10
Car Parks (Enclosed)		2.5
Corridors/Stairways		5
Warehouses/Storage		4.5

Notes:

- LPD values assume LED technology with efficacy ≥ 80 lm/W (Section 6.3). Adjustments may be made for other lamp types with Energy Commission approval.
- Daylighting zones meeting 300 lux minimum (Section 28.6.2.3) may reduce LPD by 20% with approved controls.
- Compliance requires submission of lighting layout and power calculations per Section 37.5.2.

⁸ For office and commercial buildings, these guidelines recommend a maximum LPD that is stricter than the Ghana Building Code.

10 Electrical appliances and equipment

Ghana is operating a Mandatory Appliance Standards and Labelling regime under which importers and retailers of Room Air Conditioners and Compact Fluorescent Lamps (CFL) are required to import and sell ONLY products that meet minimum efficiency and performance standards approved by the Ghana Standards Board. The Energy Efficiency Standards and Labels Programme is designed to ensure that only appliances that meet minimum energy efficiency standards enter the Ghanaian market. In accordance with the provisions of the Energy Efficiency Standards and Labelling Regulations, 2022, as referenced in Table 5, appliance manufacturers who export to Ghana and retailers who sell in Ghana are obliged to display a label which indicates the energy efficiency rating of the product before the first retail sale.

Ghana's energy efficiency label indicates a product's energy performance rating, with a 7-star rating for the most efficient and a 1-star rating for the least efficient.

Regulations from the Ghana Energy Commission were effective since November 2023, and include:

- air conditioners,
- refrigerators,
- Clothes washing machines,
- Televisions,
- computers⁹,
- Kitchen appliances (rice cookers, microwave oven, Electric kettle)
- solar panels.
- Renewable Energy Batteries
- Inverter
- Comfort fan
- Water heaters
- Electric motors
- Distribution transformers
- Set-top boxes
- Ventilating fans
- Industrial fans
- Public lighting

In general, these Guidelines recommend always choosing the electric appliances or equipment with a life cycle cost benefit and Total Cost of Ownership (TCO). Appliances and equipment with the highest rating (5-7-star) or meeting MEPS will be an advantage

10.1 Water heating

Water heating is a major use of energy in buildings, serving essential functions in both residential (cooking, hydration, and sanitation) and commercial settings (for example, hospitals and restaurants). As a result, optimising water heating systems is a key aspect of these guidelines.

Strategies to reduce the energy footprint of water heating should be emphasised. This includes promoting high-efficiency alternatives to conventional fossil or electric-powered water cylinders or geysers, such as solar water heaters, heat pump water heaters, and on-demand tankless systems. It is recommended to follow good practices like proper insulation of hot water pipes, low-flow fixtures, and optimising water storage temperatures.

⁹ Mandatory ICT Labelling was introduced in February 2024.

According to the Ghana Building Codes Part 14.4 on Hot Water, the need for installation of such systems should be critically evaluated, and it should be well justified using the recommendations and guidance provided in the Ghana Building Codes.

10.2 Electrical water heating

Ensuring energy efficiency in domestic water heating is a critical consideration for sustainable building design. Energy-efficient electric water heaters, such as those with insulated tanks, programmable thermostats, or heat pump technology, also offer significant energy savings compared to conventional models.

Additionally, behavioural changes, such as limiting water heating to essential times or using cold water where practical, can further reduce consumption. The placement of the water heater within the building, proximity to points of use, and insulation of hot water pipes are also important design considerations that can minimise heat loss and improve system efficiency. In new buildings, architects and engineers should incorporate plumbing layouts and roof space to accommodate solar heating systems, while retrofits can include simple upgrades like timer controls and low-flow fixtures. As Ghana continues to promote energy conservation and climate resilience, prioritising energy-efficient solutions for domestic water heating will reduce household costs, lower greenhouse gas emissions, and ease pressure on national electricity infrastructure.

10.3 Conservation of hot water usage

Another strategy widely used in energy conservation includes the reduction of hot water demand through technology and behavioural means. This includes the implementation of awareness campaigns to promote lower use through shorter showers, reduced washing, etc. Commonly used technology options include:

Low-Flow Showerheads:

- Reduce water usage by up to 50% compared to conventional models by limiting the flow rate without sacrificing performance.
- Significantly lower the volume of hot water needed, saving energy used for heating.

Water-Efficient Clothes Washers:

- Use advanced technologies to clean effectively while using up to 40% less water and 25% less energy than standard models.
- Energy Star-rated appliances provide substantial water and energy savings.

Water-Efficient Dishwashers:

- Designed to clean effectively with less water, reducing water use by significant amounts compared to traditional models.
- Energy-efficient dishwashers save both water and energy, contributing to lower utility bills and environmental conservation.

These types of technologies can be applied to different levels of demand, such as residential and commercial requirements, to general significant savings for the sectors.

10.4 Electrical Systems and Allied Installations Requirements

Electrical systems shall be designed and installed to optimise energy performance, reduce operational costs, and comply with applicable energy standards and codes.

- **Component Standards and Quality**
 - **Compliance with Standards:** All electrical components (wiring cables, sockets, switches, plugs, circuit breakers, appliances) must meet prescribed standards by the Energy Commission (L.I. 2478) and the Ghana Standards Authority (e.g., GS IEC 60227,

- GS IEC 60884, GS IEC 60228, GS IEC 60502-1) to minimise energy losses via low-resistance conductors.
- **Efficient Conductors:** Cables and conductors must have nominal cross-sectional areas to reduce resistive losses, voltage drops, and heat generation.
 - **Energy-Efficient Accessories:** Circuit breakers, residual current devices, switches, sockets, and extension sets must minimise power consumption and standby losses while ensuring safety.
 - **Electrical Design and Installation for Efficiency**
 - **Optimised Design:** Systems design should minimise cable lengths, using high-efficiency busbars, and balancing loads to reduce transmission losses.
 - **Conductor and Equipment Sizing:** Conductors and equipment (e.g., wiring, transformers) must be sized to prevent energy losses from overheating, ensuring safety and efficiency.
 - **Conduct energy modelling:** Simulate electrical loads and energy use to optimize system layout and component selection.
 - **Protective Measures:** Circuits must include appropriately sized circuit breakers or fuses to prevent energy waste from faults or overloading, balancing safety with efficient operation.
 - **Certification of Installers:** Electrical wiring must be undertaken by a person certified by a licensed electricity distribution utility or appointed by the Energy Commission.
 - **Connection of Electricity Supply:** An electricity distribution utility shall not supply electricity to premises unless all requirements are met and the electrical installation is completed by a certified electrician.
 - **Documentation:** Submit wiring diagrams, load calculations, and component specifications (cables, switches, protective devices) to verify compliance with respective regulations and installer certification.

11 Renewable energy

Renewable energy is one of the fundamental elements of sustainable development, to support human development towards a climate-friendly transition, providing a clean, abundant, and increasingly affordable alternative to fossil fuels.

In green building design, integrating renewable energy systems such as solar photovoltaic panels, wind turbines, small hydro (≤ 100 MW), biomass (e.g., cookstoves, biogas) and geothermal heat pumps per Act 832, Section 2, plays an important role in minimising a building's reliance on fossil-generated grid electricity. Further, the reduction of demand on grid electricity reduces stress on the grid, enabling it to reach more of the population and reduce costs. This chapter will outline good practices for incorporating on-site renewable energy, optimising system design, and integrating energy storage solutions. To ensure consistency with national energy regulations, renewable energy systems must comply with capacity limits and performance standards as outlined in relevant legislation. For example, solar PV systems under net metering are capped at 500 kW per customer (Net Metering Code, Clause 2), while institutional biomass cookstoves must not exceed 150 litres in capacity (L.I. 2454, Regulation 2). All installations must be carried out by licensed professionals and approved by the Energy Commission (Act 832, Sections 8 and 49).

11.1 Solar water heating

One of the most effective alternatives is the adoption of solar water heaters, which harness the country's abundant solar radiation to provide a renewable and cost-effective source of hot water.

For new or major retrofits of building types covered by these guidelines, where it is deemed necessary to install hot water supply systems, it is recommended that solar-based systems be installed and that such systems shall cover a minimum of 70% of the total demand for hot water. This is in line with the current Ghana Building Codes on Solar water heating.

11.2 Solar PV

Solar photovoltaic (PV) technology has emerged as one of the fastest-growing and most versatile renewable energy solutions worldwide. By directly converting sunlight into electricity, PV systems offer a clean, modular, and increasingly cost-effective pathway to decarbonise power generation. Global installed capacity has expanded more than tenfold over the past decade, driven by rapid cost declines, technological innovation, and strong policy support.

The appeal of PV lies in its scalability: from powering small rural households to supplying multi-gigawatt utility plants, the technology adapts across geographies and market needs. Its modular design and low operating costs make it particularly suited for both centralised and distributed energy systems, including integration with storage and digital solutions.

Some of the key applications that are available to the building sector include:

Table 7: Solar PV applications for buildings.

Application	Description	Typical Use Cases
Commercial & Industrial (C&I) rooftop PV	Medium-sized rooftop installations for businesses and industries.	Reducing peak demand, lowering operational costs, and enhancing corporate sustainability.
Residential rooftop PV	Small-scale systems for households, often coupled with batteries.	Reducing household bills, self-consumption, and backup power during outages.
Building-integrated PV (BIPV)	PV modules embedded into facades, windows, or roofing materials.	Urban energy supply, aesthetic integration, smart buildings.

To promote renewable energy adoption and reduce dependence on the national grid, establishing minimum requirements for the installation of solar panels in Ghana is an important solution to support safety, efficiency, and long-term system performance.

At a basic level, all solar panel installations should comply with the Ghana Electrical Wiring Regulations and relevant standards issued by the Energy Commission and the Ghana Standards Authority. Installations must be carried out by certified solar technicians or electricians to guarantee proper system design, wiring, and integration with existing electrical systems. The location of solar panels should be carefully selected to maximise exposure to direct sunlight—ideally on unshaded, north-facing roofs or open ground with a tilt angle optimised for Ghana's latitude, typically between 10° and 15°. Roofs intended to support solar panels should be structurally sound – solar ready- and able to bear additional loads, with provisions made for wind resistance and weather protection.

System sizing should be based on a detailed assessment of household or building energy needs to ensure that solar generation meets a significant portion of daily demand.

All systems must include appropriate safety components such as surge protectors, grounding equipment, circuit breakers, and isolators. For grid-tied systems, the use of approved inverters with anti-islanding protection is required to prevent backfeeding during outages, ensuring the safety of utility workers. Systems must include bi-directional meters to enable net metering (Net Metering Code, Section 5.1) and must comply with approved feed-in-tariff or net metering standards (Act 1045, Section 25). Battery storage, if included, should be safely housed in ventilated enclosures away from living spaces and comply with fire safety standards.

A minimum performance warranty of 20-25 years for panels and 5-10 years for inverters and batteries should be ensured. Every solar installation must include clear system documentation and user training for maintenance and monitoring.

All installations require detailed documentation, including system design, capacity, and compliance data, to be submitted to the Energy Commission for verification.

It is recommended that the government of Ghana consider extended producer responsibility (EPR) for building owners and developers or establish documented decommissioning and recycling protocols aligned with Ghana's Hazardous and Electronic Waste Control and Management Act, 2016 (Act 917), enacted in July 2016, which provides the framework for control, management, and disposal of hazardous waste and electrical and electronic waste.

11.3 Biomass Cookstoves

Biomass cookstoves offer a renewable alternative for cooking in both domestic and institutional settings. To ensure energy efficiency and safety, the following standards shall apply:

- Institutional cookstoves must not exceed 150 litres in capacity (L.I. 2454, Regulation 2).
- Thermal efficiency must be at least 35% for carbonised fuels and 25% for uncarbonised fuels (L.I. 2454, Table 1.1).
- Cookstoves must display clear labelling of efficiency, emissions, and safety data.
- All systems must be installed by licensed professionals and approved by the Energy Commission. These requirements support Ghana's transition to cleaner cooking technologies and reduce indoor air pollution, especially in institutional kitchens and high-use environments

12 Building control systems

Building systems and controls are advanced digital technologies integrated with the building's operating systems, such as HVAC, lighting, and water heating, to optimise their performance and efficiency. By using smart sensors, automation, and real-time data analytics, these systems adjust energy supply based on actual demand, reducing unnecessary consumption and minimising waste, such as cooling or lighting unoccupied spaces.

Implementing intelligent Building Management Systems (BMS) and controls in Ghanaian buildings represents a forward-thinking approach to improving energy efficiency, occupant comfort, and operational cost savings. Integrating smart technologies into building operations offers a practical way to optimise resource use while enhancing building performance.

12.1 Occupancy sensors

A key good practice is the use of occupancy sensors, which automatically control lighting, air conditioning, and ventilation based on room usage, thereby reducing energy waste in unoccupied

spaces. These are especially useful in office buildings, schools, and public facilities where occupancy patterns vary throughout the day.

12.2 Thermostat settings and control

Programmable thermostats are also an important tool, allowing users to set temperature schedules that align with daily routines and climatic conditions. In Ghana's hot climate, these thermostats help maintain comfort while avoiding unnecessary cooling during periods when buildings are vacant or ambient temperatures drop. Introducing practices of higher thermostat setpoints is also recommended. It is recommended that 25 degrees Celsius be the lowest set point for any room temperature in any type of building covered by these standards. This level provides comfort and minimises wasted energy from the overuse of AC systems.

12.3 Lighting controls

Automated lighting controls, including daylight sensors and timers, further contribute to efficiency by dimming or switching off artificial lighting when natural light is sufficient or when spaces are unoccupied. These systems not only conserve electricity but also extend the life of lighting fixtures. Mandatory Controls (28.6.2): Includes luminaire-level lighting controls (LLLC) per Clauses 28.6.2.1-28.6.2.6. Daylight-Responsive Controls (28.6.2.3): Dims lights to $\leq 15\%$ or off in daylight zones (>150 watts in sidelit/toplit zones).

12.4 Energy Management Systems

Incorporating energy monitoring software into a building's infrastructure allows facility managers to track real-time energy consumption, identify inefficiencies, and adjust systems accordingly. Such data-driven decision-making helps reduce utility bills and supports maintenance planning.

For effective implementation, all intelligent systems should be integrated into a centralised BMS platform that is user-friendly and scalable, with provisions for remote access and data backup. Training building users and facility personnel on the operation of these technologies is essential to maximise their benefits. Adopting these smart control practices in Ghanaian buildings will support national goals for energy conservation, promote environmental sustainability, and lower the long-term costs of building operation and maintenance. Management strategies should be used in a building management/automation system to provide for controlling and monitoring all parameters of HVAC, electrical, plumbing, firefighting, and low-voltage systems such as telephone, TV, etc. Energy Conservation should also be considered in the optimisation through targets, heat recovery and maintenance.

12.5 Green Public Procurement (GPP) for Sustainable Building Projects

"Procurement decisions for public and large-scale private building projects shall prioritise materials and systems that demonstrate low embodied carbon, support circular economy principles, and enhance operational energy efficiency. Evaluation shall include lifecycle assessments, local sourcing potential, and compatibility with climate-responsive design strategies."

13 Energy performance – energy index/specific energy consumption

The determination of the optimum performance of buildings requires the assessment of energy performance during the design phase of a building and the monitoring of a building's performance during operations.

The energy efficiency performance of a building can be assessed in several ways, but the most commonly used methods are:

1. Building simulations
2. Detailed recording of all energy usage in a fully operated building.

The objective of both approaches is to determine the energy index or the specific energy consumption, which is typically expressed in kWh/m²/year, which is a measure that is used both when evaluating whether the design of a new building complies with the regulations and when rating or certifying an existing building in comparison with other buildings of the same typology.

13.1 Energy Index

In section 3.2 of these Guidelines on Performance goals, the maximum energy index for three different new building types is specified. When proposing a specific design for a new building and when applying for a building permit, it shall be demonstrated that the energy index for the proposed building will not exceed the maximum amount. This can be demonstrated through a building simulation tool where all design elements and features are defined.

Recommended simulation tools are:

- **EnergyPlus:** A detailed building energy simulation tool for whole-building performance analysis.
- **eQUEST:** A user-friendly tool for energy analysis.
- **IES VE:** Integrated Environmental Solutions Virtual Environment for dynamic energy simulation.
- **DesignBuilder:** A commercial interface built on EnergyPlus with visual modelling capabilities. It supports advanced simulations and daylight analysis.

Standard assumptions that can have a determining impact on the performance have been defined and are included in the Annexe (Section 16.3 Operational assumptions of building equipment). These assumptions relate to the schedules of use for various categories of electrical appliances and are defined for different categories of buildings, and should be the same for any simulation in order to evaluate all buildings equally.

13.2 Specific Energy Consumption

Energy performance of existing buildings is often evaluated through stringent and complete monitoring of the energy consumption in the building and documented through direct meter reading and recording of data, or through the provision of utility bills. In addition, the building specifications and uses will need to be defined through an audit where its design is mapped, and an inventory of installed electrical appliances is developed. With such data available, the specific energy consumption can be determined (in kWh/m²/year), and this figure can then be compared with other buildings of the same function, and it can be rated accordingly. The specific energy consumption does not take into account the schedule of use, but having the inventory and audit data available, end uses, schedules, and related building performance characteristics of the building are determined and analysed to enable the identification of appropriate energy saving measures can be identified.

It is a strong recommendation that, beyond the buildings sector, but related to energy efficiency in buildings, the government support the deployment of smart meters to support the integration of smart technologies for energy efficiency.

14 MVE: Compliance pathways

To ensure a successful implementation of Ghana's BEEG, a clear, accessible, and enforceable framework for compliance is needed to guide the actions of all market participants. As such, these compliance guidelines are a central point of reference that generates understanding and agreement between the policymaking/enforcing side and the industry side. This chapter outlines the compliance pathway options that a BEEG can set for the sector to follow and to meet the performance standards outlined in these Guidelines.

BEEGs can provide different pathways to meet their energy performance requirements, offering flexibility while ensuring that the ultimate objectives of reducing energy consumption and minimising environmental impact are achieved. These pathways include either prescriptive requirements or a whole building performance approach.

- **Prescriptive approach:** The prescriptive pathway involves specific requirements for building design, systems and materials. Compliance is achieved by adhering to specific minimum standards without deviation. These requirements can cover the building envelope (roof, walls, windows and doors), HVAC systems, lighting, water heating, and renewable energy integration. The prescriptive pathway is particularly useful for traditional and standard construction projects where the energy efficiency solutions are straightforward to implement and easily measurable. Some of the examples of these requirements include:
 - Specifications for insulation, window-to-wall ratios, and shading.
 - Detailed guidelines for heating, cooling, and lighting systems, including specific wattage and efficiency thresholds.
 - Minimum requirements for solar panel and water heater installations.

This will apply to buildings following detailed requirements and scored via the questionnaire and converted to a 1–7-star rating as provided by the Energy Commission.

- **Whole building performance approach:** This approach is an alternative to the prescriptive requirements approaches and focuses on achieving a specific energy performance target for the building as a whole, allowing for greater flexibility in how these goals are met. Developers, architects, and engineers can choose the systems, materials, and technologies that best suit the building design and local conditions, provided that the building's overall energy performance meets or exceeds the established benchmark. Such a benchmark is determined on the basis of the minimum prescriptive requirements. Some of the key characteristics of this form of enforcement include:
 - Projects will use building energy modelling to demonstrate that the energy consumption of the proposed design meets or exceeds the energy performance index of the baseline design.
 - The building must meet predefined energy performance criteria such as kilowatt-hours per square meter per year (kWh/m²/year).
 - Performance standards will require that a percentage of the building's energy demand be met through renewable sources.

This pathway is better suited for more complex or unique projects where a custom approach to energy efficiency is required, such as high-rise buildings, mixed-use developments, or those incorporating advanced green technologies.

This will be applicable to buildings demonstrating efficiency beyond prescriptive limits, rated by FEC intensity against type-specific benchmarks.

- **Hybrid compliance:** A hybrid pathway combines both prescriptive and performance-based approaches applied to different elements of building design, looking to optimise technology benefits while considering ease of implementation and costs. For example, specific energy-saving measures (e.g., thermal insulation values) might be prescribed for certain building components, while the overall energy performance of the building can be performance-based. This approach offers flexibility but ensures that critical elements of building efficiency are not overlooked. The hybrid pathway is particularly suited to projects that may incorporate both standard and innovative technologies, enabling developers to meet the code's goals while optimising design and functionality.
- **Building certification:** Certification provides another avenue to comply with energy requirements based on the certification of a building by a third party. This can be used in combination with a recognised rating system that would indicate a level of performance. In this case, it is essential that the certification schemes are strongly implemented, and the levels of performance specified in the certification scheme match the needs of the country.

This option also serves as an independent validation of a building's energy performance, confirming that it meets or exceeds the standards set by the BEEG. Buildings can be certified through third-party (internationally recognised) rating systems such as LEED, BREEAM, or Green Star. These systems assess a building's overall sustainability, covering energy efficiency, water use, materials, and indoor environmental quality. Certification can be a powerful marketing tool, highlighting a building's green credentials to potential tenants, buyers, and investors.

14.1 Building simulation and estimation of building performance

Understanding the performance of building designs through computer simulations (modelling) is an essential tool for compliance under the building performance pathway and the hybrid compliance pathway. Through the use of energy modelling software, developers can simulate how a building will perform in terms of energy consumption, comfort, and sustainability before construction begins, allowing developers the opportunity for optimisation of the designs to meet performance goals.

These calculations provide an objective, data-driven method for evaluating how energy is consumed within a building, enabling developers, designers, and regulatory authorities to ensure compliance with code requirements and to optimise energy use. Further, over time, a database of performance simulations, comparisons to actual operational measures, and the implementation experience will grow a body of knowledge and expertise that provides the necessary information to refine and expand the BEEG in the future.

14.1.1 Methods for calculating energy performance

Methods to estimate energy performance use whole-building energy modelling to simulate real-world energy use under different conditions, allowing for innovative and integrated design solutions. This process provides a comprehensive evaluation of the building and the contribution that different components make to the overall building performance, enabling developers to adapt to a wide range of design strategies and technologies.

14.1.2 Energy modelling

Modelling building performance uses estimation models that incorporate detailed inputs such as building geometry, material properties, climate data, HVAC systems, lighting, and occupancy schedules

to determine demand for different energy services, which in turn, generate energy demand. Some of the more common energy modelling tools include:

- **EnergyPlus** (by U.S. DOE) A robust, open-source simulation tool for modelling heating, cooling, lighting, ventilation, and other energy flows. (<https://energyplus.net>)
- **eQUEST**: A user-friendly tool with a graphical interface that allows quick setup for energy simulations using DOE-2. (<http://www.doe2.com/equest/>)`
- **DesignBuilder**: A commercial interface built on EnergyPlus with visual modelling capabilities. It supports advanced simulations and daylight analysis. (<https://designbuilder.co.uk/>)
- **IES VE** (Integrated Environmental Solutions Virtual Environment): Comprehensive modelling for thermal performance, lighting, and HVAC systems. (<https://www.iesve.com>)

These tools vary in complexity, cost, and information requirements, which should be considered when making a choice of tool to use.

14.1.3 Key performance information needs for modelling

There are a variety of key indicators (metrics) used to assess energy performance. These include:

- **Energy Use Intensity (EUI)**: Measures total energy used per square meter annually (kWh/m²/year). Lower EUI indicates higher efficiency.
- **Heating/Cooling Load**: Quantifies the energy needed to maintain comfortable temperatures.
- **CO₂ Emissions**: Calculated from the energy mix used (e.g., electricity, gas), indicating the building's carbon footprint.
- **Thermal Comfort**: Assesses how well a building maintains comfort conditions (temperature, humidity, airflow) based on standards like ASHRAE 55.

Other important performance metrics needed for building modelling include the building envelope performance, which includes:

- **U-Value (Thermal transmittance)**: Indicates heat transfer rate; lower U-values mean better insulation.
- **SHGC (Solar Heat Gain Coefficient)**: Represents how much solar heat passes through windows.
- **Air Tightness**: Typically assessed through blower door tests to identify air leaks that compromise HVAC efficiency.

When buildings generate on-site renewable energy (e.g., through solar PV or solar thermal systems), that energy offsets their total consumption. In calculations:

- **Gross Energy Use**: Total energy demand from all sources.
- **Renewable Offset**: Energy generated from on-site renewables.
- **Net Energy Use = Gross Energy Use – Renewable Offset**
- This metric helps determine if a building is Net Zero Energy Ready or fully Net Zero.

15 MVE: Enforcement

A strong regulatory framework requires enforcement mechanisms to ensure that these standards are not just recommendations but legally binding requirements for all applicable new constructions and major retrofits.

This chapter outlines the key enforcement processes, detailing how authorities, such as building inspectors and code enforcement officers, will conduct plan reviews, site inspections, and performance testing at various stages of construction. It would also specify the roles of relevant agencies in monitoring compliance and ensuring that materials, systems, and construction practices align with BEEG requirements.

As part of the enforcement framework, the BEEG also establishes a system of penalties for non-compliance. These could range from fines and project delays to permit revocations and mandatory corrective actions. By implementing clear consequences for failing to meet energy efficiency standards, the regulatory framework ensures accountability and encourages the adoption of best practices in sustainable construction.

15.1 Integration with existing building inspection and testing requirements

During the development of this BEEG, it needs to be considered that Ghana already has a policy with a structured set of inspections and tests for buildings, including some aspects of environmental (and energy) performance through the Ghana Building Code (GhBC) GS 1207:2018. While the existing code coverage of energy requirements is limited to making recommendations and setting minimum levels of performance for certain applications, the processes of inspections and tests are already included for energy use and inspections for energy efficiency (e.g., Section 1.12.3.8- Energy Efficiency Inspections).

Based on this understanding, it is not relevant to redesign this process or to create a parallel set of inspections, adding complexity to an already heavily regulated environment, adding burden to government and industry, and ultimately likely resulting in weak compliance rates.

As such, the BEEG requirements and enforcement are being developed in alignment with the Ghanaian climate and building sector needs, providing specific energy performance targets (e.g., kWh/m²/year), methods of compliance, testing procedures, and capacity development pathways in an integrated manner.

RECOMMENDATION: THE BEEG SHOULD BE INTEGRATED AS A DEDICATED ANNEXE OR CHAPTER UNDER PART 1: SCOPE AND ADMINISTRATION AND CROSS-REFERENCED UNDER RELEVANT SECTIONS

Section 1.6 – Permits: Require BEEG compliance documentation (design-stage energy model or prescriptive checklist) as part of the permit application process.

Section 1.9 – Submission Documents: Include mandatory submission of energy modelling results or prescriptive compliance checklists, insulation details, HVAC specifications, and solar readiness provisions.

Section 1.12 – Inspections: Expand existing inspection protocols to include post-installation verification of insulation, HVAC, lighting controls, and on-site energy systems, including blower door and duct leakage tests.

Section 1.13 – Certificate of Occupancy: Make occupancy conditional on passing BEEG performance inspections

The enforcement of the BEEG within the Ghana Building Code should be structured around existing institutional mandates to ensure clarity, accountability, and sustainability. As such, the Ministry of Works and Housing (MoWH) should serve as the policy lead at the national level, responsible for embedding the BEEG into the legal and administrative framework of the national building regulations. The Energy Commission would be the technical authority, overseeing the development and maintenance of performance guidelines and the certification of professionals, while the Metropolitan, Municipal, and District Assemblies (MMDAs) would be the primary implementing bodies.

Other secondary, yet important, roles are envisioned for the Ghana Standards Authority (GSA) to provide support through the development and maintenance of testing protocols and calibration standards, ensuring uniformity and reliability across all enforcement activities and expert of organizations (such as

the Association of Ghana Industries, the Ghana Green Building Council, and the Ghana Institution of Engineers), would provide training, capacity-building, and third-party testing and verification.

15.1.1 Phased approach

To effectively integrate the BEEG into the Ghana Building Code, a staged and systematic approach is recommended. First, a formal amendment to the GS 1207:2018 code should introduce a new annex dedicated to building energy efficiency. This annex would reference the BEEG to outline both performance-based and prescriptive compliance pathways, minimum requirements by building type, and documentation standards. These changes then need to trickle down to the changes of all the relevant regional by-laws to ensure that MMDAs can implement and enforce the changes.

At the same time, relevant sections of the code, such as those on permitting, document submission, inspections, and certificate of occupancy, should be cross-referenced to incorporate BEEG compliance as a mandatory element of the approval process. To ensure usability and reduce administrative burdens, the integration process should include the development of standardised templates and checklists, aligned with the BEEG, that designers and inspectors can use during plan submission and site inspections.

Finally, recognising the need for adaptation and the development of skilled professionals, the rollout of BEEG enforcement should be phased in stages, starting with high-consumption and larger, building types (e.g., offices, hotels, hospitals) that address larger proportions of the incoming energy demand. Also, initial enforcement would focus on larger urban areas with higher starting regulatory capacity, then gradually expand nationwide as awareness and skills improve, especially in rural MMDAs.

15.2 Compliance inspection and testing

Inspections and testing form the backbone of BEEG enforcement—they verify that designs are correctly executed in the field, that systems perform as intended, and that buildings achieve expected energy performance. Unlike design checks, these processes identify deviations at the building sites, fostering accountability and ensuring code objectives are realised.

Inspections can take place before, during, and after the construction of the building to ensure it conforms to the performance standards outlined in the code. These measures act as a practical bridge between theoretical design and the actual built environment. They ensure that performance targets for energy use, thermal comfort, system efficiency, and envelope integrity are not only promised in documentation but realised on site.

A structured inspection and testing regime supports:

- **Accountability:** Holding builders and designers to approved standards.
- **Performance Assurance:** Verifying that building systems operate as intended.
- **Corrective Feedback:** Providing timely interventions to fix deficiencies before they become embedded or costly.
- **Code Evolution –** Using field data to inform future updates of the BEEG.

A robust regime of inspections and testing looks at different stages of the project with different objectives for each stage. Table 8 illustrates and summarises the regime, including recommended roles for related stakeholders.

- **Design phase review:** Before construction begins, inspections focus on verifying that design documents align with BEEG requirements. This includes reviewing architectural drawings, specifications, and energy modelling reports. Key elements include insulation values, window glazing properties, HVAC system efficiencies, and proposed lighting and control systems. In performance-based compliance paths, submitted energy simulations are checked for accuracy, adherence to prescribed methods, and consistency with the physical layout and systems of the

proposed building. The successful results of such an application will result in a license for construction being issued, and the pre-construction reviews form the baseline for later inspections.

- **Construction phase inspections:** During construction, inspections are conducted at several milestones to ensure that work is progressing following the approved design. This includes checking that insulation is properly installed (continuously, uncompressed, and free of voids). Inspectors verify that air barrier systems are complete and continuous, and that window and door installations meet specified thermal performance and sealing standards. HVAC system installation is also checked, including equipment types, placement, and duct sealing. Lighting fixtures and associated control systems (such as occupancy sensors) are visually inspected and confirmed to match the specifications in the compliance documentation.
- **Commissioning:** Once construction is complete, formal testing and commissioning ensure that the installed systems perform as intended. Examples of this type of testing include duct leakage testing to evaluate the integrity of HVAC ductwork, and thermal imaging (infrared thermography) helps identify insulation failures and thermal bridges. System commissioning involves functional tests of heating, cooling, and ventilation systems to verify they respond appropriately to controls and deliver the intended comfort and efficiency. Lighting controls, such as daylight dimmers and timed shut-offs, are tested for responsiveness and zoning accuracy. Domestic hot water systems are assessed to confirm adequate temperature control and minimal heat loss.
- **Operational performance verification:** Some BEEGs include requirements for operational verification over time, in particular, those BEEGs with industry-leading objectives or Certification schemes require periodic testing to ensure an enduring high level of performance. Energy consumption data, gathered through utility bills or smart meters, is compared to the projected Energy Use Intensity (EUI). Variations may indicate construction flaws, equipment underperformance, or improper use. This stage helps close the loop between design intent and actual building behaviour, providing insights for both code enforcement and future design improvement.
- **Special inspections for renewable energy and controls:** For buildings incorporating on-site renewable energy or advanced automation, additional inspections can be required. Solar photovoltaic systems are tested for proper orientation, output, and integration with inverters and building electrical systems. Battery storage systems are checked for safety, capacity, and smart integration. Building Automation Systems (BAS) are reviewed to confirm that their control strategies (e.g., HVAC scheduling, load shedding) are effectively managing energy use.

15.3 Roles and capacity

Enforcement of a BEEG requires a clear allocation of responsibilities across institutions with the needed policy and operational capabilities, combining national-level oversight with local-level implementation. In Ghana, the overarching responsibility for the BEEG could logically reside with either the **Energy Commission** or the **Ministry of Works and Housing (MoWH)**. The Energy Commission, already mandated to regulate energy efficiency, is well-suited to serve as the technical authority. It has experience in setting MEPS, managing appliance standards, and supporting national commitments on energy efficiency and climate change. Conversely, the MoWH, as the primary steward of the Ghana Building Code and national construction regulations, is ideally positioned to act as the policy lead and integrate the BEEG into existing construction and permitting frameworks. Further, the MoWH already has a chain of operational actionability established with local authorities and the construction industry to support the BEEG implementation. In the end, it is expected that the BEEG will be fully integrated into the Ghana Building Code (at least in operational terms) to minimise the impact on government and industry.

RECOMMENDATION: OVERALL RESPONSIBILITY TO BE WITH THE MINISTRY OF WORKS AND HOUSING

MoWH should act as the policy lead and code owner, responsible for integrating the BEEG into national building regulations and ensuring its robust operationalisation at all levels of government.

The **Energy Commission** should be integrally involved and serve as the technical authority, developing the performance criteria and training frameworks, and overseeing the suitability of the auditing and testing practices to ensure even application and develop capacity building initiatives as needed.

In either scenario, the operational enforcement is likely to primarily rest with Metropolitan, Municipal, and District Assemblies (MMDAs), which are already tasked with the existing requirements of the building code. As such, MMDAs are best placed to carry out the added inspection and testing from BEEG. Further, MMDAs have jurisdiction over local development and urban planning, giving them unique access and local knowledge to handle the added elements. With appropriate training and standardised tools, MMDA inspectors can develop the needed capacity to enforce BEEG provisions consistently across regions.

During the design review stage, MMDA planning officers and engineers would evaluate building plans for compliance with BEEG criteria. This includes confirming that submitted drawings and documentation meet requirements for insulation, glazing, equipment efficiencies, and energy modelling results (where applicable). Support for these reviews can come from professional bodies such as the Ghana Institute of Architects (GIA) and the Ghana Green Building Council, which can assist in interpreting performance-based designs and integrating energy modelling software like EnergyPlus or DesignBuilder.

As buildings move into the construction phase, **MMDA building inspectors** will conduct site visits to verify compliance with BEEG (and related) standards. Their focus includes ensuring the correct installation of insulation, continuity of air barriers, proper sealing of windows and doors, and installation of energy-efficient mechanical and lighting systems. These inspectors need practical training in recognising common non-compliance issues and using BEEG-specific checklists. Oversight during this phase can be provided by the MoWH, which sets construction policy and codes, and by the Ghana Institution of Engineers (GhIE), which supports technical capacity-building.

For specialised testing and commissioning, including HVAC system verification, lighting control testing, and hot water system commissioning, certified third-party firms (approved by a capable body such as the Energy Commission) could be involved, but with oversight remaining within the MMDAs. These firms must employ Certified Energy Auditors (CEAs) or related professionals with equivalent credentials, such as those offered by the Association of Ghana Industries (AGI) Energy Service Centre. These entities ensure that installed systems perform according to specifications and meet BEEG targets. Their services are critical during the final stages of construction before occupancy is approved.

If the need for envelope performance testing arises, such as blower door tests for air tightness and duct leakage tests, they will also be carried out by specialised testing firms. These firms usually operate independently of the construction team and are accredited by either the **Ghana Standards Authority (GSA)** or the **Energy Commission**. Their expertise includes setting up and operating diagnostic equipment, conducting tests according to national or international protocols (e.g., ASHRAE), and interpreting the results for code compliance. The **Ghana Green Building Council** may offer additional support through training and certification of test technicians.

In buildings with integrated renewable energy systems, the Renewable Energy Division of the Energy Commission will inspect installations such as solar photovoltaic (PV) systems and solar water heaters. These inspections confirm that the systems are appropriately sized, safely installed, and effectively

integrated into the building's energy supply. Support may be provided by the **Electrical Contractors Association of Ghana** and utilities like **ECG or NEDCo**, especially where grid-tied systems are involved.

This division of responsibilities looks to cover all the needs of a BEEG, with a national-level leadership role resting in central government, while the operationalisation is led by MMDAs with the support of national and local expert bodies and industry participants.

Table 8: Inspection and testing mapping of roles, responsibilities and needed expertise for the successful implementation of a BEEG. (Source: HEAT Analysis)

Function / Inspection Area	Lead Implementing Agency	Oversight Agency	Supporting Institutions	Skills and Expertise Required
Design Review & Documentation	MMDAs (District Assemblies)	MoWH or Energy Commission	Works Department, GIA, GBC, Architectural Schools	Energy modelling interpretation, review of insulation/glazing specs, HVAC layout checks, and lighting design review
Construction Phase Inspections	MMDAs (Site Engineers & Inspectors)	MoWH	GhIE, GBC, Technical Training Institutes	On-site verification of insulation, window installation, HVAC setup, and BEEG checklist use
System Testing & Commissioning	Certified Third-Party Firms	Energy Commission	AGI Energy Service Centre, GSA	Certified Energy Auditor (CEA), HVAC commissioning, lighting & control testing, report writing
Envelope Testing (Airtightness & Ducts)	Accredited Testing Firms	GSA / Energy Commission	Ghana Green Building Council, Private Testing Labs	Blower door test operation, duct leakage testing, test data analysis, equipment setup
Renewable Energy System Inspection	Energy Commission (RE Division)	Energy Commission	ECG, NEDCo, Electrical Contractors Assoc.	PV system sizing and orientation, inverter checks, system safety inspection, and connection verification
Post-Occupancy Monitoring	Works department	Works Department	Energy Commission, OHLGS, Facility Managers, Energy Performance Assessors, Utility Companies	Smart meter data analysis, EUI calculation, performance gap identification, energy audit methodology
Advice on spatial planning (e.g. orientation,	Physical Planning	Physical Planning Department	Energy Commission, LUSPA, Office of the Head of Local	Architecture

microclimate). Ensure land use and greenery compliance	Department (PPD)		Government Services (OHLGS)	Landscape use and design Zoning and code interpretation.
Screen submissions for completeness and pathway eligibility. Score Prescriptive checklists, oversee construction. Coordinate with EC for Performance/Certification validation. Issue permits and occupancy certificates.	Works Department	Works Department	Energy Commission, MMDAs, Developers, Designers (Architects/Engineers)	Strong administrative processes for a robust follow-up. Compliance pathway processes knowledge. Construction document review. On-site inspection technical expertise. Digital review tools. Enforcement processes.

15.4 Information required for validation/compliance check

Ensuring that buildings meet the energy efficiency requirements that are ultimately implemented in Ghana requires a well-structured process of validation and compliance. This process should be embedded into every stage of a building project, from design and construction to completion and occupancy. The goal is to confirm that all sustainability measures have been appropriately integrated, implemented, and verified to deliver measurable energy performance and environmental benefits.

To support this activity, this section outlines recommended practices for managing the information, data, and procedures necessary to support transparent and accountable compliance assessments in green building development from a generic perspective to inform the compliance process that is finally developed for Ghana.

15.4.1 Initial application and documentation

At the outset of a building project, the building owner or developer needs to submit a formal application for development approval accompanied by the following documents:

- **Detailed construction documents**, including architectural, structural, mechanical, electrical, and plumbing drawings.
- **Signed declarations** from the owner affirming the intention to comply with sustainable and energy-efficient building practices.
- **Evidence of compliance** with national and local building regulations.
- **Design details showing energy conservation strategies**, including building envelope performance, daylighting strategies, passive cooling techniques, and systems integration.
- **Drawings that meet standardised requirements**, such as appropriate scale, dimensions, colour coding, and orientation for easy review.

15.4.2 Design review and pre-construction assessment

A qualified energy or sustainability professional (e.g., energy assessor or building performance consultant) should review the design documentation to ensure it aligns with the intended sustainability goals. This review should cover:

- **Quantitative assessment of building geometry**, including total floor area, roof area, window-to-wall ratios, and overall built-up area.
- **Verification of key design performance indicators**, such as:
 - Thermal insulation values for walls and roofs.
 - Window performance characteristics, including U-factor, solar heat gain coefficient (SHGC), and visible light transmittance (VLT).
 - Projected energy performance index (EPI) or equivalent metric based on simulation modelling.
 - Equipment and system specifications for HVAC, lighting, and other active systems.
 - Controls and automation features for lighting, ventilation, and occupancy sensing.

Findings from the review should be documented using a **standardised compliance checklist**, and the building owner should be notified of any gaps or required corrections before approval.

15.4.3 Construction stage monitoring and verification

During construction, there should be a structured process to verify that the approved sustainability measures are being implemented on-site. This includes:

- **Site inspections** to confirm that the specifications for insulation, glazing, HVAC systems, lighting fixtures, and controls are followed as per design.
- **Use of approved materials and technologies**, supported by supplier documentation and invoices.
- **Progressive compliance checks**, where deviations from the approved plan are flagged and corrected before construction proceeds further.
- **Flexibility for improvement**, allowing updated materials or systems to be used if they offer equal or better energy performance, subject to verification and approval by the sustainability professional.

If major deviations are identified and not corrected, construction should be paused until compliance is re-established.

15.4.4 Completion stage review and certification

Upon construction completion, a final assessment should be conducted to confirm that the building meets all required sustainability and energy performance standards. This assessment should involve:

- **Comprehensive inspection of installed systems**, including:
 - HVAC and ventilation performance.
 - Lighting layout, controls, and measured lighting power density.
 - Efficiency ratings of motors, pumps, and control systems.
 - Verification of power distribution efficiency and power factor.
 - Installation of monitoring systems for energy and water use.
- **Re-calculation of energy performance metrics**, using as-built conditions and inputs into an approved simulation tool or performance calculator.

- **Compilation of as-built documentation**, including any changes from the original design, supported by purchase records, construction logs, and installer certificates.

A final compliance report should be issued, verifying that the building's energy and environmental performance align with its intended design and regulatory requirements.

15.4.5 Occupancy and post-occupancy monitoring

Before the building is occupied, an occupancy certificate should be issued only after confirmation that all compliance requirements have been met. This should include:

- Submission of a **completion report**, detailing energy performance metrics and confirmed system installations.
- Implementation of a **performance monitoring plan**, with clearly defined indicators (e.g., energy consumption, water usage, indoor air quality).
- Annual submission of **performance reports** for the first two years of operation to confirm that the building is operating as intended.
- Where underperformance is identified, an **energy audit** should be conducted, and corrective actions taken to enhance efficiency.

Continuous monitoring and adaptive management help ensure the building maintains its performance targets over time.

16 Annexe

16.1 Modelling guidelines for building energy performance assessment

The Modelling Guidelines establish a systematic framework for assessing the energy performance of buildings. This section sets out the principles, procedures, and standards used to model building energy use and efficiency, supporting alignment with the proposed Building Energy Efficiency Code (BEEC). Emphasis is placed on simulating key components such as the building envelope, HVAC systems, lighting, and internal energy loads within the context of the provided building envelope.

The key requirements to model building performance include:

1. **Purpose and Scope:** The initial point is defining the modelling inputs and assumptions, including building usage patterns, occupancy schedules, and climatic conditions, to ensure uniformity in energy simulations.
2. **Methodological Approach:** It is recommended to use certified thermal simulation software to model both the actual (proposed) building and a benchmark (reference) building with similar form and function. These simulations incorporate realistic climate data, operating profiles, and internal loads to enable fair and consistent comparisons of energy performance.
3. **Energy Performance Metrics:** Building energy efficiency is reported as annual energy use per unit of floor area, measured in kilowatt-hours per square meter per year (kWh/m²/year). This metric, known as annual energy intensity, serves as a standardised indicator to compare energy efficiency across different projects.
4. **Component-Specific Modelling Requirements** The guidelines specify detailed criteria for modelling various elements of a building's energy system, including:
 - a. **Building Envelope:** Guidance is provided on modelling the geometry, insulation levels, window properties, and other features for both the reference and proposed buildings.
 - b. **HVAC Systems:** Modelling must reflect actual design specifications, including equipment capacities and the energy use of fans, pumps, and other related components.
 - c. **Naturally Ventilated Spaces:** For non-mechanically cooled or heated zones, energy simulations should estimate the theoretical energy required to maintain comfort within accepted temperature thresholds.
 - d. **Reference Cooling Systems:** Even when the proposed building lacks cooling equipment, a standard cooling system is simulated in the reference building to maintain consistency in comparative assessments.
5. **Operational Schedules:** Recommended daily and seasonal schedules are provided for residential and non-residential building types. These schedules cover usage patterns for lighting, HVAC systems, and appliances, ensuring that energy modelling reflects typical occupancy and operation throughout the year.

16.2 Sample information requirement sheets for energy performance modelling

To support the consistent implementation of energy efficiency guidelines (or a code in the future) and ease the regulatory burden on authorities, the development of simplified assessment tools (format sheets) is recommended. These tools serve as a decision-support mechanism, enabling both developers and reviewers to quickly assess whether a proposed building design aligns with key sustainability criteria.

This section introduces an example of such information sheets currently in use in another jurisdiction. The accompanying images illustrate its interface and the intuitive nature of its operation.

16.2.1 Purpose and Functionality

The tool is designed as a user-friendly spreadsheet-based application that automates the evaluation of critical building performance parameters. It enables early-stage assessments and standardised checks for compliance with key provisions of a green building code. Using a combination of drop-down menus, embedded logic, and automatic calculations, the tool streamlines the review process and supports uniform interpretation of requirements across different users.

The tool covers a range of performance aspects commonly addressed in energy efficiency building standards, including but not limited to:

- Thermal Insulation Levels
- Window-to-Wall Ratios (WWR)
- HVAC System Efficiency
- Lighting Power Density
- Internal Loads and Operational Schedules

Each parameter is evaluated against predefined performance thresholds or baseline values, helping users quickly identify areas of compliance and those requiring improvement.

16.2.2 Key Input Categories

1. Building Characteristics

- Total and air-conditioned floor area
- Number of floors
- Window-to-wall ratio (WWR)
- Building orientation and typology

2. Material and Envelope Properties:

- Levels of thermal insulation for walls, roofs, and floors
- Glazing performance specifications (e.g. U-value, SHGC, VLT)
- Construction material choices and envelope assembly details

3. HVAC Systems

- HVAC system type (e.g., split units, central systems, VRF)
- Equipment efficiency ratings (e.g., SEER, COP)
- Ventilation rates and operational control strategies

4. Lighting and Equipment Loads

- Lighting power density (LPD) per space type
- Control systems (e.g., occupancy sensors, daylight dimming)
- Plug loads and equipment usage schedules

Submission Date:	
Competent Person Name:	
Competent Person Ref Number:	
Section 1: Project Details	
Owner:	
Contractor:	
Contact Person:	
Contact Telephone Number:	
Project Name	
Local Authority Ref Number	
Section 2: Building Details	
Physical Address	
Suburb	
Town	
Building Type	Residential
Building Floor Area (m ²)	
Plot Size (m ²)	

Figure 6: Illustration of the basic information data entry sheet of the assessment tool.

Section 3: Method of Compliance			
Method	Performance		
Software Used			
Section 3b: Performance-based Metrics			
Note: Only complete this section if the performance method has been selected			
	Reference	Proposed Building	
Lighting [kWh/m ² /yr]			Not Compliant
Cooling [kWh/m ² /yr]			
Total	0	0	
% Improvement over BEEC	0%		

Figure 7: Headline energy performance results indicating the level of compliance.

Section 4: Insulation Thickness				
K-value W/mK	Design Thickness mm	Minimum Threshold mm		Status
		0		Compliant
Supporting documentation attached				
Section 5: Window to Wall Ratio				
Orientation	Above-Grade Wall Area (m ²)	Vertical Glazing Area		Status
		(m ²)	(%)	
North	450	50	11.1%	Compliant
East	350	45	12.9%	Compliant
South	250	44	17.6%	Compliant
West	200	20	10.0%	Compliant
TOTAL COMPLIANCE	Compliant			
Supporting documentation attached				
Section 5 b) For any Non-Compliance in Section 5, show compliance here.				
Number of Windows: 1				
Reference	Window Height	Height of Overhang Above Window	Length of Overhang	Status
Window 1	0	0	0	Compliant
+ Add Window				
Supporting documentation attached				

Figure 8: Insulation and WWR entry sheet.

Section 6: Air Conditioning						
Drawing Ref	Model Ref	Rated Cooling Capacity (kW)	Rated Input Power (kW)	EER/COP	Inverter Compressor	Status
				0.0	No	Not Compliant
+ Add						
Supporting documentation attached						
Section 7: Lighting Power Density						
Drawing Ref	Description	Light Fitting Total W	Quantity	Total W		
+ Add						
Total Installed Lighting (kW)					0.00	
Total Building Area (m²)					0	
Total Lighting Power Density (W/m²)					area?	
Not Compliant						
Supporting documentation attached						

Figure 9: Input sheet for AC information of the building.

16.3 Operational assumptions of building equipment

The operating times and capacities of building equipment determine by in large the total consumption of energy in buildings. While all buildings will have some differences depending on occupants' behaviour and detailed activities performed in them, initial performance can be assessed with standardised assumptions of equipment use.

Table 9: Recommended assumptions for the schedule of operation of key energy services in office buildings.

Hour of the day	Lighting	Equipment	HVAC
1	0.1	0.05	0
2	0.1	0.05	0
3	0.1	0.05	0
4	0.1	0.05	0
5	0.1	0.05	0
6	0.5	0.5	0
7	0.8	0.8	1
8	1.0	1.0	1
9	1.0	1.0	1
10	1.0	1.0	1
11	1.0	1.0	1
12	1.0	1.0	1
13	1.0	1.0	1
14	1.0	1.0	1
15	1.0	1.0	1
16	1.0	1.0	1
17	1.0	1.0	1
18	0.5	0.5	1
19	0.1	0.05	0
20	0.1	0.05	0
21	0.1	0.05	0
22	0.1	0.05	0
23	0.1	0.05	0

Table 10: Recommended assumptions for the schedule of operation of key energy services in residential buildings.

Hour of the day	Cooling	Lighting	Equipment	Person load
1	0	0	0.05	0
2	0	0	0.05	0
3	0	0	0.05	0
4	0	0	0.05	0
5	0	0	0.05	0
6	0	0	0.05	0
7	0	0	0.5	0
8	0	0	0.5	0
9	1.0	1.0	1.0	0.1
10	1.0	1.0	1.0	0.3
11	1.0	1.0	1.0	0.3
12	1.0	1.0	1.0	0.5
13	1.0	1.0	1.0	0.6

14	1.0	1.0	1.0	0.6
15	1.0	1.0	1.0	0.8
16	1.0	1.0	1.0	1.0
17	1.0	1.0	1.0	0.8
18	1.0	1.0	1.0	0.5
19	1.0	1.0	1.0	0.2
20	0	0	0.5	0
21	0	0	0.05	0
22	0	0	0.05	0
23	0	0	0.05	0

Table 11: Recommended assumptions for the schedule of operation of key energy services in residential buildings.

Hour of the day	Cooling		Lightning		Equipment	
	Weekdays	Weekends	Weekdays	Weekends	Weekdays	Weekends
1	1.00	1.00	0	0	1.00	1.00
2	1.00	1.00	0	0	1.00	1.00
3	1.00	1.00	0	0	1.00	1.00
4	1.00	1.00	0	0	1.00	1.00
5	1.00	1.00	0	0	1.00	1.00
6	1.00	1.00	0	0	1.00	1.00
7	0	1.00	0	0	1.00	1.00
8	0	1.00	0	0	0.2	1.00
9	0	1.00	0	0	0.2	1.00
10	0	1.00	0	0	0.2	1.00
11	0	1.00	0	0	0.2	1.00
12	0	1.00	0	0	0.2	1.00
13	0	1.00	0	0	0.2	1.00
14	0	1.00	0	0	0.2	1.00
15	0	1.00	0	0	0.2	1.00
16	0	1.00	0	0	0.2	1.00
17	1.00	1.00	1.00	1.00	1.00	1.00
18	1.00	1.00	1.00	1.00	1.00	1.00
19	1.00	1.00	1.00	1.00	1.00	1.00
20	1.00	1.00	1.00	1.00	1.00	1.00
21	1.00	1.00	1.00	1.00	1.00	1.00
22	1.00	1.00	1.00	1.00	1.00	1.00
23	1.00	1.00	0	0	1.00	1.00

Table 12: Recommended assumptions for the schedule of operation of key energy services in multistorey residential buildings.

Hour of the day	Cooling		Lightning		Equipment	
	Weekdays	Weekends	Weekdays	Weekends	Weekdays	Weekends
1	1.00	1.00	0	0	1.00	1.00
2	1.00	1.00	0	0	1.00	1.00
3	1.00	1.00	0	0	1.00	1.00
4	1.00	1.00	0	0	1.00	1.00
5	1.00	1.00	0	0	1.00	1.00
6	1.00	1.00	0	0	1.00	1.00
7	0	1.00	0	0	1.00	1.00
8	0	1.00	0	0	0.2	1.00
9	0	1.00	0	0	0.2	1.00
10	0	1.00	0	0	0.2	1.00
11	0	1.00	0	0	0.2	1.00
12	0	1.00	0	0	0.2	1.00
13	0	1.00	0	0	0.2	1.00
14	0	1.00	0	0	0.2	1.00
15	0	1.00	0	0	0.2	1.00
16	0	1.00	0	0	0.2	1.00
17	1.00	1.00	1.00	1.00	1.00	1.00
18	1.00	1.00	1.00	1.00	1.00	1.00
19	1.00	1.00	1.00	1.00	1.00	1.00
20	1.00	1.00	1.00	1.00	1.00	1.00
21	1.00	1.00	1.00	1.00	1.00	1.00
22	1.00	1.00	1.00	1.00	1.00	1.00
23	1.00	1.00	0	0	1.00	1.00

16.4 List of contributors

The following is a list of individuals who provided valuable input for the generation of this document.

Name	Organization
Felix Addo Okyrieh	Environmental Protection Authority.
Esi Nerquaye-Tetteh	Environmental Protection Authority.
Joseph A Baffoe	Environmental Protection Authority.
Joy Hesse Ankomah	Environmental Protection Authority.
Aboyore Prosper	Environmental Protection Authority.
Amos Adonson	Environmental Protection Authority.
Bimpeh C. Enam	Environmental Protection Authority.
Derrick Sarfo-Fiadem	Environmental Protection Authority.
Hakeem Abeka-Brown	Environmental Protection Authority.

Hope Smith Lomotey	Environmental Protection Authority.
Rafia Immoro	Environmental Protection Authority.
Ebenezer Kyere	Energy Commission
Hubert Nsoh Zan	Energy Commission
Rita Ofosuhene	Energy Commission
Richard Don-Braimah	Ministry of Works and Housing
Emmanuel Otchere-Darko	Architectural and Engineering Services Limited (AESL)
Joseph Agyei Danquah (Dr.)	CSIR-Building and Road Research Institute
Stephen Opuku Baafi	CSIR-Building and Road Research Institute
Daniel Quartey	Ghana Green Building Council
Daniel Nsuison	Association of Ghana Industries (AGI)
Hilda Armah	Abulade Construction
Divine Alorwu	Quantity Surveyor
Michael Cudjoe	University of Ghana
Dorcas Essandoh	Ministry of Local Government
Bless M Abotsi	Ministry of Local Government
Paula Osei-Gyamerah	Ministry of Local Government
Rashifa Mohammed	Ministry of Local Government
Owureku Asamoah Asare	Ministry of Local Government
Foster Osae-Akunnor	Local Expert – architect
Amos Darko	local expert – energy EFFICIENCY
Auguster Boateng	local expert- gender
Prof. DeGraft Owusu-Manu	local expert – capacity building
Seth Bright Attipoe	Local Expert – legal
Freeman K. Agbomanyi	Ghana Institute of Architects
Prosper Agbesi Amlade	Ghana Institute of Architects
Christian Seward Mensah (Dr.)	Green Communities International
Matilda Owusu- Manu	Green Communities International
Freeman Gordor	Imperial Homes Ltd
Kwabena Gyimah (PhD)	Knust- Department of Architecture
Wisdom Gyansah	Wistech Engineering
Thomas Kutin	Wistech Engineering
Joshua Amengor	Wistech Engineering
Kobina Apeatse	Wistech Engineering

Noah Kitcher	Wistech Engineering
Augustine Owusu-Ansah	Wistech Engineering
Evans Nartey	Green Bond Theseus Development
Kenneth Dadson	FCC RESOURCES LTD
Emmanuel Obeng	Ghana Standards Authority
Deborah Laryea	Ministry of Sanitation and Water Resources

HEAT

HEAT has been operating as a consulting firm in the field of energy conservation and environmental protection since 1992. Since then, our team has been advising and supporting leading national and international organisations in implementing new policies, advancing technology transfer, as well as capacity building. Since 2016, HEAT has been part of the GFA Group.

Contact

kontakt@heat-international.de



@HEAT_GmbH

www.heat-international.de